STANDARD SPECIFICATIONS FOR CLARK INTERNATIONAL AIRPORT

Runway, Taxiway and Apron For Construction Design

STANDARD SPECIFICATIONS FOR

CLARK INTERNATIONAL AIRPORT

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PART B – GENERAL REQUIREMENT B.1

DEFINITION OF TERMS

The intent and meaning of the following terms are as defined below:

AASHTO. The American Association of State Highway and Transportation Officials.

Access road. The right-of-way, the roadway and all improvements constructed to connect the airport to a public highway.

Airport. Clark International Airport, Pampanga, Philippines.

ASTM. The American Society for Testing and Materials.

CAAP. Civil Aviation Authority of the Philippines

Calendar day. Every day shown on the calendar.

Client.

Drainage system. The system of pipes, ditches, and structures where surface or subsurface waters are collected and conducted away from the airport area.

Equipment. All machinery, tools and apparatus for the execution of the proper construction and acceptable completion of the work.

FAA. The Federal Aviation Administration of the U.S. Department of Transportation

Federal specifications. The Federal Specifications and Standards, Commercial Item Descriptions, and supplements, amendments, and indices prepared and issued by the General Services Administration of the Federal Government.

ICAO. International Civil Aviation Organization

Lighting. A system of fixtures providing or controlling the light sources used on or near the airport. Field lighting include all luminous signals, markers, floodlights, high mast lighting and illuminating devices to aid in the operation of aircraft during landing, take off and taxiing.

Materials. Any substance specified for use in the project.

Pavement. The combined surface course, base course, and subbase course considered as a single unit.

Project. The works related to the improvement of the Clark International Airport Airside

Proposal. The written offer of the Contractor, on the prescribed Proposal form, to perform the work and furnish the necessary materials in accordance with the plans and specifications.

Specifications. Written directions and requirements for completing the contracted work. Standards for materials and testing referred in the specifications shall have the same force and effect as the contract.

Structures. Culverts; catch basins, inlets, cribbing; storm and sanitary sewer lines; water lines; underdrains; electrical ducts, manholes, handholes, lighting fixtures and bases; transformers; pavements; navigational aids; vaults; and, other manmade features that may be encountered in the work but not classified in this document.

Subgrade. The soil that forms the pavement foundation.

Taxiway. The portion of the air operations area of an airport designated for aircraft movement to and from the airport's runways, aircraft parking, and terminal areas.

Work. Furnishing all labor, materials, tools, equipment, and incidentals necessary perform all duties and obligations imposed by the contract, plans, and specifications for each scope of work.

B.2 SCOPE OF WORK

Intent of contract. The intent of the contract is to provide for construction and completion, in every detail, of the work described. It is further intended that the Contractor shall furnish all labor, materials, equipment, tools, transportation, and supplies required to complete the work in accordance with the plans, specifications, and terms of the contract.

Scope of works. The scope of tendered part of the Project is as defined in the Invitation to Bid (ITB) to which this document is a part.

Removal of existing structures. All existing structures encountered within the established lines, grades, or grading sections shall be removed by the Contractor, unless such existing structures are otherwise specified to be relocated, adjusted up or down, salvaged, abandoned in place, reused in the work or to remain in place.

Should the contractor encounter an existing structure (above or below ground) in the work for which the disposition is not indicated on the plans, CIAC shall be notified prior to disturbing such structure. The disposition of existing structures so encountered shall be immediately determined by CIAC in accordance with the provisions of the contract.

Rights in and use of materials found in the work. Should the Contractor encounter any material such as (but not restricted to) sand, stone, gravel, slag, or concrete slabs within the established lines, grades, or grading sections, the use of which is intended by the terms of the contract to be either embankment or waste, the Contractor may at his or her option either:

a. Use such material in another contract item, providing such use is approved by CIAC and is in conformance with the contract specifications applicable to such use; or,
b. Remove such material from the site, upon written approval of CIAC; or
c. Use such material for the contractor's own temporary construction on site; or,
d. Use such material as intended by the terms of the contract.

Should the contractor wish to exercise option a., b., or c., the contractor shall request CIAC approval in advance of such use.

Should CIAC approve the contractor's request to exercise option a., b., or c., the contractor shall be paid for the excavation or removal of such material at the applicable contract price. The contractor shall replace, at his or her own expense, such removed or excavated material with an agreed equal volume of material that is acceptable for use in constructing embankment, backfills, or otherwise to the extent that such replacement material is needed to complete the contract work. The contractor shall not be charged for use of such material used in the work or removed from the site.

It is understood and agreed that the contractor shall make no claim for delays by reason of his or her exercise of option a., b., or c.

The contractor shall not excavate, remove, or otherwise disturb any material, structure, or part of a structure which is located outside the lines, grades, or grading sections established for the work, except where such excavation or removal is provided for in the contract, plans, or specifications.

Final cleanup. Upon completion of the work and before acceptance and final payment will be made, the contractor shall remove from the site all machinery, equipment, surplus and discarded materials, rubbish, temporary structures, and stumps or portions of trees. The contractor shall cut all brush and woods within the limits indicated and shall leave the site in a neat and presentable condition. Material cleared from the site and deposited on adjacent property will not be considered as having been disposed of satisfactorily, unless the contractor has obtained the written permission of such property owner.

Laws to be observed. The contractor shall keep fully informed of all Philippines laws, all local laws, ordinances, and regulations and all orders and decrees of bodies or tribunals having any jurisdiction or authority, which in any manner affect those engaged or employed on the work, or which in any way affect the conduct of the work. The contractor shall at all times observe and comply with all such laws, ordinances, regulations, orders, and decrees; and shall protect and indemnify CIAC and all his or her officers, agents, or servants against any claim or liability arising from or based on the violation of any such law, ordinance, regulation, order, or decree, whether by the contractor or the contractor's employees.

PART C – EARTHWORK

ITEM 100 - CLEARING AND GRUBBING

100.1 Description

This item shall consist of clearing, grubbing, removal and disposal of all vegetation and debris as designated in the Contract, except those objects that are designated to remain in place or are to be removed in accordance with other provisions of this Specification. The work shall also include the preservation from injury or defacement of all objects designated to remain.

The Contractor shall obtain written instruction from the Engineer on the work area before starting any work. He shall also submit equipment, materials and methodology for approval.

100.2 Construction Requirements

100.2.1 General

The Engineer shall establish the limits of work and designate all trees, shrubs, plants and other things to remain. The Contractor shall preserve all objects designated to remain, up to its final place in the completed works. Paint required for cut or scarred surface of trees or shrubs selected for retention shall be an approved asphaltum base paint prepared especially for tree surgery.

Clearing shall extend one (1) meter beyond the toe of the fill slopes or beyond rounding of cut slopes as the case maybe for the entire length of the project unless otherwise shown on the plans or as directed by the Engineer and provided it is within the right of way limits of the project, with the exception of trees under the jurisdiction of the Forest Management Bureau (FMB). The removal of existing structure and utilities required to permit orderly progress of work shall be accomplished by local agencies, unless otherwise shown on the plans. Whenever a telephone or telegraph pole, pipeline, conduit, sewer, roadway, or other utility is encountered and must be removed or relocated, The Contractor shall advise the Engineer who will notify the proper local authority or owner to secure prompt action.

Burning of any material in the site is not allowed.

100.2.2 Clearing and Grubbing

All surface objects and all trees, stumps, roots and other protruding obstructions, not designated to remain, shall be cleared and/or grubbed, including mowing as required, except as provided below:

1. Removal of undisturbed stumps and roots and nonperishable solid objects with a minimum depth of one (1) meter below subgrade or slope of embankment will not be required.

2. In areas outside of the grading limits of cut and embankment areas, stumps and nonperishable solid objects shall be cut off not more than 150 mm (6 inches) above the ground line or low water level.

3. In areas to be rounded at the top of cut slopes, stumps shall be cut off flush with or below the surface of the final slope line.

4. Grubbing of pits, channel changes and ditches will be required only to the depth necessitated by the proposed excavation within such areas.

5. In areas covered by cogon/talahib, wild grass and other vegetations, top soil shall be cut to a maximum depth of 150 mm below the original ground surface or as designated by The Contractor and disposed outside the clearing and grubbing limits as indicated in the typical roadway section.

Except in areas to be excavated, stump holes and other holes from which obstructions are removed shall be backfilled with suitable and approved material and compacted to the required density.

Materials and debris may be disposed off by methods and at locations approved by the Engineer, on or off the project. If disposal is by burying, the debris shall be placed in layers with the material so disturbed to avoid nesting. Each layer shall be covered or mixed with earth material by the land-fill method to fill all voids. The top layer of material buried shall be covered with at least 300 mm (12 inches) of earth or other approved material and shall be graded, shaped and compacted to present a pleasing appearance. If the disposal location is off the project, The Contractor shall make all necessary arrangements with property owners in writing for obtaining suitable disposal locations which are outside the limits of view from the project. The cost involved shall be included in the unit bid price. A copy of such agreement shall be furnished to the Engineer. The disposal areas shall be seeded, fertilized and mulched at The Contractor expense.

Woody material may be disposed off by chipping. The wood chips may be used for mulch, slope erosion control or may be uniformly spread over selected areas as directed by the Engineer. Wood chips used as mulch for slope erosion control shall have a maximum thickness of 12 mm (1/2 inch) and faces not exceeding 3900mm2 (6 square inches) on any individual surface area. Wood chips not designated for use under other sections shall be spread over the designated areas in layers not to exceed 75 mm (3 inches) loose thickness. Diseased trees shall be buried or disposed off as directed by the Engineer.

All merchantable timber in the clearing area which has not been removed from the right of way prior to the beginning of construction, shall become the property of The Contractor, unless otherwise provided.

Low hanging branches and unsound or unsightly branches on trees or shrubs designated to remain shall be trimmed as directed. Branches of trees extending over the roadbed shall be trimmed to give a clear height of 6 m (20 feet) above the roadbed surface. All trimming shall be done by skilled workmen and in accordance with good tree surgery practices.

Timber cut inside the area staked for clearing shall be felled within the area to be cleared.

Measurement and Rates

The actual area (in sq.m.) of clearing and grubbing shall be measured from the plan area as indicated on the Drawings or as instructed by the Engineer.

The rates shall be full compensation for all plant, materials, labor, equipment, transport, temporary works, establishment charges, overheads, profit and taxes required to complete the work described in this Section of the Specification and/or shown on the Drawings.

The rates shall include the following:

1. Disposal off the site
2. Backfilling and compaction of holes from the removal of tree root, vegetation or other obstructions in areas to be filled.

100.2.3 Individual Removal of Trees or Stumps

Individual trees or stumps designated by The Contractor for removal and located in areas other than those established for clearing and grubbing and roadside cleanup shall be removed and disposed off as specified under Subsection 100.2.2 except trees removed shall be cut as nearly flush with the ground as practicable without removing stumps.

Measurement and Rates

Removal of trees of 300mm trunk diameter or more (measured one meter above ground level) shall be measured in number.

100.2.4 Removal of Top Soil

Removal of top soil shall include excavation to remove the top layer of soil and the hauling to designated storage or disposal area as indicated on the drawings, instructed by the Engineer or specified herein.

Written instruction on work area and depth limits shall be obtained from the Engineer. Equipment and methodology should be approved.

All materials from topsoil removal shall remain the property of the Client. The Engineer will direct The Contractor on the transport and deposit, including temporary spoil heaps.

Generally, materials shall be set aside and preserved for re-use in the project. Materials not required by the Client shall be removed by The Contractor to a disposal area selected by CIAC and approved by the Engineer at no extra cost to the Client.

Measurement and Rates

The actual volume shall be computed from the plan area indicated on the Drawings multiplied by the average depth determined by survey on a 10m grid before start and repeat survey after completion of the work.

There will be no allowance for bulking or shrinkage, working space for excavation, earthwork supports or sloping sides of excavation even if they are indicated on the Drawings.

The rates shall be full compensation for all plant, materials, labor, equipment, transport, temporary works, establishment charges, overheads, profit and taxes required to complete the work.

The rates for Topsoil Removal shall further include for (a) Reinstating any existing adjacent surface pavement or sodding disturbed by the topsoil removal; (b) Removal of all water including surface and groundwater by whatever means necessary; (c) Forming any trial holes to locate existing pipes or cables; (d) Excavating by hand or machine; (e) Additional volumes required to accommodate working space to excavations, earthwork supports or sloping sides of any excavations; (f) Multiple handling, including relocating spoil heaps as necessary to permit construction of the permanent works; (g) Removal and disposal off-Site, as instructed by the Engineer; and (h) Selecting, setting aside, and preserving any material suitable for backfilling or topsoil work purposes as determined by the Engineer

ITEM 101 - REMOVAL OF STRUCTURES AND OBSTRUCTIONS

101.1 Description

This Item shall consist of the removal wholly or in part, and satisfactory disposal of all buildings, fences, structures, old pavements, abandoned pipe lines, and any other obstructions which are not designated or permitted to remain, except for the obstructions to be removed and disposed off under other items in the Contract. It shall also include the salvaging of designated materials and backfilling the resulting trenches, holes, and pits.

The schedule of removal could be referred to airfield drawing package for reference. The number of elements listed on the drawing shall be confirmed on site by CIAC. CIAC need to submit a full list of elements to be removed to the Engineer for approval.

Contractor shall submit demolition and removal plan for approval of the engineer. Special care should be practiced during excavation as the area may have unexploded ordnance or explosives left behind by the previous user of the airfield. If unexploded ordnance are unearth, CIAC must be notified immediately. Contractor shall not disturb unearth ordnance or explosives.

101.2 Construction Requirements

101.2.1 General

CIAC shall perform the work described above, within and adjacent to the roadway, on Government land or easement, as shown on the Plans or as directed by the Engineer. All designated salvable material shall be removed, without unnecessary damage, in sections or pieces which may be readily transported, and shall be stored by CIAC at specified places on the project or as otherwise shown in the Special Provisions. Perishable materials shall be handled as designated in Subsection 100.2.2 Nonperishable material may be disposed off outside the limits of view from the project with written permission of the property owner on whose property the material is placed. Copies of all agreements with property owners are to be furnished to the Engineer. Basements or cavities left by the structure removal shall be filled with acceptable material to the level of the surrounding ground and, if within the prism of construction, shall be compacted to the required density.

101.2.2 Removal of Existing Bridges, Culverts, and other Drainage Structures

All existing bridges, culverts and other drainage structures in use by traffic shall not be removed until satisfactory arrangements have been made to accommodate traffic. The removal of existing culverts within embankment areas will be required only as necessary for the installation of new structures. Abandoned culverts shall be broken down, crushed and sealed or plugged. All retrieved culvert for future use as determined by the Engineer shall be carefully removed and all precautions shall be employed to avoid breakage or structural damage to any of its part. All sections of structures removed which are not designated for stockpiling or re-laying shall become the property of the Government and be removed from the project or disposed off in a manner approved by the Engineer.

Unless otherwise directed, the substructures of existing structures shall be removed down to the natural stream bottom and those parts outside of the stream shall be removed down to at least 300 mm (12 inches) below natural ground surface. Where such portions of existing structures lie wholly or in part within the limits for a new structure, they shall be removed as necessary to accommodate the construction of the proposed structure.

Steel bridges and wood bridges when specified to be salvaged shall be carefully dismantled without damaged. Steel members shall be match marked unless such match marking is waived by the Engineer. All salvaged material shall be stored as specified in Subsection 101.2.1.

Structures designated to become the property of the CIAC shall be removed from the right-of-way.

Blasting or other operations necessary for the removal of an existing structure or obstruction, which may damage new construction, shall be completed prior to placing the new work, unless otherwise provided in the Special Provisions.

101.2.3 Removal of Pipes Other than Pipe Culverts

Unless otherwise provided, all pipes shall be carefully removed and every precaution taken to avoid breakage or damage. Pipes to be re-laid shall be removed and stored when necessary so that there will be no loss of damage before re-laying. CIAC shall replace sections lost from storage or damaged by negligence, at his own expense.

101.2.4 Removal of Existing Pavement, Sidewalks, Curbs, etc.

All concrete pavement, base course, sidewalks, curbs, gutters, etc., designated for removal, and shall be:

1. Broken into pieces and used for riprap on the project, or

2. Broken into pieces, the size of which shall not exceed 300 mm (12 inches) in any dimension and stockpiled at designated locations on the project for use by the Government, or

3. Otherwise demolished and disposed off as directed by the Engineer. When specified, ballast, gravel, bituminous materials or other surfacing or pavement materials shall be removed and stockpiled as required in Subsection 101.2.1, otherwise such materials shall be disposed as directed.

There will be no separate measurement for work done to excavate for removal of structures and obstructions or for backfilling and compacting the remaining cavity.

ITEM 102 - EXCAVATION

102.1 Description

This Item shall consist of excavation for both soft and hard soil strata to all required areas of the site. Excavation shall include supports to sides or additional excavation to form sloped sides, working space, disposal of all water (including surface and ground water), segregation of material suitable for backfilling or embankment, handling, stockpiling, disposal, shaping and trimming completed excavation surface in accordance with the locations, lines, levels, grades and dimensions shown on the drawings and specified herein.

102.1.1 Classification

Excavation includes general excavation to reduce levels, where applicable and structural excavation for foundations and other below ground structures including excavation to expose underground anomalies and remove in fill unsuitable materials found on underground cavities and replaced with suitable materials and compacted in the permanent works to meet the requirements of Section 2140 Embankment all in accordance with the written instruction of the Engineer.

Excavation shall also include excavation in and the necessary diversion or containment of canals or watercourses, with all necessary pumping, draining, sheeting, bracing and the construction, maintenance and subsequent removal of cribs and cofferdams.

Prior to start of Excavation, CIAC shall obtain the Engineer's written instructions regarding work area and depth limits, and approval for the equipment and materials to be used and the method of work execution. The work methodology must include proposals for protecting the excavated areas from slippage and the surface run-off of water and other material to adjacent areas or watercourses.

All materials arising from Excavation shall remain the property of the Client and the Engineer will direct the Contractor where the materials are to be transported and deposited.

The concept of Site development is "cut and fill" and consequently no excavated materials shall be removed from the Site. Excavated materials shall all be set aside for re-use including treating by crushing, grading or otherwise, placed and compacted in the permanent Works to meet the requirements of Embankment, including transporting and placing by CIAC to various locations around the Site.

Where specifically and exceptionally instructed in writing by the Engineer that materials are not required to be retained by CIAC, materials shall be removed by the Contractor from the Site to a disposal area to be selected by the Contractor (and approved by the Engineer) at the expense of the Contractor.

Excavation shall be classified as:

1. Unclassified Excavation. Unclassified excavation shall consist of the excavation and disposal of all materials regardless of its nature, not classified and included in the Bill of Quantities under other pay items. Excavation may be executed with hydraulic excavators, scrapers, bulldozers (with or without rippers or similar attachments) regardless of their proportion and hardness, except rock and boulder.

2. Rock Excavation. Rock excavation shall consist of igneous, sedimentary and metamorphic rock which cannot be excavated without blasting or the use of rippers, and all boulders or other detached stones each having a volume of 1 cubic meter or more as determined by physical measurements or visually by the Engineer.

3. Muck Excavation. Muck excavation shall consist of the removal and disposal of deposits of saturated or unsaturated mixtures of soils and organic matter not suitable for foundation material regardless of moisture content.

4. Drainage excavation shall consist of excavating for drainage ditches such as intercepting inlet or outlet ditches; for temporary levee construction; or for any other type as designed or as shown on the plans. The work shall be performed in sequence with the other construction activities. Intercepting ditches shall be constructed prior to starting adjacent excavation operations. All satisfactory material shall be placed in embankment fills; unsuitable material shall be placed in designated waste areas or as directed by the Engineer. All necessary work shall be performed true to final line, elevation, and cross-section. The Contractor shall maintain ditches constructed on the project to the required cross-section and shall keep them free of debris or obstructions until the project is accepted.

5. Unsuitable excavation. Any material containing vegetable or organic matter, such as muck, peat, organic silt, or sod shall be considered unsuitable for use in embankment construction. Material, suitable for topsoil may be used on the embankment slope when approved by the Engineer.

102.1.2 Borrow Excavation

Borrow excavation shall consist of the excavation and utilization of approved material required for the construction of embankments or for other portions of the work, and shall be obtained from approved sources, in accordance with Clause 61 of Standard Specifications for Public Works and Highways, Volume 1 and the following:

1. Borrow, Case 1

Borrow Case 1 will consist of material obtained from sources designated on the Plans or in the Special Provisions.

2. Borrow, Case 2

Borrow Case 2 will consist of material obtained from sources provided by the Contractor.

The material shall meet the quality requirements determined by the Engineer unless otherwise provided in the Contract.

102.2 Construction Requirements

102.2.1 General

Before beginning excavation, grading, and embankment operations in any area, the area shall be completely cleared, grubbed and top soil removed.

When the Contractor’s excavating operations encounter artifacts of historical, archaeological significance or hazardous materials, the operations shall be temporarily discontinued and the Engineer shall be notified. At the direction of the Engineer, the Contractor shall excavate the site in such a manner as to preserve the artifacts encountered and allow for their removal.

Those areas outside of the limits of the pavement areas where the top layer of soil material has become compacted by hauling or other Contractor activities shall be scarified and disked to a depth of 100 mm, to loosen and pulverize the soil.

If it is necessary to interrupt existing surface drainage, sewers or under-drainage, conduits, utilities, or similar underground structures, the Contractor shall be responsible for and shall take all necessary precautions to preserve them or provide temporary services. When such facilities are encountered, the Contractor shall notify the Engineer, who shall arrange for their removal if necessary. The Contractor, at his expense, shall satisfactorily repair all damage to such facilities or structures that may result from any of the Contractor's operations during the period of the contract.

When there is evidence of discrepancies on the actual elevations and that shown on the Plans, a pre-construction survey referred to the datum plane used in the approved Plan shall be undertaken by the Contractor under the control of the Engineer to serve as basis for the computation of the actual volume of the excavated materials.

All excavations shall be finished to reasonably smooth and uniform surfaces. No materials shall be wasted without authority of the Engineer. Excavation operations shall be conducted so that material outside of the limits of slopes will not be disturbed. Prior to excavation, all necessary clearing and grubbing in that area shall have been performed in accordance with Item 100, Clearing and Grubbing.

The removal of existing structures and utilities required to permit the orderly progress of work will be accomplished by someone other than the Contractor; for example, the utility unless otherwise shown on the plans. All existing foundations shall be excavated at least 60 cm below the top of subgrade or as indicated on the plans, and the material disposed of as directed by the Engineer. All foundations thus excavated shall be backfilled with suitable material and compacted as specified.

The subgrade under areas to be paved shall be compacted to meet Item 105 requirements.

102.2.2 Conservation of Topsoil

Where provided for on the Plans or in the Special Provisions, suitable topsoil encountered in excavation and on areas where embankment is to be placed shall be removed to such extent and to such depth as the Engineer may direct. The removed topsoil shall be transported and deposited in storage piles at locations approved by the Engineer. The topsoil shall be completely removed to the required depth from any designated area prior to the beginning of regular excavation or embankment work in the area and shall be kept separate from other excavated materials for later use.

102.2.3 Utilization of Excavated Materials

All suitable material removed from the excavation shall be used in the formation of the embankment, subgrade, shoulders, slopes, bedding, and backfill for structures, and for other purposes shown on the Plans or as directed. The Engineer will designate as unsuitable those soils that cannot be properly compacted in embankments. All unsuitable material shall be disposed off as shown on the Plans or as directed without delay to the Contractor.

Only approved materials shall be used in the construction of embankments and backfills.

All excess material, including rock and boulders that cannot be used in embankments shall be disposed as directed.

Material encountered in the excavation and determined by the Engineer as suitable for topping, road finishing, slope protection, or other purposes shall be conserved and utilized as directed by the Engineer.

Borrow material shall not be placed until after the readily accessible roadway excavation has been placed in the fill, unless otherwise permitted or directed by the Engineer. If the Sub-contractor places more borrow than is required and thereby causes a waste of excavation, the amount of such waste will be deducted from the borrow volume.

102.2.4 Pre-watering

Excavation areas and borrow pits may be pre-watered before excavating the material. When pre-watering is used, the areas to be excavated shall be moistened to the full depth, from the surface to the bottom of the excavation. The water shall be controlled so that the excavated material will contain the proper moisture to permit compaction to the specified density with the use of standard compacting equipment. Pre-watering shall be supplemented where necessary, by truck watering units, to ensure that the embankment material contains the proper moisture at the time of compaction.

The Contractor shall provide drilling equipment capable of suitably checking the moisture penetration to the full depth of the excavation.

102.2.5 Presplitting

Unless otherwise provided in the Contract, rock excavation which requires drilling and shooting shall be presplit.

Presplitting to obtain faces in the rock and shale formations shall be performed by:
1. Drilling holes at uniform intervals along the slope lines,
2. Loading and stemming the holes with appropriate explosives and stemming material, and
3. Detonating the holes simultaneously.

Prior to starting drilling operations for presplitting, the Contractor shall furnish the Engineer a plan outlining the position of all drill holes, depth of drilling, type of explosives to be used, loading pattern and sequence of firing.

The drilling and blasting plan is for record purposes only and will not absolve the Contractor of his responsibility for using proper drilling and blasting procedures. Controlled blasting shall begin with a short test section of a length approved by the Engineer. The test section shall be presplit, production drilled and blasted and sufficient material excavated whereby the Engineer can determine if the Contractor's methods are satisfactory. The Engineer may order discontinuance of the presplitting when he determines that the materials encountered have become unsuitable for being presplit.

The holes shall be charged with explosives of the size, kind, strength, and at the spacing suitable for the formations being presplit, and with stemming material which passes a 9.5 mm (3/8 inch) standard sieve and which has the qualities for proper confinement of the explosives.

The finished presplit slope shall be reasonably uniform and free of loose rock. Variance from the true plane of the excavated backslope shall not exceed 300 mm (12 inches); however, localized irregularities or surface variations that do not constitute a safety hazard or an impairment to drainage courses or facilities will be permitted.

A maximum offset of 600 mm (24 inches) will be permitted for a construction working bench at the bottom of each lift for use in drilling the next lower presplitting pattern.

102.2.6 Excavation of Ditches, Gutters, etc.

All materials excavated from side ditches and gutters, channel changes, irrigation ditches, inlet and outlet ditches, toe ditchers, furrow ditches, and such other ditches as may be designated on the Plans or staked by the Engineer, shall be utilized as provided in Subsection 102.2.3.

Ditches shall conform to the slope, grade, and shape of the required cross-section, with no projections of roots, stumps, rock, or similar matter. The Contractor shall maintain and keep open and free from leaves, sticks, and other debris all ditches dug by him until final acceptance of the work.

Furrow ditches shall be formed by plowing a continuous furrow along the line staked by the Engineer. Methods other than plowing may be used if acceptable to the Engineer. The ditches shall be cleaned out by hand shovel work, by ditcher, or by some other suitable method, throwing all loose materials on the downhill side so that the bottom of the finished ditch shall be approximately 450 mm (18 inches) below the crest of the loose material piled on the downhill side. Hand finish will not be required, but the flow lines shall be in satisfactory shape to provide drainage without overflow.

102.2.7 Excavation of Roadbed Level

Rock shall be excavated to a depth of 150 mm (6 inches) below subgrade within the limits of the roadbed, and the excavation backfilled with material designated on the Plans or approved by the Engineer and compacted to the required density.

When excavation methods employed by the Contractor leave undrained pockets in the rock surface, the Contractor shall at his own expense, properly drain such depressions or when permitted by the Engineer fill the depressions with approved impermeable material.

Material below subgrade, other than solid rock shall be thoroughly scarified to a depth of 150 mm (6 inches) and the moisture content increased or reduced, as necessary, to bring the material throughout this 150 mm layer to the moisture content suitable for maximum compaction. This layer shall then be compacted in accordance with Subsection 104.3.3.

102.2.8 Borrow Areas

The Contractor shall notify the Engineer sufficiently in advance of opening any borrow areas so that cross-section elevations and measurements of the ground surface after stripping may be taken, and the borrow material can be tested before being used. Sufficient time for testing the borrow material shall be allowed.

All borrow areas shall be bladed and left in such shape as to permit accurate measurements after excavation has been completed. The Contractor shall not excavate beyond the dimensions and elevations established, and no material shall be removed prior to the staking out and cross-sectioning of the site. The finished borrow areas shall be approximately true to line and grade established and specified and shall be finished, as prescribed in Clause 61 of Standard Specifications for Public Works and Highways, Volume 1. When necessary to remove fencing, the fencing shall be replaced in at least as good condition as it was originally. The Contractor shall be responsible for the confinement of livestock when a portion of the fence is removed.

102.2.9 Removal of Unsuitable Material

Where the Plans show the top portion of the roadbed to be selected topping, all unsuitable materials shall be excavated to the depth necessary for replacement of the selected topping to the required compacted thickness.

Where excavation to the finished graded section results in a subgrade or slopes of unsuitable soil, the Engineer may require the Contractor to remove the unsuitable material and backfill to the finished graded section with approved material. The Contractor shall conduct his operations in such a way that the Engineer can take the necessary cross-sectional measurements before the backfill is placed.

The excavation of muck shall be handled in a manner that will not permit the entrapment of muck within the backfill. The material used for backfilling up to the ground line or water level, whichever is higher, shall be rock or other suitable granular material selected from the roadway excavation, if available. If not available, suitable material shall be obtained from other approved sources. Unsuitable material removed shall be disposed in designated areas shown on the Plans or approved by the Engineer.

102.2.10 Finishing and Protection of Subgrade

After the subgrade is substantially complete, the Contractor shall remove any soft or other unstable material over the full width of the subgrade that will not compact properly. All low areas, holes or depressions in the subgrade shall be brought to grade with suitable select material. Scarifying, blading, rolling and other methods shall be performed to provide a thoroughly compacted subgrade shaped to the lines and grades shown on the plans.

Grading of the subgrade shall be performed so that it will drain readily. The Contractor shall protect the subgrade from damage and limit hauling over the finished subgrade to only traffic essential for construction purposes. All ruts or rough places that develop in the completed subgrade shall be graded and re-compacted.

No subbase, base, or surface course shall be placed on the subgrade until the subgrade has been approved by the Engineer.

102.3 Testing Requirements

ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using

	Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3))
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2700 kN-m/m3))
ASTM D2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

ITEM 103 - STRUCTURE EXCAVATION

103.1 Description

This Item shall consist of the necessary excavation for foundation of bridges, culverts, underdrains, and other structures not otherwise provided for in the Specifications. Except as otherwise provided for pipe culverts, the backfilling of completed structures and the disposal of all excavated surplus materials, shall be in accordance with these Specifications and in reasonably close conformity with the Plans or as established by the Engineer.

This Item shall include the necessary diversion of live streams, bailing, pumping, draining, sheeting, bracing, and the necessary construction of cribs and cofferdams, and furnishing the materials therefore, and the subsequent removal of cribs and cofferdams and the placing of all necessary backfill.

It shall also include the furnishing and placing of approved foundation fill material to replace unsuitable material encountered below the foundation elevation of structures.

No allowance will be made for classification of different types of material encountered.

103.2 Construction Requirements

103.2.1 Clearing and Grubbing

Prior to starting excavation operations in any area, all necessary clearing and grubbing in that area shall have been performed in accordance with Item 100, Clearing and Grubbing.

103.2.2 Excavation

1. General, all structures. The Contractor shall notify the Engineer sufficiently in advance of the beginning of any excavation so that cross- sectional elevations and measurements may be taken on the undisturbed ground. The natural ground adjacent to the structure shall not be disturbed without permission of the Engineer.

Trenches or foundation pits for structures or structure footings shall be excavated to the lines and grades or elevations shown on the Plans or as staked by the Engineer. They shall be of sufficient size to permit the placing of structures or structure footings of the full width and length shown. The elevations of the bottoms of footings, as shown on the Plans, shall be considered as approximate only and the Engineer may order, in writing, such changes in dimensions or elevations of footings as may be deemed necessary, to secure a satisfactory foundation.

Boulders, logs, and other objectionable materials encountered in excavation shall be removed.

After each excavation is completed, the Contractor shall notify the Engineer to that effect and no footing, bedding material or pipe culvert shall be placed until the Engineer has approved the depth of excavation and the character of the foundation material.

2. Structures other than pipe culverts. All rock or other hard foundation materials shall be cleaned all loose materials, and cut to a firm surface, either level, stepped, or serrated as directed by the

Engineer. All seams or crevices shall be cleaned and grouted. All loose and disintegrated rocks and thin strata shall be removed. When the footing is to rest on material other than rock, excavation to final grade shall not be made until just before the footing is to be placed. When the foundation material is soft or mucky or otherwise unsuitable, as determined by the Engineer, the Contractor shall remove the unsuitable material and backfill with approved granular material. This foundation fill shall be placed and compacted in 150 mm (6 inches) layers up to the foundation elevation.

When foundation piles are used, the excavation of each pit shall be completed before the piles are driven and any placing of foundation fill shall be done after the piles are driven. After the driving is completed, all loose and displaced materials shall be removed, leaving a smooth, solid bed to receive the footing.

3. Pipe Culverts. The width of the pipe trench shall be sufficient to permit satisfactory jointing of the pipe and thorough tamping of the bedding material under and around the pipe.

Where rock, hardpan, or other unyielding material is encountered, it shall be removed below the foundation grade for a depth of at least 300 mm or 4 mm for each 100 mm of fill over the top of pipe, whichever is greater, but not to exceed three-quarters of the vertical inside diameter of the pipe. The width of the excavation shall be at least 300 mm (12 inches) greater than the horizontal outside diameter of the pipe. The excavation below grade shall be backfilled with selected fine compressible material, such as silty clay or loam, and lightly compacted in layers not over 150 mm (6 inches) in un-compacted depth to form a uniform but yielding foundation.

Where a firm foundation is not encountered at the grade established, due to soft, spongy, or other unstable soil, such unstable soil under the pipe and for a width of at least one diameter on each side of the pipe shall be removed to the depth directed by the Engineer and replaced with approved granular foundation fill material properly compacted to provide adequate support for the pipe, unless other special construction methods are called for on the Plans.

The foundation surface shall provide a firm foundation of uniform density throughout the length of the culvert and, if directed by the Engineer, shall be cambered in the direction parallel to the pipe centerline.

Where pipe culverts are to be placed in trenches excavated in embankments, the excavation of each trench shall be performed after the embankment has been constructed to a plane parallel to the proposed profile grade and to such height above the bottom of the pipe as shown on the Plans or directed by the Engineer.

103.2.3 Utilization of Excavated Materials

All excavated materials, so far as suitable, shall be utilized as backfill or embankment. The surplus materials shall be disposed in such manner as not to obstruct the stream or otherwise impair the efficiency or appearance of the structure. No excavated materials shall be deposited at any time so as to endanger the partly finished structure.

103.2.4 Cofferdams

Suitable and practically watertight cofferdams shall be used wherever water- bearing strata are encountered above the elevation of the bottom of the excavation. If requested, the Contractor shall submit drawings showing his proposed method of cofferdam construction, as directed by the Engineer.

Cofferdams or cribs for foundation construction shall in general, be carried well below the bottoms of the footings and shall be well braced and as nearly watertight as practicable. In general, the interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors, and to permit pumping outside of the forms. Cofferdams or cribs which are tilted or moved laterally during the process of sinking shall be righted or enlarged so as to provide the necessary clearance.

When conditions are encountered which, as determined by the Engineer, render it impracticable to dewater the foundation before placing the footing, the Engineer may require the construction of a concrete foundation seal of such dimensions as he may consider necessary, and of such thickness as to resist any possible uplift. The concrete for such seal shall be placed as shown on the Plans or directed by the Engineer. The foundation shall then be dewatered and the footing placed. When weighted cribs are employed and the mass is utilized to overcome partially the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire mass of the crib to the foundation seal. When a foundation seal is placed under water, the cofferdams shall be vented or ported at low water level as directed.

Cofferdams shall be constructed so as to protect green concrete against damage from sudden rising of the stream and to prevent damage to the foundation by erosion. No timber or bracing shall be left in cofferdams or cribs in such a way as to extend into substructure masonry, without written permission from the Engineer.

Any pumping that may be permitted from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of any portion of the concrete material being carried away. Any pumping required during the placing of concrete, or for a period of at least 24 hours thereafter, shall be done from a suitable sump located outside the concrete forms. Pumping to dewater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure.

Unless otherwise provided, cofferdams or cribs, with all sheeting and bracing involved therewith, shall be removed by the Contractor after the completion of the substructure. Removal shall be effected in such manner as not to disturb or mar finished masonry.

103.2.5 Preservation of Channel

Unless otherwise permitted, no excavation shall be made outside of caissons, cribs, cofferdams, or sheet piling, and the natural stream bed adjacent to structure shall not be disturbed without permission from the Engineer. If any excavation or dredging is made at the side of the structure before caissons, cribs, or cofferdams are sunk in place, the Contractor shall, after the foundation base is in place, backfill all such excavations to the original ground surface or stream bed with material satisfactory to the Engineer.

103.2.6 Backfill and Embankment for Structures Other Than Pipe Culverts

Excavated areas around structures shall be backfilled with free draining granular material approved by the Engineer and placed in horizontal layers not over 150 mm (6 inches) in thickness, to the level of the original ground surface. Each layer shall be moistened or dried as required and thoroughly compacted with mechanical tampers.

In placing backfills or embankment, the material shall be placed simultaneously in so far as possible to approximately the same elevation on both sides of an abutment, pier, or wall. If conditions require placing backfill or embankment appreciably higher on one side than on the opposite side, the additional material on the higher side shall not be placed until the masonry has been in place for 14 days, or until tests made by the laboratory under the supervision of the Engineer establishes that the masonry has attained sufficient strength to withstand any pressure created by the methods used and materials placed without damage or strain beyond a safe factor.

Backfill or embankment shall not be placed behind the walls of concrete culverts or abutments or rigid frame structures until the top slab is placed and cured. Backfill and embankment behind abutments held at the top by the superstructure, and behind the sidewalls of culverts, shall be carried up simultaneously behind opposite abutments or sidewalls.

All embankments adjacent to structures shall be constructed in horizontal layers and compacted as prescribed in Subsection 104.3.3 except that mechanical tampers may be used for the required compaction. Special care shall be taken to prevent any wedging action against the structure and slopes bounding or within the areas to be filled shall be benched or serrated to prevent wedge action. The placing of embankment and the benching of slopes shall continue in such a manner that at all times there will be horizontal berm of thoroughly compacted material for a distance at least equal to the height of the abutment or wall to the backfilled against except insofar as undisturbed material obtrudes upon the area.

Broken rock or coarse sand and gravel shall be provided for a drainage filter at weepholes as shown on the Plans.

103.2.7 Bedding, Backfill, and Embankment for Pipe Culverts

Bedding, Backfill and Embankment for pipe culverts shall be done in accordance with Item 500, Pipe Culverts and Storm Drains.

ITEM 104 - EMBANKMENT

104.1 Description

This Item shall consist of the construction of embankment in accordance with this Specification and in conformity with the lines, grades and dimensions shown on the Plans or established by the Engineer.

104.2 Material Requirements

Embankments shall be constructed of suitable materials, in consonance with the following definitions:

1. Suitable Material – Material which is acceptable in accordance with the Contract and which can be compacted in the manner specified in this Item. It can be common material or rock.

Selected Borrow, for topping – soil of such gradation that all particles will pass a sieve with 75 mm (3 inches) square openings and not more than 15 mass percent will pass the 0.075 mm (No. 200) sieve, as determined by AASHTO T 11. The material shall have a plasticity index of not more than 6 as determined by ASSHTO T 90 and a liquid limit of not more than 30 as determined by AASHTO T 89.

2. Unsuitable Material – Material other than suitable materials such as:

a. Materials containing detrimental quantities of organic materials, such as grass, roots and sewerage.

b. Organic soils such as peat and muck.
c. Soils with liquid limit exceeding 80 and/or plasticity index exceeding 55.
d. Soils with a natural water content exceeding 100%
e. Soils with very low natural density, 800 kg/m3 or lower
f. Soils that cannot be properly compacted as determined by the Engineer

104.3 Construction Requirements

104.3.1 General

Prior to construction of embankment, all necessary clearing and grubbing in that area shall have been performed in conformity with Item 100, Clearing and Grubbing.

Embankment construction shall consist of constructing roadway embankments, including preparation of the areas upon which they are to be placed; the construction of dikes within or adjacent to the roadway; the placing and compacting of approved material within roadway areas where unsuitable material has been removed; and the placing and compacting of embankment material in holes, pits, and other depressions within the roadway area.

Embankments and backfills shall contain no muck, peat, sod, roots or other deleterious matter. Rocks, broken concrete or other solid, bulky materials shall not be placed in embankment areas where piling is to be placed or driven.

Where shown on the Plans or directed by the Engineer, the surface of the existing ground shall be compacted to a depth of 150 mm (6 inches) and to the specified requirements of this Item.

Where provided on the Plans and Bill of Quantities the top portions of the roadbed in both cuts and embankments, as indicated, shall consist of selected borrow for topping from excavations.

104.3.2 Methods of Construction

Where there is evidence of discrepancies on the actual elevations and that shown on the Plans, a preconstruction survey referred to the datum plane used in the approved Plan shall be undertaken by the Contractor under the control of the Engineer to serve as basis for the computation of the actual volume of the embankment materials.

When embankment is to be placed and compacted on hillsides, or when new embankment is to be compacted against existing embankments, or when embankment is built one-half width at a time, the existing slopes that are steeper than 3:1 when measured at right angles to the roadway shall be continuously benched over those areas as the work is brought up in layers. Benching will be subject to the Engineer's approval and shall be of sufficient width to permit operation of placement and compaction equipment. Each horizontal cut shall begin at the intersection of the original ground and the vertical sides of the previous cuts. Material thus excavated shall be placed and compacted along with the embankment material in accordance with the procedure described in this Section.

Unless shown otherwise on the Plans or special Provisions, where an embankment of less than 1.2 m (4 feet) below subgrade is to be made, all sod and vegetable matter shall be removed from the surface upon which the embankment is to be placed, and the cleared surface shall be completely broken up by plowing, scarifying, or steeping to a minimum depth of 150 mm except as provided in Subsection 102.2.2. This area shall then be compacted as provided in Subsection 104.3.3. Sod not required to be removed shall be thoroughly disc harrowed or scarified before construction of embankment. Wherever a compacted road surface containing granular materials lies within 900 mm (36 inches) of the subgrade, such old road surface shall be scarified to a depth of at least 150 mm (6 inches) whenever directed by the Engineer. These scarified materials shall then be compacted as provided in Subsection 104.3.3.

When shoulder excavation is specified, the roadway shoulders shall be excavated to the depth and width shown on the Plans. The shoulder material shall be removed without disturbing the adjacent existing base course material, and all excess excavated materials shall be disposed as provided in Subsection 102.2.3. If necessary, the areas shall be compacted before being backfilled.

Roadway embankment of earth material shall be placed in horizontal layers not exceeding 200 mm (8 inches), loose measurement, and shall be compacted as specified before the next layer is placed. However, thicker layer maybe placed if vibratory roller with high compactive effort is used provided that density requirement is attained and as approved by the Engineer. Trial section to this effect must be conducted and approved by the Engineer. Effective spreading equipment shall be used on each lift to obtain uniform thickness as determined in the trial section prior to compaction. As the compaction of each layer progresses, continuous leveling and manipulation will be required to assure uniform density. Water shall be added or removed, if necessary, in order to obtain the required density. Removal of water shall be accomplished through aeration by plowing, blading, discing, or other methods satisfactory to the Engineer.

Where embankment is to be constructed across low swampy ground that will not support the mass of trucks or other hauling equipment, the lower part of the fill may be constructed by dumping successive loads in a uniformly distributed layer of a thickness not greater than necessary to support the hauling equipment while placing subsequent layers.

When excavated materials contain more than 25 mass percent of rock larger than 150 mm in greatest diameter and cannot be placed in layers of the thickness prescribed without crushing, pulverizing or further breaking down the pieces resulting from excavation methods, such materials may be placed on the embankment in layers not exceeding in thickness the approximate average size of the larger rocks, but not greater than 600 mm (24 inches).

Even though the thickness of layers is limited as provided above, the placing of individual rocks and boulders greater than 600 mm in diameter will be permitted provided that when placed, they do not exceed 1200 mm (48 inches) in height and provided they are carefully distributed, with the interstices filled with finer material to form a dense and compact mass.

Each layer shall be leveled and smoothed with suitable leveling equipment and by distribution of spalls and finer fragments of earth. Lifts of material containing more than 25 mass percent of rock larger than 150 mm in greatest dimensions shall not be constructed above an elevation 300 mm (12 inches) below the finished subgrade. The balance of the embankment shall be composed of suitable material smoothed and placed in layers not exceeding 200 mm (8 inches) in loose thickness and compacted as specified for embankments.

Dumping and rolling areas shall be kept separate, and no lift shall be covered by another until compaction complies with the requirements of Subsection 104.3.3.

Hauling and leveling equipment shall be so routed and distributed over each layer of the fill in such a manner as to make use of compaction effort afforded thereby and to minimize rutting and uneven compaction.

104.3.3 Compaction

104.3.3.1 Compaction Trials

Before commencing the formation of embankments, the Contractor shall submit in writing to the Engineer for approval his proposals for the compaction of each type of fill material to be used in the works. The proposals shall include the relationship between the types of compaction equipment, and the number of passes required and the method of adjusting moisture content. The Contractor shall carry out full scale compaction trials on areas not less than 10 m wide and 50 m long as required by the Engineer and using his proposed procedures or such amendments thereto as may be found necessary to satisfy the Engineer that all the specified requirements regarding compaction can be consistently achieved. Compaction trials with the main types of fill material to be used in the works shall be completed before work with the corresponding materials will be allowed to commence.
Throughout the periods when compaction of earthwork is in progress, the Contractor shall adhere to the compaction procedures found from compaction trials for each type of material being compacted, each type of compaction equipment employed and each degree of compaction specified.

104.3.3.2 Earth

The Contractor shall compact the material placed in all embankment layers and the material scarified to the designated depth below subgrade in cut sections, until a uniform density of not less than 95 mass percent of the maximum dry density determined by AASHTO T99 Method C, is attained, at a moisture content determined by the Engineer to be suitable for such density. Acceptance of compaction may be based on adherence to an approved roller pattern developed as set forth in Item 106, Compaction Equipment and Density Control Strips.

The Contractor shall during progress of the Work, make density tests of compacted material in accordance with AASHTO T191, T205, or other approved field density tests, including the use of properly calibrated nuclear testing devices. A correction for coarse particles may be made in accordance with AASHTO T224. If, by such tests, the Engineer determines that the specified density and moisture conditions have not been attained, the Contractor shall perform additional work as may be necessary to attain the specified conditions.

At least one group of three in-situ density tests shall be carried out for each 500 m of each layer of compacted fill.

104.3.3.3 Rock

Density requirements will not apply to portions of embankments constructed of materials which cannot be tested in accordance with approved methods.

Embankment materials classified as rock shall be deposited, spread and leveled the full width of the fill with sufficient earth or other fine material so deposited to fill the interstices to produce a dense compact embankment. In addition, one of the rollers, vibrators, or compactors meeting the requirements set forth in Subsection 106.2.1, Compaction Equipment, shall compact the embankment full width with a minimum of three complete passes for each layer of embankment.

104.3.4 Protection of Roadbed during Construction

During the construction of the roadway, the roadbed shall be maintained in such condition that it will be well drained at all times. Side ditches or gutters emptying from cuts to embankments or otherwise shall be so constructed as to avoid damage to embankments by erosion.

104.3.5 Protection of Structure

If embankment can be deposited on one side only of abutments, wing walls, piers or culvert headwalls, care shall be taken that the area immediately adjacent to the structure is not compacted to the extent that it will cause overturning of, or excessive pressure against the structure. When noted on the Plans, the fill adjacent to the end bent of a bridge shall not be placed higher than the bottom of the backfill of the bent until the superstructure is in place. When embankment is to be placed on both sides of a concrete wall or box type structure, operations shall be so conducted that the embankment is always at approximately the same elevation on both sides of the structure.

104.3.6 Rounding and Warping Slopes

Rounding-Except in solid rock, the tops and bottoms of all slopes, including the slopes of drainage ditches, shall be rounded as indicated on the Plans. A layer of earth overlaying rock shall be rounded above the rock as done in earth slopes.

Warping-adjustments in slopes shall be made to avoid injury in standing trees or marring of weathered rock, or to harmonize with existing landscape features, and the transition to such adjusted slopes shall be gradual. At intersections of cuts and fills, slopes shall be adjusted and warped to flow into each other or into the natural ground surfaces without noticeable break.

104.3.7 Finishing Roadbed and Slopes

After the roadbed has been substantially completed, the full width shall be conditioned by removing any soft or other unstable material that will not compact properly or serve the intended purpose. The resulting areas and all other low sections, holes of depressions shall be brought to grade with suitable selected material. Scarifying, blading, dragging, rolling, or other methods of work shall be performed or used as necessary to provide a thoroughly compacted roadbed shaped to the grades and cross-sections shown on the Plans or as staked by the Engineer.

All earth slopes shall be left with roughened surfaces but shall be reasonably uniform, without any noticeable break, and in reasonably close conformity with the Plans or other surfaces indicated on the Plans or as staked by the Engineer, with no variations therefrom readily discernible as viewed from the road.

104.3.8 Serrated Slopes

Cut slopes in rippable material (soft rock) having slope ratios between 0.75:1 and 2:1 shall be constructed so that the final slope line shall consist of a series of small horizontal steps. The step rise and tread dimensions shall be shown on the Plans. No scaling shall be performed on the stepped slopes except for removal of large rocks which will obviously be a safety hazard if they fall into the ditch line or roadway.

104.3.9 Earth Berms

When called for in the Contract, permanent earth berms shall be constructed of well graded materials with no rocks having a diameter greater than 0.25 the height of the berm. When local material is not acceptable, acceptable material shall be imported, as directed by the Engineer.

104.3.9.1 Compacted Berm

Compacted berm construction shall consist of moistening or drying and placing material as necessary in locations shown on the drawings or as established by the Engineer. Material shall contain no frozen material, roots, sod, or other deleterious materials. Contractor shall take precaution to prevent material from escaping over the embankment slope. Shoulder surface beneath berm will be roughened to provide a bond between the berm and shoulder when completed. The Contractor shall compact the material placed until at least 90 mass percent of the maximum density is obtained as determined by AASHTO T99, Method C. The cross-section of the finished compacted berm shall reasonably conform to the typical cross-section as shown on the Plans.

104.3.9.2 Uncompacted Berm

Uncompacted berm construction shall consist of drying, if necessary and placing material in locations shown on the Plans or as established by the Engineer. Material shall contain no frozen material, roots, sod or other deleterious materials. Sub-contractor shall take precautions to prevent material from escaping over the embankment slope.

ITEM 105 - SUBGRADE PREPARATION

105.1 Description

This Item shall consist of the preparation of the subgrade for the support of overlying structural layers. It shall extend to full width of the airside pavement area. Unless authorized by the Engineer, subgrade preparation shall not be done unless the Contractor is able to start immediately the construction of the pavement structure.

105.2 Material Requirements

Unless otherwise stated in the Contract and except when the subgrade is in rock cut, all materials below subgrade level to a depth 150 mm or to such greater depth as may be specified shall meet the requirements of Subsection 104.2, Selected Borrow for Topping.

105.3 Construction Requirements

105.3.1 Prior Works

Prior to commencing preparation of the subgrade, all culverts, cross drains, ducts and the like (including their fully compacted backfill), ditches, drains and drainage outlets shall be completed. Any work on the preparation of the subgrade shall not be started unless prior work herein described shall have been approved by the Engineer.

105.3.2 Subgrade Level Tolerances

The finished compacted surface of the subgrade shall conform to the allowable tolerances as specified hereunder:

Permitted variation from design level of surface	+20 mm -30 mm
Permitted surface irregularity measured by 3-m straight edge	30 mm
Permitted variation from design crossfall or camber	±0.5 %
Permitted variation from design longitudinal grade over 25 m length	±0.1 %

105.3.3 Subgrade in Common Excavation

Unless otherwise specified, all materials below subgrade level in earth cuts to a depth 150 mm or other depth shown on the Plans or as directed by the Engineer shall be excavated. The material, if suitable, shall be set aside for future use or, if unsuitable, shall be disposed in accordance with the requirements of Subsection 102.2.9. Where material has been removed from below subgrade level, the resulting surface shall be compacted to a depth of 150 mm and in accordance with other requirements of Subsection 104.3.3.
All materials immediately below subgrade level in earth cuts to a depth of 150 mm, or to such greater depth as may be specified, shall be compacted in accordance with the requirements of Subsection 104.3.3.

105.3.4 Subgrade in Rock Excavation

Surface irregularities under the subgrade level remaining after trimming of the rock excavation shall be leveled by placing specified material and compacted to the requirements of Subsection 104.3.3.

105.3.5 Subgrade on Embankment

After the embankment has been completed, the full width shall be conditioned by removing any soft or other unstable material that will not compact properly. The resulting areas and all other low sections, holes, or depressions shall be brought to grade with suitable material. The entire roadbed shall be shaped and compacted to the requirements of Subsections 104.3.3. Scarifying, blading, dragging, rolling, or other methods of work shall be performed or used as necessary to provide a thoroughly compacted roadbed shaped to the cross-sections shown on the Plans.

105.3.6 Subgrade on Existing Pavement

Where the new pavement is to be constructed immediately over an existing Portland Cement concrete pavement and if so specified in the Contract the slab be broken into pieces with greatest dimension of not more than 500 mm and the existing pavement material compacted as specified in Subsection 104.3.3, as directed by the Engineer. The resulting subgrade level shall, as part pavement construction be shaped to conform to the allowable tolerances of Subsection 105.3.2 by placing and compacting where necessary a leveling course comprising of the material for the pavement course to be placed immediately above.
Where the new pavement is to be constructed immediately over an existing asphalt concrete pavement or gravel surface pavement and if so specified in the Contract the pavement shall be scarified, thoroughly loosened, reshaped and re-compacted in accordance with Subsection 104.3.3. The resulting subgrade level shall conform to the allowable tolerances of Subsection 105.3.2.

105.3.7 Removal of existing pavement

The existing concrete pavement to be removed shall be freed from the pavement to remain by sawing through the complete depth of the slab 30 cm inside the perimeter of the final removal limits or outside the dowels, whichever is greater when the limits of removal are located on the joints. The pavement between the perimeter of the pavement removal and the saw cut shall be carefully broken up and removed using hand-held jackhammers, weighing 14 kg or less, or other light- duty equipment which will not cause distress in the pavement which is to remain in place. The Contractor shall have the option of sawing through the dowels at the joint, removing the pavement and installing new dowels. Where the perimeter of the removal limits is not located on the joint and there are no dowels present, then the perimeter shall be saw cut the full depth of the pavement. The pavement inside the saw cut shall be removed by methods suitable to the Engineer which will not cause distress in the pavement which is to remain in place. If the material is to be wasted on the airport site, it shall be reduced to a maximum size designated by the Engineer. The Contractor's removal operation shall not cause damage to cables, utility ducts, pipelines, or drainage structures under the pavement. Concrete slabs that are damaged by under breaking shall be removed. Any damage shall be repaired at the Contractor's expense.

Asphalt concrete pavement to be removed shall be cut to the full depth of the bituminous material around the perimeter of the area to be removed. The pavement shall be removed so the joint for each layer of pavement replacement is offset 30 cm from the joint in the preceding layer. This does not apply if the removed pavement is to be replaced with concrete or soil.

105.3.8 Removal of paint and rubber

All paint and rubber over 1 foot (30 cm) wide that will affect the bond of the new overlay shall be removed from the surface of the existing pavement. Chemicals, high-pressure water, heater scarifier (asphaltic concrete only), cold milling, or sandblasting may be used. Any methods used shall not cause major damage to the pavement. Major damage is defined as changing the properties of the pavement or removing pavement over 1/8 inch (3 mm) deep. If chemicals are used, they shall comply with the environmental protection regulations. No material shall be deposited on the runway shoulders. All wastes shall be disposed of in areas indicated in this specification or shown on the plans.

105.3.9 Removal of Existing Joint Sealant and Cleaning Prior to Sealing

All existing joint sealants will be removed by plowing or use of hand tools. Any remaining sealant and or debris will be removed by use of wire brushes or other tools as necessary. Re-saw joints removing no more than 1/16 inch (2 mm) from each joint face. Immediately after sawing, flush out joint with water and other tools as necessary to completely remove the slurry. Allow sufficient time to dry out joints prior to sealing.

Cleaning prior to sealing. Immediately before sealing, joints shall be cleaned by removing any remaining laitance and other foreign material. Clean joints by sandblasting, or other method approved by the Engineer, on each joint face with nozzle held at an angle and not more than three inches (75 mm) from face. Following sandblasting, clean joints with air free of oil and water. Joint surfaces will be surface-dry prior to installation of sealant.

105.3.10 Protection of Completed Work

The Contractor shall be required to protect and maintain at his own expense the entire work within the limits of his Contract in good condition satisfactory to the Engineer from the time he first started work until all work shall have been completed. Maintenance shall include repairing and re-compacting ruts, ridges, soft spots and deteriorated sections of the subgrade caused by the traffic of the Contractor’s vehicle/equipment or that of the public.

105.3.11 Templates and Straight-edges

The Contractor shall provide for use of the Engineer, approved templates and straight-edges in sufficient number to check the accuracy of the work, as provided in this Specification.

ITEM 106 - COMPACTION EQUIPMENT AND DENSITY CONTROL STRIPS

106.1 Description

When specified, this procedure will be used to determine density requirements of selected embankments, subgrade, bases, and bituminous concrete. The procedure will consist of control strip construction to establish target densities for the specified course plus use of sand-cone method of density testing equipment to determine in- place densities obtained during the construction process.

The subgrade including fills at the airside pavement area shall be compacted to meet the following requirements:

0 - 300mm below formation level - Density to be 98% Modified Proctor MDD;

300mm - 600mm below formation level - Density to be 95% Modified Proctor

MDD

106.2 Construction Requirements

106.2.1 Compaction Equipment

Compaction equipment shall be capable of obtaining compaction requirements without detrimentally affecting the compacted material. The equipment shall be modern, efficient compacting units approved by the Engineer. The compacting units may be of any type, provided they are capable of compacting each lift of material as specified and meet the minimum requirements as contained herein. Minimum requirements for rollers are as follows:

1. Sheepsfoot, tamping or grid rollers shall be capable of exerting a force of 45 Newton per millimeter (250 pounds per inch) of length of roller drum.
2. Steel-wheel rollers other than vibratory shall be capable of exerting a force of not less than 45 Newton per millimeter of width of the compression roll or rolls.
3. Vibratory steel-wheel rollers shall have a minimum mass of 6 tonnes. The compactor shall be equipped with amplitude and frequency controls and specifically designed to compact the material on which it is used.
4. Pneumatic-tire rollers shall have smooth tread tires of equal size that will provide a uniform compacting pressure for the full width of the roller and capable of exerting a ground pressure of at least 550 kpa (80 pounds per square inch).
5. Heavier compacting unit may be required to achieve the specified density of the embankment.

106.2.2 Construction of Control Strips and Determination of Target Density

To determine target density, a control strip shall be constructed at the beginning of work for each course of material to be compacted. Each control strip, constructed to acceptable density and surface tolerances shall remain in place and become a section of the completed roadway. Unacceptable control strip shall be corrected or removed and replaced at the Contractor's expense. A control strip shall have an area of approximately 335 square meters and shall be of the same depth specified for the construction of the course which it represents.

The materials used in the construction of the control strip shall conform to the specification requirements. They shall be furnished from the same source and shall be of the same type to be used in the remainder of the course represented by the control strip. The underlying grade or pavement structure upon which a control strip is to be constructed shall have the prior approval of the Engineer.

The equipment used in the construction of the control strip shall be approved by the Engineer and shall be of the same type and mass to be used on the remainder of the course represented by the control strip.

Compaction of control strips shall commence immediately after the course has been placed to the specified thickness and shall be continuous and uniform over the entire surface. Compaction of the control strip shall be continued until no discernible increase in density can be obtained by additional compactive effort.

Upon completion of the compaction, the mean density of the control strip will be determined by averaging the results of ten in-place density tests taken at randomly selected sites within the control strip. The mean density of the control strip shall be the target density for the remainder of the course which it represents.

If the mean density of the control strip is less than 98 percent of the density of laboratory compacted specimens as determined by testing procedures appropriate for the material being placed, the Engineer may order the construction of another control strip.

A new control strip may also be ordered by the Engineer or requested by the Contractor when:

1. A change in the material or job-mix formula, is made.
2. Ten days of production have been accepted without construction of a new control strip.
3. There is reason to believe that a control strip density is not representative of the material being placed.

ITEM 107 – OVERHAUL

107.1 Description

Overhaul shall consist of authorized hauling in excess of the free-haul distance. Free-haul distance is the specified distance that excavated material shall be hauled without additional compensation. Unless otherwise provided in the Contract, the free-haul distance shall be 600 meters.

PART D – SUBBASE AND BASE COURSE ITEM 200 –

AGGREGATE SUBBASE COURSE

200.1 Description

This item shall consist of furnishing, placing and compacting an aggregate subbase course on a prepared subgrade in accordance with this Specification and the lines, grades and cross-sections shown on the Plans, or as directed by the Engineer.

200.2 Materials

200.2.1 Material Requirements

Aggregate for subbase shall consist of hard, durable particles or fragments of crushed stone, crushed slag, or crushed or natural gravel and filler of natural or crushed sand or other finely divided mineral matter. This mixture must be uniform and shall comply with the requirements of these specifications as to gradation, soil constants, and shall be capable of being compacted into a dense and stable subbase. The composite material shall be free from vegetable matter and lumps or balls of clay, and shall be of such nature that it can be compacted readily to form a firm, stable subbase.

The subbase material shall conform to Table 200.1, Grading Requirements

Table 200.1 – Grading Requirements

Sieve Designation		Mass Percent Passing
Standard, mm	Alternate US Standard	
50	2”	100
25	1”	55 – 85
9.5	3/8”	40 – 75
0.075	No. 200	0 - 12

The fraction passing the 0.075 mm (No. 200) sieve shall not be greater than 0.66 (two thirds) of the fraction passing the 0.425 mm (No. 40) sieve.

The fraction passing the 0.425 mm (No. 40) sieve shall have a liquid limit not greater than 35 and plasticity index not greater than 12 as determined by AASHTO T89 and T90, respectively.

The coarse portion, retained on a 2.00 mm (No. 10) sieve, shall have a mass percent of wear not exceeding 50 by the Los Angeles Abrasion Tests as determined by AASHTO T96.

The material shall have a soaked CBR value of not less than 25% as determined by AASHTO T193. The CBR value shall be obtained at the maximum dry density and determined by AASHTO T180, Method D.

200.2.2 Sampling and Testing

Material used on the project shall be sampled per ASTM D75 and tested per ASTM C136 and ASTM C117. Results shall be furnished to the Engineer by the Contractor prior to the start of construction. Testing frequencies for the particle size distribution for preliminary shall be minimum once per day during construction.

200.3 Construction Requirements

200.3.1 General

The subbase course shall be placed where designated on the plans or as directed by the Engineer. The material shall be shaped and thoroughly compacted within the tolerances specified.

Granular sub-bases which, due to grain sizes or shapes, are not sufficiently stable to support the construction equipment without movement, shall be mechanically stabilized to the depth necessary to provide stability as directed by the Engineer. The mechanical stabilization shall include the addition of a fine-grained medium to bind the particles of the subbase material sufficiently to furnish a bearing strength, so the course will not deform under construction equipment traffic. The addition of the binding medium to the subbase material shall not increase the soil constants of that material above the specified limits.

200.3.2 Preparation of Existing Surface

The existing surface shall be graded and finished as provided under Item 105, Subgrade Preparation, before placing the subbase material.

200.3.3 Placing

Prior to constructing the subbase course, clean the underlying course or subgrade of all foreign substances. The subgrade shall meet the requirements stated in Item 105. The surface of the underlying course or subgrade shall meet specified compaction and surface tolerances. Correct ruts, or soft yielding spots, in the underlying courses and subgrade areas having inadequate compaction and deviations of the surface from the specified requirements by loosening and removing soft or unsatisfactory material and by adding approved material, re- shaping to line and grade, and re-compacting to specified density requirements.

The subbase course shall be constructed in layers of not less than inches (75 mm) nor more than 8 inches (200 mm) of compacted thickness. The required subbase thickness are shown on airfield drawing package. The subbase material shall be deposited and spread evenly to a uniform thickness and width. The material, as spread, shall be of uniform gradation with no pockets of fine or coarse materials. The subbase, unless otherwise permitted by the Engineer, shall not be spread more than 2,000 square yards (1700 m2) in advance of the rolling. Any necessary sprinkling shall be kept within this limit. No material shall be placed in snow or on a soft, muddy, or frozen course.

During the transportation, placing and spreading, sufficient caution shall be exercised to prevent the incorporation of subgrade, shoulder, or foreign material in the subbase course mixture.

The aggregate subbase material shall be placed at a uniform mixture on a prepared subgrade in a quantity which will provide the required compacted thickness. When more than one layer is required, each layer shall be shaped and compacted before the succeeding layer is placed.

The placing of material shall begin at the point designated by the Engineer. Placing shall be from vehicles especially equipped to distribute the material in a continuous uniform layer or windrow. The layer or windrow shall be of such size that when spread and compacted the finished layer be in reasonably close conformity to the nominal thickness shown on the Plans.

When hauling is done over previously placed material, hauling equipment shall be dispersed uniformly over the entire surface of the previously constructed layer, to minimize rutting or uneven compaction.

200.3.4 Spreading and Compacting

When uniformly mixed, the mixture shall be spread to the plan thickness, for compaction.

Where the required thickness is 150 mm or less, the material may be spread and compacted in one layer. Where the required thickness is more than 150 mm, the aggregate subbase shall be spread and compacted in two or more layers of approximately equal thickness, and the maximum compacted thickness of any layer shall not exceed 150 mm. All subsequent layers shall be spread and compacted in a similar manner.

The moisture content of subbase material shall, if necessary, be adjusted prior to compaction by watering with approved sprinklers mounted on trucks or by drying out, as required in order to obtain the required compaction.

Immediately following final spreading and smoothening, each layer shall be compacted to the full width by means of approved compaction equipment. Rolling shall progress gradually from the sides to the center, parallel to the centerline of the road and shall continue until the whole surface has been rolled. Any irregularities or depressions that develop shall be corrected by loosening the material at these places and adding or removing material until surface is smooth and uniform. Along curbs, headers, and walls, and at all places not accessible to the roller, the subbase material shall be compacted thoroughly with approved tampers or compactors.

If the layer of subbase material, or part thereof, does not conform to the required finish, the Contractor shall, at his own expense, make the necessary corrections.

Compaction of each layer shall continue until a field density of at least 100 percent of the maximum dry density determined in accordance with AASHTO T180, Method D has been achieved. In-place density determination shall be made in accordance with AASHTO T191.

200.3.5 Trial Sections

Before subbase construction is started, the Contractor shall spread and compact trial sections as directed by the Engineer. The purpose of the trial sections is to check the suitability of the materials and the efficiency of the equipment and construction method which is proposed to be used by the Contractor. Therefore, the Contractor must use the same material, equipment and procedures that he proposes to use for the main work. One trial section of about 500 m2 shall be made for every type of material and/or construction equipment/procedure proposed for use.

After final compaction of each trial section, the Contractor shall carry out such field density tests and other tests required as directed by the Engineer.

If a trial section shows that the proposed materials, equipment or procedures in the Engineer's opinion are not suitable for subbase, the material shall be removed at the Contractor's expense, and a new trial section shall be constructed.

If the basic conditions regarding the type of material or procedure change during the execution of the work, new trial sections shall be constructed.

200.3.6 Tolerances

Aggregate subbase shall be spread with equipment that will provide a uniform layer which when compacted will conform to the design level and transverse slopes as shown on the Plans. The allowable tolerances shall be as specified hereunder:

Permitted variation from design thickness of layer	+ -	12 mm 0 mm
Permitted variation from design level of surface	+ -	10 mm 20 mm
Permitted surface irregularity measured by 3.7-m straight-edge		9 mm
Permitted variation from design crossfall or camber	±	0.3%

Permitted variation from design longitudinal grade over 25 m in length	±	±0.1%

Where any of these tolerances are exceeded, correct such areas by scarifying, adding new material of proper gradation or removing material, and compacting, as directed. Where the measured thickness is 1/2 inch (12 mm) or thicker than shown, the course will be considered as conforming with the specified thickness requirements plus 1/2 inch (12 mm). The average job thickness shall be the average of the job measurements as specified above but within 1/4 inch (6 mm) of the thickness shown. The thickness of the completed subbase course shall be determined by depth tests or sample holes taken at intervals so each test shall represent no more than 500 square yard (420 square meter).

200.3.7 Operation in pits

The subbase material shall be obtained from pits or sources that have been approved by the Engineer. The material in the pits shall be excavated and handled to produce a uniform and satisfactory product. All work involved in clearing and stripping pits and handling unsuitable material encountered shall be performed by the Contractor. The cost of this work is incidental to this item.

200.4 Testing Requirements

ASTM C117	Standard Test Method for Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM D75	Standard Practice for Sampling Aggregates
ASTM D422	Standard Test Method for Particle-Size Analysis of Soils
ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3))
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3))
ASTM D2487	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D4253	Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4718	Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
ASTM D6938	Standard Test Method for Density and Unit Weight of Soil in Place by the

	Sand-Cone Method

ITEM 202 - CRUSHED AGGREGATE BASE COURSE

202.1 Description

This Item shall consist of furnishing, placing and compacting crushed gravel, crushed stone or crushed rock on a prepared subgrade/subbase in one or more layers in accordance with this Specification and lines, grades, thickness and typical cross-sections shown on the Plans or as established by the Engineer.

202.2 Material Requirements

202.2.1 Crushed Aggregate

It shall consist of hard, durable particles or fragments of stone or gravel crushed to the size and of the quality requirements of this Item. It shall be clean and free from vegetable matters, lumps or balls of clay and other deleterious substances. The material shall be of such nature that it can be compacted readily to form a firm, stable base. If necessary, fine aggregate may be added to produce the correct gradation. The fine aggregate shall be produced by crushing stone, gravel or slag that meet the coarse aggregate requirements for wear and soundness.

The base material shall conform to the grading requirements of Table 202.1, whichever is called for in the Bill of Quantities.

Table 202.1 – Grading Requirements

Sieve Designation		Mass Percent Passing	
Standard mm	Alternate US Standard	Grading A	Grading B
37.5	1-1/2"	100	
25	1"	-	100
19	¾"	60-85	-
12.5	½"	-	60-90
4.75	No. 4	30-55	35-65
0.425	No. 40	8-25	10-30
0.075	No. 200	2-14	5-15

The portion of the material passing the 0.075 mm (No. 200) sieve shall not be greater than 0.66 (two thirds) of the fraction passing the 0.425 mm (No. 40) sieve.

The portion of the material passing the 0.425 mm (No. 40) sieve shall have a liquid limit of not more than 25 and a plasticity index of not more than 6 as determined by AASHTO T89 and T90, respectively.

The coarse aggregate retained on a 2.00 mm (No. 10) sieve shall have a mass percent of wear not exceeding 45 by the Los Angeles Abrasion Test as determined by AASHTO T96, and not less than 50 mass percent shall have at least one (1) fractured face.

The material passing the 19 mm (3/4 inch) sieve shall have a minimum soaked CBR-value of 80% tested according to AASHTO T193. The CBR-value shall be obtained at the maximum dry density determined according to AASHTO T180, Method D.

If filler, in addition to that naturally present, is necessary for meeting the grading requirements or for satisfactory bonding, it shall be uniformly blended with the crushed base course material on the road or in a pugmill unless otherwise specified or approved. Filler shall be obtained from sources approved by the Engineer, free from hard lumps and not contain more than 15 percent of material retained on the 4.75 mm (No. 4) sieve.

202.2.2 Sampling and Testing for Gradation

Gradation tests shall be performed by the Contractor per ASTM C136 and sieve analysis on material passing the No. 200 sieve (75 mm) per ASTM C112. The Contractor shall take at least two (2) aggregate base samples per lot to check the final gradation. Sampling shall be per ASTM D75. The lot will be consistent with the lot size used for density. The samples shall be taken from the in-place, un- compacted material in the presence of the Engineer. Sampling points and intervals will be designated by the Engineer.

202.3 Construction Requirements

202.3.1 Preparation of Existing Surface

The existing surface shall be graded and finished as provided under Item 105, Subgrade Preparation, before placing the base material.

202.3.2 Placing

It shall be in accordance with all the requirements of Subsection 200.3.3, Placing.

202.3.3 Spreading and Compaction

It shall be in accordance with all the requirements of Subsection 200.3.4, Spreading and Compacting.

202.3.4 Trial Sections

Trial sections shall conform in all respects to the requirements specified in Subsection 200.3.5.

202.3.5 Material Requirements

After the course has been compacted, the surface shall be tested for smoothness and accuracy of grade and crown. Any portion lacking the required smoothness or failing in accuracy of grade or crown shall be scarified to a depth of at least 3 inches (75 mm), reshaped and re-compacted to grade until the required smoothness and accuracy are obtained and approved by the Engineer. Any deviation in surface tolerances shall be corrected by the Contractor at his expense. The smoothness and accuracy requirements specified here apply only to the top layer when base course is constructed in more than one layer.

a. Smoothness

The finished surface shall not vary more than 3/8 inch (9 mm) when tested with a 12 foot (3.7 m) straightedge applied parallel with and at right angles to the centerline. The straightedge shall be moved continuously at half the length of the 12 foot (3.7 m) straightedge for the full length of each line on a 50 foot (15 m) grid.

b. Accuracy

The grade and crown shall be measured on a 50 foot (15 m) grid and shall be within +0 and -1/2 inch (12 mm) of the specified grade.

202.3.6 Thickness Control

The thickness of the base course shall be within +0 and -1/2 inch (12 mm) of the specified thickness as determined by depth tests taken by the Contractor in the presence of the Engineer. Tests shall be taken at intervals representing no more than 300 square yards (250 square meter) per test. Sampling locations will be determined by the Engineer per ASTM D3665. Where the thickness is deficient by more than 1/2 inch (12 mm), the Contractor shall correct such areas at no additional cost by scarifying to a depth of at least 3 inches (75 mm), adding new material of proper gradation, and the material shall be blended and re-compacted to grade. Additional test holes may be required to identify the limits of deficient areas. The Contractor shall replace, at his expense, base material where depth tests have been taken.

202.3.7 Protection

Perform construction when the atmospheric temperature is above 35°F (2°C). When the temperature falls below 35°F (2°C), protect all completed areas by approved methods against detrimental effects of freezing. Correct completed areas damaged by freezing, rainfall, or other weather conditions to meet specified requirements. When the aggregates contain frozen materials or when the underlying course is frozen or wet, the construction shall be stopped. Hauling equipment may be routed over completed portions of the base course, provided no damage results. Equipment shall be routed over the full width of the base course to avoid rutting or uneven compaction. The Engineer will stop all hauling over completed or partially completed base course when, in the Engineer’s opinion, such hauling is causing damage. Any damage to the base course shall be repaired by the Contractor at his expense.

202.3.8 Maintenance

The Sub-contractor shall maintain the base course in a satisfactory condition until the full pavement section is completed and accepted by the Engineer. The surface shall be kept clean and free from foreign material and properly drained at all times. Maintenance shall include immediate repairs to any defects and shall be repeated as often as necessary to keep the area intact. Any base course that is not paved over prior to the onset of winter shall be retested to verify that it still complies with the requirements of this specification. Any area of base course that is damaged shall be reworked or replaced as necessary to comply with this specification.

Equipment used in the construction of an adjoining section may be routed over completed base course, if no damage results and the equipment is routed over the full width of the base course to avoid rutting or uneven compaction.

The Contractor shall remove all survey and grade hubs from the base courses prior to placing any bituminous surface course.

202.4 Testing Requirements

ASTM C29	Standard Test Method for Bulk Density (“Unit Weight”) and Voids in Aggregate
ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C117	Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131	Standard Test Method for Resistance to Degradation of Small- Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregate
ASTM D75	Standard Practice for Sampling Aggregates
ASTM D422	Standard Test Method for Particle-Size Analysis of Soils
ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3))
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2700 kN-m/m3))
ASTM D2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2419	Standard Test Method for Sand Equivalent Value of Soils and

	Fine Aggregate
ASTM D3665	Standard Practice for Random Sampling of Construction Materials
ASTM D4718	Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
ASTM D4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D5821	Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

ITEM 206 - PORTLAND CEMENT TREATED PLANT MIX BASE COURSE

206.1 Description

This Item shall consist of a foundation for surface course composed of aggregate, Portland Cement and water in proper proportions, mixed by a travel plant or in a central plant and spread and compacted on a prepared subgrade/subbase in one or more layers, in accordance with this Specification and the lines, grades, thickness and typical cross-sections shown on the Plans or as established by the Engineer.

206.2 Material Requirements

206.2.1 Description

It shall consist of any combination of gravel, sand, silt and clay or other approved combination of materials free from vegetable or other objectionable matter. It may be materials encountered in the construction site or materials obtained from approved sources. The crushed or uncrushed granular material shall consist of hard, durable stones and rocks, of accepted quality, free from an excess of flat, elongated, soft or disintegrated pieces or other objectionable matter. It is the intent of this Specification to utilize soils existing on the roadbed if the quality is satisfactory. If the quality and/or quantity is deficient, the soil aggregate shall be obtained wholly or partly from approved outside sources.

The soil-aggregate shall conform to the grading requirements of Table 206. 1.

Table 206.1 – Grading Requirements

Sieve Designation		Mass Percent Passing	
Standard mm	Alternate US Standard	Grading A	Grading B
50	2”	100	100
4.75	No. 4	45-100	55-100
1.80	No. 10	37-80	45-100
0.450	No. 40	15-20	25-80
0.210	No. 80	0-25	10-35

The percentage of wear of the crushed aggregate retained on the No. 4 (4.75-mm) sieve shall not be greater than 40% when tested in accordance with ASTM C131. The sodium sulfate soundness loss shall not exceed 10%, or the magnesium sulfate soundness loss shall not exceed 15%, after five cycles, when tested in accordance with ASTM C88.

The materials passing the 4.75 mm (No. 4) sieve produced in the crushing operation of either stone or gravel shall be incorporated in the base material to the extent permitted by the gradation requirements. The liquid limit shall not more than 25 and plasticity index shall not be more than six (6) when tested in accordance with ASTM D4318.

206.2.1.1 New Soil-Aggregate

It shall conform to the applicable requirements of Subsection 206.2.1, Soil Aggregate.

206.2.1.2 Salvaged Soil-Aggregate

Where soil-aggregate required is already in place, the Contractor shall not be responsible for its grading or quality except for removal of oversized materials as directed by the Engineer. In general, salvaged soil-aggregate to be used for lime stabilized road mix base course will consist of material meeting the requirements given in Subsection 206.2.1, Soil Aggregate.

206.2.2 Portland Cement

It shall conform to the requirements of Item 700, Hydraulic Cement.

206.2.3 Water

It shall conform to the requirements of Item 714, Water.

206.2.4 Proportioning of Mixture

The amount of cement to be added to the soil-aggregate shall be from 6 to 10 mass percent of the dry soil. The exact percentage to be added shall be fixed by the Engineer on the basis of preliminary laboratory tests and trial mixes of the materials furnished by the Contractor.

206.2.5 Strength Requirements

CBR Test for Gravelly Soils. The mixture passing the 19 mm (3/4 inch) sieve shall have a minimum soaked CBR-value of 100% tested according to AASHTO T193. The CBR-value shall be obtained at the maximum dry density determined according to AASHTO T180, Method D.

Unconfined Compression Test for Finer Textured Soils. The 7-day compressive strength of laboratory specimen molded and compacted in accordance with ASTM D1632 to a density of 100% of maximum dry density determined according to AASHTO T134, Method B, shall not be less than 2.1 MPa (300 psi) when tested in accordance with ASTM D1633.

206.3 Construction Requirements

206.3.1 Weather Limitations

Portland cement shall not be applied during windy, rainy or impending bad weather. In the event rain occurs, work shall be promptly stopped and the entire section shall be reconstructed in accordance with this Specification.

206.3.2 Travel Plant Method

The salvaged or new soil-aggregate shall be pulverized until at least 80 mass percent of all material other than stone or gravel will pass a 4.75 mm (No. 4) sieve.

Any material retained on a 50 mm (2 inches) sieve and other unsuitable material shall be removed. If additional material is specified, it shall be blended with the existing material. All butt joints at existing pavements or other structures shall be cleaned prior to mixing.

The subgrade/subbase shall support all equipment required in the construction of the base course. Soft or yielding areas shall be corrected prior to mixing.

The soil-aggregate to be treated shall be placed in a uniform windrow and spread to a uniform thickness to the required width. The specified quantity of Portland cement shall be applied uniformly in a trench on top of the windrows or spread uniformly over the soil-aggregate. Spread cement that has been lost shall be replaced, without additional compensation, before mixing is started.

Mixing shall be accomplished by means of a mixer that will thoroughly blend the cement with the soil-aggregate. The mixer shall be equipped with a water metering device that will introduce the required quantity of water during the mixing cycle. The cement soil-aggregate mixture shall be sufficiently blended to prevent the formation of cement balls when water is applied.

A maximum time of 2 hours shall be permitted for wet mixing, laydown, and finishing when this method is used.

206.3.3 Central Plant Method

The soil-aggregate shall be proportioned and mixed with cement and water in a central mixing plant. The plant shall be equipped with feeding and metering devices which will introduce the cement, soil-aggregate, and water into the mixer in the quantities specified. Mixing shall continue until a uniform mixture has been obtained.

206.3.4 Spreading, Compaction and Finishing

The mixture shall be spread on a prepared and moistened subgrade/subbase in a uniform layer by an approved equipment. Not more than 60 minutes shall elapse between the start of mixing and the time of starting compaction of the spread mixture.

After the material is spread, the surface shall be rolled. Rolling shall be parallel to the road center line and shall commence at the outer edges of the road, overlapping the shoulders and progress toward the center, overlapping on successive passes by at least one-half the width of the roller, except that on super-elevated curves rolling shall progress from the lower to the upper edge. Each pass shall terminate at least 910 mm (3 ft) in advance or to the rear of the end of the preceding pass. During compaction, the surface shall be dragged or bladed as necessary to fill ruts and to remove incipient corrugation or other irregularities. Rolling shall continue until the surface is of uniform texture and satisfactory compaction is obtained. Initial rolling shall be performed with a pneumatic tire roller and final rolling with a 3-wheel or tandem-type steel wheel roller. Rolling shall be discontinued whenever it begins to produce excessive pulverizing of the aggregate or displacement of the mixture.

When the compacted thickness of the road mix lime stabilized base course is to be more than 150 mm, the mixture shall be spread from the windrow and compacted in two (2) approximately equal layers, the first layer to be bladed and rolled before the second layer is spread.

Compaction shall continue until a field density of not less than 100% of the compacted maximum dry density determined in accordance with AASHTO T180, Method D has been attained. Field Density test shall be in accordance with AASHTO T191

The compaction and finishing shall be completed within 2 hours of the time water is added to the mixture.

206.3.5 Protection, Curing and Maintenance

The completed cement treated base shall be cured with a bituminous curing seal applied as soon as possible after the completion of final rolling. The surface shall be kept moist until the seal is applied.

The rate of application shall be between 0.5 L/m2 to 1.00 L/m2 of surface. The exact rate will be determined by the Engineer. Curing seal will be applied in sufficient quantity to provide a continuous film over the base. The film shall be maintained at least 5 days unless the treated base is protected by a subsequent course.

After the lime-stabilized base course has been finished as specified herein, the surface shall be protected against rapid drying for a period of at least five (5) days by either of the following curing methods:

1. Maintain in a thorough and continuously moist condition by sprinkling with water.

2. Cover the completed surface with a 50 mm layer of earth or sand and maintain in moist condition.

3. Apply on the surface an asphalt membrane of the type and quantity approved by the Engineer.

4. Apply on the surface a liquid membrane curing compound of the type and quantity approved by the Engineer.

The Contractor shall be required to maintain at his own expense the entire work within the limits of his Contract in good condition satisfactory to the Engineer from the time he first started work until all work shall have been completed. Maintenance shall include immediate repairs of any defects that may occur before and after the lime-stabilized base course has been compacted and finished, which work shall be done by the Contractor at his own expense and repeated as may be necessary to keep the base continuously intact.

206.3.6 Trial Sections

Trial sections of the stabilized base shall be constructed at least 2 weeks before actual base construction. These shall conform to the applicable requirements of Subsections 200.3.5, Trial Sections.

206.3.7 Tolerances

The aggregate base course shall be laid to the designed level and transverse slopes shown on the Plans. The allowable tolerances shall be in accordance with following:

Permitted variation from design thickness of layer	±	12 mm
Permitted variation from design level of surface	+ -	5 mm 10 mm
Permitted surface irregularity measured by 3.7-m straight-edge		9 mm
Permitted variation from design crossfall or camber	±	0.2%
Permitted variation from design longitudinal grade over 25 m in length	±	±0.1%

If the average lot thickness is deficient by more than one inch (25 mm), it shall be removed and replaced at the Contractor's expense. When such measurement is deficient by more than 1/2 inch (12 mm) but less than one inch (25 mm) from the plan thickness, one additional core shall be taken at random from each sub-lot within the lot.

206.3.8 Traffic

The Contractor will not be permitted to drive heavy equipment over completed portions prior to the end of five (5) days curing period except pneumatic-tired equipment required for constructing adjoining sections. Turning areas on completed portions of the base shall be protected by a layer of stable granular materials of not less than 50 mm of compacted depth.

206.4 Testing Requirements

ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C131	Standard Test Method for Resistance to Degradation of Small- Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregate
ASTM C174	Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM D75	Standard Practice for Sampling Aggregates
ASTM D558	Standard Test Methods for Moisture-Density (Unit Weight) Relations of Soil-Cement Mixtures
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1633	Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders
ASTM D2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D3665	Standard Practice for Random Sampling of Construction Materials
ASTM D3666	Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM T135	Standard Method of Test for Wetting-and-Drying Test of Compacted Soil-Cement Mixtures
ASTM T136	Standard Method of Test for Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures

206.5 Material Requirements

ASTM C150	Standard Specification for Portland Cement
ASTM C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C595	Standard Specification for Blended Hydraulic Cements
ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C989	Standard Specification for Slag Cement for Use in Concrete and

	Mortars
ASTM D977	Standard Specification for Emulsified Asphalt
ASTM D2397	Standard Specification for Cationic Emulsified Asphalt
ASTM C150	Standard Specification for Portland Cement

ITEM 208 - P-306 LEAN CONCRETE BASE COURSE

208.1 Description

This item shall consist of a subbase material, herein termed lean concrete, that is composed of aggregate and cement uniformly blended together and mixed with water. The mixture may also include approved cementitious additives, in the form of fly ash or slag, and chemical admixtures. The mixed material shall be spread, shaped, and consolidated using concrete paving equipment in accordance with these specifications and in conformity to the lines, grades, dimensions, and typical cross-sections shown on the plans.

208.2 Materials

208.2.1 Aggregate

The coarse aggregate fraction shall be crushed stone, crushed or uncrushed gravel, crushed and adequately seasoned, air-cooled, iron blast furnace slag, crushed recycled concrete, or a combination thereof. The fine aggregate fraction may be part of the natural aggregate blend as obtained from the borrow source or it may be natural sand that is added at the time of mixing.

The aggregate shall consist of hard, durable particles, free from an excess of flat, elongated, soft, or disintegrated pieces, or objectionable matter such as roots, sod, weeds, organic impurities, etc. A flat particle is one having a ratio of width to thickness greater than five; an elongated particle is one having a ratio of length to width greater than five.

The design aggregate blend shall conform to the gradation(s) shown in the table below, when tested in accordance with ASTM C136. The aggregates shall be within the limits for deleterious material contained in ASTM C33 Table 3 type 4S. Aggregates shall not contain any substance which may be deleteriously reactive with the alkalies in the cement, except as permitted in ASTM C33.

Aggregate Gradation for Lean Concrete

Sieve Size (Square openings)		Percentage by Weight Passing	
		Gradation A	Gradation B
2”	50 mm	-	-
1-1/2”	38 mm	100	-
1”	25 mm	70-95	100
¾”	19 mm	55-85	70-100
No. 4	4.75 mm	30-60	35-65
No. 40	0.425 mm	10-30	15-30
No. 200	0.075 mm	0-15	0-15

208.2.2 Cement

Cement shall conform to the requirements of ASTM C150. Where history of sulfate traction with the selected aggregate, Type II shall be used.

208.2.3 Cemetitious Additives

Pozzolanic and slag cement may be added to the lean concrete mix. If used, each material must meet the following requirements:

208.2.3.1 Pozzolan

Pozzolanic materials must meet the requirements of ASTM C618, Class N, F, or C Fly Ash, except the loss on ignition shall be 6% for Class N and F.

208.2.3.2 Ground Granulated Blast Furnace Slag (Slag Cement)

Slag shall conform to ASTM C989, Grade 120.

208.2.4 Chemical Admixtures

The Contractor shall submit certificates indicating that the material to be furnished meets all the requirements listed below. In addition, the Engineer may require the Contractor to submit complete test data showing that the material to be furnished meets all the requirements of the cited specification.

208.2.4.1 Air-entraining Admixtures

Air-entraining admixtures shall meet the requirements of ASTM C260.

208.2.4.2 Water-reducing Admixtures

Water-reducing, set-controlling admixtures shall meet the requirements of ASTM C494, Type A, D, E, F, or G. Water-reducing admixtures shall be added at the mixer separately from air-entraining admixtures in accordance with the manufacturer’s printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

208.2.4.3 Retarding Admixtures

Retarding admixtures shall meet the requirements of ASTM C494, Type B or D.

208.2.4.4 Water-reducing admixtures

Accelerating admixtures shall meet the requirements of ASTM C494, Type C.

208.2.5 Water

Water used in mixing or curing shall be potable, clean and free of oil, salt, acid, alkali, sugar, vegetable, or other deleterious substances injurious to the finished product.

208.2.6 Curing Materials

For curing lean concrete, use white-pigmented, liquid membrane-forming compound conforming to ASTM C309, Type 2, Class B, or clear or translucent Type 1-D, Class B with white fugitive dye.

208.3 Composition of Mixture

208.3.1 Mix Design

The lean concrete mix design shall be based on trial batch results conducted in the laboratory. The lean concrete shall be designed to meet the criteria in this section.

208.3.1.1 Compressive Strength

Compressive strength shall not be less than 500 pounds per square inch (3,445 kPa) nor greater than 800 pounds per square inch (5,516 kPa) at seven (7) days. Three-day and seven-day strengths shall be taken as the average of two compressive strength test results. All compressive strength specimens shall be prepared and tested in accordance with ASTM C192 and ASTM C39, respectively.

If the 3-day strength is greater than 500 pounds per square inch (3,447 kPa), the Contractor shall construct transverse joints in the lean concrete layer in accordance with Subsection 208.5.10.2.

If there is a change in aggregate sources, type of cement used, or pozzolanic materials, a new mix design must be submitted.

208.3.1.2 Air Content

The percentage of air entrainment shall be 6%, ±1/2%. Air content shall be determined by testing in accordance with ASTM C231 for gravel and stone coarse aggregate and ASTM C173 for slag and other highly porous coarse aggregate.

208.3.2 Submittals

At least 30 days prior to the placement of the lean concrete, the Contractor shall submit certified test reports to the Engineer for those materials proposed for use during construction, as well as the mix design information for the lean concrete material. Tests older than six (6) months shall not be used. The certification shall show the appropriate ASTM or AASHTO specifications or tests for the material, the name of the company performing the tests, the date of the tests, the test results, and a statement that the material did or did not comply with the applicable specifications. The submittal package shall include the following:

1. Sources of materials, including aggregate, cement, admixtures, and curing and bond breaking materials.

2. Physical properties of the aggregates, cement, admixtures, curing and bond breaking materials.

3. Mix design

   - Mix identification number
   - Weight of saturated surface-dry aggregates (fine and coarse)
   - Combined aggregate gradation
   - Cement factor
   - Water content
   - Water-cementitious material ratio (by weight)
   - Volume of admixtures and yield for one cubic yard (cubic meter) of lean concrete

4. Laboratory test results:

   - Slump
   - Air content
   - Compressive strength at 3, 7, and 28 days (average values)
   - Freeze-thaw weight loss (when applicable)

In addition, where applicable, the Sub-contractor shall submit for approval by the Contractor a jointing plan for transverse joints in the lean concrete layer. During production, the Sub-contractor shall submit batch tickets for each delivered load.

208.4 Submittals

208.4.1 General

All equipment necessary to mix, transport, place, compact, and finish the lean concrete material shall be furnished by the Contractor. The equipment shall be subject to inspection and approval by the Engineer.

208.4.2 Mixing

Lean concrete may be mixed in a stationary mixer (central batch plant or at the site), or in a truck mixer. The mixer type and capacity shall be inspected and approved by the Engineer before production begins. Each mixer shall have attached in a prominent place a manufacturer's nameplate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum or blades.

208.4.2.1 Stationary Plant Mixer

The batch plant and equipment shall conform to the requirements of ASTM C94. The Engineer shall have unrestricted access to the plant at all times for inspection of the plant's equipment and operation and for sampling the lean concrete mixture and its components.
The mixers shall be examined daily for changes in condition due to accumulation of hard concrete or mortar or wear of blades.

208.4.2.2 Truck Mixers

Truck mixers used for mixing lean concrete shall conform to the requirements of ASTM C94. Lean concrete may be entirely mixed in a truck mixer or partially mixed in a stationary mixer with mixing completed in a truck mixer. Truck mixers shall be equipped with an accurate continuous registering electronically or mechanically activated revolution counter, to verify the number of drum revolutions.

208.4.3 Hauling

Mixed lean concrete shall be hauled from the stationary plant to the job site in a truck agitator, a truck mixer operating at agitating speed, or a non-agitating truck. All equipment shall conform to the requirements of ASTM C94. When truck mixers are used to mix lean concrete, they may be transported to the job site in the same truck operating at agitating speeds, truck agitators, or a non-agitating truck. The bodies of non-agitating trucks shall be smooth, metal containers and shall be capable of discharging the concrete at a controlled rate without segregation.

208.4.4 Placing and Finishing

208.4.4.1 Forms

Straight side forms shall be made of steel and shall be furnished in sections not less than 10 feet (3 m) in length. Forms shall have a depth equal to the pavement thickness at the edge. Flexible or curved forms of proper radius shall be used for curves of 100 feet (30 m) radius or less. Forms shall be provided with adequate devices to secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms with battered top surfaces and bent, twisted or broken forms shall not be used. Built-up forms shall not be used, except as approved by the Engineer.

The top face of the form shall not vary from a true plane more than 1/8 inch (3 mm) in 10 feet (3 m), and the upstanding leg shall not vary more than 1/4 inch (6 mm). The forms shall contain provisions for locking the ends of abutting sections together tightly for secure setting. Wood forms may be used under special conditions, when accepted by the Engineer.

208.4.4.2 Fixed Form or Slip-form Pavers

Lean concrete can be placed using fixed form or slip-form pavers. The paver shall be fully energized, self-propelled and capable of spreading, consolidating, and finishing the lean concrete material, true to grade, tolerances, and cross-sections. The paver shall be capable of finishing the surface so that hand finishing is not required. The paver shall be of sufficient weight and power to construct the maximum specified concrete paving lane width, at adequate forward speed, without transverse, longitudinal or vertical instability or without displacement. The slip-form paver shall be equipped with electronic or hydraulic horizontal and vertical control devises using guide wires or stringlines on both sides of the machine. Slope control will not be allowed.

Concrete Pavers

Concrete pavers are approved as paver-finishing machines for lean concrete, provided they are capable of handling the amount of lean concrete required for the full-lane width specified, and consolidating the lean concrete full depth. A concrete paver is a power-driven machine with augers, strike-off and tamper bars ahead of a pan screed, with at least one trailing oscillating screed or belt finisher.

208.4.5 Consolidation

For side-form construction, vibrators may be either the surface pan type for pavements less than 8 inches (200 mm) thick or the internal type with either immersed tube or multiple spuds for the full width of the slab. They may be attached to the spreader or the finishing machine, or they may be mounted on a separate carriage. They shall not come in contact with the joint, subgrade, or side forms.

For slip-form construction, the paver shall vibrate the lean concrete for the full width and depth of the strip of pavement being placed. Vibration shall be accomplished by internal vibrators.

The number, spacing, frequency, and eccentric weights of vibrators shall be provided to achieve acceptable consolidation without segregation and finishing quality. Adequate power to operate all vibrators at the weight and frequency required for a satisfactory finish shall be available on the paver. The internal vibrators may be supplemented by vibrating screeds operating on the surface of the lean concrete. The Contractor shall constantly monitor the frequency of each of the individual vibrators and shall provide constant monitoring of the consolidation process to avoid honeycombing or segregation. Areas that are visually determined to be honeycombed or segregated shall be corrected at the Contractor’s expense.

The vibrators and tamping elements shall be automatically controlled so that they stop operation as forward motion ceases. Any override switch shall be of the spring- loaded, momentary-contact type.

Hand held vibrators may be used in irregular areas.

208.4.6 Jointing

The Contractor shall provide sawing equipment adequate in number of units and power to produce contraction or construction joints of the required dimensions as shown on the plans. The Contractor shall provide at least one standby saw in good working order and a supply of saw blades at the site of the work at all times during sawing operations.

208.5 Construction Methods

208.5.1 Weather Limitations

208.5.1.1 Cold Weather

Unless authorized by the Engineer, the temperature of the mixed lean concrete shall not be less than 50°F (10°C) at the time of placement. In addition, the lean concrete shall not be placed when the ambient temperature is below 40°F (4°C) or when conditions indicate that the temperature may fall below 35°F (2°C) within 24 hours. Under no circumstances shall the lean concrete be placed on frozen underlying courses or mixed when the aggregate is frozen.

When mixing and placing is authorized during cold weather, the Engineer may require the water and/or the aggregates to be heated to not less than 70°F (21°C) nor more than 150°F (66°C). The aggregates may be heated by either steam or dry heat prior to being placed in the mixer. The apparatus used shall heat the mass uniformly and shall be arranged to preclude the possible occurrence of overheated areas which might be detrimental to the materials. The Contractor shall adhere to the practices recommended in American Concrete Institute (ACI) 306R, Guide to Cold Weather Concreting.

208.5.1.2 Hot Weather

To prevent rapid drying of newly constructed lean concrete, the lean concrete temperature from initial mixing through final cure shall not exceed 90°F (32°C). The aggregates and/or mixing water shall be cooled as necessary to maintain the lean concrete temperature at or not more than the specified maximum. Ice or ice water may be substituted for the mixing water for this purpose. The Contractor shall adhere to the practices recommended in ACI 305R.

In addition, during periods of warm weather when the maximum daily air temperature exceeds 85°F (30°C), the forms and/or the underlying material shall be sprinkled with water immediately before placing the lean concrete.

208.5.1.3 Rain

All mixing and batching operations should be halted during rain showers and any plastic lean concrete placed should be covered immediately. The lean concrete shall be kept covered with plastic sheeting or other waterproof material until such time that the rain does not make any surface indentation on the lean concrete layer. Areas damaged by rain shall be refinished or replaced.

208.5.2 Form Setting

Forms shall be set sufficiently in advance of the lean concrete placement to ensure continuous paving operation. After the forms have been set to correct grade, the grade shall be thoroughly tamped, either mechanically or by hand, at both the inside and outside edges of the base of the forms. Forms shall be staked into place with not less than three (3) pins for each 10 feet (3 m) section. A pin shall be placed at each side of every joint.

Form sections shall be tightly locked and shall be free from play or movement in any direction. The forms shall not deviate from true line by more than 1/4 inch (6mm) at any joint. Forms shall be so set that they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms shall be cleaned and oiled prior to the placing of lean concrete.

The alignment and grade elevations of the forms shall be checked and corrections made by the Contractor immediately before placing the lean concrete. When any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked.

208.5.3 Preparation of underlying course

The underlying course shall be checked by the Engineer before placing and spreading operations are started, to ensure it is free of any ruts, depressions, or bumps and is finished to the correct grade. Any ruts or soft yielding places in the underlying course shall be corrected at the Contractor’s expense before the lean concrete mixture is placed. The underlying course should be wetted down in advance of placing the lean concrete to ensure a firm, moist condition at the time of lean concrete placement. The underlying course shall be protected from frost. Usage of chemicals to eliminate frost is not permissible.

208.5.4 Grade Control

Grade control between the edges of the pavement shall be accomplished at intervals of 50 feet (15 m) or less on the longitudinal grade and at 25 feet (7.5 m) or less on the transverse grade. To protect the underlying course and ensure proper drainage, the lean concrete paving shall begin along the centerline of the pavement on a crowned section or on the greatest contour elevation of a pavement with variable cross slope.

208.5.5 Handling, Measuring, and Batching Material

The batch plant site, layout, equipment, and provisions for transporting material shall assure a continuous supply of material to the work. Stockpiles shall be constructed in a manner that prevents segregation and intermixing of deleterious materials.

Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. Rail shipments requiring more than 12 hours transit will be accepted as adequate binning if the car bodies permit free drainage.

Batching plants shall be equipped to proportion aggregates and bulk cement, by weight, automatically using approved interlocked proportioning devises. When bulk cement is used, the Contractor shall use a suitable method such as a chute, boot or other device approved by the Engineer to handle the cement between the weighing hopper and the transporting container or into the batch itself for transportation to the mixer, to prevent loss of cement. The device shall provide positive assurance that each batch has the specified cement content.

208.5.6 Mixing

All lean concrete shall be mixed and delivered to the site per the requirements of ASTM C94. The mixing time should be adequate to produce lean concrete that is uniform in appearance, with all ingredients evenly distributed. Mixing time shall be measured from the time all materials are emptied into the drum (provided all the water is added before one-fourth the preset mixing time has elapsed) and continues until the time the discharge chute is opened to deliver the lean concrete.

If mixing in a plant, the mixing time shall not be less than 50 or greater than 90 seconds. If mixing in a truck, the mixing time shall not be less than 70 or more than 125 truck-drum revolutions at a mixing speed of not less than six (6) or more than 18 truck-drum revolutions per minute.

Re-tempering lean concrete by adding water or by other means will not be permitted, except when lean concrete is delivered in truck mixers. With truck mixers, additional water may be added to the batch materials and additional mixing performed to allow proper placement of the material, provided (a) the addition of water is performed within 45 minutes after the initial mixing operations and (b) the slump and water/cementitious ratio specified in the mix design is not exceeded.

208.5.7 Hauling

The elapsed time from the addition of cementitious material to the mix until the lean concrete is deposited in place at the work site shall not exceed 45 minutes when the concrete is hauled in non-agitating trucks, or 90 minutes when it is hauled in truck mixers or truck agitators.

208.5.8 Placing, Consolidating, and Finishing

Prior to placement of the lean concrete layer, the prepared underlying course shall be moistened with water, without saturating, to prevent rapid loss of moisture from the lean concrete. In cold weather, the underlying course shall be protected so that it will be entirely free of frost when lean concrete is placed.

The Contractor has the option of side- form or slip-form paving. Either option shall require the hauled lean concrete material to be discharged onto the prepared underlying course such that segregation of the mix is minimized and minimum handling of the mix is needed. The lean concrete shall be placed continuously at a uniform rate without unscheduled stops except for equipment failure or other emergencies. Avoid contamination of plastic lean concrete with foreign material on construction equipment, workman's footwear, or any other sources. Lean concrete shall not be mixed, placed, or finished when the natural light is insufficient, unless an adequate artificial lighting system is provided.

208.5.8.1 Side-form Construction

For side-form placement, the Contractor shall verify the elevations of the fixed forms so the thickness and finished grade of the lean concrete layer will be in accordance with the requirements of the project plans and specifications. The lean concrete shall be spread uniformly between the forms immediately after it is placed using a spreading machine. Necessary hand spreading shall be done with shovels. Rakes shall not be allowed for spreading lean concrete.

The spreading shall be followed immediately by thorough consolidation using vibrating screeds or spud vibrators. Vibrators may be external or internal type, depending on the thickness of the lean concrete layer. The surface vibrators may be attached to the spreader or they may be mounted on a separate carriage. They shall not come in contact with the joint, subgrade, or side forms. When spud vibrators are used, the lean concrete shall be thoroughly consolidated against and along the faces of all forms and previously placed lean concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form. In no case shall the vibrator be operated longer than 20 seconds in any one location, nor shall the vibrators be used to move the lean concrete.

Hand finishing will not be permitted except in areas where the mechanical finisher cannot operate.

208.5.8.2 Slip-form Construction

For slip-form construction, the Contractor shall verify the elevations of the guide wires controlling slip-form pavers such that the thickness and finished grade of the lean concrete will be in accordance with the requirements of the project plans and specifications. The slip-form paver should spread, consolidate, and shape the freshly placed lean concrete in one complete pass of the machine. The machine shall vibrate and finish the lean concrete for the full width and depth of the layer.

208.5.9 Final Finishing

Final finishing shall be accomplished while the lean concrete is still in the plastic state. Limited surface refinishing by hand is acceptable to meet the grade and surface tolerance established in Subsections 208.6.2.3 and 208.6.2.4, after strike off and consolidation.
If the overlying layer is to be PCC pavement, the surface of the lean concrete shall not be textured. If the overlying layer is to be HMA pavement, and if the bond between the HMA layer and the lean concrete is considered important for pavement performance, tining or scarifying the surface to provide a coarse texture may be permitted.

208.5.10 Joints

Joints shall be constructed as shown on the plans.

208.5.10.1 Construction Joints

Locate all longitudinal and transverse construction joints as shown on the plans. If longitudinal joints are not shown, locate longitudinal joints within 6 inches (150 mm) from planned joints in the PCC to be placed over the lean concrete.

208.5.10.2 Contraction Joints

If required by Subsection 208-3.1.1 or if shown on the plans, transverse contraction joints shall be constructed by sawing the hardened lean concrete to a depth of at least one-third the thickness of the lean concrete base. These joints shall match within 3 inches (75 mm) the planned joints of the overlying concrete surface.

208.5.10.3 Concrete Saws

When sawing of joints are specified, the Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions and at the required rate. The Contractor shall provide at least one standby saw in good working order. An ample supply of saw blades shall be maintained at the site of the work at all times during sawing operations. The Contractor shall provide adequate artificial lighting facilities for night sawing. All equipment shall be on the job at all times during lean concrete placement.

208.5.11 Curing

Immediately after the finishing operations are complete and within two (2) hours of placement of the lean concrete, the entire surface and edges of the newly placed lean concrete shall be sprayed uniformly with white pigmented, liquid membrane forming curing compound. The layer should be kept moist using a moisture- retaining cover or a light application of water until the curing material is applied. The curing compound shall not be applied during rainfall.

The curing material shall be applied at a maximum rate of 200 square feet per gallon (5.0 m2/l) using pressurized mechanical sprayers. The spraying equipment shall be a fully atomizing type equipped with a tank agitator. At the time of use, the curing compound in the tank shall be thoroughly and uniformly mixed with the pigment. During application the curing compound shall be continuously stirred by mechanical means.

Hand spraying of odd widths or shapes and lean concrete surfaces exposed by the removal of forms is permitted.

If the film of curing material becomes damaged from any cause, including sawing operations, within the required 7-day curing period or until the overlying course is constructed, the damaged portions shall be repaired immediately with additional compound or other approved means as quickly as practical.

Edges of the lean concrete layer shall be sprayed with curing compound immediately following placement with slip-form pavers or when side-forms are removed.

208.5.11.1 Curing in Cold Weather

The lean concrete shall be maintained at a temperature of at least 50°F (10°C) during curing. Cover lean concrete and provide with a source of heat sufficient to maintain 50°F (10°C) minimum while curing. The Contractor shall adhere to the practices recommended in ACI 306R. The Contractor shall be responsible for the quality and strength of the lean concrete placed during cold weather, and any lean concrete injured by frost action shall be removed and replaced at the Contractor’s expense.

208.5.11.2 Curing in Hot Weather

Lean concrete temperature from initial mixing through final cure shall not exceed

90°F (32°C). Shade the fresh lean concrete and start curing as soon as the surface is sufficiently hard to permit curing without damage. The Contractor shall adhere to the practices recommended in ACI 305R.

208.5.12 Protection

The Contractor shall protect the lean concrete from injurious action by sun, rain, flowing water, frost, or mechanical injury. Protect lean concrete surfaces from foot and vehicular traffic and other sources of abrasion for a minimum of 72 hours. The Engineer shall decide when the pavement shall be opened to traffic. Traffic shall not be allowed on the pavement until test specimens made per ASTM C31 have attained a compressive strength of 350 psi (2,413 kPa) when tested per ASTM C39. The Contractor shall maintain continuity of applied curing method for the entire curing period.

208.5.13 Bond-Breaker

When the lean concrete is placed directly beneath PCC pavement, a bond-breaker shall be used. The entire surface of the lean concrete shall be coated with a de- bonding compound applied in a sufficient quantity to prevent bonding between the PCC pavement and the lean concrete. The Contractor shall be responsible for selecting the de-bonding compound and determining the appropriate application rate. This application shall be made at least eight (8) hours and not more than 24 hours before placement of the PCC pavement. If an impervious membrane is used as a bond breaker, a second application of curing materials is required and shall be placed no more than 24 hours prior to placement of the PCC pavement. After application of the bond-breaker coat, traffic will be limited to that required for placement of the PCC pavement.

208.6 Material Acceptance

208.6.1 Acceptance Sampling and Testing

All acceptance sampling and testing, with the exception of coring for thickness determination, necessary to determine conformance with the requirements specified in this section will be performed by the Engineer. The Contractor shall provide the required lean concrete samples during construction for acceptance testing purposes. The samples shall be taken in the presence of the Engineer.

The lean concrete layer shall be tested for air content, strength, thickness, grade, and surface tolerance. Sampling and testing for air shall be as specified in Subsection 208.6.1.1. Sampling and testing for strength, thickness, grade, and surface tolerance shall be on a lot basis, with a lot consisting of either: (1) one day's production not to exceed 2,000 square yards (1700 sq m), or (2) a half day's production, where a day's production is expected to consist of between 2,000 and 4,000 square yards (1675 and 3350 m2).

Each lot will be divided into four equal sub-lots. In the event that only three sub-lots are produced, the three sub-lots shall constitute a complete lot. If only one or two sub-lots are produced, they shall be incorporated into the next lot, and the total number of sub-lots shall be used in the acceptance plan calculation.

End-of-production sub-lots (sub-lots associated with the final placement of lean concrete for the project which are less than a complete lot) shall be handled as (1) three sub-lots shall constitute a lot, or (2) one or sub-lots shall be incorporated into the previous lot.

208.6.1.1 Air Content Testing

Air content tests shall be performed on the first three truckloads of lean concrete produced at the start of operations each day and the first three truckloads produced after any scheduled or non-scheduled shutdown. Additional tests shall be performed each time a sample is taken for a strength test and when requested by the Engineer.

Air content tests shall be made in accordance with ASTM C231. Air content test results shall be between 4% and 8%.

If the first test on a truckload of lean concrete is not within the specification limits, a second test on the same truckload shall be made. If the second test is within the specification limits, the lean concrete will be accepted with respect to entrained air content. If the second test is not within the specification limits, the truckload shall be rejected.

208.6.1.2 Compressive Strength Testing

One sample of freshly delivered lean concrete shall be taken from each sub-lot for compressive strength testing. The lean concrete shall be sampled in accordance with ASTM C172. Sampling locations shall be determined per ASTM D3665.

At least two test cylinders shall be made from each sample per ASTM C31. The 7- day compressive strength of each cylinder shall be determined per ASTM C39.

The Contractor shall provide adequate facilities for the initial curing of cylinders. During the 24 hours after molding, the temperature immediately adjacent to the specimens must be maintained in the range of 60 to 80°F (16 to 27°C), and loss of moisture from the specimens must be prevented. The specimens may be stored in tightly constructed wooden boxes, damp sand pits, temporary buildings at construction sites, under wet burlap in favorable weather or in heavyweight closed plastic bags, or use other suitable methods, provided the temperature and moisture loss requirements are met

The compressive strength for each sub-lot shall be computed by averaging the 7- day compressive strengths of the two test cylinders representing that sub-lot. The compressive strength of the lot shall be the average compressive strength of the individual sub-lots comprising the lot.

Specimens that are noticeably defective shall not be considered in the determination of the strength. If the test specimens fail to conform to the requirements for strength, the Engineer shall request changes in the lean concrete mixture to increase the strength to meet the requirements.

If the maximum 7-day compressive strength values exceed the maximum strength requirements when evaluated in accordance with Subsection 208.6.2.1, the Contractor shall propose a jointing plan for approval by the Engineer.

208.6.1.3 Thickness Testing

After the lean concrete base has cured for three (3) days, one 4-inch (100 mm) diameter core per sub-lot shall be obtained per ASTM D3665. The thickness of each sampled core shall be determined using the caliper measurement procedures per ASTM C174. The average thickness for the lot shall be determined using the individual sub-lot core thicknesses. Acceptance criteria for lean concrete thickness are provided in Subsection 208.6.2.2.

When such measurement is deficient more than 1/2 inch (12 mm) and not more than 1 inch (25 mm) from the plan thickness, two additional cores shall be taken at random and used in determining the average thickness for that lot. The thickness of the cores shall be determined by average caliper measurement of cores tested in accordance with ASTM C174.

At all locations where cores have been drilled, the resulting holes shall be filled with lean concrete or non-shrink grout material, as approved by the Engineer.

208.6.1.4 Grade Testing

The elevations of the finished lean concrete shall be surveyed on both sides of the lean concrete lane, every 25 feet (7.5 m).

208.6.1.5 Surface Tolerance Testing

After the lean concrete has hardened sufficiently, it shall be tested for surface tolerance with a 12 feet (3.7 m) straightedge provided by the Contractor.

208.6.2 Acceptance Criteria

Acceptance of lean concrete will be based on compressive strength, thickness, grade, and surface tolerance, as described in the Subsections below.

208.6.2.1 Compressive Strength Requirements

The lean concrete shall meet all of the following compressive strength requirements on a lot basis:

- The compressive strength of the lot, tested at seven (7) days, shall be greater than 500 pounds per square inch (3,445 kPa). When a given lot of lean concrete fails to meet the minimum compressive strength requirements, the entire lot shall be replaced at the Contractor's expense.

- Not more than 20% of the individual cylinders in a given lot, tested at seven (7) days, shall have a compressive strength greater than 800 pounds per square inch (5,512 kPa). When greater than 20% of the individual cylinders in a given lot have 7-day compressive strengths in excess of 800 pounds per square inch (5,512 kPa), and transverse joints have not been constructed, a bond-breaker shall be used.

208.6.2.2 Thickness Requirements

The completed thickness shall be as shown on the plans. When the average lot thickness is not deficient by more than 1/2 inch (12 mm) from the plan thickness and works done are acceptable, measurement shall be made. If the lot average thickness is deficient by more than one inch (25 mm), it shall be removed and replaced at the Contractor's expense. When such measurement is deficient more than 1/2 inch (12 mm) and not more than one inch (25 mm) from the plan thickness, one additional core shall be taken at random from each sub-lot within the lot. The thickness of these additional cores shall be determined as,

- The lean concrete shall be tested for thickness using the same lot and sub-lots established for density testing. After three (3) days of curing, one 3-inch (75 mm) diameter core per sub-lot shall be obtained from a random location, per ASTM D3665. The thickness of each sampled core shall be determined using the caliper measurement procedures provided in ASTM C174. The average thickness for the lot shall be determined using the individual sub-lot core thicknesses.

A new lot average thickness shall be recomputed based on these additional cores and the original cores taken from each sub-lot. When the recomputed average lot thickness is not deficient by more than 1/2 inch (12 mm) from the plan thickness and works done are acceptable, measurement shall be made. If the average lot thickness is deficient by more than 1/2 inch (12 mm) from the plan thickness, the entire lot shall be removed and replaced at the Contractor's expense, unless the Engineer has allowed in writing to retain such works.

208.6.2.3 Grade Requirements

When the completed surface is more than 1/2 inch (12 mm) above the grade shown in the plans, the surface shall be trimmed at the Contractor's expense using an approved grinding machine to an elevation that falls within a tolerance of 1/4 inch (6 mm).

208.6.2.4 Surface Tolerance Requirements

Surface deviations shall not exceed 3/8 inch (9 mm) from a 12-foot (3.7-m) straightedge laid in any location parallel with or at right angles to the longitudinal axis of the centerline (includes along all edges of the paving lane). Any high spots of more than 3/8 inch (9 mm) in 12-foot (3.7-

m) shall be marked and immediately trimmed with an approved grinding machine. If the overlying layer is PCC pavement, the ground surface shall be sprayed with a double application of the curing compound at the specified rate prior to paving.

208.7 Testing Requirements

ASTM C31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM C172	Standard Practice for Sampling Freshly Mixed Concrete
ASTM C173	Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C174	Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C192	Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C1260	Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1567	Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregates (Accelerated Mortar-Bar Method)
AASHTO T136	Standard Method of Test for Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures
ASTM D3665	Standard Practice for Random Sampling of Construction Materials

208.8 Material Requirements

ACI 305R	Guide to Hot Weather Concreting
ACI 306R	Guide to Cold Weather Concreting
ASTM C33	Standard Specification for Concrete Aggregates
ASTM C94	Standard Specification for Ready-Mixed Concrete
ASTM C150	Standard Specification for Portland Cement
ASTM C260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494	Standard Specification for Chemical Admixtures for Concrete

ASTM C595	Standard Specification for Blended Hydraulic Cements
ASTM C618	Specification for Coal Fly Ash and Raw and Calcined Natural Pozzolans for Use in Concrete
ASTM C989	Standard Specification for Slag Cement for Use in Concrete and Mortars

PART E – SURFACE COURSES

ITEM 301 - BITUMINOUS PRIME COAT

301.1 Description

This Item shall consist of preparing and treating an aggregate base course with material as required by the Engineer, preparatory to the construction of a bituminous surface course.

301.2 Material Requirements

Bituminous material shall be either Rapid Curing (RC) or Medium Curing (MC) Cut- back Asphalt, whichever is called for in the Bill of Quantities. It shall conform to the requirements of Item 702, Bituminous Materials. The type and grade shall be specified in the Special Provisions.

301.3 Construction Requirements

301.3.1 Surface Condition

Prime coat shall be applied only to surfaces which are dry or slightly moist. No prime coat shall be applied when the weather is foggy or rainy.

301.3.2 Equipment

The liquid bituminous material shall be sprayed by means of a pressure distributor of not less than 1000 liters capacity, mounted on pneumatic tires of such width and number that the load produced on the road surface will not exceed 1 kN (100 kgf) per cm width of tire.

The tank shall have a heating device able to heat a complete charge of bituminous liquid to 1800C. The heating device shall be such that overheating will not occur. Consequently, the flames must not directly touch the casing of the tank containing the bituminous liquid. The liquid shall be insulated in such a way that the drop in temperature when the tank is filled with bituminous liquid at 1800C and not heated will be less than 20C per hour. A thermometer shall be fixed to the tank in order to be able to measure continuously the temperature of the liquid. The thermometer shall be placed in such a way that the highest temperature in tank is measured. The tank shall be furnished with a calibrated dipstick to indicate the contents. The pipes for filling the tank shall be furnished with an easily changeable filter.

The distributor shall be able to vary the spray width of the bituminous liquid in maximum steps of 100 mm to a total width of 4 m. The spraying bar shall have nozzles from which the liquid is sprayed fan-shaped on the road surface equally distributed over the total spraying width.

For adding the liquid bituminous material, the distributor shall have a pump either driven by a separate motor, or with a device to synchronize its speed with the speed of the distributor. The pump shall be furnished with an indicator showing the rate of flow. The suction side of the pump shall have an easily changeable filter. A thermometer shall be fixed, such that it indicates the temperature of the liquid immediately before it leaves the spraying bar.

The distributor shall be furnished with a tachometer, indicating its forward speed, which shall be visible from the driver's seat. The distributor shall be designed so that the deviation from the prescribed rate of application does not exceed 10% and shall be equipped with a device for hand spraying of the bituminous liquid.

301.3.3 Application of Bituminous Material

Immediately before applying the prime coat, the full width of surface to be treated shall be swept with a power broom and if necessary, scraped to remove all dirt and other objectionable materials. When required by the Engineer, immediately prior to the application of the prime coat, the surface shall be slightly sprayed with water but not saturated. Bituminous material shall be applied by means of a pressure distributor at the temperature given in Item 702, Bituminous Materials. The rate of application of the bituminous material shall be within the range of 1 to 2 litres/m2, the exact rate to be ordered by the Engineer.

The prime coat shall be left undisturbed for a period of at least 24 hours and shall not be opened to traffic until it has penetrated and cured sufficiently so that it will not be picked up by the wheels of passing vehicles. The Contractor shall maintain the prime coat until the next course is applied. Care shall be taken that the application of bituminous material is not in excess of the specified amount, any excess shall be blotted with sand or removed as directed by the Engineeor. All areas inaccessible to the distributor shall be sprayed manually using the device for hand spraying. The surface of structures and trees adjacent to the areas being treated shall be protected in such a manner as to prevent their being spattered or marred.

ITEM 302 - BITUMINOUS TACK COAT

302.1 Description

This Item shall consist of preparing and treating an existing bituminous or cement concrete surface with bituminous material in accordance with the Plans and Specifications, preparatory to the construction of a bituminous surface course.

302.2 Material Requirements

Bituminous material shall be either Rapid Curing (RC) Cut-back or Emulsified Asphalt, whichever is called for in the Bill of Quantities. It shall conform to the requirements of Item 702, Bituminous Materials. The type and grade will be specified in the Special Provisions.

302.3 Construction Requirements

302.3.1 Surface Condition

The tack coat shall be applied only when the existing surface is dry and the atmospheric temperature is 50°F (10°C) or above; the temperature has not been below 35°F (2°C) for the 12 hours prior to application; and when the weather is not foggy or rainy. The temperature requirements may be waived when directed by the Engineer.

302.3.2 Equipment

The liquid bituminous material shall be sprayed by means of a self-powered pressure bituminous material distributor of not less than 1000 liters capacity, mounted on pneumatic tires of such width and number that the load produced on the road surface will not exceed 1 kN(100 kgf) per cm width of tire.

Provide a distributor with pneumatic tires of such size and number that the load produced on the base surface does not exceed 65.0 psi (4.5 kg/sq cm) of tire width to prevent rutting, shoving or otherwise damaging the base, surface or other layers in the pavement structure. Design and equip the distributor to spray the bituminous material in a uniform coverage at the specified temperature, at readily determined and controlled rates from 0.05 to 2.0 gallons per square yard (0.23 to 9.05 L/square meter), with a pressure range of 25 to 75 psi (172.4 to 517.1 kPa) and with an allowable variation from the specified rate of not more than ±5%, and at variable widths. Include with the distributor equipment a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating of materials to the proper application temperature, a thermometer for reading the temperature of tank contents, and a hand hose attachment suitable for applying bituminous material manually to areas inaccessible to the distributor. Equip the distributor to circulate and agitate the bituminous material during the heating process. If the distributor is not equipped with an operable quick shutoff valve, the prime operations shall be started and stopped on building paper. The Contractor shall remove blotting sand prior to asphalt concrete lay down operations at no additional expense to the Engineer.

The tank shall have a heating device able to heat a complete charge of bituminous liquid to 180°C. The heating device shall be such that overheating will not occur. Consequently, the flames must not directly touch the casing of the tank containing the bituminous liquid. The liquid shall be insulated in such a way that the drop in temperature when the tank is filled with bituminous liquid at 180°C and not heated will be less than 2°C per hour. A thermometer shall be fixed to the tank in order to be able to measure continuously the temperature of the liquid. The thermometer shall be placed in such a way that the highest temperature in tank is measured. The tank shall be furnished with a calibrated dipstick to indicate the contents. The pipes for filling the tank shall be furnished with an easily changeable filter.

The distributor shall be able to vary the spray width of the bituminous liquid in maximum steps of 100 mm to a total width of 4 m. The spraying bar shall have nozzles from which the liquid is sprayed fan-shaped on the road surface equally distributed over the total spraying width.

For adding the liquid bituminous material, the distributor shall have a pump either driven by a separate motor, or with a device to synchronize its speed with the speed of the distributor. The pump shall be furnished with an indicator showing the rate of flow. The suction side of the pump shall have an easily changeable filter. A thermometer shall be fixed, such that it indicates the temperature of the liquid immediately before it leaves the spraying bar.

The distributor shall be furnished with a tachometer, indicating its forward speed, which shall be visible from the driver's seat. The distributor shall be designed so that the deviation from the prescribed rate of application does not exceed 10% and shall be equipped with a device for hand spraying of the bituminous liquid.

A power broom and power blower suitable for cleaning the surfaces to which the bituminous coat is to be applied shall be provided.

302.3.3 Application of Bituminous Material

Immediately before applying the tack coat, the full width of the surface to be treated shall be cleaned of loose and foreign materials by means of a power broom or power blower, supplemented as necessary by hand sweeping.

Where required by the Engineer, immediately prior to the application of the tack coat, the surface shall be lightly sprayed with water but not saturated. Bituminous material shall be applied by means of a pressure distributor at the temperature given in Item 702, Bituminous Materials, of the particular material being used. The rate of application of either the Rapid Curing Cut-back or the Emulsified Asphalt shall be within the range of 0.20 to 0.50 litre/m2, the exact rate as determined by the Engineer.

Care shall be taken that the application of bituminous material is not in excess of the specified amount; any excess shall be blotted by sand or removed as directed by the Engineer. All areas inaccessible to the distributor shall be treated manually using the device for hand spraying. The surfaces of structures and trees adjacent to the areas being treated shall be protected in such a manner so as to prevent their being spattered or marred.

Traffic shall be kept off the tack coat at all times. The tack coat shall be sprayed only so far in advance on the surface course as will permit it to dry to a "tacky" condition. The Contractor shall maintain the tack coat until the next course has been applied. Any area that has become fouled by traffic or otherwise, shall be cleaned and re-sprayed at the Contractor's expense before the next course is applied.

302.3.4 Bituminous Material Contractor's Responsibility

The Contractor shall provide a statement of source and character of the proposed bituminous material which must be submitted and approved by the Engineer before any shipment of bituminous materials to the project.

The Contractor shall furnish the vendor's certified test reports for each carload, or equivalent, of bituminous material shipped to the project. The tests reports shall be provided to and approved by the Engineer before the bituminous material is applied. If the bituminous material does not meet the specifications, it shall be replaced at the Contractor's expense. Furnishing the vendor's certified test report for the bituminous material shall not be interpreted as a basis for final acceptance.

302.3.5 Freight and Weigh Bills

The Contractor shall submit waybills and delivery tickets, during progress of the work. Before the final statement is allowed, file with the Engineer certified waybills and certified delivery tickets for all bituminous materials used in the construction of the pavement covered by the contract. Do not remove bituminous material from storage until the initial outage and temperature measurements have been taken. The delivery or storage units will not be released until the final outage has been taken.

302.4 Material Requirements

ASTM D633	Standard Volume Correction Table for Road Tar
ASTM D977	Standard Specification for Emulsified Asphalt
ASTM D1250	Standard Guide for Use of the Petroleum Measurement Tables
ASTM D2028	Standard Specification for Cutback Asphalt (Rapid-Curing Type)
ASTM D2397	Standard Specification for Cationic Emulsified Asphalt
ASTM D3628	Standard Practice for Selection and Use of Emulsified Asphalts

ITEM 303 - BITUMINOUS SEAL COAT

303.1 Description

This Item shall consist of an application of bituminous material with or without an application of aggregate on an existing bituminous surface course as required by the Engineer.

303.2 Material Requirements

303.2.1 Quantities of Materials

The approximate amounts of materials per square metre for seal coats of the several types shall be as provided in Table 303.1. The exact amounts to be used shall be set by the Engineer.

Table 303.1 – Quantities of Materials for Seal Coats

	Type 1	Type 2	Type 3
Bituminous material L/m2	0.20 – 0.50	0.50 – 1.00	0.85 – 1.50
Cover aggregate, kg/m2	none	5.00 – 10.00	8.00 – 14.00

303.2.2 Bituminous Materials

Bituminous material shall be Asphalt Cement, Penetration Grade 120-150, Rapid Curing (RC) or Medium Curing (MC) Cut-back Asphalt. It shall conform to the requirements of Item 702, Bituminous Materials, whichever is called for in the Bill of Quantities. The type and grade of asphalt cement or cut-back asphalt will be specified in the Special Provisions.

303.2.3 Cover Aggregate

Cover Aggregate for Type 2 seal coat shall consist of sand and fine screenings, reasonably free from dirt or other organic matter.

Aggregate for Type 3 seal coat shall be crushed stone, crushed slag or crushed gravel. Only one type of aggregate shall be used in a project unless alternative types are approved.

Aggregate gradation shall conform to Table 303.2 when tested by AASHTO T27.

Table 303.2 – Grading Requirements

Sieve Designation		Mass Percent Passing		
Standard mm	Alternate U.S. Standard	Type 2	Type 3	
			Grading A	Grading B
12.50	½ in.	-	-	100
Sieve Designation		Mass Percent passing		
9.50	3/8 in.	100	100	85-100

4.75	No. 4	85-100	85-100	10-30
2.36	No. 8	60-100	10-40	0-10
1.18	No. 16	-	0-10	0-5
0.300	No. 50	-	0-5	-
0.150	No. 100	0-10	-	-

The aggregate shall have a mass percent of wear not exceeding 40 when tested by AASHTO T96.

When crushed slag is used, it shall be of uniform density and quality and shall have a density of not less than 960 kg/m3 (60 lb/cu. ft.) as determined by AASHTO T19.

303.3 Construction Requirements

303.3.1 Weather and Moisture Conditions

Seal coating shall not be undertaken during foggy or rainy weather or when the surface to be treated is wet. Wet cover coat material shall not be used on the work. No seal coating work shall be continued at night unless provided with sufficient lighting. The Engineer shall always be consulted before the commencement of the work and all work shall be terminated at once in the event of rain.

303.3.2 Preparation of Surface

Seal coating operations shall not be started until the bituminous surface is thoroughly compacted by traffic and rolling. In no event shall seal coat be placed on newly constructed or reconditioned surfaces in less than ten (10) days after such surface is laid and opened to traffic, unless ordered in writing by the Engineer.

Immediately prior to applying the bituminous material, the surface shall be cleaned of all dirt, sand, dust and objectionable material. This cleaning shall be effected by means of a rotary power broom or a power blower, unless other methods are authorized by the Engineer. Dried mud or other foreign material which cannot be removed otherwise shall be removed by hand methods.

303.3.3 Application of Bituminous Material

Bituminous material shall be applied by means of a pressure distributor at the rate of approximately 0.9 to 1.8 litres for asphalt cement and 1.5 to 3.0 litres for cut-back asphalt, per square metre of surface, in a uniform, unbroken spread over the section to be treated. The pressure distributor used for applying asphaltic materials shall be equipped with pneumatic tires and shall be designed and operated so as to distribute the asphaltic material at the specified rate. It shall be equipped with a fifth wheel tachometer registering the speed and so located as to be visible to the truck driver. The distributor pump shall be equipped with a gauge registering litres per minute passing through the nozzles and readily visible to the operator. Other suitable measuring devices approved by the Engineer may be used. The exact quantity to be applied shall be determined by the Engineer.

The temperature at the time of application shall be within the range of temperature specified under Item 702, Bituminous Materials. Care shall be taken that the application of bituminous material at the junction of spreads is not in excess of the specified quantities. Any excess shall be removed from the surface by a squeegee. If necessary, to obtain proper junction of spreads, a strip of Manila paper approximately 1 metre wide and at least as long as the spray bar shall be used at the beginning and end of each spread. The paper shall be removed after use.

Any skipped areas or recognized deficiencies shall be corrected immediately by hand application and hand operated pressure devices or by other equally suitable means.

In the event that any structure becomes discolored with bituminous material, the Contractor, at his own expense, shall remove the discoloration to the satisfaction of the Engineer.

303.3.4 Application of the Cover Aggregate

Immediately after the application of asphalt, the cover aggregate shall be evenly spread over the surface at the rate of approximately 0.004 to 0.007 cubic metre per square metre. The exact quantity shall be as directed by the Engineer. Spreading shall be accomplished by aggregate spreader only so that an even and accurate distribution is obtained. The use of spreader boards attached to tail gates of trucks shall not be permitted. The tires of the aggregate trucks shall at no time come in contact with the uncovered and newly applied asphalt.

As soon as the cover aggregate has been spread, the surface shall be broomed lightly with approved push or drag broom to insure an even distribution, and shall then be rolled with an approved power roller weighing not less than 5, nor more than 6 tonnes to a uniform surface.

303.3.5 Maintenance

The Contractor shall be responsible for the maintenance of the surface until the work is accepted by the Engineer. The maintenance work shall consist of keeping any excess aggregate evenly spread over the asphalt surface by approved sweeping devices. It shall also consist of keeping all potholes or failures which may occur, repaired by use of additional asphalt and necessary aggregate. All fat or bleeding surfaces shall be covered with approved cover aggregate so that the asphalt will not adhere to, or be picked up by the wheels of vehicles.

ITEM 304 - BITUMINOUS SURFACE TREATMENT

304.1 Description

This Item shall consist of either a single application of bituminous material followed by a single spreading of aggregate (single surface treatment) or two applications of bituminous material each followed by a spreading of aggregate (double surface treatment) as required by the Engineer.

304.2 Material Requirements

304.2.1 Quantities of Materials

The approximate amounts of materials per square metre and sequence of operations for single and double surface treatment shall be as provided in Table 304.1 and Table 304.2, whichever is called for in the Bill of Quantities.

The quantities given in the Tables are those of aggregates having a bulk specific gravity of 2.65 as determined by AASHTO T84 and T85. Proportionate corrections will be made when the aggregate furnished on the job has a bulk specific gravity above 2.75 or below 2.55. In such case, the corrected amount will be the product of the quantity shown in the tables and the ratio of the bulk specific gravity of aggregate to 2.65.

The amounts given in the Tables are approximate and the exact amounts will be set by the Engineer. Total amount of bituminous material per square metre may be varied by the Engineer as necessary to fit conditions, but the total amount of aggregate per square metre, after adjusting for specific gravity will not be changed.

Table 304.1 – Quantities of Materials and Sequence of Operations Using Cut-Back Asphalt or Asphalt Cement

Aggregate Grading and Sequence of Operations	Single S.T.	Double S.T.
First Course: Apply bituminous material, L/m2	0.7 – 1.1 AC 0.9 – 1.5 MC	1.6 – 2.0 AC 1.8 – 2.3 MC
Spread Aggregate: Grading A, kg/m2 Grading B, kg/m2	11.0 – 14.0	22.0 – 27.0
Second Course: Apply bituminous material, L/m2		2.3 – 2.7 AC 2.8 – 3.5 MC
Spread Aggregate: Grading C, kg/m2		11.0 – 14.0

Table 304.2 – Quantities of Materials and Sequence of Operations Using Emulsified Asphalt

Aggregate Grading and Sequence of Operations	Single S.T.	Double S.T.
First Course: Apply bituminous material, L/m2	0.9 – 1.6	1.4 – 2.0
Spread Aggregate: Grading A, kg/m2 Grading B, kg/m2	11.0 – 14.0	14.0 – 19.0
Second Course: Apply bituminous material, L/m2		2.1 – 3.0
Spread Aggregate: Grading C, kg/m2		5.0 – 8.0

304.2.2 Bituminous Materials

Bituminous materials shall be either CRS-1 (Cationic Rapid Setting), CRS-2 (Cationic Rapid Setting), RS-1 (Rapid Setting), RS-2 (Rapid Setting), AC 120-150 (Asphalt cement), MC 250-800 (Medium Curing), whichever is called for in the Bill of Quantities. It shall conform to the requirements of Item 702, Bituminous Materials, Penetration Grade No. of asphalt cement, the type and grade of cut-back and emulsified asphalt will be specified in the Special Provisions.

304.2.3 Aggregates

The aggregates shall be crushed stone, crushed slag, or crushed gravel. Only one type of aggregate shall be used in a project unless alternative types are approved. The gradation shall conform to Table 304.3.

Table 304.3 – Aggregate Grading Requirements

Sieve Designation		Mass Percent Passing		
Standard mm	Alternative U.S. Standard	Grading A	Grading B	Grading C
25.0	1”	100	-	-
19.0	¾”	90-100	-	-
12.5	½”	20-55	100	-
9.5	3/8”	0-15	85-100	100
4.75	No. 4	0-5	10-30	85-100
2.36	No. 8	-	0-10	10-40
1.18	No. 16	-	0-5	0-10
0.300	No. 50	-	-	0-5

The aggregate shall have a mass percent of wear not exceeding 40 when tested by AASHTO T96.

When crushed gravel is used, not less than 50 mass percent of the particles retained on the 4.75 mm (No. 4) sieve shall have at least one fractured face.

When crushed slag is used, it must be of uniform density and quality and shall have a density not less than 960 kg/m3 (60 lb/cu.ft.) as determined by AASHTO T19.

304.3 Construction Requirements

304.3.1 Rates of Application/Spreading of Asphalt and Aggregate

The rates of application/spreading of asphalt and aggregate shall be within the range in Table 304.1 and 304.2 respectively. These quantities are given as guide only and will vary considerably according to the type and condition of the surface, the grading, type, shape and absorbency of the aggregate, the weather condition and the traffic. The actual quantities to be used for surface treatment shall be determined by the Contractor in accordance with the design methods for one- size aggregate given in the Asphalt Institute Manual (MS-13), Asphalt Surface Treatment. The proposed design shall be subject to the approval of the Engineer.

The Contractor shall furnish the Engineer a certified vendor's certificate in duplicate immediately upon delivery of asphaltic material to the Site.

The Contractor shall provide weighing equipment on the Site to control the application of aggregates. The weighing equipment shall have an approved multiple beam type scale with indicator and other necessary dials for accurately weighing the aggregate. The scale shall be protected by a weather-proof house with a floor area not less than 10 m2. The Contractor shall at his own expense have the scale tested and approved by the Department of Public Works and Highways.

304.3.2 Equipment

Equipment for applying the bituminous material shall conform to the requirements of Subsection 301.3.2, Equipment. A mechanical spreader shall be used for spreading the aggregates. It shall be capable of spreading the aggregate uniformly over the full width of the area being treated and shall have controls to regulate the feed gates, the feed roll, the auger and the truck hatch. The equipment shall be subject to the approval of the Engineer.

304.3.3 Application of Bituminous Material

The application of bituminous material shall be done when the weather is warm and dry.

The required asphaltic material shall be applied to the surface at least twenty four (24) hours after it has been prime coated.

Prior to applying the asphaltic material, dirt and other objectionable material shall be removed from the surface. If so directed by the Engineer, the surface shall be cleaned by power broom until all dust and loose materials are removed. Asphaltic material shall be applied on a dry surface whenever cut-back or asphalt cement is used; moist surface when emulsified asphalt is used.

Spraying shall not be done unless the road temperature has been above 200C for at least one hour prior to the commencement of spraying operations, and the temperature shall not be less than 200C during the spraying.

The application temperature for asphalt cement shall be within the range that produces a viscosity of 10 to 60 second Saybolt Furol and for cut-back asphalt shall be within the range given in Item 702, Bituminous Material. The temperature shall be such that no fogging occurs.

304.3.4 Spreading of Aggregate

Immediately after applying the asphaltic material, dry aggregate shall be uniformly and evenly distributed over the treated surface from an approved mechanical aggregate spreader. The truck carrying the aggregate shall move backward as it spreads the aggregate so as to prevent the tires of the truck and the mechanical aggregate spreader from driving directly on the newly sprayed asphalt.

No portion of the sprayed surface shall remain uncovered for a period in excess of 2 minutes. Immediately after spreading the aggregate, the treated surface shall be rolled with an approved pneumatic-tire roller.

Where asphaltic material is exposed during rolling, the area shall be covered with additional aggregate and further rolled until an even surface results.

304.3.5 Control of Traffic

The Contractor shall take all steps necessary to control traffic over newly-laid bituminous surface treatment so that the surface is not damaged in any way. Traffic shall be prohibited from traveling at speeds in excess of 40 km/h until the asphaltic material has set. The Contractor shall ensure that no vehicles, including those delivering aggregates, shall be permitted to turn around on newly-laid material.

ITEM 310 - BITUMINOUS CONCRETE SURFACE COURSE, HOT-LAID

310.1 Description

This Item shall consist of constructing a bituminous concrete surface course composed of aggregates, mineral filler, and bituminous material mixed in a central plant, constructed and laid hot on the prepared base in accordance with this Specification and in conformity with lines, grades, thickness and typical cross- section as required by the Engineer.

310.2 Material Requirements

310.2.1 Composition and Quality of Bituminous Mixture (Job-Mix Formula)

The bituminous mixture shall be composed of aggregate, mineral filler, hydrated lime, and bituminous material.

At least three weeks prior to production, the Contractor shall submit in writing a job- mix formula for each mixture supported by laboratory test data along with samples and sources of the components and viscosity-temperature relationships information to the Engineer for testing and approval.

Each job-mix formula submitted shall propose definite single values for:

1. The percentage of aggregate passing each specified sieve size.
2. The percentage of bituminous material to be added.
3. The temperature of the mixture delivered on the road.
4. The kind and percentage of additive to be used.
5. The kind and percentage of mineral filler to be used.

After the job-mix is established, all mixture furnished for the project shall conform thereto within the following ranges of tolerances:

Passing No. 4 and larger sieves	±	7 percent
Passing No. 8 to No. 100 sieves (inclusive)	±	4 percent
Passing No. 200 sieve	±	2 percent
Bituminous Material		0.4 percent
Temperature of Mixture		10°C

Should a change in source of material be proposed or should a job-mix formula prove unsatisfactory, a new job-mix formula shall be submitted by the Contractor in writing and be approved by the Engineer prior to production.

Approval of a new JMF may require laboratory testing and verification. The mixture shall have a minimum compressive strength of 1.4 MPa (200 psi). The mixture shall have a mass percent air voids with the range of 3 to 5.

The mixture shall also have an index of retained strength of not less than 70 when tested by AASHTO T165. For aggregates having maximum sizes over 25 mm (1 inch), AASHTO T165 will be modified to use 150 mm x 150 mm (6 x 6 inches) cylindrical specimens. The 150 mm (6 inches cylinders will be compacted by the procedures outlined in AASHTO T167 modified to employ 10 repetitions of a molding load of 9.6 MPa (1400 psi), with no appreciable holding time after each application of the full load.

310.2.2 Bituminous Material

It shall be either Medium Curing (MC) Cut-back Asphalt or Asphalt Cement, whichever is called for in the Bill of Quantities. It shall conform to the requirements of Item 702, Bituminous Materials. The penetration grade, type and grade of bituminous material shall be specified in the Special Provisions.

310.2.3 Aggregates

Aggregates shall conform to the applicable requirements of Item 703, Aggregates.

310.2.4 Mineral Filler

It shall conform to the requirements of Item 703A, Mineral Filler.

310.2.5 Hydrated Lime

It shall conform to the requirements of Item 701, Construction Lime.

310.2.6 Proportioning of Mixtures

The proportion of bituminous material on the basis of total dry aggregate shall be from 5.0 to 8.0 mass percent. The exact percentage to be used shall be fixed by the Engineer in accordance with the job-mix formula and the other quality control requirements.

During the mixing operation, one-half to one (0.5 to 1.0) mass percent of hydrated lime, dry aggregate basis, shall be added to the mixture. The lower percentage limit is applicable to aggregates which are predominantly calcareous.

310.3 Construction Requirements

310.3.1 Weather Limitations

Bituminous Plant mix shall not be placed on any wet surface, or when weather conditions would prevent the proper handling or finishing of the bituminous mixtures.

310.3.2 Construction Equipment

1. Bituminous Mixing Plant

   Sufficient storage space shall be provided for each size of aggregate. The different aggregate sizes shall be kept separated until they have been delivered to the cold elevator feeding the drier. The storage yard shall be maintained neat and orderly and the separate stockpiles shall be readily accessible for sampling.

   Plants used for the preparation of bituminous mixtures shall conform to the requirements for all plants under (a) below except that scale requirements shall apply only where weight proportioning is used. In addition, batch mixing plants and continuous mixing plants shall conform to the respective requirements which follow this Subsection.

   a. Requirements for all Plants.

   Mixing plants shall be of sufficient capacity and coordinated to adequately handle the proposed bituminous construction.

   1. Plant Scales.

      Scales shall be accurate to 0.5 percent of the maximum load that may be required. Poises shall be designed to be locked in any position to prevent unauthorized change of position. In lieu of plant and truck scales, the Contractor may provide an approved automatic printer system which will print the weights of the material delivered, provided the system is used in conjunction with an approved automatic batching and mixing control system. Such weights shall be evidenced by a weight ticket for each load.

      Scales shall be inspected and sealed as often as the Engineer may deem necessary to assure their continued accuracy. The Contractor shall have on hand not less than ten 20-kg weights for testing the scales.

   2. Equipment for Preparation of Bituminous Material.

      Tanks for the storage of bituminous material shall be equipped with the proper devices to heat and hold the material at the required temperatures. The heating shall be accomplished by steam coils, electricity, or other approved means so that no flame shall be in contact with the tank. The circulating system for the bituminous material shall be designed to assure proper and continuous circulation during the operating period. Provision shall be made for measuring and sampling storage tanks.

3. Feeder for Drier

The plant shall be provided with accurate mechanical means for uniformly feeding the aggregate into the drier so that uniform production and temperature will be obtained.

4. Drier

The plant shall include a drier or driers which continuously agitate during the heating and drying process. For cold-type bituminous mix, equipment for mechanical cooling of the dried aggregate to the temperature prescribed for cold mixtures shall be provided and shall be capable of supplying prepared material for the mixer to operate at full capacity.

5. Screens

Plant screens, capable of screening all aggregate to the specified sizes and proportions and having normal capacities in excess of the full capacity of the mixer, shall be provided.

6. Bins

The plant shall include storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be arranged to assure separate and adequate storage of appropriate fractions of the mineral aggregates. Separate dry storage shall be provided for filler or hydrated lime when used and the plant shall be equipped to feed such material into the mixer. Each bin shall be provided with overflow pipes, of such size and at such locations as to prevent backing up of material into other compartments or bins. Each compartment shall be provided with individual outlet gate, constructed so that when closed, there shall be no leakage. The gates shall cut off quickly and completely. Bins shall be so constructed that samples can be readily obtained. Bins shall be equipped with adequate tell-tale devices to indicate the position of the aggregates in the bins at the lower quarter points.

7. Bituminous Control Gate

Satisfactory means, either by weighing or metering, shall be provided to obtain the proper amount of bituminous material in the mix within the tolerance specified. Means shall be provided for checking the quantity or rate of flow of bituminous material into the mixer.

8. Thermometric Equipment

An armored thermometric of adequate range in temperature reading shall be fixed in the bituminous feed line at a suitable location near the charging valve at the mixer unit.

The plant shall also be equipped with either an approved dial-scale, mercury-actuated thermometer, an electric pyrometer, or other approved thermometric instrument so placed at the discharge chute of the drier as to register automatically or indicate the temperature of the heated aggregates.

The Engineer may require replacement of any thermometer by an approved temperature-recording apparatus for better regulation of the temperature of aggregates.

9. Dust Collector

The plant shall be equipped with a dust collector constructed to waste or return uniformly all or any part of the material to the hot elevator collected as directed.

10. Truck Scales

The bituminous mixture shall be weighed on approved scales furnished by the Contractor or on public scales at the Contractor's expense. Such scales shall be inspected and sealed as often as the Engineer deems necessary to assure their accuracy.

11. Safety Requirements

Adequate and safe stairways to the mixer platform and sampling points shall be provided, and guarded ladders to other plant units shall be placed at all points where accessibility to plant operations is required. Accessibility to the top of truck bodies shall be provided by a platform or other suitable device to enable the Engineer to obtain sampling and mixture temperature data. A hoist or pulley system shall be provided to raise scale calibration equipment, sampling equipment and other similar equipment from ground to the mixer platform and return. All gears, pulleys, chains, sprockets, and other dangerous moving parts shall be thoroughly guarded and protected. Ample and unobstructed space shall be provided on the mixing platform. A clear and unobstructed passage shall be maintained at all times in and around the truck loading area. This area shall be kept free from drippings from the mixing platforms.

b. Requirements for Batching Plants.

1. Weigh box or hopper.

The equipment shall include a means for accurately weighing each size of aggregate in a weight box or hopper suspended on scales and of ample size to hold a full batch without hand raking or running over. The gate shall close tightly so that no material is allowed to leak into the mixer while a batch is being weighed.

2. Bituminous Control

The equipment used to measure the bituminous material shall be accurate to plus or minus 0.5 percent. The bituminous material bucket shall be a non-tilting type with a loose sheet metal cover. The length of the discharge opening or spray bar shall be less than ¾ the length of the mixer and it shall discharge directly into the mixer. The bituminous material bucket, its discharge valve or valves and spray bar shall be adequately heated. Steam jackets, if used, shall be efficiently drained and all connections shall be so constructed that they will not interfere with the efficient operation of the bituminous scales. The capacity of the bituminous material bucket shall be at least 15 percent in excess of the weight of bituminous material required in any batch. The plant shall have an adequately heated quick-acting, non-drip, charging valve located directly over the bituminous material bucket.

The indicator dial shall have a capacity of at least 15 percent in excess of the quantity of bituminous material used in a batch. The controls shall be constructed so that they may be locked at any dial setting and will automatically reset to that reading after the addition of bituminous material to each batch. The dial shall be in full view of the mixer operator. The flow of bituminous material shall be automatically controlled so that it will begin when the dry mixing period is over. All of the bituminous material required for one batch shall be discharged in not more than 15 seconds after the flow has started. The size and spacing of the spray bar openings shall provide a uniform application of bituminous material the full length of the mixer. The section of the bituminous line between the charging valve and the spray bar shall be provided with a valve and outlet for checking the meter when a metering device is substituted for a bituminous material bucket.

3. Mixer

The batch mixer shall be an approved type capable of producing a uniform mixture with the job-mix tolerances. If not enclosed, the mixer box shall be equipped with a dust hood to prevent loss of dust.

The clearance of blades from all fixed and moving parts shall not exceed 25 mm (1 inch) unless the maximum diameter of the aggregate in the mix exceed 30 mm (1-1/4 inches), in which case the clearance shall not exceed 40 mm (1-1/2 inches).

4. Control of Mixing Time

   The mixer shall be equipped with an accurate time lock to control the operation of a complete mixing cycle. It shall lock the weigh box gate after the charging of the mixer until the closing of the mixer gate at the completion of the cycle. It shall lock the bituminous material bucket throughout the dry and wet mixing periods. The dry mixing period is defined as the interval of time between the opening of the weigh box gate and the start of introduction of bituminous material. The wet mixing period is the interval of time between the start of introduction of bituminous material and the opening of the mixer gate.

   The control of the timing shall be flexible and capable of being set at intervals of 5 seconds or less throughout a total cycle of up to 3 minutes. A mechanical batch counter shall be installed as a part of the timing device and shall be so designed as to register only completely mixed batches.

   The setting of time interval shall be performed in the presence and at the direction of the Engineer who shall then lock the case covering the timing device until such time as a change is to be made in the timing periods.

c. Requirement for Continuous Mixing Plants

1. Aggregate Proportioning

   The plant shall include means for accurately proportioning each size of aggregate.

   The plant shall have a feeder mounted under each compartment bin. Each compartment bin shall have an accurately controlled individual gate to form an orifice for volumetrically measuring the material drawn from each compartment. The feeding orifice shall be rectangular with one dimension adjustable by positive mechanical means provided with a lock.

   Indicators shall be provided for each gate to show the respective gate opening in millimeter.

2. Weight Calibration of Aggregate Feed

The plant shall include a means for calibration of gate openings by weighing test samples. Provision shall be made so that materials fed out of individual orifice may be by passed to individual test boxes. The plant shall be equipped to conveniently handle individual test samples weighing not less than 50 kilograms. Accurate scales shall be provided by the Contractor to weigh such test samples.

3. Synchronization of Aggregate Feed and Bituminous Material Feed.

Satisfactory means shall be provided to afford positive interlocking control between the flow of aggregate from the bins and the flow of bituminous material from the meter or other proportioning device. This control shall be accomplished by interlocking mechanical means or by any other positive method satisfactory to the Engineer.

4. Mixer

The plants shall include a continuous mixer of an approved type, adequately heated and capable of producing a uniform mixture within the job-mix tolerances. It shall be equipped with a discharge hopper with dump gates which will permit rapid and complete discharge of the mixture. The paddles shall be adjustable for angular position on the shafts and reversible to retard the flow of the mix. The mixer shall have a manufacturer's plate giving the net volumetric contents of the mixer of the several heights inscribed on a permanent gauge. Charts shall be provided showing the rate of feed or aggregate per minute for the aggregate being used.

2. Hauling Equipment

Trucks used for hauling bituminous mixtures shall have tight, clean, smooth metal beds which have been thinly coated with approved material to prevent the mixture from adhering to the beds. Each truck shall have a cover of canvass or other suitable material of such size as to protect the mixture from the weather. When necessary, such that the mixture will be delivered on the road at the specified temperature, truck beds shall be insulated and covers shall be securely fastened.

Truck beds shall be drained prior to loading.

3. Bituminous Pavers

The equipment shall be self-contained, power-propelled units, provided with an adjustable activated screed or strike-off assembly, heated if necessary, and capable of spreading and finishing courses of bituminous plant mix material in lane widths applicable to the specified typical section and thickness shown on the Plans.

Pavers shall be equipped with a control system capable of automatically maintaining the screen elevation as specified herein. The control system shall be automatically actuated from either a reference line or surface through a system of mechanical sensors or sensor directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. When directed, the transverse slope control system shall be made inoperative and the screed shall be controlled by sensor directed automatic mechanisms which will independently control the elevation of each end of the screed from reference lines or surface.

The controls shall be capable of working in connection with any of the following attachments.

a. Ski-type device of not less than 9 m (30 feet) in length or as directed by the Engineer.

b. Taut stringline (wire) set to grade.

c. Short ski or shoe

The Contractor shall furnish the long ski, the short ski or shoe and furnish and install all required stakes and wire for a taut stringline.

Should the automatic control systems become inoperative during the day’s work, the Contractor will be permitted to finish the day’s work using manual controls, however, work shall not be resumed thereafter until the automatic control system has been made operative.

The Contractor shall provide and have ready for use at all times enough covers, as may be necessary, for use in any emergency such as rain, chilling wind, on unavoidable delay, for the purpose of covering or protecting any material that may have been dumped and not spread.

4. Rollers

The equipment shall be of the steel and/or pneumatic tire type and shall be in good condition, capable of reversing without backlash, and shall be operated at speeds slow enough to avoid displacement of the bituminous mixture. The number and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. The use of equipment which results in excessive crushing of the aggregate will not be permitted.

310.3.3 Conditioning of Existing Surface

Immediately before placing the bituminous mixture, the existing surface shall be cleaned of loose or deleterious material by brooming or other approved means.

Contract surface or curb, gutters, manholes and other structures shall be painted with a thin, uniform coating of bituminous material prior to the bituminous mixture being placed against them.

310.3.4 Preparation of Bituminous Material

The bituminous material shall be heated so as to avoid local overheating and provide a continuous supply of the bituminous material to the mixer at a uniform temperature. The temperature of asphalt cement delivered to the mixer shall be as required to achieve a kinematic viscosity in the range of 150-300 mm2/s, as determined by AASHTO T201. Asphalt cement shall not be used while it is foaming nor shall be heated above 159°C (320°F) at any time after delivery in the project.

310.3.5 Preparation of Aggregate

Aggregates for pug mill mixing shall be heated, dried and delivered to the mixing unit at a temperature within the range ±17°C (±30°F) of the bitumen. Moisture content of the aggregate shall not exceed one mass percent at the time it is introduced into the mixing unit. Flames used for drying and heating shall be properly adjusted to avoid damage to the aggregate and to avoid soot on the aggregate. Moisture content of the mixture from drum dryer plants shall not exceed three (3) percent of the output, as determined by AASHTO T110.

310.3.6 Mixing

The dried aggregates and the bituminous material shall be measured or gauged and introduced into the mixer in the amount specified by the job mix formula.

After the required amounts of aggregate and bituminous material have been introduced into the mixer, the material shall be mixed until a complete and uniform coating of the particles and a thorough distribution of the bituminous material throughout the aggregate is secured.

310.3.7 Spreading and Finishing

The mixture shall be spread and struck off to the grade and elevation established. Bituminous pavers shall be used to distribute the mixture either over the entire width or over such partial width as may be practicable.

The longitudinal joint in one layer shall offset that in the layer immediately below approximately 15 cm (6 inches); however, the joint in the top layer shall be at the center line of the pavement if the roadway comprises two (2) lanes, or at lane lines if the roadway is more than two (2) lanes, unless otherwise directed.

On areas where irregularities or unavoidable obstacle makes the use of mechanical spreading and finishing equipment impracticable, the mixture may be placed and finished by hand tools.

The mixture shall be placed at a temperature not less than 107°C (225°F) as measured in the truck just prior to dumping into the spreader.

When tar is used, the mixture shall be placed at between 66°C and 107°C (150°F

and 225°F).

When production of the mixture can be maintained and when practical, pavers shall be used in echelon to place the wearing course in adjacent lanes.

310.3.8 Compaction

Immediately after the mixture has been spread, struck off and surface irregularities adjusted, it shall be thoroughly and uniformly compacted by rollers as specified under Subsection 310.3.2 (4).

The surface shall be rolled when the mixture is in proper condition and when the rolling does not cause under displacement, cracking and shoving. Rolling shall begin at the sides and proceeds longitudinally parallel toward the road centerline, each trip overlapping ½ the roller width, gradually progressing to the crown of the road. When paving in echelon or abutting a previously placed lane, the longitudinal joint should be rolled first followed by the regular rolling procedure. On super- elevated curves, the rolling shall begin at the low side and progress to the high side overlapping of longitudinal trips parallel to the center line.

Rollers shall move at a slow but uniform speed with the drive roll or wheels nearest the paver. Rolling shall be continued until roller marks are eliminated and a minimum of 97 mass percent of the density of the laboratory compacted specimens prepared in accordance with AASHTO T166 has been obtained.

Any displacement occurring as a result of the reversing of the direction of a roller, or from other causes, shall be corrected at once by the use of rakes and addition of fresh mixture when required. Care shall be exercised in rolling not to displace the line and grade of the edges of the bituminous mixture.

To prevent adhesion of the mixture to the rollers, the wheels shall be kept properly moistened with water or water mixed with very small quantities of detergent or other approved material. Excess liquid will not be permitted.

Along forms, curbs, headers, walls and other places not accessible to the rollers, the mixture shall be thoroughly compacted with hot hand tampers, smoothing irons or with mechanical tampers.

310.3.9 Joints

Placing of the bituminous paving shall be continuous as possible. Rollers shall not pass over the unprotected end of a freshly laid mixture unless authorized by the Engineer. Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the course. When directed by the Engineer, a brush coat of bituminous material shall be used on contact surfaces of transverse joints before additional mixture is placed against the previously rolled material.

310.3.10 Acceptance, Sampling and Testing

The Contractor shall cut full depth samples as directed, from the finished pavement, for testing. Samples shall be neatly cut by saw or core drill. Each sample shall be at least 150 mm x 150 mm or 100 mm diameter full depth. At least one, but not more than three samples shall be taken for each full day's operation. If no core samples were taken during the day's operation, core samples shall be taken from the completed pavement for every 100 L. M. per lane. The Contractor shall supply and furnish new material to backfill boreholes left by the samples taken.

No acceptance and measurement shall be made on completed asphalt pavement unless core test for thickness determination is conducted, except for Barangay Roads where the implementing office is allowed to waive such test.

The samples obtained will be used to measure the thickness of the pavement. The same samples will be used to test the density of the compacted pavement by AASHTO T166.

The compacted pavement shall have a density equal to, or greater than 97 mass percent of the density of a laboratory specimen. The asphalt pavement represented by the cores shall not be accepted if the deficiency in density is more than 2%.

The compacted pavement shall have a thickness tolerances of -5 mm. Thickness in excess of the specified thickness shall not be considered in the measurement of asphalt pavement. The asphalt pavement represented by the individual core shall not be accepted if the deficiency in the core thickness as obtained in accordance with ASTM D3549 is more than 5 mm. Averaging of the density and thickness of asphalt cores is not permitted.

If the deficiency in the core thickness is more than 5 mm, additional layer may be permitted in order to meet the designed thickness, however, the minimum additional asphalt overlay thickness should be dependent on the minimum thickness capacity of asphalt paver but it should not be less than 50 mm (2 inches) and that proper construction procedures are followed.

310.3.11 Surface Tolerances

The surface will be checked by the use of a 3-m straight-edge at sites selected by the Engineer. The straight-edge will be applied at right angles, as well as, parallel to the centerline of the roadbed.

The variation of the surface from the testing edge of the straight-edge between any two contacts with the surface shall not exceed 6 mm.

Tests will be made immediately after initial compaction and any variations detected shall be corrected by removing or adding materials, as may be necessary. Rolling shall then be continued as specified. After final rolling, the smoothness of the course shall be checked again and any area defective in texture or composition shall be corrected, including removal and replacement of unsatisfactory material at the Sub- contractor's expense as directed by the Engineer.

ITEM 311 - P-501 PORTLAND CEMENT CONCRETE PAVEMENT

311.1 Description

This Item shall consist of pavement of Portland Cement Concrete, with or without reinforcement, constructed on the prepared base in accordance with this Specification and in conformity with lines, grades, thickness and typical cross- section as required by the Engineer.

Before Portland Cement Concrete Pavement Construction is started, the Contractor shall spread and compact trial sections as directed by the Engineer. The purpose of the trial sections is to check the suitability of the materials and the efficiency of the equipment and construction method which is proposed to be used by the Contractor. Therefore, the Contractor must use the same material, equipment and procedures that he proposes to use for the main work. One trial section of about 500 m2 shall be made for every type of material and/or construction equipment/procedure proposed for use.

If a trial section shows that the proposed materials, equipment or procedures in the Engineer's opinion are not suitable for subbase, the material shall be removed at the Contractor's expense, and a new trial section shall be constructed. If the trial section is accepted, the completed section can be retained as part of the permanent work.

If the basic conditions regarding the type of material or procedure change during the execution of the work, new trial sections shall be constructed.

311.2 Material Requirements

311.2.1 Aggregate

311.2.1.1 Reactivity

Fine and Coarse aggregates to be used in all concrete shall be evaluated and tested by the Contractor for alkali-aggregate reactivity in accordance with both ASTM C1260 and ASTM C1567. Aggregate and mix proportion reactivity tests shall be performed for each project.

1. Coarse and fine aggregate shall be tested separately in accordance with ASTM C1260. The aggregate shall be considered innocuous if the expansion of test specimens, tested in accordance with ASTM C1260, does not exceed 0.10% at 28 days (30 days from casting).

2. Combined coarse and fine aggregate shall be tested in accordance with ASTM C1567, modified for combined aggregates, using the proposed mixture design proportions of aggregates, cementitious materials, and/or specific reactivity reducing chemicals. If lithium nitrate is proposed for use with or without supplementary cementitious materials, the aggregates shall be tested in accordance with Corps of Engineers (COE) Concrete Research Division (CRD) C662. If lithium nitrate admixture is used, it shall be nominal 30% ± 0.5% weight lithium nitrate in water.

3. If the expansion of the proposed combined materials test specimens, tested in accordance with ASTM C1567, modified for combined aggregates, or COE CRD C662, does not exceed 0.10% at 28 days, the proposed combined materials will be accepted. If the expansion of the proposed combined materials test specimens is greater than 0.10% at 28 days, the aggregates will not be accepted unless adjustments to the combined materials mixture can reduce the expansion to less than 0.10% at 28 days, or new aggregates shall be evaluated and tested.

311.2.1.2 Fine Aggregate

Fine aggregate shall conform to the requirements of ASTM C33. The fine aggregate shall be well-graded from coarse to fine and shall conform to Table 311.1 and shall have a fineness modulus of not less than 2.50 nor more than 3.40. The soundness loss shall not exceed 10% when sodium sulfate is used or 15% when magnesium sulfate is used, after five cycles, when tested per ASTM C88.

Table 311.1 – Grading Requirements for Fine Aggregate

Sieve Designation	Mass Percent Passing
9.5 mm (3/8 in)	100
4.75 mm (No. 4)	95 – 100
2.36 mm (No. 8)	-
1.18 mm (No. 16)	45 – 80
0.600 mm (No. 30)	-
0.300 mm (No. 50)	5 – 30
0.150 mm (No. 100)	0 – 10

The amount of deleterious material in the fine aggregate shall not exceed the following limits:

Limits for Deleterious Substances in Fine Aggregate for Concrete

Deleterious material	ASTM	Percentage by Mass
Clay Lumps and friable particles	ASTM C142	1.0
Material finer than 0.075mm (No. 200 sieve)	ASTM C117	3.0
Lightweight particles	ASTM C123 using a medium with a density of Sp. Gr. of 2.0	0.5
Total of all deleterious Material		3.0

311.2.1.3 Coarse Aggregate

The gradation of coarse aggregate shall conform to Table 311.2 when tested in accordance with ASTM C136. When the nominal maximum size of the aggregate is greater than one inch (25 mm), the aggregates shall be furnished in two size groups.

Table 311.2 – Grading Requirement for Coarse Aggregate

Sieve Designation		Mass Percent Passing		
Standard mm	Alternate U. S. Standard	Grading A	Grading B	Grading C
75.00	3 in.	100	-	-
63.00	2-1/2 in.	90-100	100	100
50.00	2 in.	-	90-100	95-100
37.5	1-1/2 in.	25-60	35-70	-
25.0	1 in.	-	0-15	35-70
19.0	¾ in.	0-10	-	-
12.5	½ in.	0-5	0-5	10-30
4.75	No. 4	-	-	0-5

Aggregates delivered to the mixer shall consist of crushed stone, crushed or uncrushed gravel, air-cooled iron blast furnace slag, crushed recycled concrete pavement, or a combination. The aggregates should be free of ferrous sulfides, such as pyrite, that would cause “rust” staining that can bleed through pavement markings. Steel blast furnace slag shall not be permitted. The aggregate shall be composed of clean, hard, uncoated particles. Dust and other coating shall be removed from the aggregates by washing.

The percentage of wear shall be no more than 40% when tested in accordance with ASTM C131.

The quantity of flat, elongated, and flat and elongated particles in any size group coarser than 3/8 sieve (9 mm) shall not exceed 8% by weight when tested in accordance with ASTM D4791. A flat particle is defined as one having a ratio of width to thickness greater than 5. An elongated particle is one having a ratio of length to width greater than 5.

The soundness loss shall not exceed 12% when sodium sulfate is used or 18% when magnesium sulfate is used, after five cycles, when tested per ASTM C88.

The amount of deleterious material in the coarse aggregate shall not exceed the following limits:

Limits for Deleterious Substances in Coarse Aggregate for Concrete

Deleterious material	ASTM	Percentage by Mass
Clay Lumps and friable particles	ASTM C 142	1.0
Material finer than 0.075mm (No. 200 sieve)	ASTM 117	1.0
Lightweight particles	ASTM C123 using a medium with density of Sp. Gr. of 2.0	0.5
Chert (less than 2.40 Sp. Gr.)	ASTM C123 using a medium with a density of Sp. Gr. of 2.0	1.0
Total of all deleterious Material		3.0

311.2.1.4 Combined Aggregate Gradation

If substituted for the grading requirements specified for coarse aggregate and for fine aggregate when approved by the Engineer, the combined aggregate grading shall meet the following requirements:

1. The materials selected and the proportions used shall be such that when the Coarseness Factor (CF) and the Workability Factor (WF) are plotted on a diagram as described in d. below, the point thus determined shall fall within the parallelogram described therein.

2. The CF shall be determined from the following equation:

   CF = (cumulative percent retained on the 3/8 in. sieve) (100) / (cumulative percent retained on the No. 8 sieve)

3. The Workability Factor WF is defined as the percent passing the No. 8 (2.36 mm) sieve based on the combined gradation. However, WF shall be adjusted, upwards only, by 2.5 percentage points for each 94 pounds (42 kg) of cementitious material per cubic meter yard greater than 564 pounds per cubic yard (335 kg per cubic meter).

4. A diagram shall be plotted using a rectangular scale with WF on the Y-axis with units from 20 (bottom) to 45 (top), and with CF on the X-axis with units from 80 (left side) to 30 (right side). On this diagram a parallelogram shall be plotted with corners at the following coordinates (CF-75, WF-28), (CF-75, WF-40), (CF-45, WF-32.5), and (CF-45, WF-44.5). If the point determined by the intersection of the computed CF and WF does not fall within the above parallelogram, the grading of each size of aggregate used and the proportions selected shall be changed as necessary.

311.2.1.5 Cementitious Materials

1. Fly ash

Fly ash shall meet the requirements of ASTM C618, with the exception of loss of ignition, where the maximum shall be less than 6%. Fly ash for use in mitigating alkali-silica reactivity shall have a Calcium Oxide (CaO) content of less than 13% and a total available alkali content less than 3% per ASTM C311. Fly ash produced in furnace operations using liming materials or soda ash (sodium carbonate) as an additive shall not be acceptable. The Contractor shall furnish the previous three most recent, consecutive ASTM C618 reports for each source of fly ash proposed in the mix design, and shall furnish each additional report as they become available during the project. The reports can be used for acceptance or the material may be tested independently by the Engineer.

2. Slag cement (ground granulated blast furnace(GGBF))

Slag cement shall conform to ASTM C989, Grade 100 or Grade 120. Slag cement shall be used only at a rate between 25% and 55% of the total cementitious material by mass.

3. Raw or calcined natural pozzolan

Natural pozzolan shall be raw or calcined and conform to ASTM C618, Class N, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction and shall have a loss on ignition not exceeding 6%. Class N pozzolan for use in mitigating Alkali-Silica Reactivity shall have a total available alkali content less than 3%.

311.2.1.6 Joint Seal

The joint seal for the joints in the concrete pavement shall meet the requirements of item P-605 stated under FAA AC 150/5370-10G and shall be of the type specified in the plans.

311.2.1.7 Isolation Joint Filler

Poured joint fillers shall be mixed asphalt and mineral or rubber filler conforming to the applicable requirements of Item 705, Joint Materials.

Preformed joint filler shall conform to the applicable requirements of Item 705 and shall be where shown on the plans. It shall be punched to admit the dowels where called for in the Plans.

311.2.1.8 Reinforcing Steel

It shall conform to the requirements of following ASTM specifications

ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A706	Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A775	Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A934	Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM A1064	Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM A184 or A704	Bar mats

The reinforcement shall be the same as or equivalent to material shown on the airfield drawing package.

311.2.1.9 Dowel and Tie Bars

Dowels and tie bars shall conform to the requirements of ASTM A615 and shall be free from burring or other deformation restricting slippage in the concrete, except that rail steel shall not be used for tie bars that are to be bent and re-straightened during construction.

Tie bars shall be deformed bars and conform to the requirements of ASTM A615. Tie bars designated as Grade 60 in ASTM A615 or ASTM A706 shall be used for construction requiring bent bars.

Dowels shall be plain round bars with bond-breaker coated by the manufacturer. Before delivery to the site of work, one-half of the length of each dowel shall be painted with one coat of approved lead or tar paint. Dowel sleeves or inserts are not permitted. Grout retention rings shall be fully circular metal or plastic devices capable of supporting the dowel until the grout hardens.

311.2.1.10 Water

Water used in mixing, curing or other designated application shall be reasonably clean and free of oil, salt, acid, alkali, grass or other substances injurious to the finished product. Water will be tested in accordance with and shall meet the requirements of Item 714, Water. Water which is drinkable may be used without test. Where the source of water is shallow, the intake shall be so enclosed as to exclude silt, mud, grass or other foreign materials.

311.2.1.11 Admixtures

The Contractor shall submit certificates indicating that the material to be furnished meets all of the requirements indicated below. In addition, the Engineer may require the Contractor to submit complete test data from an approved laboratory showing that the material to be furnished meets all of the requirements of the cited specifications. Subsequent tests may be made of samples taken by the Engineer from the supply of the material being furnished or proposed for use on the work to determine whether the admixture is uniform in quality with that approved.

1. Air-entraining Admixtures

   It shall conform to the requirements of ASTM C260 and shall consistently entrain the air content in the specified ranges under field conditions. The air- entrainment agent and any water reducer admixture shall be compatible.

   Air content shall be tested in accordance with ASTM C231 for gravel and stone coarse aggregate and ASTM C173 for slag and other highly porous coarse aggregate. The recommended air content are listed in the table below,

Recommended Air Content (%)

Exposure Level	Maximum Size Aggregate Inch (mm)				
	2” (50mm)	1-1/2: (38mm)	1” (25mm)	3/4” (19mm)	1/2” (12 mm)
Mild	2.0	2.5	3.0	3.5	4.0
Moderate	4.0	4.5	4.5	3.5	5.5
Severe	5.0	5.5	6.0	6.0	7.0

2. Water-reducing Admixtures

   It shall conform to the requirements of ASTM C494, Type A, B, or D. ASTM C494, Type F and G high range water reducing admixtures and ASTM C1017 flowable admixtures shall not be used.

3. Other Admixtures

The use of set retarding, and set-accelerating admixtures shall be approved by the Engineer. Retarding shall conform to the requirements of ASTM C494, Type A, B, or D and set-accelerating shall conform to the requirements of ASTM C494, Type C. Calcium chloride and admixtures containing calcium chloride shall not be used.

4. Lithium Nitrate

The lithium admixture shall be a nominal 30% aqueous solution of Lithium Nitrate, with a density of 10 pounds/gallon (1.2 kg/L), and shall have the approximate chemical form as shown below:

Constituent	Limit (Percent by Mass)
LiNO3 (Lithium Nitrate)	30 ± 0.5
SO4 (Sulfate Ion)	0.1 (max)
Cl (Chloride Ion)	0.2 (max)
Na (Sodium Ion)	0.1 (max)
K (Potassium Ion)	0.1 (max)

Provide a trained manufacturer's representative to supervise the lithium nitrate admixture dispensing and mixing operations.

311.2.1.12 Curing Materials

Curing materials shall conform to the following requirements as specified;

a. Liquid membrane forming compounds	ASTM C309
b. White burlap-polyethylene sheeting c. White polyethylene film	ASTM C171

Cotton mats and water-proof paper could be used.

311.2.1.13 Calcium Chloride/Calcium Nitrate

It shall conform to AASHTO M144, if specified or permitted by the Engineer, as accelerator.

311.2.1.14 Storage of Cement and Aggregate

All cement shall be stored, immediately upon delivery at the Site, in weatherproof building which will protect the cement from dampness. The floor shall be raised from the ground. The buildings shall be placed in locations approved by the Engineer. Provisions for storage shall be ample, and the shipments of cement as received shall be separately stored in such a manner as to allow the earliest deliveries to be used first and to provide easy access for identification and inspection of each shipment. Storage buildings shall have capacity for storage of a sufficient quantity of cement to allow sampling at least twelve (12) days before the cement is to be used. Bulk cement, if used, shall be transferred to elevated air tight and weatherproof bins. Stored cement shall meet the test requirements at any time after storage when retest is ordered by the Engineer. At the time of use, all cement shall be free-flowing and free of lumps.

The handling and storing of concrete aggregates shall be such as to prevent segregation or the inclusion of foreign materials. The Engineer may require that aggregates be stored on separate platforms at satisfactory locations.

In order to secure greater uniformity of concrete mix, the Engineer may require that the coarse aggregate be separated into two or more sizes. Different sizes of aggregate shall be stored in separate bins or in separate stockpiles sufficiently removed from each other to prevent the material at the edges of the piles from becoming intermixed.

311.2.1.15 Storage of Cement and Aggregate

The Contractor shall prepare the design mix based on the absolute volume method as outlined in the American Concrete Institute (ACI) Standard 211.1, "Recommended Practice for Selecting Proportions for Normal and Heavyweight Concrete".

It is the intent of this Specification to require at least 364 kg of cement per cubic meter of concrete to meet the minimum strength requirements. the Contractor shall determine from laboratory tests of the materials to be used, the cement content and the proportions of aggregate and water that will produce workable concrete having a slump of between 40 and 75 mm (1-1/2 and 3 inches) if not vibrated or between 10 and 40 mm (1/2 and 1-1/2 inches) if vibrated, and a flexural strength of not less than 4.83 MPa (700 psi) when tested by the third-point method at fourteen (14) days in accordance with AASHTO T97 and T177, respectively; or a compressive strength of 35 MPa (5000 psi) for cores taken at fourteen (14) days and tested in accordance with AASHTO T24.

Slump shall be determined using AASHTO T119.

The designer shall consider the use of lean concrete (Econocrete) mixtures using local materials or specifically modified conventional concrete mixes in base course and in the lower course composite, monolithic concrete pavements using a minimum of 75 mm (3 inches) of conventional concrete as the surface course.

The mix design shall be submitted to the Engineer for approval and shall be accompanied with certified test data from an approved laboratory demonstrating the adequacy of the mix design. A change in the source of materials during the progress of work may necessitate a new design mix.

311.2.2 Portland Cement

It shall conform to the applicable requirements of Item 700, Hydraulic Cement. Only Type I Portland Cement shall be used unless otherwise provided for in the Special Provisions. Different brands or the same brands from different mills shall not be mixed nor shall they be used alternately unless the mix is approved by the Engineer. However, the use of Portland Pozzolan Cement Type IP meeting the requirements of AASHTO M240/ASTM C595, Specifications for Blended Hydraulic Cement shall be allowed, provided that trial mixes shall be done and that the mixes meet the concrete strength requirements, the AASHTO/ASTM provisions pertinent to the use of Portland Pozzolan Type IP shall be adopted.

If aggregates are deemed innocuous when tested in accordance with clause 311.2.2.1(1) and accepted in accordance with clause 311.2.2.1(2), higher equivalent alkali content in the cement may be allowed if approved by the Engineer and FAA. Cement which for any reason, has become partially set or which contains lumps of caked cement will be rejected. Cement salvaged from discarded or used bags shall not be used.

Samples of Cement shall be obtained in accordance with AASHTO T127.

311.3 Mix Design

311.3.1 General

No concrete shall be placed until the mix design has been submitted to the Engineer for review and the Engineer has taken appropriate action. The Engineer's review shall not relieve the Contractor of the responsibility to select and proportion the materials to comply with this section.

311.3.2 Proportions

The laboratory preparing the mix design shall be accredited in accordance with ASTM C1077. The mix design for all Portland cement concrete placed under P-501 shall be stamped or sealed by the responsible professional Engineer of the laboratory. Concrete shall be proportioned to achieve a 28-day flexural strength that meets or exceeds the acceptance criteria contained in Subsection 311.5.2 for a flexural strength of 4.8 MPa per ASTM C78. The mix shall be developed using the procedures contained in the Portland Cement Association's (PCA) publication, "Design and Control of Concrete Mixtures".

The minimum cementitious material shall be adequate to ensure a workable, durable mix. The minimum cementitious material (cement plus fly ash, or slag cement) shall be 470 pounds per cubic yard (280 kg per cubic meter). The ratio of water to cementitious material, including free surface moisture on the aggregates but not including moisture absorbed by the aggregates shall not be more than 0.45 by weight.

Flexural strength test specimens shall be prepared in accordance with ASTM C192 and tested in accordance with ASTM C78. The mix determined shall be workable concrete having a maximum allowable slump between one and two inches (25mm and 50 mm) as determined by ASTM C143. For slip-form concrete, the slump shall be between 1/2 inch (12 mm) and 1-1/2 inch (38 mm). At the start of the project, the Contractor shall determine a maximum allowable slump for slip-form pavement which will produce in-place pavement to control the edge slump. The selected slump shall be applicable to both pilot and fill-in lanes.

Before the start of paving operations and after approval of all material to be used in the concrete, the Contractor shall submit a mix design showing the proportions and flexural strength obtained from the concrete at seven (7) and 28 days. The mix design shall include copies of test reports, including test dates, and a complete list of materials including type, brand, source, and amount of cement, fly ash, ground slag, coarse aggregate, fine aggregate, water, and admixtures. The mix design shall be submitted to the Engineer at least 30 days prior to the start of operations. The submitted mix design shall not be more than 90 days old. Production shall not begin until the mix design is approved in writing by the Engineer.

If a change in sources is made, or admixtures added or deleted from the mix, a new mix design must be submitted to the Engineer for approval.

The results of the mix design shall include a statement giving the maximum nominal coarse aggregate size and the weights and volumes of each ingredient proportioned on a one cubic yard (meter) basis. Aggregate quantities shall be based on the mass in a saturated surface dry condition. The recommended mixture proportions shall be accompanied by test results demonstrating that the proportions selected will produce concrete of the qualities indicated. Trial mixtures having proportions, slumps, and air content suitable for the work shall be based on methodology described in PCA's publication, Design and Control of Concrete Mixtures, modified as necessary to accommodate flexural strength.

The submitted mix design shall be stamped or sealed by the responsible professional Engineer of the laboratory and shall include the following items as a minimum:

1. Coarse, fine and combined aggregate gradations and plots including fineness modulus of the fine aggregates;
2. Reactivity Test Results
3. Coarse aggregate quality test results, including deleterious materials
4. Fine aggregate quality test results, including deleterious materials
5. Mill Certificates for cement and supplemental cementitious materials
6. Certified test results for all admixtures, including Lithium Nitrate if applicable
7. Specified flexural strength, slump and air content
8. Recommended proportions/volumes for proposed mixture and trial water-cementitious materials ration, including actual slump and air content
9. Flexural and compressive strength summaries and plots, including all individual beam and cylinder breaks
10. Correlation ratios for acceptance testing and Contractor Quality Control testing, when applicable
11. Historical record of test results documenting production standard deviation, when applicable.

311.4 Construction Requirements

311.4.1 Equipment

Equipment and tools necessary for handling materials and performing all parts of the work shall be approved by the Engineer as to design, capacity and mechanical condition but does not relieve the Contractor of the responsibility for the proper operation of equipment and maintaining the equipment in good working condition. The equipment shall be at the jobsite sufficiently ahead of the start of construction operations to be examined thoroughly and approved.

1. Batching Plant and Equipment

   A. General.

   The batching shall include bins, weighing hoppers, and scales for the fine aggregate and for each size of coarse aggregate. If cement is used in bulk, a bin, a hopper, and separate scale for cement shall be included. The weighing hopper shall be properly sealed and vented to preclude dust duriing operation. The batch plant shall be equipped with a suitable non-resettable batch counter which will correctly indicate the number of batches proportioned.

   B. Bins and Hoppers.

   Bins with adequate separate compartments for fine aggregate and for each size of coarse aggregate shall be provided in the batching plant.

   C Scales

   Scales for weighing aggregates and cement shall be of either the beam type or the springless-dial type. They shall be accurate within one-half percent (0.5%) throughout the range of use. Poises shall be designed to be locked in any position and to prevent unauthorized change.

   Scales shall be inspected and sealed as often as the Engineer may deem necessary to assure their continued accuracy.

   D. Automatic Weighing Devices.

   Unless otherwise allowed on the Contract, batching plants shall be equipped with automatic weighing devices of an approved type to proportion aggregates and bulk cement.

2. Mixers.

A. General

Concrete may be mixed at the Site of construction or at a central plant, or wholly or in part in truck mixers. Each mixer shall have a manufacturer's plate attached in a prominent place showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum or blades.

B. Mixers at Site of Construction.

Mixing shall be done in an approved mixer capable of combining the aggregates, cement and water into a thoroughly mixed and uniform mass within the specified mixing period and discharging and distributing the mixture without segregation on the prepared grade. The mixer shall be equipped with an approved timing device which will automatically lock the discharge lever when the drum has been charged and released it at the end of the mixing period. In case of failure of the timing device, the mixer may be used for the balance of the day while it is being repaired, provided that each batch is mixed 90 seconds. The mixer shall be equipped with a suitable non-resettable batch counter which shall correctly indicate the number of the batches mixed.

C. Truck Mixer and Truck Agitators

Truck mixers used for mixing and hauling concrete and truck agitators used for hauling central-mixed concrete shall conform to the requirements of ASTM C94.

D. Non-Agitator Truck

Bodies of non-agitating hauling equipment for concrete shall be smooth, mortar-tight metal containers and shall be capable of discharging the concrete at a satisfactory controlled rate without segregation conforming to the requirements of ASTM C94.

E. Transfer and spreading equipment

Equipment for transferring concrete from the transporting equipment to the paving lane in front of the paver shall be specially manufactured, self-propelled transfer equipment which will accept the concrete outside the paving lane and will transfer and spread it evenly across the paving lane in front of the paver and strike off the surface evenly to a depth which permits the paver to operate efficiently.

3. Paving and Finishing Equipment

The concrete shall be placed with an approved slip-form paver designed to spread, consolidate, screed and float finish the freshly placed concrete in one complete pass of the machine in such a manner that a minimum of hand finishing will be necessary to provide a dense and homogeneous pavement in conformance with the Plans and Specifications.

The paver-finisher shall be a heavy duty, self-propelled machine designed specifically for paving and finishing high quality concrete pavements. It shall weigh at least 2,200 lbs per foot (3274 kg/m) of paving lane width and powered by an engine having at least 6.0 horsepower per foot of lane width. The finishing machine shall be equipped with at least two (2) oscillating type transverse screed.

Vibrator shall be the internal type. Operating frequency for internal vibrators shall be between 8,000 and 12,000 vibrations per minute. Average amplitude for internal vibrators shall be 0.025-0.05 inch (0.06 - 0.13 cm).

The number, spacing, and frequency shall be as necessary to provide a dense and homogeneous pavement and meet the recommendations of American Concrete Institute (ACI) 309, Guide for Consolidation of Concrete. Adequate power to operate all vibrators shall be available on the paver. The vibrators shall be automatically controlled so that they shall be stopped as forward motion ceases. The Sub-contractor shall provide an electronic or mechanical means to monitor vibrator status. The checks on vibrator status shall occur a minimum of two times per day or when requested by the Engineer.

Hand held vibrators may be used in irregular areas only, but shall meet the recommendations of ACI 309R, Guide for Consolidation of Concrete.

The Contractor shall provide detailed method statement including equipment for the final concrete curing after application of curing medium. Detailed statements shall include protection measures to protect green concrete from rain damage.

4. Concrete Saw

The Contractor shall provide sawing equipment in adequate number of units and power to complete the sawing with a water-cooled diamond edge saw blade or an abrasive wheel to the required dimensions and at the required rate. He shall provide at least one (1) stand-by saw in good working condition and with an ample supply of saw blades.

5. Forms

Straight side forms shall be made of steel and shall be furnished in sections not less than 10 feet 3 m) in length. Forms shall have a depth equal to the pavement thickness at the edge, and a base width equal to or greater than the depth. Flexible or curved forms of proper radius shall be used for curves of 100-foot (31 m) radius or less. Forms shall be provided with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms with battered top surfaces and bent, twisted or broken forms shall not be used. Built-up forms shall not be used, except as approved by the Engineer. The top face of the form shall not vary from a true plane more than 1/8 inch (3 mm) in 10 feet (3 m), and the upstanding leg shall not vary more than 1/4 inch (6 mm). The forms shall contain provisions for locking the ends of abutting sections together tightly for secure setting. Wood forms may be used under special conditions, when approved by the Engineer.

All forms shall be rigidly supported on bed of thoroughly compacted material during the entire operation of placing and finishing the concrete. Forms shall be provided with adequate devices for secure setting so that when in place, they will withstand, without visible spring or settlement, the impact and vibration of the consolidation and finishing or paving equipment.

311.4.2 Preparation of Grade

After the subgrade of base has been placed and compacted to the required density, the areas which will support the paving machine and the grade on which the pavement is to be constructed shall be trimmed to the proper elevation by means of a properly designed machine extending the prepared work areas compacted at least 60 cm beyond each edge of the proposed concrete pavement. If loss of density results from the trimming operations, it shall be restored by additional compaction before concrete is placed. If any traffic is allowed to use the prepared subgrade or base, the surface shall be checked and corrected immediately ahead of the placing concrete.

The subgrade or base shall be uniformly moist when the concrete is placed.

311.4.3 Setting Forms

1. Base Support

The foundation under the forms shall be hard and true to grade so that the form when set will be firmly in contact for its whole length and at the specified grade. (Any roadbed, which at the form line is found below established grade, shall be filled with approved granular materials to grade in lifts of three (3) cm or less, and thoroughly rerolled or tamped.) Imperfections or variations above grade shall be corrected by tamping or by cutting as necessary.

2. Form Setting

Forms shall be set sufficiently in advance of the point where concrete is being placed. After the forms have been set to correct grade, the grade shall be thoroughly tamped, mechanically or by hand, at both the inside and outside edges of the base of the forms. Forms shall be staked into place sufficiently to maintain the form in position for the method of placement. The forms shall not deviate from true line by more than one (1) cm at any point.

Form sections shall be tightly locked and shall be free from play or movement in any direction. The forms shall not deviate from true line by more than 1/8 inch (3 mm) at any joint. Forms shall be so set that they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms shall be cleaned and oiled prior to the placing of concrete.

3. Grade and Alignment

The alignment and grade elevations of the forms shall be checked and corrections made by the Contractor immediately before placing the concrete. Testing as to crown and elevation, prior to placing of concrete can be made by means of holding an approved template in a vertical position and moved backward and forward on the forms.

When any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked.

311.4.4 Conditioning of Subgrade or Base Course

When side forms have been securely set to grade, the subgrade or base course shall be brought to proper cross-section. High areas shall be trimmed to proper elevation. Low areas shall be filled and compacted to a condition similar to that of surrounding grade. The finished grade shall be maintained in a smooth and compacted condition until the pavement is placed.

The prepared underlying surface shall be moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from the concrete. Damage caused by hauling or usage of other equipment shall be corrected and retested at the option of the Engineer. If damage occurs to a stabilized subbase, it shall be corrected full depth by the Contractor. A template shall be provided and operated on the forms immediately in advance of the placing of all concrete. The template shall be propelled only by hand and not attached to a tractor or other power unit. Templates shall be adjustable so that they may be set and maintained at the correct contour of the underlying surface. The adjustment and operation of the templates shall be such as will provide an accurate retest of the grade before placing the concrete thereon. All excess material shall be removed and wasted. Low areas shall be filled and compacted to a condition similar to that of the surrounding grade. The underlying surface shall be protected so that it will be entirely free from frost when the concrete is placed. The use of chemicals to eliminate frost in the underlying surface shall not be permitted.

The template shall be maintained in accurate adjustment, at all times by the Contractor, and shall be checked daily.

Unless waterproof subgrade or base course cover material is specified, the subgrade or base course shall be uniformly moist when the concrete is placed. If it subsequently becomes too dry, the subgrade or base course shall be sprinkled, but the method of sprinkling shall not be such as to form mud or pools of water.

311.4.5 Handling, Measuring and Batching Materials

The batch plant site, layout, equipment and provisions for transporting material shall be such as to assure a continuous supply of material to the work. Stockpiles shall be built up in layers of not more than one (1) meter in thickness. Each layer shall be completely in place before beginning the next which shall not be allowed to "cone" down over the next lower layer. Aggregates from different sources and of different grading shall not be stockpiled together.

Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All washed aggregates and aggregates produced or handled by hydraulic methods, shall be stockpiled or binned for draining at least twelve (12) hours before being batched.

When mixing is done at the side of the work. Aggregates shall be transported from the batching plant to the mixer in batch boxes, vehicle bodies, or other containers of adequate capacity and construction to properly carry the volume required. Partitions separating batches shall be adequate and effective to prevent spilling from one compartment to another while in transit or being dumped. When bulk cement is used, the Contractor shall use a suitable method of handling the cement from weighing hopper to transporting container or into the batch itself for transportation to the mixer, with chute, boot or other approved device, to prevent loss of cement, and to provide positive assurance of the actual presence in each batch of the entire cement content specified.

Bulk cement shall be transported to the mixer in tight compartments carrying the full amount of cement required for the batch. However, if allowed in the Special Provisions, it may be transported between the fine and coarse aggregate. When cement is placed in contact with the aggregates, batches may be rejected unless mixed within 1-1/2 hours of such contact. Cement in original shipping packages may be transported on top of the aggregates, each batch containing the number of sacks required by the job mix.

The mixer shall be charged without loss of cement. Batching shall be so conducted as to result in the weight to each material required within a tolerance of one (1) percent for the cement and two (2) percent for aggregates.

Water may be measured either by volume or by weight. The accuracy of measuring the water shall be within a range of error of not over than one (1) percent. Unless the water is to be weighed, the water-measuring equipment shall include an auxiliary tank from which the measuring tank shall be equipped with an outside tap and valve to provide checking the setting, unless other means are provided for readily and accurately determining the amount of water in the tank. The volume of the auxiliary tank shall be at least equal to that of the measuring tank.

311.4.6 Mixing Concrete

The concrete may be mixed at the site of the work, in a central-mix plant, or in truck mixers. The mixer shall be of an approved type and capacity. Mixing time will be measured from the time all materials, except water, are in the drum. All concrete shall be mixed and delivered in accordance with requirements of ASTM C94, except that the minimum required revolutions at the mixing speed for transit-mixed concrete may be reduced to not less than that recommended by the mixer manufacturer. The number of revolutions recommended by the mixer manufacturer shall be indicated on the manufacturer's serial plate attached to the mixer. The Contractor shall furnish test data acceptable to the Engineer verifying that the make and model of the mixer will produce uniform concrete conforming to the provision of ASTM C94 at the reduced number of revolutions shown on the serial plate.

When mixed at the site or in a central mixing plant, the mixing time shall not be less than fifty (50) seconds nor more than ninety (90) seconds, unless mixer performance tests prove adequate mixing of the concrete is a shorter time period.

Four (4) seconds shall be added to the specified mixing time if timing starts at the instant the skip reaches its maximum raised positions. Mixing time ends when the discharge chute opens. Transfer time in multiple drum mixers is included in mixing time. The contents of an individual mixer drum shall be removed before a succeeding batch is emptied therein.

The mixer shall be operated at the drum speed as shown on the manufacturer's name plate attached on the mixer. Any concrete mixed less than the specified time shall be discarded and disposed off by the Contractor at his expense. The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity in cubic meter, as shown on the manufacturer's standard rating plate on the mixer, except that an overload up to ten (10) percent above the mixer's nominal capacity may be permitted provided concrete test data for strength, segregation, and uniform consistency are satisfactory, and provided no spillage of concrete takes place.

The batches shall be so charged into the drum that a portion of the mixing water shall be entered in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first fifteen (15) seconds of the mixing period. The throat of the drum shall be kept free of such accumulations as may restrict the free flow of materials into the drum.

Mixed concrete from the central mixing plant shall be transported in truck mixers, truck agitators, or non-agitating trucks. The elapsed time from the addition of cementitious material to the mix until the concrete is deposited in place at the work site shall not exceed thirty (30) minutes when the concrete is hauled in non-agitating trucks, nor ninety (90) minutes when the concrete is hauled in truck mixers or truck agitators. Re-tempering concrete by adding water or by other means will not be permitted. With transit mixers additional water may be added to the batch materials and additional mixing performed to increase the slump to meet the specified requirements provided the addition of water is performed within forty five (45) minutes after the initial mixing operations and provided the water/cementitious ratio specified in the approved mix design is not exceeded, and approved by the Engineer.

In exceptional cases and when volumetric measurements are authorized for small project requiring less than seventy five (75) cubic meter of concrete per day of pouring, the weight proportions shall be converted to equivalent volumetric proportions. In such cases, suitable allowance shall be made for variations in the moisture condition of the aggregates, including the bulking effect in the fine aggregate. Batching and mixing shall be in accordance with ASTM C685, Section 6 through 9.

Concrete mixing by chute is allowed provided that a weighing scales for determining the batch weight will be used.

Re-tempering concrete by adding water or by other means shall not be permitted, except that when concrete is delivered in truck mixers, additional water may be added to the batch materials and additional mixing performed to increase the slump to meet the specified requirements, if permitted by the Engineer, provided all these operations are performed within forty-five (45) minutes after the initial mixing operation and the water-cement ratio is not exceeded. Concrete that is not within the specified slump limits at the time of placement shall not be used. Admixtures for increasing the workability or for accelerating the setting of the concrete will be permitted only when specifically approved by the Engineer.

311.4.7 Limitation of Mixing

No concrete shall be mixed, placed or finished when natural light is insufficient, unless an adequate and approved artificial lighting system is operated.

311.4.7.1 Mixing Concrete

During periods of hot weather when the maximum daily air temperature exceeds 85°F (30°C), the Engineer shall require that steps be taken to prevent the temperature of mixed concrete from exceeding a maximum temperature of 90°F (32°C)

Concrete not in place within ninety (90) minutes from the time the ingredients were charged into the mixing drum or that has developed initial set shall not be used. Re-tempering of concrete or mortar which has partially hardened, that is remixing with or without additional cement, aggregate, or water, shall not be permitted.

The finished surfaces of the newly laid pavement shall be kept damp by applying a water-fog or mist with approved spraying equipment until the pavement is covered by the curing medium. When necessary, wind screens shall be provided to protect the concrete from an evaporation rate in excess of 0.2 psf (0.98 kg/m2 per hour) per hour. When conditions are such that problems with plastic cracking can be expected, and particularly if any plastic cracking begins to occur, the Sub-contractor shall immediately take such additional measures as necessary to protect the concrete surface. Such measures shall consist of wind screens, more effective fog sprays, and similar measures commencing immediately behind the paver. If these measures are not effective in preventing plastic cracking, paving operations shall be immediately stopped.

311.4.7.2 Cold Weather – Not applicable.

311.4.7.3 Temperature management program

Prior to the start of paving operation for each day of paving, the Contractor shall provide the Engineer with a Temperature Management Program for the concrete to be placed to assure that uncontrolled cracking is avoided. As a minimum the program shall address the following items:

(1) Anticipated tensile strains in the fresh concrete as related to heating and cooling of the concrete material.

(2) Anticipated weather conditions such as ambient temperatures, wind velocity, and relative humidity; and anticipated evaporation rate using Figure 11-8, PCA, Design and Control of Concrete Mixtures.

(3) Anticipated timing of initial sawing of joint.

(4) Anticipated number and type of saws to be used.

311.4.7.4 Rain

In order that the concrete may be properly protected against the effects of rain before the concrete is sufficiently hardened, the Contractor will be required to have available at all times materials for the protection of the edges and surface of the unhardened concrete. The Contractor shall provide detailed method statement describe measures to protect green concrete damage by rain in the final curing stage.

311.4.8 Placing Concrete

At any point in concrete conveyance, the free vertical drop of the concrete from one point to another or to the underlying surface shall not exceed 3 feet (1 m). The finished concrete product must be dense and homogeneous, without segregation and conforming to the standards in this specification. Backhoes and grading equipment shall not be used to distribute the concrete in front of the paver. Front end loaders will not be used. All concrete shall be consolidated without voids or segregation, including under and around all load-transfer devices, joint assembly units, and other features embedded in the pavement. Hauling equipment or other mechanical equipment can be permitted on adjoining previously constructed pavement when the concrete strength reaches a flexural strength of 700psi (4830 kPa), based on the average of four field cured specimens per 2,000 cubic yards (1,530 cubic meters) of concrete placed. Also, subgrade and subbase planers, concrete pavers, and concrete finishing equipment may be permitted to ride upon the edges of previously constructed pavement when the concrete has attained a minimum flexural strength of 400 psi (2757 kPa).

Concrete shall be deposited in such a manner to require minimal re-handling. Unless truck mixers or non-agitating hauling equipment are equipped with means to discharge concrete without segregation of the materials, the concrete shall be unloaded into an approved spreading device and mechanically spread on the grade in such a manner as to prevent segregation. Placing shall be continuous between transverse joints without the use of intermediate bulkheads. Necessary hand spreading shall be done with shovels, not rakes. Workmen shall not be allowed to walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances.

When concrete is to be placed adjoining a previously constructed lane and mechanical equipment will be operated upon the existing lane, that previously constructed lane shall have attained the strength for fourteen (14) day concrete. If only finishing equipment is carried on the existing lane, paving in adjoining lanes may be permitted after three (3) days.

Concrete shall be thoroughly consolidated against and along the faces of all forms and along the full length and on both sides of all joint assemblies, by means of vibrators inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form. In no case shall the vibrator be operated longer than fifteen (15) seconds in any one location.

Concrete shall be deposited as near as possible to the expansion and contraction joints without disturbing them, but shall not be dumped from the discharge bucket or hopper into a joint assembly unless the hopper is well centered on the joint assembly. Should any concrete material fall on or be worked into the surface of a complete slab, it shall be removed immediately.

311.4.9 Test Specimens

As work progresses, at least one (1) set consisting of three (3) concrete beam test specimens, 150 mm x 150 mm x 525 mm or 900 mm shall be taken from each 330 m2 of pavement, 230 mm depth, or fraction thereof placed each day. Test specimens shall be made under the supervision of the Engineer, and the Contractor shall provide all concrete and other facilities necessary in making the test specimens and shall protect them from damage by construction operations. Cylinder samples shall not be used as substitute for determining the adequacy of the strength of concrete.

To insure that the concrete attains he required strength, test samples must be taken from the concrete in place and tested'

The beams shall be made, cured, and tested in accordance with AASHTO T23 and T97.
The concrete cylinders must be tested in accordance with AASHTO C 470/C 470M-02a

311.4.10 Strike-off of Concrete and Placement of Reinforcement

Following the placing of the concrete, it shall be struck off to conform to the cross- section shown on the Plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement will be at the elevation shown on the Plans. When reinforced concrete pavement is placed in two (2) layers, the bottom layer shall be struck off and consolidated to such length and depth that the sheet of fabric or bar mat may be laid full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed directly upon the concrete, after which the top layer of the concrete shall be placed, struck off and screeded. Any portion of the bottom layer of concrete which has been placed more than 30 minutes without being covered with the top layer shall be removed and replaced with freshly mixed concrete at the Contractor's expense. When reinforced concrete is placed in one layer, the reinforcement may be firmly positioned in advance of concrete placement or it may be placed at the depth shown on the Plans in plastic concrete, after spreading by mechanical or vibratory means.

Reinforcing steel shall be free from dirt, oil, paint, grease, mill scale and loose or thick rust which could impair bond of the steel with the concrete.

311.4.11 Joints

Joints shall be constructed as shown on the plans and in accordance with these requirements. All joints shall be constructed with their faces perpendicular to the surface of the pavement and finished or edged as shown on the plans. Joints shall not vary more than 1/2 inch (12 mm) from their designated position and shall be true to line with not more than 1/4 inch (6 mm) variation in 10 feet (3 m). The surface across the joints shall be tested with a 12 feet (3 m) straightedge as the joints are finished and any irregularities in excess of 1/4 inch (6 mm) shall be corrected before the concrete has hardened. All joints shall be so prepared, finished, or cut to provide a groove of uniform width and depth as shown on the plans.

1. Longitudinal Joint

   Longitudinal construction joints shall be slip-formed or formed against side forms as shown in the plans.

Deformed steel tie bars of specified length, size, spacing and materials shall be placed perpendicular to the longitudinal joints, they shall be placed by approved mechanical equipment or rigidly secured by chair or other approved supports to prevent displacement. Tie bars shall not be painted or coated with asphalt or other materials or enclosed in tubes or sleeves. When shown on the Plans and when adjacent lanes of pavement are constructed separately, steel side forms shall be used which will form a keyway along the construction joint. Tie bars, except those made of rail steel, may be bent at right angles against the form of the first lane constructed and straightened into final position before the concrete of the adjacent lane is placed, or in lieu of bent tie bars, approved two-piece connectors may be used.

Longitudinal formed joints shall consist of a groove or cleft, extending downward from and normal to, the surface of the pavement. These joints shall be effected or formed by an approved mechanically or manually operated device to the dimensions and line indicated on the Plans and while the concrete is in a plastic state. The groove or cleft shall be filled with either a premolded strip or poured material as required.

The longitudinal joints shall be continuous, there shall be no gaps in either transverse or longitudinal joints at the intersection of the joints.

Longitudinal sawed joints shall be cut by means of approved concrete saws to the depth, width and line shown on the Plans. Suitable guide lines or devices shall be used to assure cutting the longitudinal joint on the true line. The longitudinal joint shall be sawed before the end of the curing period or shortly thereafter and before any equipment or vehicles are allowed on the pavement. The sawed area shall be thoroughly cleaned and, if required, the joint shall immediately be filled with sealer.

Longitudinal pavement insert type joints shall be formed by placing a continuous strip of plastic materials which will not react adversely with the chemical constituent of the concrete.

2. Isolation Joint

Isolation joints shall be installed as shown on the plans. The premolded filler of the thickness as shown on the plans, shall extend for the full depth and width of the slab at the joint, except for space for sealant at the top of the slab. The filler shall be securely staked or fastened into position perpendicular to the proposed finished surface. A cap shall be provided to protect the top edge of the filler and to permit the concrete to be placed and finished. After the concrete has been placed and struck off, the cap shall be carefully withdrawn leaving the space over the premolded filler. The edges of the joint shall be finished and tooled while the concrete is still plastic. Any concrete bridging the joint space shall be removed for the full width and depth of the joint.

The isolation joint filler shall be continuous from form to form, shaped to subgrade and to the keyway along the form. Preformed joint filler shall be furnished in lengths equal to the pavement width or equal to the width of one lane. Damaged or repaired joint filler shall not be used.

The isolation joint filler shall be held in a vertical position. An approved installing bar, or other device, shall be used if required to secure preformed expansion joint filler at the proper grade and alignment during placing and finishing of the concrete. Finished joint shall not deviate more than 6 mm from a straight line. If joint fillers are assembled in sections, there shall be no offsets between adjacent units. No plugs of concrete shall be permitted anywhere within the expansion space.

3. Contraction Joint

Contraction joints shall be installed at the locations and spacing as shown on the plans. Contraction joints shall be installed to the dimensions required by forming a groove or cleft in the top of the slab while the concrete is still plastic or by sawing a groove into the concrete surface after the concrete has hardened. The depth of the weakened plane joint should at all times not be less than 50 mm, while the width should not be more than 6 mm.

a. Transverse Strip Contraction Joint. It shall be formed by installing a parting strip to be left in place as shown on the Plans.

b. Formed Groove. It shall be made by depressing an approved tool or device into the plastic concrete. The tool or device shall remain in place at least until the concrete has attained its initial set and shall then be removed without disturbing the adjacent concrete, unless the device is designed to remain in the joint. The groove shall be finished or cut clean so that spalling will be avoided at intersections with other joints. Grooving shall produce a slot at least 1/8 inch (3 mm) wide and to the depth shown on the plans.

c. Sawed Contraction Joint. It shall be created by sawing grooves in the surface of the pavement of the width not more than 6 mm, depth should at all times not be less than 50 mm, and at the spacing and lines shown on the Plans, with an approved concrete saw. After each joint is sawed, it shall be thoroughly cleaned including the adjacent concrete surface. Sawing shall produce a slot at least 1/8 inch (3 mm) wide and to the depth shown on the plans.

d. Sawing of the joint shall commence as soon as the concrete has hardened sufficiently to permit sawing without excessive ravelling, usually 4 to 24 hours. All joints shall be sawed before uncontrolled shrinkage cracking takes place. If necessary, the sawing operations shall be carried on during the day or night, regardless of weather conditions. The sawing of any joint shall be omitted if crack occurs at or near the joint location prior to the time of sawing. Sawing shall be discounted when a crack develops ahead of the saw. In general, all joints should be sawed in sequence. If extreme condition exist which make it impractical to prevent erratic cracking by early sawing, the contraction joint groove shall be formed prior to initial set of concrete as provided above.

4. Construction Joint

It shall be constructed when there is an interruption of more than 30 minutes in the concreting operations. No transverse joint shall be constructed within

1.50 m of an expansion joint, contraction joint, or plane of weakness. If sufficient concrete has been mixed at the time of interruption to form a slab of at least 1.5 m long, the excess concrete from the last preceding joint shall be removed and disposed as directed.

5. Tie bars

Tie bars shall consist of deformed bars installed in joints as shown on the plans. Tie bars shall be placed at right angles to the centerline of the concrete slab and shall be spaced at intervals shown on the plans. They shall be held in position parallel to the pavement surface and in the middle of the slab depth. When tie bars extend into an unpaved lane, they may be bent against the form at longitudinal construction joints, unless threaded bolt or other assembled tie bars are specified. Tie bars shall not be painted, greased, or enclosed in sleeves. When slip-form operations call for tie bars, two-piece hook bolts can be installed.

6. Dowel bars

Dowel bars or other load-transfer units of an approved type shall be placed across joints as shown on the plans. They shall be of the dimensions and spacings as shown and held rigidly in the middle of the slab depth in the proper horizontal and vertical alignment by an approved assembly device to be left permanently in place. The dowel or load-transfer and joint devices shall be rigid enough to permit complete assembly as a unit ready to be lifted and placed into position. The dowels shall be coated with a bond-breaker or other lubricant recommended by the manufacturer and approved by the Engineer.

Dowels bars at longitudinal construction joints shall be bonded in drilled holes.

6. Placing dowels and tie bars

The method used in installing and holding dowels in position shall ensure that the error in alignment of any dowel from its required horizontal and vertical alignment after the pavement has been completed will not be greater than 1/8 inch per feet (3 mm per 0.3 m). Except as otherwise specified below, horizontal spacing of dowels shall be within a tolerance of ±5/8 inch (16 mm). The vertical location on the face of the slab shall be within a tolerance of ±1/2 inch (12 mm). The vertical alignment of the dowels shall be measured parallel to the designated top surface of the pavement, except for those across the crown or other grade change joints. Dowels across crowns and other joints at grade changes shall be measured to a level surface. Horizontal alignment shall be checked perpendicular to the joint edge. The horizontal alignment shall be checked with a framing square. Dowels or tie bars shall not be placed closer than 0.6 times the dowel bar or tie bars length to the planned joint line. If the last regularly spaced longitudinal dowel or tie bars is closer than that dimension, it shall be moved away from the joint to a location 0.6 times the dowel bar or tie bars length, but not closer than 6 inches (150 mm) to its nearest neighbor. The portion of each dowel intended to move within the concrete or expansion cap shall be wiped clean and coated with a thin, even film of lubricating oil or light grease before the concrete is placed. Dowels shall be installed as specified in the following Subsections.

(1) Contraction Joints

Dowels and tie bars in longitudinal and transverse contraction joints within the paving lane shall be held securely in place, as indicated, by means of rigid metal frames or basket assemblies of an approved type. The basket assemblies shall be held securely in the proper location by means of suitable pins or anchors. Do not cut or crimp the dowel basket tie wires. At the Sub-contractor's option, in lieu of the above, dowels and tie bars in contraction joints shall be installed near the front of the paver by insertion into the plastic concrete using approved equipment and procedures. Approval will be based on the results of a preconstruction demonstration, showing that the dowels and tie bars are installed within specified tolerances.

(2) Construction Joints

Install dowels and tie bars by the cast-in- place or the drill-and-dowel method. Installation by removing and replacing in preformed holes will not be permitted. Dowels and tie bars shall be prepared and placed across joints where indicated, correctly aligned, and securely held in the proper horizontal and vertical position during placing and finishing operations, by means of devices fastened to the forms. The spacing of dowels and tie bars in construction joints shall be as indicated.

(3) Dowels installed in isolation joints and other hardened concrete

Install dowels for isolation joints and in other hardened concrete by bonding the dowels into holes drilled into the hardened concrete. The concrete shall have cured for seven (7) days or reached a minimum flexural strength of 450 psi (3.1 MPa) before drilling commences. Holes 1/8 inch (3 mm) greater in diameter than the dowels shall be drilled into the hardened concrete using rotary-core drills. Rotary-percussion drills may be used, provided that excessive spalling does not occur to the concrete joint face. Modification of the equipment and operation shall be required if, in the Engineer's opinion, the equipment and/or operation is causing excessive damage. Depth of dowel hole shall be within a tolerance of ±1/2 inch (12 mm) of the dimension shown on the drawings. On completion of the drilling operation, the dowel hole shall be blown out with oil-free, compressed air. Dowels shall be bonded in the drilled holes using epoxy resin. Epoxy resin shall be injected at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel will not be permitted. The dowels shall be held in alignment at the collar of the hole, after insertion and before the grout hardens, by means of a suitable metal or plastic grout retention ring fitted around the dowel. Dowels required to be installed in any joints between new and existing concrete shall be grouted in holes drilled in the existing concrete, all as specified above.

311.4.12 Final Strike-off (Consolidation and Finishing)

1. Sequence

The sequence of operations shall be the strike-off and consolidation, floating and removal of laitance, straight-edging and final surface finish. Work bridges or other devices necessary to provide access to the pavement surface for the purpose of finishing straight-edging, and make corrections as hereinafter specified, shall be provided by the Contractor.

In general, the addition of water to the surface of the concrete to assist in finishing operations will not be permitted. If the application of water to the surface is permitted, it shall be applied as fog spray by means of an approved spray equipment.

2. Finishing Joints

The concrete adjacent to joints shall be compacted or firmly placed without voids or segregation against the joint material assembly, also under and around all load transfer devices, joint assembly units, and other features designed to extend into the pavement. Concrete adjacent to joints shall be mechanically vibrated as required in Subsection 311.4.8, Placing Concrete.

After the concrete has been placed and vibrated adjacent to the joints, the finishing machine shall be brought forward, operating in a manner to avoid damage or misalignment of joints. If uninterrupted operation of the finishing machine, to over and beyond the joints causes segregation of concrete, damage to, or misalignment of the joints, the finishing machine shall be stopped when the front screed is approximately 20 cm (8 inches) from the joint. Segregated concrete shall be removed from in front of and off the joint. The front screed shall be lifted and set directly on top of the joint and the forward motion of the finishing machine resumed. When the second screed is close enough to permit the excess mortar in front of it to flow over the joint, it shall be lifted and carried over the joint. Thereafter, the finishing machine may be run over the joint without lifting the screeds, provided there is no segregated concrete immediately between the joint and the screed or on top of the joint.

3. Machine Finishing

a. Non-vibratory Method.

The concrete shall be distributed or spread as soon as placed. As soon as the concrete has been placed, it shall be struck off and screeded by an approved finishing machine. The machine shall go over each area of pavement as many times and at such intervals as necessary to give the proper compaction and leave a surface of uniform texture. Excessive operation over a given area shall be avoided. The tops of the forms shall be kept clean by an effective device attached to the machine and the travel of the machine in the forms shall be maintained true without wobbling or other variation tending to affect the precision finish.

During the first pass of the finishing machine, a uniform ridge of concrete shall be maintained ahead of the front screed in its entire length.

b. Vibratory Method

When vibration is specified, vibrators for full width vibration of concrete paving slabs, shall meet the requirements in Subsection 311.4.1, Equipment. If uniform and satisfactory density of the concrete is not obtained by the vibratory method at joints, along forms, at structures, and throughout the pavement, the Contractor will be required to furnish equipment and method which will produce pavement conforming to the Specifications. All provisions in item (a) above not in conflict with the provisions for the vibratory method shall govern.

c. Other types of finishing equipment

Clary screeds, other rotating tube floats, or bridge deck finishers are not allowed on mainline paving, but may be allowed on irregular or odd- shaped slabs, and near buildings or trench drains, subject to the Engineer's approval.
Bridge deck finishers shall have a minimum operating weight of 7500 pounds (3400 kg) and shall have a transversely operating carriage containing a knock-

down auger and a minimum of two immersion vibrators. Vibrating screeds or pans shall be used only for isolated slabs where hand finishing is permitted as specified, and only where specifically approved.

4. Hand Finishing

Hand finishing methods may only be used under the following conditions:

a. In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade.

b. In narrow widths or areas of irregular dimensions where operations of the mechanical equipment is impractical, hand methods may be used.

Concrete, as soon as placed, shall be struck off and screeded. An approved portable screed shall be used. A second screed shall be provided for striking off the bottom layer of concrete if reinforcement is used.

The screed for the surface shall be at least 60 cm (2 feet) longer than the maximum width of the slab to be struck off. It shall be of approved design, sufficiently rigid to retain its shape, and constructed either of metal or other suitable material shod with metal.

Consolidation shall be attained by the use of suitable vibrator or other approved equipment.

In operation, the screed shall be moved forward on the forms with a combined longitudinal and transverse shearing motion, moving always in the direction in which the work is progressing and so manipulated that neither end is raised from the side forms during the striking off process. If necessary, this shall be repeated until the surface is of uniform texture, true to grade and cross-section, and free from porous areas.

5. Floating

After the concrete has been struck off and consolidated, it shall be further smoothed, trued, and consolidated by means of a longitudinal float, either by hand or mechanical method.

a. Hand Method

The hand-operated longitudinal float shall be not less than 365 cm (12 feet) in length and 15 cm (6 inches) in width, properly stiffened to prevent flexibility and warping. The longitudinal float, operated from foot bridges resting on the side forms and spanning but not touching the concrete, shall be worked with a sawing motion while held in a floating position parallel to the road center line, and moving gradually from one side of the pavement to the other. Movement ahead along the center line of the pavement shall be in successive advances of not more than one-half the length of the float. Any excess water or soupy material shall be wasted over the side forms on each pass.

b. Mechanical Method

The mechanical longitudinal float shall be of a design, approved by the Engineer, and shall be in good working condition. The tracks from which the float operates shall be accurately adjusted to the required crown. The float shall be accurately adjusted and coordinated with the adjustment of the transverse finishing machine so that a small amount of mortar is carried ahead of the float at all times. The forward screed shall be adjusted so that the float will lap the distance specified by the Engineer on each transverse trip. The float shall pass over each areas of pavement at least two times, but excessive operation over a given area will not be permitted. Any excess water or soupy material shall be wasted over the side forms on each pass.

c. Alternative Mechanical Method

As an alternative, the Contractor may use a machine composed of a cutting and smoothing float or floats suspended from and guided by a rigid frame. The frame shall be carried by four or more visible wheels riding on, and constantly in contact with the side forms. If necessary, following one of the preceding method of floating, long handled floats having blades not less than 150 cm (5 feet) in length and 15 cm (6 inches) in width may be used to smooth and fill in open-textured areas in the pavement. Long-handled floats shall not be used to float the entire surface of the pavement in lieu of, or supplementing, one of the preceding methods of floating. When strike off and consolidation are done by the hand method and the crown of the pavement will not permit the use of the longitudinal float, the surface shall be floated transversely by means of the long-handled float. Care shall be taken not to work the crown out of the pavement during the operation. After floating, any excess water and laitance shall be removed from the surface of the pavement by a 3-m straight-edge or more in length. Successive drags shall be lapped one-half the length of the blade.

6. Straight-edge Testing and Surface Correction

After the pavement has been struck off and while the concrete is still plastic, it shall be tested for trueness with a Contractor furnished 12-foot (3.7- m) straightedge swung from handles 3 feet (1 m) longer than one-half the width of the slab. The straightedge shall be held in contact with the surface in successive positions parallel to the centerline and the whole area gone over from one side of the slab to the other, as necessary. Advancing shall be in successive stages of not more than one-half the length of the straightedge. Any excess water and laitance in excess of 1/8 inch (3 mm) thick shall be removed from the surface of the pavement and wasted. Any depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. High areas shall be cut down and refinished. Straightedge testing and surface corrections shall continue until the entire surface is found to be free from observable departures from the straightedge and until the slab conforms to the required grade and cross- section. The use of long-handled wood floats shall be confined to a minimum; they may be used only in emergencies and in areas not accessible to finishing equipment.

7. Final Finish

If the surface texture is brush or broom finished, it shall applied when the water sheen has practically disappeared. The broom shall be drawn from the center to the edge of the pavement with adjacent strokes slightly overlapping. The brooming operation should be so executed that the corrugations produced in the surface shall be uniform in appearance and not more than 1.5 mm in depth. Brooming shall be completed before the concrete is in such condition that the surface will be unduly roughened by the operation. The surface thus finished shall be free from rough and porous areas, irregularities, and depressions resulting from improper handling of the broom. Brooms shall be of the quality size and construction and be operated so as to produce a surface finish meeting the approval of the Engineer. Subject to satisfactory results being obtained and approval of the Engineer, the Contractor will be permitted to substitute mechanical brooming in lieu of the manual brooming herein described.

If the surface texture is belt finished, when straight-edging is complete and water sheen has practically disappeared and just before the concrete becomes non-plastic, the surface shall be belted with 2-ply canvass belt not less than 20 cm wide and at least 100 cm longer than the pavement width. Hand belts shall have suitable handles to permit controlled, uniform manipulation. The belt shall be operated with short strokes transverse to the center line and with a rapid advances parallel to the center line.

If the surface texture is drag finished, a drag shall be used which consists of a seamless strip of damp burlap or cotton fabric, which shall produce a uniform of gritty texture after dragging it longitudinally along the full width of pavement. For pavement 5 m or more in width, the drag shall be mounted on a bridge which travels on the forms. The dimensions of the drag shall be such that a strip of burlap or fabric at least 100 cm wide is in contact with the full width of pavement surface while the drag is used. The drag shall consist of not less than 2 layers of burlap with the bottom layer approximately 15 cm wider than the layer. The drag shall be maintained in such condition that the resultant surface is of uniform appearance and reasonably free from grooves over 1.5

mm in depth. Drag shall be maintained clean and free from encrusted mortar. Drags that cannot be cleaned shall be discarded and new drags be substituted.

Regardless of the method used for final finish, the hardened surface of pavement shall have a coefficient of friction of 0.25 or more. Completed pavement that is found to have a coefficient of friction less than 0.25 shall be grounded or scored by the Sub-contractor at his expense to provide the required coefficient of friction.

8. Edging at Forms and Joints

After the final finish, but before the concrete has taken its initial set, the edges of the pavement along each side of each slab, and on each side of transverse expansion joints, formed joints, transverse construction joints, and emergency construction joints, shall be worked with an approved tool and rounded to the radius required by the Plans. A well – defined and continuous radius shall be produced and a smooth, dense mortar finish obtained. The surface of the slab shall not be unduly disturbed by tilting the tool during the use.

At all joints, any tool marks appearing on the slab adjacent to the joints shall be eliminated by brooming the surface. In doing this, the rounding of the corner of the slab shall not be disturbed. All concrete on top of the joint filler shall be completely removed.

All joints shall be tested with a straight-edge before the concrete has set and correction made if one edge of the joint is higher than the other.

311.4.13 Surface Test

As soon as the concrete has hardened sufficiently, the pavement surface shall be tested with a 3-m straight-edge or other specified device. Areas showing high spots of more than 3 mm but not exceeding 12 mm in 3 m shall be marked and immediately ground down with an approved grinding tool to an elevation where the area or spot will not show surface deviations in excess of 3 mm when tested with 3 m straight-edge. Where the departure from correct cross-section exceeds 12 mm, the pavement shall be removed and replaced by and at the expense of the Contractor.

Any area or section so removed shall be not less than 1.5 m in length and not less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than 1.5 m in length, shall also be removed and replaced.

311.4.14 Surface Test

Immediately after the finishing operations have been completed and the concrete has sufficiently set, the entire surface of the newly placed concrete shall be cured in accordance with either one of the methods described herein. Failure to provide sufficient cover material of whatever kind the Contractor may elect to use, or the lack of water to adequately take care of both curing and other requirements, shall be a cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than ½ hour between stages of curing or during the curing period.

When a two-saw-cut method is used to construct the contraction joint, the curing compound shall be applied to the saw-cut immediately after the initial cut has been made. The sealant reservoir shall not be sawed until after the curing period has been completed. When the one cut method is used to construct the contraction joint, the joint shall be cured with wet rope, wet rags, or wet blankets. The rags, ropes, or blankets shall be kept moist for the duration of the curing period.

In all congested places, concrete works should be designed so that the designed strength is attained.

1. Cotton of Burlap Mats

   The surface of the pavement shall be entirely covered with mats. The mats used shall be of such length (or width) that as laid they will extend at least twice the thickness of the pavement beyond the edges of the slab. The mat shall be placed so that the entire surface and the edges of the slab are completely covered. Prior to being placed, the mats shall be saturated thoroughly with water. The mat shall be so placed and weighted down so as to cause them to remain in intimate contact with the covered surface. The mat shall be maintained fully wetted and in position for 72 hours after the concrete has been placed unless otherwise specified.

2. Waterproof Paper

   The top surface and sides of the pavement shall be entirely covered with waterproof paper, the units shall be lapped at least 45 cm. The paper shall be so placed and weighted down so as to cause it to remain in intimate contact with the surface covered. The paper shall have such dimension but each unit as laid will extend beyond the edges of the slab at least twice the thickness of the pavement, or at pavement width and 60 cm strips of paper for the edges. If laid longitudinally, paper not manufactured in sizes which will provide this width shall be securely sewed or cemented together, the joints being securely sealed in such a manner that they do not open up or separate during the curing period. Unless otherwise specified, the covering shall be maintained in place for 72 hours after the concrete has been placed. The surface of the pavement shall be thoroughly wetted prior to the placing of the paper.

3. Straw Curing

When this type of curing is used, the pavement shall be cured initially with burlap or cotton mats, until after final set of the concrete or, in any case, for 12 hours after placing the concrete. As soon as the mats are removed, the surface and sides of the pavement shall be thoroughly wetted and covered with at least 20 cm of straw or hay, thickness of which is to be measured after wetting. If the straw or hay covering becomes displaced during the curing period, it shall be replaced to the original depth and saturated. It shall be kept thoroughly saturated with water for 72 hours and thoroughly wetted down during the morning of the fourth day, and the cover shall remain in place until the concrete has attained the required strength.

4. Impervious Membrane Method

The entire surface of the pavement shall be sprayed uniformly with white pigmented curing compound immediately after the finishing of the surface and before the set of the concrete has taken place, or if the pavement is cured initially with jute or cotton mats, it may be applied upon removal of the mass. The curing compound shall not be applied during rain.

Curing compound shall be applied under pressure at the rate 4 L to not more than 14 m2 by mechanical sprayers. The spraying equipment shall be equipped with a wind guard. At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. During application, the compound shall be stirred continuously by effective mechanical means. Hand spraying of odd widths or shapes and concrete surface exposed by the removal of forms will be permitted. Curing compound shall not be applied to the inside faces of joints to be sealed, but approved means shall be used to insure proper curing at least 72 hours and to prevent the intrusion of foreign material into the joint before sealing has been completed. The curing compound shall be of such character that the film will harden within 30 minutes after application. Should the film be damaged from any cause within the 72 hour curing period, the damaged portions shall be repaired immediately with additional compound.

5. White Polyethylene Sheet

The top surface and sides of the pavement shall be entirely covered with polyethylene sheeting. The units used shall be lapped at least 45 cm. The sheeting shall be so placed and weighted down so as to cause it to remain intimate contact with the surface covered. The sheeting as prepared for use shall have such dimension that each unit as laid will extend beyond the edges of the slab at least twice the thickness of the pavement. Unless otherwise specified, the covering shall be maintained in place for 72 hours after the concrete has been placed.

6. Concrete Protection for Hot Weather

Concrete should be continuous moisture cured for the entire curing period and shall commence as soon as the surfaces are finished and continue for at least 24 hours. However, if moisture curing is not practical beyond 24 hours, the concrete surface shall be protected from drying with application of a liquid membrane-forming curing compound while the surfaces are still damp. Other curing methods may be approved by the Engineer.

311.4.15 Removal of Forms

After forms for concrete shall remain in place undisturbed for not less than twenty four (24) hours after concrete pouring. In the removal of forms, crowbars should be used in pulling out nails and pins. Care should be taken so as not to break the edges of the pavement. In case portions of the concrete are spalled, they shall be immediately repaired with fresh mortar mixed in the proportion of one part of Portland Cement and two parts fine aggregates. Major honeycomb areas will be considered as defective work and shall be removed and replaced at the expense of the Contractor. Any area or section so removed shall not be less than the distance between weakened plane joint nor less than the full width of the lane involved.

311.4.16 Sealing Joints

Joints shall be sealed with **Polyurethane sealant PU810** soon after completion of the curing period and before the pavement is opened to traffic, including the Contractor's equipment. Just prior to sealing, each joint shall be thoroughly cleaned of all foreign materials including membrane curing compound and the joint faces shall be clean and surface dry when the seal is applied.

The sealing material shall be applied to each joint opening to conform to the details shown on the Plans or as directed by the Engineer. Material for seal applied hot shall be stirred during heating so that localized overheating does not occur. The pouring shall be done in such a manner that the material will not be spilled on the exposed surfaces of the concrete. The use of sand or similar material as a cover for the seal will not be permitted.

Preformed elastomeric gaskets for sealing joints shall be of the cross-sectional dimensions shown on the Plans. Seals shall be installed by suitable tools, without elongation and secured in placed with an approved lubricant adhesive which shall cover both sides of the concrete joints. The seals shall be installed in a compressive condition and shall at time of placement be below the level of the pavement surface by approximately 6 mm.

The seals shall be in one piece for the full width of each transverse joint.

311.4.17 Protection of Pavement

The Contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by his own employees and agents until accepted by the Engineer. This shall include watchmen to direct traffic and the erection of and maintenance of warning signs, lights, pavement bridges or cross-overs, etc. The Plans or Special Provisions will indicate the location and type of device or facility required to protect the work and provide adequately for traffic. Any damage to the pavement occurring prior to final acceptance shall be repaired or the pavement replaced at the Contractor's expense.

Aggregates, rubble, or other similar construction materials shall not be placed on airfield pavements. Traffic shall be excluded from the new pavement by erecting and maintaining barricades and signs until the concrete is at least seven (7) days old, or for a longer period if directed by the Engineer.

In paving intermediate lanes between newly paved pilot lanes, operation of the hauling and paving equipment will be permitted on the new pavement after the pavement has been cured for seven (7) days and the joints have been sealed or otherwise protected, and the concrete has attained a minimum field cured compressive strength of 7000 psi (4830 kPa) and approved means are furnished to prevent damage to the slab edge.

All new and existing pavement carrying construction traffic or equipment shall be continuously kept completely clean, and spillage of concrete or other materials shall be cleaned up immediately upon occurrence.

Damaged pavements shall be removed and replaced at the Contractor's expense. Slabs shall be removed to the full depth, width, and length of the slab.

All boreholes after thickness and/or strength determinations of newly constructed asphalt and concrete pavements shall be immediately filled/restored with the prescribed concrete/asphalt mix after completion of the drilling works.

311.4.18 Concrete Pavement

If the Contract calls for the construction of pavement without the use of fixed forms, the following provisions shall apply:

1. Grade

    After the grade or base has been placed and compacted to the required density, the areas which will support the paving machine shall be cut to the proper elevation by means of a properly designed machine. The grade on which the pavement is to be constructed shall then be brought to the proper profile by means of properly designed machine. If the density of the base is disturbed by the grading operation, it shall be corrected by additional compaction before concrete is placed. The grade should be constructed sufficiently in advance of the placing of the concrete. If any traffic is allowed to use the prepared grade, the grade shall be checked and corrected immediately before the placing of concrete.

2. Placing Concrete - Slip Form Method

The concrete shall be distributed uniformly into final position by a self- propelled slip-form paver without delay. The alignment and elevation of the paver shall be regulated from outside reference lines established for this purpose. The paver shall vibrate the concrete for the full width and depth of the strip of pavement being placed and the vibration shall be adequate to provide a consistency of concrete that will stand normal to the surface with sharp well-defined edges. The sliding forms shall be rigidly held together laterally to prevent spreading of the forms. The plastic concrete shall be effectively consolidated by internal vibration with transverse vibrating units for the full width of the pavement and/or a series of equally placed longitudinal vibrating units. The space from the outer edge of the pavement to longitudinal unit shall not exceed 9 inches (23 cm) for slip form and at the end of the dowels for the fill-in lanes. The spacing of internal units shall be uniform and shall not exceed 18 inches (0.5 m).

The term internal vibration means vibrating units located within the specified thickness of pavement section.

The rate of vibration of each vibrating unit shall be within 8000 to 12000 cycles per minute and the amplitude of vibration shall be sufficient to be perceptible on the surface of the concrete along the entire length of the vibrating unit and for a distance of at least one foot (30 cm). The frequency of vibration or amplitude shall vary proportionately with the rate of travel to result in a uniform density and air content. The paving machine shall be equipped with a tachometer or other suitable device for measuring and indicating the actual frequency of vibrations.

The concrete shall be held at a uniform consistency. The slip-form paver shall be operated with as nearly a continuous forward movement as possible and all operations of mixing, delivering, and spreading concrete shall be coordinated to provide uniform progress with stopping and starting of the paver held to a minimum. If for any reason, it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped immediately. No tractive force shall be applied to the machine, except that which is controlled from the machine.

When concrete is being placed adjacent to an existing pavement, that part of the equipment which is supported on the existing pavement shall be equipped with protective pads on crawler tracks or rubber-tired wheels on which the bearing surface is offset to run a sufficient distance from the edge of the pavement to avoid breaking the pavement edge.

Not more than 15% of the total free edge of each 500 foot (150 m) segment of pavement, or fraction thereof, shall have an edge slump exceeding 1/4 inch (6 mm), and none of the free edge of the pavement shall have an edge slump exceeding 3/8 inch (9 mm). (The total free edge of 500 feet (150 m) of pavement will be considered the cumulative total linear measurement of pavement edge originally constructed as nonadjacent to any existing pavement; that is, 500 feet (150 m) of paving lane originally constructed as a separate lane will have 1,000 feet (300 m) of free edge, 500 feet (150 m) of fill-in lane will have no free edge, etc.). The area affected by the downward movement of the concrete along the pavement edge shall be limited to not more than 18 inches (0.5 m) from the edge. When excessive edge slump cannot be corrected before the concrete has hardened, the area with excessive

3. Placing Concrete - Side Form Method

Side form sections shall be straight, free from warps, bends, indentations, or other defects. Defective forms shall be removed from the work. Metal side forms shall be used except at end closures and transverse construction joints where straight forms of other suitable material may be used.

Side forms may be built up by rigidly attaching a section to either top or bottom of forms. If such build-up is attached to the top of metal forms, the build-up shall also be metal.

Width of the base of all forms shall be equal to or greater than the specified pavement thickness.

Side forms shall be of sufficient rigidity, both in the form and in the interlocking connection with adjoining forms, that springing will not occur under the weight of sub-grading and paving equipment or from the pressure of the concrete. The Contractor shall provide sufficient forms so that there will be no delay in placing concrete due to lack of forms.

Before placing side forms, the underlying material shall be at the proper grade. Side forms shall have full bearing upon the foundation throughout their length and width of base and shall be placed to the required grade and alignment of the finished pavement. They shall be firmly supported during the entire operation of placing, compacting, and finishing the pavement.

Forms shall be drilled in advance of being placed to line and grade to accommodate tie bars where these are specified.

Immediately in advance of placing concrete and after all subbase operations are completed, side forms shall be trued and maintained to the required line and grade for a distance sufficient to prevent delay in placing.

Side forms shall remain in place at least 12 hours after the concrete has been placed, and in all cases until the edge of the pavement no longer requires the protection of the forms. Curing compound shall be applied to the concrete immediately after the forms have been removed.

Side forms shall be thoroughly cleaned and oiled each time they are used and before concrete is placed against them.

Concrete shall be spread, screeded, shaped and consolidated by one or more self-propelled machines. These machines shall uniformly distribute and consolidate concrete without segregation so that the completed pavement will conform to the required cross-section with a minimum of handwork.

The number and capacity of machines furnished shall be adequate to perform the work required at a rate equal to that of concrete delivery.

Concrete for the full paving width shall be effectively consolidated by internal vibrators without causing segregation. Internal type vibrators' rate of vibration shall be not less than 7,000 cycles per minute. Amplitude of vibration shall be sufficient to be perceptible on the surface of the concrete more than one foot (30 cm) from the vibrating element. The Contractor shall furnish a tachometer or other suitable device for measuring and indicating frequency of vibration.

Power to vibrators shall be connected so that vibration ceases when forward or backward motion of the machine is stopped.

The provisions relating to the frequency and amplitude of internal vibration shall be considered the minimum requirements and are intended to ensure adequate density in the hardened concrete.

4. Consolidation

Concrete shall be consolidated with the specified type of lane-spanning, gang-mounted, mechanical, immersion type vibrating equipment mounted in front of the paver, supplemented, in rare instances as specified, by hand- operated vibrators. The vibrators shall be inserted into the concrete to a depth that will provide the best full-depth consolidation but not closer to the underlying material than inches (50 mm). Excessive vibration shall not be permitted. If the vibrators cause visible tracking in the paving lane, the paving operation shall be stopped and equipment and operations modified to prevent it. Concrete in small, odd-shaped slabs or in isolated locations inaccessible to the gang-mounted vibration equipment shall be vibrated with an approved hand-operated immersion vibrator operated from a bridge spanning the area. Vibrators shall not be used to transport or spread the concrete. Hand-operated vibrators shall not be operated in the concrete at one location for more than 20 seconds. Insertion locations for hand-operated vibrators shall be between 6 to 15 inches (150 to 400 mm) on centers. For each paving train, at least one additional vibrator spud, or sufficient parts for rapid replacement and repair of vibrators shall be maintained at the paving site at all times. Any evidence of inadequate consolidation (honeycomb along the edges, large air pockets, or any other evidence) shall require the immediate stopping of the paving operation and adjustment of the equipment or procedures as approved by the Engineer.

If a lack of consolidation of the concrete is suspected by the Engineer, referee testing may be required. Referee testing of hardened concrete will be performed by the Engineer by cutting cores from the finished pavement after a minimum of 24 hours curing. Density determinations will be made by the Engineer based on the water content of the core as taken. ASTM C642 shall be used for the determination of core density in the saturated-surface dry condition. When required, referee cores will be taken at the minimum rate of one for each 500 cubic yards (382 m2) of pavement, or fraction. The Contractor shall be responsible for all referee testing cost if they fail to meet the required density.

The average density of the cores shall be at least 97% of the original mix design density, with no cores having a density of less than 96% of the original mix design density. Failure to meet the referee tests will be considered evidence that the minimum requirements for vibration are inadequate for the job conditions. Additional vibrating units or other means of increasing the effect of vibration shall be employed so that the density of the hardened concrete conforms to the above requirements.

5. Protection Against Rain

In order that the concrete may be properly protected against rain before the concrete is sufficiently hardened, the Contractor will be required to have available at all times, materials for the protection of the edges and surface of the unhardened concrete. Such protective materials shall consist of standard metal forms or wood planks having a nominal thickness of not less than 50 mm (2 inches) and a nominal width of not less than the thickness of the pavement at its edge for the protection of the pavement edges, and covering material such as burlap or cotton mats, curing paper or plastic sheeting materials for the protection of the surface of the pavement. When rain appears imminent, all paving operations shall stop and all available personnel shall begin placing forms against the sides of the pavement and covering the surface of the unhardened concrete with the protective covering.

The following requirements shall be met:

(1) Concrete shall not be laid during rain. Alternatively, with the approval of the Engineer, the Contractor may provide suitable protection to the concrete during transportation

and placing to enable completion of the finishing processes (including the necessary joint forming) to a standard equal to that of the approved trial area.

(2) All precautions necessary shall be taken to protect freshly placed concrete from rainwater running off adjacent areas.

(3) Where a new concrete surface is damaged by light rain, the surface may be re-textured to a standard equal to that of the approved trial area, provided that the re-texturing is completed within the time constraints of 90mins. Re-texturing of surfaces affected by heavy rain or surface run-off from other pavement areas is not permitted.

(4) Surfaces directly affected by light rain, whether re-textured or not, shall be tested to ensure adequate surface texture has been achieved.

(5) Surfaces affected by heavy rain or run-off from other pavement areas shall be broken out and replaced.

311.4.19 Opening to Traffic

The pavement shall not be opened to traffic until test specimens molded and cured in accordance with ASTM C31 have attained a flexural strength of 4.83 MPa when tested in accordance with ASTM C78. If such tests are not conducted, the pavement shall not be opened to traffic until 14 days after the concrete was placed. Prior to opening the pavement to construction traffic, all joints shall either be sealed or protected from damage to the joint edge and intrusion of foreign materials into the joint. As a minimum, backer rod or tape may be used to protect the joints from foreign matter intrusion.

Except for the saws required and the coring rigs required, the concrete shall not be subjected to traffic or other loads for at least 7 days after lying. Then, and only subject to the approval of the Engineer, the concrete shall be used by the minimum of equipment essential for continuing the work. Traffic shall only run on the new concrete when no other means of access is possible to areas being laid later.

Metal wheels shall not be allowed to run on the new concrete at any time. The flanged wheels used on spreading, compacting and finishing equipment when running on the form rails shall be replaced by rubber tyred wheels when they are run on the concrete and the crawler tracks of slip-form pavers shall be fitted with neoprene pads.

Protection of the finished concrete shall be the responsibility of the Contractor. Precautions shall be taken to prevent damage to the edges, marking of the surface or chipping of the joint or groove arises. Any damage or defacement shall be made good by the methods and to the standards of this Specification.

311.4.20 Repair, Removal, or Replacement of Slabs

1. General

New pavement slabs that are broken or contain cracks or are otherwise defective or unacceptable shall be removed and replaced or repaired, as directed by the Engineer and as specified hereinafter at no cost to the Engineer. Spalls along joints shall be repaired as specified. Removal of partial slabs is not permitted. Removal and replacement shall be full depth, shall be full width of the slab, and the limit of removal shall be normal to the paving lane and to each original transverse joint. The Engineer will determine whether cracks extend full depth of the pavement and may require cores to be drilled on the crack to determine depth of cracking. Such cores shall be 4 inch (100 mm) diameter, shall be drilled by the Contractor and shall be filled by the Contractor with a well consolidated concrete mixture bonded to the walls of the hole with epoxy resin, using approved procedures. Drilling of cores and refilling holes shall be at no expense to the Engineer. All epoxy resin used in this work shall conform to ASTM C881, Type V. Repair of cracks as described in this section shall not be allowed if in the opinion of the Engineer the overall condition of the pavement indicates that such repair is unlikely to achieve an acceptable and durable finished pavement. No repair of cracks shall be allowed in any panel that demonstrates segregated aggregate with an absence of coarse aggregate in the upper 1/8 inch (3 mm) of the pavement surface.

2. Shrinkage Cracks

Shrinkage cracks, which do not exceed 4 inches (100 mm) in depth, shall be cleaned and then pressure injected with epoxy resin, Type IV, Grade 1, using procedures as approved by the Engineer. Care shall be taken to assure that the crack is not widened during epoxy resin injection. All epoxy resin injection shall take place in the presence of the Engineer. Shrinkage cracks, which exceed 4 inches (100 mm) in depth, shall be treated as full depth cracks in accordance with Subsections 4.19b and 4.19c.

3. Slabs with cracks through interior areas

Interior area is defined as that area more than 6 inches (150 mm) from either adjacent original transverse joint. The full slab shall be removed and replaced at no cost to the Engineer, when there are any full depth cracks, or cracks greater than 4 inches (100 mm) in depth, that extend into the interior area.

4. Cracks close to and parallel to joints

All cracks essentially parallel to original joints, extending full depth of the slab, and lying wholly within 6 inches (150 mm) either side of the joint shall be treated as specified here. Any crack extending more than 6 inches (150 mm) from the joint shall be treated as specified above in Subsection 311.4.20 (4) (c).

(a) Full depth cracks present, original joint not opened

When the original un-cracked joint has not opened, the crack shall be sawed and sealed, and the original joint filled with epoxy resin as specified below. The crack shall be sawed with equipment specially designed to follow random cracks. The reservoir for joint sealant in the crack shall be formed by sawing to a depth of 3/4 inches (19 mm), ±1/16 inch (2 mm), and to a width of 5/8 inch (16 mm), ±1/8 inch (3 mm). Any equipment or procedure which causes raveling or spalling along the crack shall be modified or replaced to prevent such raveling or spalling. The joint sealant shall be a liquid sealant as specified. Installation of joint seal shall be as specified for sealing joints or as directed. If the joint sealant reservoir has been sawed out, the reservoir and as much of the lower saw cut as possible shall be filled with epoxy resin, Type IV, Grade 2, thoroughly tooled into the void using approved procedures.

If only the original narrow saw cut has been made, it shall be cleaned and pressure injected with epoxy resin, Type IV, Grade 1, using approved procedures. If filler type material has been used to form a weakened plane in the transverse joint, it shall be completely sawed out and the saw cut pressure injected with epoxy resin, Type IV, Grade 1, using approved procedures. Where a parallel crack goes part way across paving lane and then intersects and follows the original joint which is cracked only for the remained of the width, it shall be treated as specified above for a parallel crack, and the cracked original joint shall be prepared and sealed as originally designed.

(b) Full depth cracks present, original joint also cracked

At a joint, if there is any place in the lane width where a parallel crack and a cracked portion of the original joint overlap, the entire slab containing the crack shall be removed and replaced for the full lane width and length.

5. Removal and Replacement of Full Slabs

Where it is necessary to remove full slabs, unless there are dowels present, all edges of the slab shall be cut full depth with a concrete saw. All saw cuts shall be perpendicular to the slab surface. If dowels, or tie bars are present along any edges, these edges shall be sawed full depth just beyond the end of the dowels or tie bars. These joints shall then be carefully sawed on the joint line to within one inch (25 mm) of the depth of the dowel or tie bar.

The main slab shall be further divided by sawing full depth, at appropriate locations, and each piece lifted out and removed. Suitable equipment shall be used to provide a truly vertical lift, and approved safe lifting devices used for attachment to the slabs. The narrow strips along doweled edges shall be carefully broken up and removed using light, hand-held jackhammers, 30 lb (14 kg) or less, or other approved similar equipment.

Care shall be taken to prevent damage to the dowels, tie bars, or to concrete to remain in place. The joint face below dowels shall be suitably trimmed so that there is not abrupt offset in any direction greater than 1/2 inch (12 mm) and no gradual offset greater than one inch (25 mm) when tested in a horizontal direction with a 12-foot (3.7-m) straightedge.

No mechanical impact breakers, other than the above hand-held equipment shall be used for any removal of slabs. If underbreak between 1-1/2 and 4 inches (38 and 100 mm) deep occurs at any point along any edge, the area shall be repaired as directed before replacing the removed slab. Procedures directed will be similar to those specified for surface spalls, modified as necessary.

If underbreak over 4 inches (100 mm) deep occurs, the entire slab containing the underbreak shall be removed and replaced. Where there are no dowels or tie bars, or where they have been damaged, dowels or tie bars of the size and spacing as specified for other joints in similar pavement shall be installed by epoxy grouting them into holes drilled into the existing concrete using procedures as specified. Original damaged dowels or tie bars shall be cut off flush with the joint face. Protruding portions of dowels shall be painted and lightly oiled. All four (4) edges of the new slab shall contain dowels or original tie bars.

Placement of concrete shall be as specified for original construction. Prior to placement of new concrete, the underlying material (unless it is stabilized) shall be re-compacted and shaped as specified in the appropriate section of these specifications. The surfaces of all four joint faces shall be cleaned of all loose material and contaminants and coated with a double application of membrane forming curing compound as bond breaker. Care shall be taken to prevent any curing compound from contacting dowels or tie bars. The resulting joints around the new slab shall be prepared and sealed as specified for original construction.

6. Repairing spalls along joints

Where directed, spalls along joints of new slabs, and along parallel cracks used as replacement joints, shall be repaired by first making a vertical saw cut at least one inch (25 mm) outside the spalled area and to a depth of at least 2 inch (50 mm). Saw cuts shall be straight lines forming rectangular areas. The concrete between the saw cut and the joint, or crack, shall be chipped out to remove all unsound concrete and at least 1/2 inch (12 mm) of visually sound concrete. The cavity thus formed shall be thoroughly cleaned with high-pressure water jets supplemented with compressed air to remove all loose material. Immediately before filling the cavity, a prime coat of epoxy resin, Type

III, Grade I, shall be applied to the dry-cleaned surface of all sides and bottom of the cavity, except any joint face.

The prime coat shall be applied in a thin coating and scrubbed into the surface with a stiff-bristle brush. Pooling of epoxy resin shall be avoided. The cavity shall be filled with low slump Portland cement concrete or mortar or with epoxy resin concrete or mortar. Concrete shall be used for larger spalls, generally those more than 1/2 cu. ft. (0.014 m3) in size and mortar shall be used for the smaller ones. Any spall less than 0.1 cu. ft. (0.003 m3) shall be repaired only with epoxy resin mortar or a Grade III epoxy resin.

Portland cement concrete and mortar mixtures shall be proportioned as directed and shall be mixed, placed, consolidated, and cured as directed. Epoxy resin mortars shall be made with Type III, Grade 1, epoxy resin, using proportions and mixing and placing procedures as recommended by the manufacturer and approved by the Contractor. The epoxy resin materials shall be placed in the cavity in layers not over 2 inches (50 mm) thick. The time interval between placements of additional layers shall be such that the temperature of the epoxy resin material does not exceed 140°F (60°C) at any time during hardening. Mechanical vibrators and hand tampers shall be used to consolidate the concrete or mortar.

Any repair material on the surrounding surfaces of the existing concrete shall be removed before it hardens. Where the spalled area abuts a joint, an insert or other bond-breaking medium shall be used to prevent bond at the joint face. A reservoir for the joint sealant shall be sawed to the dimensions required for other joints, or as required to be routed for cracks. The reservoir shall be thoroughly cleaned and sealed with the sealer specified for the joints.

If any spall penetrates half the depth of the slab or more, the entire slab shall be removed and replaced as previously specified If any spall would require over 25% of the length of any single joint to be repaired, the entire slab shall be removed and replaced. Repair of spalls as described in this section shall not be allowed if in the opinion of the Engineer the overall condition of the pavement indicates that such repair is unlikely to achieve an acceptable and durable finished pavement. No repair of spalls shall be allowed in any panel that demonstrates segregated aggregate with a significant absence of coarse aggregate in the upper one- eight (1/8th) inch of the pavement surface.

7. Diamond Grinding of PCC surfaces

Diamond grinding of the hardened concrete with an approved diamond grinding machine should not be performed until the concrete is 14 days or more old and concrete has reached full minimum strength. When required, diamond grinding shall be accomplished by sawing with saw blades impregnated with industrial diamond abrasive.

The saw blades shall be assembled in a cutting head mounted on a machine designed specifically for diamond grinding that will produce the required texture and smoothness level without damage to the pavement. The saw blades shall be 1/8-inch (3-mm) wide and there shall be a minimum of 55 to 60 blades per 12 inches (300 mm) of cutting head width; the actual number of blades will be determined by the Sub-contractor and depend on the hardness of the aggregate. Each machine shall be capable of cutting a path at least 3 feet (0.9 m) wide. Equipment that causes ravels, aggregate fractures, spalls or disturbance to the joints will not be permitted.

The area corrected by diamond grinding the surface of the hardened concrete should not exceed 10% of the total area of any sub-lot. The depth of diamond grinding shall not exceed 1/2 inch (13 mm) and all areas in which diamond grinding has been performed will be subject to the final pavement thickness tolerances specified. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. All pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified above may require removing and replacing in conformance with Subsection 311.4.20.

311.4.21 Existing Concrete Pavement Removal and Repair

All operations shall be carefully controlled to prevent damage to the concrete pavement and to the underlying material to remain in place. All saw cuts shall be made perpendicular to the slab surface.

1. Removal of Existing Pavement Slab

   When it is necessary to remove existing concrete pavement and leave adjacent concrete in place, unless there are dowels present, the joint between the removal areas and adjoining pavement to stay in place, including dowels or tie bars, shall first be cut full depth with a standard diamond-type concrete saw. If dowels are present at this joint, the saw cut shall be made full depth just beyond the end of dowels. The edge shall then be carefully sawed on the joint line to within one inch (25 mm) of the top of the dowel. Next, a full depth saw cut shall be made parallel to the joint at least 24 inches (600 mm) from the joint and at least 12 inches (300 mm) from the end of any dowels. All pavement between this last saw cut and the joint line shall be carefully broken up and removed using hand-held jackhammers,

   30 lb (14 kg) or less, or the approved light-duty equipment which will not cause stress to propagate across the joint saw cut and cause distress in the pavement which is to remain in place. Where dowels are present, care shall be taken to produce an even, vertical joint face below the dowels. If the Contractor is unable to produce such a joint face, or if underbreak or other distress occurs, the Contractor shall saw the dowels flush with the joint. The Contractor shall then install new dowels, of the size and spacing used for other similar joints, by epoxy resin bonding them in holes drilled in the joint face as

specified in Subsection 311.4.11 (7). All this shall be at no additional cost to the Engineer.

Dowels of the size and spacing indicated shall be installed as shown on the drawings by epoxy resin bonding them in holes drilled in the joint face as specified in Subsection 311.4.11 (7). The joint face shall be sawed or otherwise trimmed so that there is no abrupt offset in any direction greater than 1/2 inches (12 mm) and no gradual offset greater than one inch (25 mm) when tested in a horizontal direction with a 12-foot (3.7-m) straightedge.

2. Edge Repair

The edge of existing concrete pavement against which new pavement abuts shall be protected from damage at all times. Areas that are damaged during construction shall be repaired at no cost to the Engineer.

(1) Spall Repair

Spalls shall be repaired where indicated and where directed by the Engineer. Repair materials and procedures shall be as previously specified in Subsection 311.4.20 (6).

2) Underbreak Repair

All underbreak shall be repaired. First, all delaminated and loose material shall be carefully removed. Next, the underlying material shall be recompacted, without addition of any new material. Finally, the void shall be completely filled with paving concrete, thoroughly consolidated. Care shall be taken to produce an even joint face from top to bottom. Prior to placing concrete, the underlying material shall be thoroughly moistened. After placement, the exposed surface shall be heavily coated with curing compound.

(3) Underlying Material

The underlying material adjacent to the edge and under the existing pavement which is to remain in place shall be protected from damage or disturbance during removal operations and until placement of new concrete, and shall be shaped as shown on the drawings or as directed. Sufficient material shall be kept in place outside the joint line to prevent disturbance (or sloughing) of material under the pavement that is to remain in place. Any material under the portion of the concrete pavement to remain in place, which is disturbed or loses its compaction shall be carefully removed and replaced with concrete as specified in Subsection 311.4.21.2 (2). The underlying material outside the joint line shall be thoroughly compacted and moist when new concrete is placed.

311.5 Acceptance of Concrete

311.5.1 Acceptance Sampling and Testing

All acceptance sampling and testing necessary to determine conformance with the requirements specified in this section, with the exception of coring for thickness determination, will be performed by the Contractor under the supervision of the Engineer. The Contractor shall bear the cost of providing curing facilities for the strength specimens, per Subsection 311.5.1.1 (3), and coring and filling operations, per Subsection 311.5.1.2 (1). Testing organizations performing these tests shall be accredited in accordance with ASTM C1077. The laboratory accreditation must be current and listed on the accrediting authority's website. All test methods required for acceptance sampling and testing must be listed on the lab accreditation. A copy of the laboratory's current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction.

Concrete shall be accepted for strength and thickness on a lot basis. A lot shall consist of a day's production not to exceed 2,000 cubic yards (1530 cubic meters)

Prior to use of materials, the Contractor shall submit certified test reports to the Engineer for those materials proposed for use during construction. The certification shall show the appropriate ASTM test for each material, the test results, and a statement that the material passed or failed. The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

311.5.1.1 Flexural Strength

(1) Sampling

Each lot shall be divided into four equal sub-lots. One sample shall be taken for each sub-lot from the plastic concrete delivered to the job site. Sampling locations shall be determined by the Engineer in accordance with random sampling procedures contained in ASTM D3665. The concrete shall be sampled in accordance with ASTM C172.

(2) Testing

Two (2) specimens shall be made from each sample. Specimens shall be made in accordance with ASTM C31 and the flexural strength of each specimen shall be determined in accordance with ASTM C78. The flexural strength for each sub-lot shall be computed by averaging the results of the two test specimens representing that sub-lot.

Immediately prior to testing for flexural strength, the beam shall be weighed and measured for determination of a sample unit weight. Measurements shall be made for each dimension; height, depth, and length, at the mid-point of the specimen and reported to the nearest 1/10 inch (3 mm). The weight of the specimen shall be reported to the nearest 0.1 pound (45 gm). The sample unit weight shall be calculated by dividing the sample weight by the calculated volume of the sample. This information shall be reported as companion information to the measured flexural strength for each specimen.

The samples will be transported while in the molds. The curing, except for the initial cure period, will be accomplished using the immersion in saturated lime water method.

Slump, air content, and temperature tests will also be conducted by the quality assurance laboratory for each set of strength test samples, per ASTM C31.

(3) Curing

The Contractor shall provide adequate facilities for the initial curing of beams. During the 24 hours after molding, the temperature immediately adjacent to the specimens must be maintained in the range of 60° to 80°F (16° to 27°C), and loss of moisture from the specimens must be prevented. The specimens may be stored in tightly constructed wooden boxes, damp sand pits, temporary buildings at construction sites, under wet burlap in favorable weather, or in heavyweight closed plastic bags, or using other suitable methods, provided the temperature and moisture loss requirements are met.

(4) Acceptance

Acceptance of pavement for flexural strength will be determined by the Engineer in accordance with Subsection 311.5.2.2

311.5.1.2 Pavement Thickness

(1) Sampling

Each lot shall be divided into four equal sub-lots and one core shall be taken by the Contractor for each sub-lot. Sampling locations shall be determined by the Engineer in accordance with random sampling procedures contained in ASTM D3665. Areas, such as thickened edges, with planned variable thickness, shall be excluded from sample locations.

Cores shall be neatly cut with a core drill. The Contractor shall furnish all tools, labor, and materials for cutting samples and filling the cored hole. Core holes shall be filled by the Contractor with a non-shrink grout approved by the Engineer within one day after sampling.

(2) Testing

The thickness of the cores shall be determined by the Engineer by the average caliper measurement in accordance with ASTM C174.

(3) Acceptance

Acceptance of pavement for thickness shall be determined by the Engineer in accordance with Subsection 311.5.2.3.

311.5.1.3 Partial lots

When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot, or when the Engineer and the Contractor agree in writing to allow overages or minor placements to be considered as partial lots, the following procedure will be used to adjust the lot size and the number of tests for the lot.
Where three sub-lots have been produced, they shall constitute a lot. Where one or two sub-lots have been produced, they shall be incorporated into the next lot or the previous lot and the total number of sub-lots shall be used in the acceptance criteria calculation, that is, n=5 or n=6.

311.5.1.4 Outliers

All individual flexural strength tests within a lot shall be checked for an outlier (test criterion) in accordance with ASTM E178, at a significance level of 5%. Outliers shall be discarded, and the percentage of material within specification limits (PWL) shall be determined using the remaining test values.

311.5.2 Acceptance Criteria

1. General

Acceptance will be based on the following characteristics of the completed pavement discussed in Subsection 311.5.2 (5):

(a) Flexural strength
(b) Thickness
(c) Smoothness
(d) Grade
(e) Edge slump

Flexural strength and thickness shall be evaluated for acceptance on a lot basis using the method of estimating PWL. Acceptance using PWL considers the variability (standard deviation) of the material and the testing procedures, as well as the average (mean) value of the test results to calculate the percentage of material that is above the lower specification tolerance limit (L).

Acceptance for flexural strength will be based on the criteria contained in accordance with Subsection 311.5.2 (5) (1). Acceptance for thickness will be based on the criteria contained in Subsection 311.5.2 (5) (2). Acceptance for smoothness will be based on the criteria contained in Subsection 311.5.2 (5) (3). Acceptance for grade will be based on the criteria contained in Subsection 311.5.2 (5) (4).

The Engineer may at any time, notwithstanding previous plant acceptance, reject and require the Contractor to dispose of any batch of concrete mixture which is rendered unfit for use due to contamination, segregation, or improper slump. Such rejection may be based on only visual inspection.

2. Flexural Strength

Acceptance of each lot of in-place pavement for flexural strength shall be based on PWL. The Contractor shall target production quality to achieve 90 PWL or higher.

3. Pavement Thickness

Acceptance of each lot of in-place pavement shall be based on PWL. The Contractor shall target production quality to achieve 90 PWL or higher.

4. Percentage of Material Within Limits (PWL)

The lower specification tolerance limit (L) for flexural strength and thickness shall be:

Lower Specification Tolerance Limit (L)	
Flexural Strength	0.93 x strength specified in Subsection 311.3.2
Thickness	Lot Plan Thickness in inches, - 0.50 in

5. Percentage of Material Within Limits (PWL)

a. Flexural Strength

If the PWL of the lot equals or exceeds 90%, the lot shall be acceptable.

(b) Thickness

If the PWL of the lot equals or exceeds 90%, the lot shall be acceptable.

(c) Smoothness

As soon as the concrete has hardened sufficiently, but not later than 48 hours after placement, the surface of each lot shall be tested in both longitudinal and transverse directions for smoothness to reveal all surface irregularities exceeding the tolerances specified. The Contractor shall furnish paving equipment and employ methods that produce a surface for each section of pavement having an average profile index meeting the requirements of Subsection 311.6.3 when evaluated with a profilograph; and the finished surface of the pavement shall not vary more than 1/4 inch (6mm) when evaluated with a 12-foot (3.7m) straightedge. When the surface smoothness exceeds specification tolerances which cannot be corrected by diamond grinding of the pavement, full depth removal and replacement of pavement shall be to the limit of the longitudinal placement. Corrections involving diamond grinding will be subject to the final pavement thickness tolerances specified.

(1) Transverse measurements

Transverse measurements will be taken for each lot placed. Transverse measurements will be taken perpendicular to the pavement centerline each 50 feet (15m) or more often as determined by the Engineer.

(i) Testing shall be continuous across all joints, starting with one- half the length of the straight edge at the edge of pavement section being tested and then moved ahead one-half the length of the straight edge for each successive measurement. Smoothness readings will not be made across grade changes or cross slope transitions; at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Deviations on final pavement > 1/4 inch (6mm) in transverse direction shall be corrected with diamond grinding per Subsection 311.4.20 or by removing and replacing full depth of pavement. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

(ii) The joint between lots shall be tested separately to facilitate smoothness between lots. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface, with half the straightedge on one side of the joint and the other half of the straightedge on the other side of the joint. Measure the maximum gap between the straightedge and the pavement surface in the area between these two high points. One measurement shall be taken at the joint every 50 feet (15m) or more often if directed by the Engineer. Maximum gap on final pavement surface > 1/4 inch (6mm) in transverse direction shall be corrected with diamond grinding per Subsection 311.4.20 or by removing and replacing full depth of surface.

Each measurement shall be recorded and a copy of the data shall be furnished to the Engineer at the end of each days testing.

(2) Longitudinal measurements

Longitudinal measurements will be taken for each lot placed. Longitudinal tests will be parallel to the centerline of paving; at the center of paving lanes when widths of paving lanes are less than 20 feet (6m); and at the one third points of paving lanes when widths of paving lanes are 20 ft (6m) or greater.

(i) Longitudinal Short Sections

Longitudinal Short Sections are when the longitudinal lot length is less than 200 feet (60m) and areas not requiring a profilograph. When approved by the Engineer, the first and last 15 feet (4.5m) of the lot can also be considered as short sections for smoothness. The finished surface shall not vary more than 1/4inch (6mm) when evaluated with a 12-foot (3.7m) straightedge. Smoothness readings will not be made across grade changes or cross slope transitions, at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. Testing shall be continuous across all joints, starting with one-half the length of the straight edge at the edge of pavement section being tested and then moved ahead one-half the length of the straight edge for each successive measurement. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Deviations on final pavement surface > 1/4 inch (6mm) in longitudinal direction will be corrected with diamond grinding per Subsection 311.4.20g or by removing and replacing full depth of surface. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

(ii) Profilograph Testing.

Profilograph testing shall be performed by the Contractor using approved equipment and procedures as described as ASTM E1274. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate “must grind” bumps and the Profile Index for the pavement using a 0.2 inch (5 mm) blanking band. The bump template must span one inch (25 mm) with an offset of 0.4 inches (10 mm). The profilograph must be calibrated prior to use and operated by a factory or State DOT approved operator. Profilograms shall be recorded on a longitudinal scale of one inch (25 mm) equals 25 feet (7.5 m) and a vertical scale of one inch (25 mm) equals one inch (25 mm). A copy of the reduced tapes shall be furnished to the Engineer at the end of each days testing.

The pavement must have an average profile index meeting the requirements of Subsection 311.6.3. Deviations on final surface in longitudinal direction shall be corrected with diamond grinding per Subsection 311.4.20 or by removing and replacing full depth of pavement. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

Where corrections are necessary, second profilograph runs shall be performed to verify that the corrections produced an average profile index of 15 inches (38 cm) per mile or less. If the initial average profile index was less than 15 inches (38 cm), only those areas representing greater than 0.4 inch (10 mm) deviation will be re-profiled for correction verification

(iii) Final profilograph

Final profilograph, full length of runway, shall be performed to facilitate testing of smoothness between lots. Profilograph testing shall be performed by the Contractor using approved equipment and procedures as described as ASTM E1274. The pavement must have an average profile index meeting the requirements of Subsection 311.6.3. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate “must grind” bumps and the Profile Index for the pavement using a 0.2 inch (5 mm) blanking band. The bump template must span one inch (25 mm) with an offset of 0.4 inches (10 mm). The profilograph must be calibrated prior to use and operated by a factory or State DOT approved, trained operator. Profilograms shall be recorded on a longitudinal scale of one inch (25 mm) equals 25 feet (7.5 m) and a vertical scale of one inch (25 mm) equals one inch (25 mm). A copy of the reduced tapes shall be furnished to the Engineer at the end of each days testing. Profilograph of final runway shall be performed one foot right and left of runway centerline and 15 feet right and left of centerline. Any areas that indicate “must grind” will be corrected as directed by the Engineer.

Smoothness testing indicated in the above Subsections except Subsection (iii) shall be performed within 48 hours of placement of material. Smoothness texting indicated in Subsection (iii) shall be performed within 48 hours final paving completion. The primary purpose of smoothness testing is to identify areas that may be prone to ponding of water which could lead to hydroplaning of aircraft. If the Contractor's machines and/or methods are producing significant areas that need corrective actions then production should be stopped until corrective measures can be implemented. If corrective measures are not implemented and when directed by the Engineer, production shall be stopped until corrective measures can be implemented.

(d) Grade

An evaluation of the surface grade shall be made by the Engineer for compliance to the tolerances contained below. The finish grade will be determined by running levels at intervals of 50 feet (15 m) or less longitudinally and all breaks in grade transversely (not to exceed 50 feet (15 m)) to determine the elevation of the completed pavement. The documentation, stamped and signed by a licensed surveyor, shall be provided by the Contractor to the Engineer.

(1) Lateral Deviation

Lateral deviation from established alignment of the pavement edge shall not exceed ±0.10 feet (3 mm) in any lane.

(2) Vertical Deviation

Vertical deviation from established grade shall not exceed ±0.04 feet (12 mm) at any point.

(e) Edge Slump

When excessive edge slump cannot be corrected before the concrete has hardened, the area with excessive edge slump shall be removed and replaced at the expense of the Contractor as directed by the Engineer in accordance with Subsection 311.4.8 (1).

6. Removal and Replacement of Concrete

Any area or section of concrete that is removed and replaced shall be removed and replaced back to planned joints. The Contractor shall replace damaged dowels and the requirements for doweled longitudinal construction joints in Subsection 311.4.11 shall apply to all contraction joints exposed by concrete removal. Removal and replacement shall be in accordance with Subsection 311.4.21.

311.5.3 Tolerance and Pavement thickness

1. General

The thickness of the pavement will be determined by measurement of cores from the completed pavement in accordance with AASHTO T148.

The completed pavement shall be accepted on a lot basis. A lot shall be considered as 1000 linear meters of pavement when a single traffic lane is poured or 500 linear meters when two lanes are poured concurrently. The last unit in each slab constitutes a lot in itself when its length is at least ½ of the normal lot length. If the length of the last unit is shorter than ½ of the normal lot length, it shall be included in the previous lot.

Other areas such as intersections, entrances, crossovers, ramp, etc., will be grouped together to form a lot. Small irregular areas may be included with other unit areas to form a lot.

Each lot will be divided into five (5) equal segments and one core will be obtained from each segment in accordance with AASHTO T24.

2. Pavement Thickness

It is the intent of this Specification that the pavement has a uniform thickness as called for on the Plans for the average of each lot as defined. After the pavement has met all surface smoothness requirements, cores for thickness measurements will be taken.

In calculating the average thickness of the pavement, individual measurements which are in excess of the specified thickness by more than 5 mm will be considered as the specified thickness plus 5 mm and measurement which are less than the specified thickness by more than 25 mm shall not be included in the average. When the average thickness for the lot is deficient, the contract unit price will be adjusted for thickness in accordance with Subsection (3 below).

Individual areas within a segment found deficient in thickness by more than 25 mm shall be evaluated by the Engineer, and if in his judgment, the deficient areas warrant removal, they shall be removed and replaced by the Contractor with pavement of the specified thickness at his entire expense. However, if the evaluation of the Engineer is that the deficient area should not be removed and replaced, such area will not be paid.

When the measurement of any core is less than the specified thickness by more than 25 mm, the actual thickness of the pavement in this area will be determined by taking additional cores at no less than 5 m intervals parallel to the center line in each direction from the affected location until a core is found in each direction, which is not deficient in thickness by more than 25 mm. The area of slab for which no measurement will be made shall be the product of the paving width multiplied by the distance along the center line of the road between transverse sections found not deficient in thickness by more than 25 mm. The thickness of the remainder of the segment to be used to get the average thickness of each lot shall be determined by taking the average thickness of additional cores which are not deficient by more than 25 mm.

3. Adjustment for Thickness

When the average thickness of the pavement per lot is deficient, re- measurement shall be considered for the works done as per following table:

Deficiency in the Average Thickness per lot (mm)	Payment per lot with deficiency
0 – 25	By Measurement
More than 25	Remove and replace/ No payment

No acceptance and measurement shall be made on completed pavement unless core test for thickness determination is conducted, except for Barangay Roads where the Implementing Office is allowed to waive such test.

311.6 Quality Control

311.6.1 Quality Control of Concrete

1. General

The Contractor shall be responsible for the quality control of all materials during the handling, blending, and mixing and placement operations.

2. Quality Control Plan

The Contractor shall furnish the Engineer a Quality Control Plan detailing his production control procedures and the type and frequency of sampling and testing to insure that the concrete produces complies with the Specifications. The Engineer shall be provided free access to recent plant production records, and if requested, informational copies of mix design, materials certifications and sampling and testing reports.

3. Qualification of Workmen

Experienced and qualified personnel shall perform all batching or mixing operation, for the concrete mix, and shall be present at the plant and job site to control the concrete productions whenever the plant is in operation. They shall be identified, and duties defined as follows:

a. Concrete Batcher.

The person performing the batching or mixing operation shall be capable of accurately conducting aggregate surface moisture determination and establishing correct scale weights for concrete materials. He shall be capable of assuring that the proportioned batch weights of materials are in accordance with the mix design.

b. Concrete Technician.

The person responsible for concrete production control and sampling and testing for quality control shall be proficient in concrete technology and shall have a sound knowledge of the Specifications as they relate to concrete production. He shall be capable of conducting tests on concrete and concrete materials in accordance with these Specifications. He shall be capable of adjusting concrete mix designs for improving workability and Specification compliance and preparing trial mix designs. He shall be qualified to act as the concrete batcher in the batcher's absence.

4. Quality Control Testing

The Contractor shall perform all sampling, testing and inspection necessary to assure quality control of the component materials and the concrete.

The Contractor shall be responsible for determining the gradation of fine and coarse aggregates and for testing the concrete mixture for slump, air content, water-cement ratio and temperature. He shall conduct his operations so as to produce a mix conforming to the approved mix design.

5. Documentation

The Contractor shall maintain adequate records of all inspections and tests. The records shall indicate the nature and number of observations made, the number and type of deficiencies found, the quantities approved and rejected, and nature of any corrective action taken.

The Engineer may take independent assurance samples at random location for acceptance purposes as he deems necessary.

311.6.2 Quality Control Testing

The Contractor shall perform all quality control tests necessary to control the production and construction processes applicable to this specification and as set forth in the Quality Control Program. The testing program shall include, but not necessarily be limited to, tests for aggregate gradation, aggregate moisture content, slump, and air content.

A Quality Control Testing Plan shall be developed as part of the Quality Control Program.

311.6.2.1 Fine Aggregate

(1) Gradation

A sieve analysis shall be made at least twice daily in accordance with ASTM C136 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt.

(2) Moisture content.

If an electric moisture meter is used, at least two direct measurements of moisture content shall be made per week to check the calibration. If direct measurements are made in lieu of using an electric meter, two tests shall be made per day. Tests shall be made in accordance with ASTM C70 or ASTM C566.

311.6.2.2 Coarse Aggregate

(1) Gradation

A sieve analysis shall be made at least twice daily for each size of aggregate. Tests shall be made in accordance with ASTM C136 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt.

(2) Moisture content.

If an electric moisture meter is used, at least two direct measurements of moisture content shall be made per week to check the calibration. If direct measurements are made in lieu of using an electric meter, two tests shall be made per day. Tests shall be made in accordance with ASTM C566.

311.6.2.3 Slump

Four slump tests shall be performed for each lot of material produced in accordance with the lot size defined in Subsection 311.5.1. One test shall be made for each sub-lot. Slump tests shall be performed in accordance with ASTM C143 from material randomly sampled from material discharged from trucks at the paving site. Material samples shall be taken in accordance with ASTM C172.

311.6.2.4 Air Content

Four air content tests, shall be performed for each lot of material produced in accordance with the lot size defined in Subsection 311.5.1. One test shall be made for each sub-lot. Air content tests shall be performed in accordance with ASTM C231 for gravel and stone coarse aggregate and ASTM C173 for slag or other porous coarse aggregate, from material randomly sampled from trucks at the paving site. Material samples shall be taken in accordance with ASTM C172.

311.6.2.5 Unit Weight and Yield Test

Four- unit weight and yield tests shall be made in accordance with ASTM C138. The samples shall be taken in accordance with ASTM C172 and at the same time as the air content tests.

311.6.3 Control Chart

The Contractor shall maintain linear control charts for fine and coarse aggregate gradation, slump, moisture content and air content.

Control charts shall be posted in a location satisfactory to the Engineer and shall be kept up to date at all times. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the Action and suspension limits, or Specification limits, applicable to each test parameter, and the Sub-contractor's test results. The Contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the Contractor's projected data during production indicates a potential problem and the Contractor is not taking satisfactory corrective action, the Engineer may halt production or acceptance of the material.

(1) Fine and coarse aggregate gradation

The Contractor shall record the running average of the last five gradation tests for each control sieve on linear control charts. Specification limits contained in the Lower Specification Tolerance Limit (L) table above and the Control Chart Limits table below shall be superimposed on the Control Chart for job control.

(2) Slump and Air Content

The Contractor shall maintain linear control charts both for individual measurements and range (that is, difference between highest and lowest measurements) for slump and air content in accordance with the following Action and Suspension Limits.

Control Chart Limits

Control Parameter	Individual Measurements		Range Suspension Limit
	Action Limit	Suspension Limit	
Slip Form:			
Slump	+0 to -1 inch (0-25 mm)	+0.5 to -1.5 inch (12-38 mm)	±1.5 inch (38 mm)

Air Content	±1.2%	±1.8%	±2.5%
Side Form:			
Slump	+0.5 to -1 inch (12-25 mm)	+1 to -1.5 inch (25-38mm)	±1.5 inch (38 mm)
Air Content	±1.2%	±1.8%	±2.5%

The individual measurement control charts shall use the mix design target values as indicators of central tendency.

311.6.4 Corrective Action

The Contractor Quality Control Program shall indicate that appropriate action shall be taken when the process is believed to be out of control. The Contractor Quality Control Program shall detail what action will be taken to bring the process into control and shall contain sets of rules to gauge when a process is out of control. As a minimum, a process shall be deemed out of control and corrective action taken if any one of the following conditions exists.

(1) Fine and coarse aggregate gradation

When two consecutive averages of five tests are outside of the specification limits in Subsection 311.2.2, immediate steps, including a halt to production, shall be taken to correct the grading.

(2) Fine and coarse aggregate moisture content

Whenever the moisture content of the fine or coarse aggregate changes by more than 0.5%, the scale settings for the aggregate batcher and water batcher shall be adjusted.

(3) Slump

The Contractor shall halt production and make appropriate adjustments whenever:

(a) one point falls outside the Suspension Limit line for individual measurements or range, or

(b) two points in a row fall outside the Action Limit line for individual measurements.

(4) Air Content

The Contractor shall halt production and adjust the amount of air- entraining admixture whenever:

(a) point falls outside the Suspension Limit line for individual measurements or range, or

(b) two points in a row fall outside the Action Limit line for individual measurements.
Whenever a point falls outside the Action Limits line, the air-entraining admixture dispenser shall be calibrated to ensure that it is operating correctly and with good reproducibility.

311.7 Testing Requirements

ASTM C31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C70	Standard Test Method for Surface Moisture in Fine Aggregate
ASTM C78	Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C117	Standard Test Method for Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131	Standard Test Method for Resistance to Degradation of Small- Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM C138	Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ASTM C142	Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C143	Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C172	Standard Practice for Sampling Freshly Mixed Concrete
ASTM C173	Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C174	Standard Test Method for Measuring Thickness of Concrete

	Elements Using Drilled Concrete Cores
ASTM C227	Standard Test Method for Potential Alkali Reactivity of Cement- Aggregate Combinations (Mortar-Bar Method)
ASTM C231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C289	Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)
ASTM C295	Standard Guide for Petrographic Examination of Aggregates for Concrete
ASTM C114	Standard Test Methods for Chemical Analysis of Hydraulic Cement
ASTM C311	Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland Cement Concrete
ASTM C566	Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland Cement Concrete
ASTM C645	Standard Test Method for Density, Absorption, and Voids in Hardened Concrete
ASTM C666	Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
ASTM C1077	Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C2360	Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1567	Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM C3665	Standard Practice for Random Sampling of Construction Materials
ASTM C4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM E178	Standard Practice for Dealing With Outlying Observations
ASTM E1274	Standard Test Method for Measuring Pavement Roughness Using a Profilograph
U.S. Army Corps of Engineers (USACE) Concrete Research Division (CRD)	Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials, Lithium Nitrate Admixture and Aggregate (Accelerated Mortar-Bar Method)

C662	

311.8 Material Requirements

ASTM A184	Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A704	Standard Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement
ASTM A706	Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A714	Standard Specification for High-Strength Low-Alloy Welded and Seamless Steel Pipe
ASTM A775	Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A934	Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM A996	Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
ASTM A1064	Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM A1078	Standard Specification for Epoxy-Coated Steel Dowels for Concrete Pavement
ASTM C33	Standard Specification for Concrete Aggregates
ASTM C94	Standard Specification for Ready-Mixed Concrete
ASTM C150	Standard Specification for Portland Cement
ASTM C171	Standard Specification for Sheet Materials for Curing Concrete
ASTM C260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494	Standard Specification for Chemical Admixtures for Concrete
ASTM C595	Standard Specification for Blended Hydraulic Cements
ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C881	Standard Specification for Epoxy-Resin-Base Bonding
ASTM C989	Standard Specification for Slag Cement for Use in Concrete and Mortar
ASTM D1751	Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient

	Bituminous Types)
ASTM D1752	Standard Specification for Preformed Sponge Rubber and Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving And Structural Construction
ACI 211.1	Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 305R	Guide to Hot Weather Concreting
ACI 306R	Guide to Cold Weather Concreting
ACI 309R	Guide for Consolidation of Concrete
AC 150/5320-6	Airport Pavement Design and Evaluation
PCA	Design and Control of Concrete Mixtures

ITEM 312 - P-403 HOT MIX ASPHALT (HMA) PAVEMENTS

312.1 Description

This item shall consist of pavement courses composed of mineral aggregate and asphalt cement binder (asphalt binder) mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and shall conform to the lines, grades, thicknesses, and typical cross-sections shown on the plans. Each course shall be constructed to the depth, typical section, and elevation required by the plans and shall be rolled, finished, and approved before the placement of the next course.

312.2 Materials

312.2.1 Aggregate

Aggregates shall consist of crushed stone, crushed gravel, crushed slag, screenings, natural sand and mineral filler, as required. The aggregates should be free of ferrous sulfides, such as pyrite, that would cause “rust” staining that can bleed through pavement markings. The portion retained on the No. 4 (4.75 mm) sieve is coarse aggregate. The portion passing the No. 4 (4.75 mm) sieve and retained on the No. 200 (0.075 mm) sieve is fine aggregate, and the portion passing the No. 200 (0.075 mm) sieve is mineral filler.

a. Coarse Aggregate

Coarse aggregate shall consist of sound, tough, durable particles, free from films of matter that would prevent thorough coating and bonding with the bituminous material and free from organic matter and other deleterious substances. The percentage of wear shall not be greater than 40% when tested in accordance with ASTM C131. The sodium sulfate soundness loss shall not exceed 12%, or the magnesium sulfate soundness loss shall not exceed 18%, after five cycles, when tested in accordance with ASTM C88. Clay lumps and friable particles shall not exceed 1.0% when tested in accordance with ASTM C142.

For pavements designed for aircraft gross weights of 60,000 pounds (27200 kg) or more, the Contractor shall specify 75% for two fractured faces and 85% for one fractured face. For pavements designed for aircraft gross weights less than 60,000 pounds (27200 kg), the Contractor shall specify 50% for two fractured faces and 65% for one fractured face. The area of each face shall be equal to at least 75% of the smallest mid-sectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces. Fractured faces shall be achieved by crushing.

b. Fine Aggregate

Fine aggregate shall consist of clean, sound, tough, durable, angular shaped particles produced by crushing stone, slag, or gravel that meets the requirements for wear and soundness specified for coarse aggregate. The aggregate particles shall be free from coatings of clay, silt, or other objectionable matter.

The fine aggregate, including any blended material for the fine aggregate, shall have a plasticity index of not more than six (6) and a liquid limit of not more than 25 when tested in accordance with ASTM D4318.

The soundness loss shall not exceed 10% when sodium sulfate is used or 15% when magnesium sulfate is used, after five cycles, when tested per ASTM C88.

Clay lumps and friable particles shall not exceed 1.0%, by weight, when tested in accordance with ASTM C142.

Natural (non-manufactured) sand may be used to obtain the gradation of the aggregate blend or to improve the workability of the mix. The amount of sand to be added will be adjusted to produce mixtures conforming to requirements of this specification. If used, the natural sand shall meet the requirements of ASTM D1073 and shall have a plasticity index of not more than six (6) and a liquid limit of not more than 25 when tested in accordance with ASTM D4318.

The aggregate shall have sand equivalent values of 45 or greater when tested in accordance with ASTM D2419.

c. Sampling

ASTM D75 shall be used in sampling coarse and fine aggregate, and ASTM C183 shall be used in sampling mineral filler.

312.2.2 Mineral Filler

If filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D242

312.2.3 Asphalt Cement Binder

Asphalt cement binder shall conform to ASTM D6373 Performance Grade (PG) 22. A certificate of compliance from the manufacturer shall be included with the mix design submittal.

The supplier’s certified test report with test data indicating grade certification for the asphalt binder shall be provided to the Engineer for each load at the time of delivery to the mix plant. A certified test report with test data indicating grade certification for the asphalt binder shall also be provided to the Engineer for any modification of the asphalt binder after delivery to the mix plant and before use in the HMA.

312.2.4 Asphalt Cement Binder

Prior to delivery of materials to the job site, the Contractor shall submit certified test reports to the Engineer for the following materials:

a. Coarse Aggregate

(1) Present of wear
(2) Soundness
(3) Clay Lumps and Friable Particles
(4) Percent Fractured Faces
(5) Flat and Elongated Particles

b. Fine Aggregate

(1) Liquid Limit and Plasticity Index
(2) Soundness
(3) Clay Lumps and Friable Particles
(4) Percent Natural Sand
(5) Sand Equivalent c.

c. Mineral Filler

d. Asphalt Binder

Test results for asphalt binder shall include temperature/viscosity charts for mixing and compaction temperatures.

The certifications shall show the appropriate ASTM tests for each material, the test results, and a statement that the material meets the specification requirement.

The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

312.2.5 Anti-Stripping Agent

Any anti-stripping agent or additive if required shall be heat stable, shall not change the asphalt cement viscosity beyond specifications, shall contain no harmful ingredients, shall be added in recommended proportion by approved method, and shall be a material approved by the Department of Transportation of the State in which the project is located.

312.3 Composition

312.3.1 Composition Mixture

The HMA mix shall be composed of a mixture of well-graded aggregate, filler and anti-strip agent if required, and asphalt binder. The several aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of the job mix formula (JMF).

312.3.2 Job Mix Formula (JMF)

No hot-mixed asphalt (HMA) for measurement shall be produced until a JMF has been approved in writing by the Engineer. The asphalt mix-design and JMF shall be prepared by an accredited laboratory that meets the requirements of Subsection 312.3.4. The HMA shall be designed using procedures contained in ASTM D6927.

Tensile strength ratio (TSR) of the composite mixture, as determined by ASTM D4867, shall not be less than 75 when tested at a saturation of 70-80% or an anti- stripping agent shall be added to the HMA, as necessary, to produce a TSR of not less than 75 when tested at a saturation of 70-80%. If an anti-strip agent is required, it shall be provided by the Contractor at no additional cost to the Engineer.

The JMF shall be submitted in writing by the Contractor at least 30 days prior to the start of paving operations. The JMF shall be developed within the same construction season using aggregates currently being produced.

The submitted JMF shall be stamped or sealed by the responsible professional Engineer of the laboratory and shall include the following items as a minimum:

a. Percent passing each sieve size for total combined gradation, individual gradation of all aggregate stockpiles and percent by weight of each stockpile used in the job mix formula.

b. Percent of asphalt cement.

c. Asphalt performance grade and type of modifier if used.

d. Number of blows per side of molded specimen.

e. Laboratory mixing temperature.

f. Laboratory compaction temperature.

g. Temperature-viscosity relationship of the PG asphalt cement binder showing acceptable range of mixing and compaction temperatures and for modified binders include supplier recommended mixing and compaction temperatures.

h. Plot of the combined gradation on the 0.45 power gradation curve.

i. Graphical plots of stability, flow, air voids, voids in the mineral aggregate, and unit weight versus asphalt content.

j. Specific gravity and absorption of each aggregate.

k. Percent natural sand.

l. Percent fractured faces.

m. Percent by weight of flat particles, elongated particles, and flat and elongated particles (and criteria).

n. Tensile Strength Ratio (TSR).

o. Date the JMF was developed. Mix designs that are not dated or which are from a prior construction season shall not be accepted.

The Contractor shall submit to the Engineer the results of verification testing of three (3) asphalt samples prepared at the optimum asphalt content. The average of the results of this testing shall indicate conformance with the JMF requirements specified in Tables 1 and 3.

When the project requires asphalt mixtures of differing aggregate gradations, a separate JMF and the results of JMF verification testing shall be submitted for each mix.

The JMF for each mixture shall be in effect until a modification is approved in writing by the Engineer. Should a change in sources of materials be made, a new JMF must be submitted within 15 days and approved by the Engineer in writing before the new material is used. After the initial production JMF has been approved by the Engineer and a new or modified JMF is required for whatever reason, the subsequent cost of the Engineer's approval of the new or modified JMF will be borne by the Contractor.

There will be no time extension given or considerations for extra costs associated with the stoppage of production paving or restart of production paving due to the time needed for the Engineer to approve the initial, new or modified JMF.

The Marshall Design Criteria applicable to the project shall be as specified in Table 312.1.

Table 312.1 - Marshall Design Criteria

Test Property	Value
Number of blows	75
Stability, pounds (Newtons) minimum	1800 (8006)
Flow, 0.01 inch (0.25 mm)	8-16
Air voids (percent)	3.5
Percent voids in mineral aggregate, minimum	See Table 312.2

Table 312.2 - Minimum Percent Voids In Mineral Aggregate (VMA)

Aggregate	Minimum VMA
Gradation 3	16
Gradation 2	15
Gradation 1	14

The mineral aggregate shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to the gradation or gradations specified in Table 312.3 when tested in accordance with ASTM C136 and ASTM C117.

The gradations in Table 312.3 represent the limits that shall determine the suitability of aggregate for use from the sources of supply, be well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa.

Table 312.3 - Aggregate - HMA Pavements

Sieve Size	Percentage by Weight Passing Sieves
	Gradation
1 inch (25 mm)	100
3/4 inch (19 mm)	76-98
1/2 inch (12 mm)	66-86
3/8 inch (9 mm)	57-77
No. 4 (4.75 mm)	40-60
No. 8 (2.36 mm)	26-46
No. 16 (1.18 mm)	17-37
No. 30 (0.600 mm)	11-27
No. 50 (0.300 mm)	7-19
No. 100 (0.150 mm)	6-16
No. 200 (0.075 mm)	3-6
Asphalt Percent:	
Stone or gravel	4.5-7.0
Slag	5.0-7.5

312.3.3 Job Mix Formula (JMF) laboratory

The Contractor's laboratory used to develop the JMF shall be accredited in accordance with ASTM D3666. The laboratory accreditation must be current and listed on the accrediting authority's website. All test methods required for developing the JMF must be listed on the lab accreditation. A copy of the laboratory's current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction.

312.4 Construction Methods

312.4.1 Weather limitations

The HMA shall not be placed upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 312.4. The temperature requirements may be waived by the Engineer, if requested; however, all other requirements including compaction shall be met.

Table 312.4 - Surface Temperature Limitations of Underlying Course

Mat Thickness	Base Temperature (Minimum)	
	Degrees F	Degrees C
3 inches (7.5 cm) or greater	40	4
Greater than 2 inches (50 mm) but less than 3 inches (7.5 cm)	45	7

312.4.2 Weather limitations

Plants used for the preparation of HMA shall conform to the requirements of American Association of State Highway and Transportation Officials (AASHTO) M156 with the following changes:

a. Requirements for all plants include:

(1) Truck scales

The HMA shall be weighed on approved scales furnished by the Contractor, or on certified public scales at the Contractor's expense. Scales shall be inspected and sealed as often as the Engineer deems necessary to assure their accuracy.

In lieu of scales, and as approved by the Engineer, HMA weights may be determined by the use of an electronic weighing system equipped with an automatic printer that weighs the total HMA production and as often thereafter as requested by the Engineer.

(2) Testing facilities

The Contractor shall ensure laboratory facilities are provided at the plant for the use of the Engineer. The lab shall have sufficient space and equipment so that both testing representatives (Engineer's and Contractor's) can operate efficiently. The lab shall meet the requirements of ASTM D3666 including all necessary equipment, materials, and current reference standards to comply with the specifications and masonry saw with diamond blade for trimming pavement cores and samples.

The plant testing laboratory shall have a floor space area of not less than 200 square feet (18.5 sq m), with a ceiling height of not less than 7-1/2 feet (2 m). The laboratory shall be weather tight, sufficiently heated in cold weather, air-conditioned in hot weather to maintain temperatures for testing purposes of 70°F ±5°F (21°C ±2.3°C). The plant testing laboratory shall be located on the plant site to provide an unobstructed view, from one of its windows, of the trucks being loaded with the plant mix materials. In addition, the facility shall include the minimum:

(a) Adequate artificial lighting.
(b) Electrical outlets sufficient in number and capacity for operating the required testing equipment and drying samples.
(c) A minimum of two (2) Underwriter's Laboratories approved fire extinguishers of the appropriate types and class.
(d) Work benches for testing.
(e) Desk with chairs and file cabinet.
(f) Sanitary facilities convenient to testing laboratory.
(g) Exhaust fan to outside air.
(h) Sink with running water.

Failure to provide the specified facilities shall be sufficient cause for disapproving HMA plant operations.

Laboratory facilities shall be kept clean, and all equipment shall be maintained in proper working condition. The Engineer shall be permitted unrestricted access to inspect the Contractor's laboratory facility and witness quality control activities. The Engineer will advise the Contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to be adversely affecting the test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are satisfactorily corrected.

(3) Inspection of plant

The Engineer, or Engineer's authorized representative, shall have access, at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant: verifying weights, proportions, and material properties; and checking the temperatures maintained in the preparation of the mixtures.

(4) Storage bins and surge bins

The HMA stored in storage and surge bins shall meet the same requirements as HMA loaded directly into trucks and may be permitted under the following conditions:

(a) Stored in non-insulated bins for a period of time not to exceed three (3) hours.
(b) Stored in insulated storage bins for a period of time not to exceed eight (8) hours.

If the Engineer determines that there is an excessive amount of heat loss, segregation or oxidation of the HMA due to temporary storage, no temporary storage will be allowed.

312.4.3 Hauling equipment

Trucks used for hauling HMA shall have tight, clean, and smooth metal beds. To prevent the HMA from sticking to the truck beds, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other material approved by the Engineer.

Petroleum products shall not be used for coating truck beds. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary, to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers shall be securely fastened.

312.4.3.1 Material transfer vehicle (MTV)

Material transfer Vehicles shall be required due to the improvement in smoothness and decrease in both physical and thermal segregation. To transfer the material from the hauling equipment to the paver, use a self-propelled, material transfer vehicle with a swing conveyor that can deliver material to the paver without making contact with the paver. The MTV shall be able to move back and forth between the hauling equipment and the paver providing material transfer to the paver, while allowing the paver to operate at a constant speed. The Material Transfer Vehicle will have remixing and storage capability to prevent physical and thermal segregation.

312.4.4 HMA pavers

HMA pavers shall be self-propelled with an activated heated screed, capable of spreading and finishing courses of HMA that will meet the specified thickness, smoothness, and grade.

The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the HMA uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

If, during construction, it is found that the spreading and finishing equipment in use leaves tracks or indented areas, or produces other blemishes in the pavement that are not satisfactorily corrected by the scheduled operations, the use of such equipment shall be discontinued and satisfactory equipment shall be provided by the Contractor.

312.4.4.1 HMA pavers

The HMA paver shall be equipped with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices that will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within ±0.1%.

The controls shall be capable of working in conjunction with any of the following attachments:

a. Ski-type device of not less than 30 feet (9 m) in length
b. Taut stringline (wire) set to grade
c. Short ski or shoe
d. Laser control

312.4.5 Rollers

Rollers of the vibratory, steel wheel, and pneumatic-tired type shall be used. They shall be in good condition, capable of operating at slow speeds to avoid displacement of the HMA. The number, type, and weight of rollers shall be sufficient to compact the HMA to the required density while it is still in a workable condition.

All rollers shall be specifically designed and suitable for compacting hot mix bituminous concrete and shall be properly used. Rollers that impair the stability of any layer of a pavement structure or underlying soils shall not be used. Depressions in pavement surfaces caused by rollers shall be repaired by the Contractor at their own expense.

The use of equipment that causes crushing of the aggregate will not be permitted.

312.4.5.1 Density device

The Contractor shall have on site a density gauge during all paving operations in order to assist in the determination of the optimum rolling pattern, type of roller and frequencies, as well as to monitor the effect of the rolling operations during production paving. The Contractor shall also supply a qualified technician during all paving operations to calibrate the density gauge and obtain accurate density readings for all new HMA. These densities shall be supplied to the Engineer upon request at any time during construction.

312.4.6 Preparation of asphalt binder

The asphalt binder shall be heated in a manner that will avoid local overheating and provide a continuous supply of the bituminous material to the mixer at a uniform temperature. The temperature of the unmodified asphalt binder delivered to the mixer shall be sufficient to provide a suitable viscosity for adequate coating of the aggregate particles, but shall not exceed 325°F (160°C) when added to the aggregate. The temperature of modified asphalt binder shall be no more than 350°F (175°C) when added to the aggregate.

312.4.7 Preparation of mineral aggregate

The aggregate for the HMA shall be heated and dried. The maximum temperature and rate of heating shall be such that no damage occurs to the aggregates. The temperature of the aggregate and mineral filler shall not exceed 350°F (175°C) when the asphalt binder is added. Particular care shall be taken that aggregates high in calcium or magnesium content are not damaged by overheating. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

312.4.8 Preparation of HMA

The aggregates and the asphalt binder shall be weighed or metered and introduced into the mixer in the amount specified by the JMF.

The combined materials shall be mixed until the aggregate obtains a uniform coating of asphalt binder and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but not less than 25 seconds for batch plants. The wet mixing time for all plants shall be established by the Contractor, based on the procedure for determining the percentage of coated particles described in ASTM D2489, for each individual plant and for each type of aggregate used. The wet mixing time will be set to achieve 95% of coated particles. For continuous mix plants, the minimum mixing time shall be determined by dividing the weight of its contents at operating level by the weight of the mixture delivered per second by the mixer. The moisture content of all HMA upon discharge shall not exceed 0.5%.

312.4.9 Preparation of the underlying surface

Immediately before placing the HMA, the underlying course shall be cleaned of all dust and debris. A prime coat and tack coat shall be applied in accordance with Item 301 and 302, if shown on the plans.

312.4.10 Laydown plan, transporting, placing, and finishing

Prior to the placement of the HMA, the Contractor shall prepare a laydown plan for approval by the Engineer. This is to minimize the number of cold joints in the pavement. The laydown plan shall include the sequence of paving laydown by stations, width of lanes, temporary ramp locations, and laydown temperature. The laydown plan shall also include estimated time of completion for each portion of the work (that is, milling, paving, rolling, cooling, etc.). Modifications to the laydown plan shall be approved by the Engineer.

The HMA shall be transported from the mixing plant to the site in vehicles conforming to the requirements of Subsection 312.4.3. Deliveries shall be scheduled so that placing and compacting of HMA is uniform with minimum stopping and starting of the paver. Hauling over freshly placed material shall not be permitted until the material has been compacted, as specified, and allowed to cool to atmospheric temperature.

The alignment and elevation of the paver shall be regulated from outside reference lines established for this purpose for the first lift of all runway and taxiway pavements. Successive lifts of HMA surface course may be placed using a ski, or laser control per Subsection 312.4.4.1, provided grades of the first lift of bituminous surface course meet the tolerances of Subsections 312.5.2 (2) (5) as verified by a survey. Contractor shall survey each lift of HMA surface course and certify to the Engineer that every lot of each lift meets the grade tolerances of Subsection 312.5.2 (2) (5) before the next lift can be placed.

The initial placement and compaction of the HMA shall occur at a temperature suitable for obtaining density, surface smoothness, and other specified requirements but not less than 250°F (121°C).

Edges of existing HMA pavement abutting the new work shall be saw cut and carefully removed as shown on the drawings and coated with asphalt tack coat before new material is placed against it.

Upon arrival, the mixture shall be placed to the full width by a bituminous paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the HMA mat. Unless otherwise permitted, placement of the HMA shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. Additional screed sections shall not be attached to widen paver to meet the minimum lane width requirements specified above unless additional auger sections are added to match. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least one foot (30 cm); however, the joint in the surface top course shall be at the centerline of crowned pavements. Transverse joints in one course shall be offset by at least 10 feet (3 m) from transverse joints in the previous course.

Transverse joints in adjacent lanes shall be offset a minimum of 10 feet (3 m).

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the HMA may be spread and fluted by hand tools.

Areas of segregation in the course, as determined by the Engineer, shall be removed and replaced at the Contractor’s expense. The area shall be removed by saw cutting and milling a minimum of 2 inches (50 mm) deep. The area to be removed and replaced shall be a minimum width of the paver and a minimum of 10 feet (3 m) long.

312.4.11 Compaction of HMA

After placing, the HMA shall be thoroughly and uniformly compacted by power rollers. The surface shall be compacted as soon as possible when the mixture has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Contractor. The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once.

Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until the surface is of uniform texture, true to grade and cross-section, and the required field density is obtained. To prevent adhesion of the mixture to the roller, the wheels shall be equipped with a scraper and kept properly moistened using a water-soluble asphalt release agent approved by the Engineer.

In areas not accessible to the roller, the mixture shall be thoroughly compacted with approved power driven tampers. Tampers shall weigh not less than 275 pounds (125 kg), have a tamping plate width not less than 15 inches (38 cm), be rated at not less than 4,200 vibrations per minute, and be suitably equipped with a standard tamping plate wetting device.

Any HMA that becomes loose and broken, mixed with dirt, contains check-cracking, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor’s expense. Skin patching shall not be allowed.

312.4.12 Joints

The formation of all joints shall be made in such a manner as to ensure a continuous bond between the courses and obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade. The roller shall not pass over the unprotected end of the freshly laid HMA except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. In both methods, all contact surfaces shall be coated with an asphalt tack coat before placing any fresh HMA against the joint.

Longitudinal joints which are have been left exposed for more than four (4) hours; the surface temperature has cooled to less than 175°F (80°C); or are irregular, damaged, uncompacted or otherwise defective shall be cut back 3 inches (75 mm) to 6 inches (150 mm) to expose a clean, sound, uniform vertical surface for the full depth of the course. All cutback material shall be removed from the project. An asphalt tack coat or other product approved by the Engineer shall be applied to the clean, dry joint prior to placing any additional fresh HMA against the joint. Any laitance produced from cutting joints shall be removed by vacuuming and washing. The cost of this work shall be considered incidental to the cost of the HMA.

312.4.13 Diamond grinding

When required, diamond grinding shall be accomplished by sawing with saw blades impregnated with industrial diamond abrasive. The saw blades shall be assembled in a cutting head mounted on a machine designed specifically for diamond grinding that will produce the required texture and smoothness level without damage to the pavement. The saw blades shall be 1/8-inch (3-mm) wide and there shall be a minimum of 55 to 60 blades per 12 inches (300 mm) of cutting head width; the actual number of blades will be determined by the Contractor and depend on the hardness of the aggregate. Each machine shall be capable of cutting a path at least 3 feet (0.9 m) wide. Equipment that causes ravels, aggregate fractures, spalls or disturbance to the pavement will not be permitted. The depth of grinding shall not exceed 1/2 inch (13mm) and all areas in which diamond grinding has been performed will be subject to the final pavement thickness tolerances specified. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. It may be necessary to seal a larger area to avoid surface treatment creating any conflict with runway or taxiway markings.

312.4.14 Nighttime Paving Requirements

Paving during nighttime construction shall require the following:

a. All paving machines, rollers, distribution trucks and other vehicles required by the Contractor for his operations shall be equipped with artificial illumination sufficient to safely complete the work.

b. Minimum illumination level shall be 20 horizontal foot-candles and maintained in the following areas:

(1) An area of 30 feet (9 m) wide by 30 feet (9 m) long immediately behind the paving machines during the operations of the machines.
(2) An area of 15 feet (4.5 m) wide by 30 feet (9 m) long immediately in front and back of all rolling equipment, during operation of the equipment.
(3) An area of 15 feet (4.5 m) wide by 15 feet (4.5 m) long at any point where an area is being tack coated prior to the placement of pavement.

c. As partial fulfillment of the above requirements, the Contractor shall furnish and use, complete artificial lighting units with a minimum capacity of 3,000 watt electric beam lights, affixed to all equipment in such a way to direct illumination on the area under construction.

d. A lighting plan must be submitted by the Contractor and approved by the Engineer prior to the start of any nighttime work.

312.5 Material Acceptance

312.5.1 Acceptance sampling and testing

Unless otherwise specified, all acceptance sampling and testing necessary to determine conformance with the requirements specified in this section will be performed by the Contractor under supervision of the Engineer.

Testing organizations performing these tests shall be accredited in accordance with ASTM D3666. The laboratory accreditation must be current and listed on the accrediting authority's website. All test methods required for acceptance sampling and testing must be listed on the lab accreditation. A copy of the laboratory's current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction. All equipment in Contractor furnished laboratories shall be calibrated by an independent testing organization prior to the start of operations.

a. Hot mixed asphalt

All Plant-produced HMA shall be tested for air voids and stability and flow on a lot basis. Sampling shall be from material deposited into trucks at the plant or from trucks at the job site. Samples shall be taken in accordance with ASTM D979.

A standard lot shall be equal to one day's production or 2000 tons (1814 metric tons) whichever is smaller. If the day's production is expected to exceed 2000 tons (1814 metric tons), but less than 4000 tons (3628 metric tons), the lot size shall be 1/2 day's production. If the day's production exceeds 4000 tons (3628 metric tons), the lot size shall be an equal sized fraction of the day's production, but shall not exceed 2000 tons (1814 metric tons). Where more than one plant is simultaneously producing HMA for the job, the lot sizes shall apply separately for each plant

(1) Sampling

Each lot will consist of four equal sublots. Sufficient HMA for preparation of test specimens for all testing will be sampled by the Engineer on a random basis, in accordance with the procedures contained in ASTM D3665. Samples will be taken in accordance with ASTM D979. The sample of HMA may be put in a covered metal tin and placed in an oven for not less than 30 minutes nor more than 60 minutes to stabilize to compaction temperature. The compaction temperature of the specimens shall be as specified in the JMF.

(2) Testing

Sample specimens shall be tested for stability and flow in accordance with ASTM D6927. Air voids will be determined by the Engineer in accordance with ASTM D3203. One set of laboratory compacted specimens will be prepared for each sublot in accordance with ASTM D6926 at the number of blows required by Subsection 312.3.2, Table

1. Each set of laboratory compacted specimens will consist of three test specimens prepared from the same sample. The manual hammer in ASTM D6926 shall be used.

Prior to testing, the bulk specific gravity of each test specimen shall be measured by the Contractor in accordance with ASTM D2726 using the procedure for laboratory-prepared thoroughly dry specimens for use in computing air voids and pavement density.

For air voids determination, the theoretical maximum specific gravity of the mixture shall be measured one time for each sublot in accordance with ASTM D2041. The value used in the air voids computation for each sublot shall be based on theoretical maximum specific gravity measurement for the sublot. The stability and flow for each sublot shall be computed by averaging the results of all test specimens representing that sublot.

(3) Acceptance

Acceptance of plant produced HMA for stability, flow, and air voids shall be determined by the Engineer in accordance with the requirements of Subsection 312.5.1.

b. In-place HMA

HMA placed in the field shall be tested for mat and joint density on a lot basis. A standard lot shall be equal to one day's production or 2000 tons (1814 metric tons) whichever is smaller. If the day's production is expected to exceed 2000 tons (1814 metric tons), but less than 4000 tons (3628 metric tons), the lot size shall be 1/2 day's production. If the day's production exceeds 4000 tons (3628 metric tons), the lot size shall be an equal sized fraction of the day's production, but shall not exceed 2000 tons (1814 metric tons).

(1) Mat density

The lot size shall be the same as that indicated in Subsection 312.5.1a. The lot shall be divided into four equal sublots. One core of finished, compacted HMA shall be taken by the Contractor from each sublot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D3665. Cores for mat density shall not be taken closer than one foot (30 cm) from a transverse or longitudinal joint.

(2) Joint density

The lot size shall be the total length of longitudinal joints constructed by a lot of HMA as defined in Subsection 312.5.1a. The lot shall be divided into four equal sublots. One core of finished, compacted HMA shall be taken by the Contractor from each sublot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D3665. All cores for joint density shall be taken centered on the joint. The minimum core diameter for joint density determination shall be 5 inches (125 mm).

(3) Sampling

Samples shall be neatly cut with a diamond core drill bit. Samples will be taken in accordance with ASTM D979. The minimum diameter of the sample shall be 5 inches (125 mm). Samples that are defective, as a result of sampling, shall be discarded and another sample taken. The Contractor shall furnish all tools, labor, and materials for cutting samples, cleaning, and filling the cored pavement. Cored pavement shall be cleaned and core holes shall be filled in a manner acceptable to the Engineer and within one day after sampling. Laitance produced by the coring operation shall be removed immediately. The top most lift of bituminous material shall be completely bonded to the underlying layers of bituminous material. If any of the cores reveal that the surface is not bonded to the bituminous layer immediately below the surface then additional cores shall be taken as directed by the Engineer in accordance with Subsection 312.5.1b to determine the extent of any delamination. All delaminated areas shall be completely removed by milling to the limits and depth and replaced as directed by the Engineer.

(4) Testing

The bulk specific gravity of each cored sample will be measured by the Engineer in accordance with ASTM D2726. Samples will be taken in accordance with ASTM D979. The percent compaction (density) of each sample will be determined by dividing the bulk specific gravity of each sublot sample by the average bulk specific gravity of all laboratory prepared specimens for the lot, as determined in Subsection 312.5.1a (2). The bulk specific gravity used to determine the joint density at joints formed between different lots shall be the lowest of the bulk specific gravity values from the two different lots.

(5) Acceptance

Acceptance of field placed HMA for mat density will be determined by the Engineer in accordance with the requirements of Subsection 312.5.2 (2) (1). Acceptance for joint density will be determined by the Engineer in accordance with the requirements of Subsection 312.5.2 (2) (2).

c. Partial lots HMA

When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot, or when the Contractor and the Engineer agree in writing to allow overages or other minor tonnage placements to be considered as partial lots, the following procedure will be used to adjust the lot size and the number of tests for the lot.

The last batch produced where production is halted will be sampled, and its properties shall be considered as representative of the particular sublot from which it was taken. In addition, an agreed to minor placement will be sampled, and its properties shall be considered as representative of the particular sublot from which it was taken. Where three sublots are produced, they shall constitute a lot. Where one or two sublots are produced, they shall be incorporated into the next lot, and the total number of sublots shall be used in the acceptance plan calculation, that is, n = 5 or n = 6, for example. Partial lots at the end of asphalt production on the project shall be included with the previous lot. The lot size for field placed material shall correspond to that of the plant material, except that, in no cases, shall less than three (3) cored samples be obtained, that is, n = 3.

312.5.2 Acceptance criteria

a. General

Acceptance will be based on the following characteristics of the HMA and completed pavement and test results:

(1) Air Voids

(2) Mat density
(3) Joint density
(4) Thickness
(5) Smoothness
(6) Grade
(7) Stability
(8) Flow

Mat density will be evaluated for acceptance in accordance with Subsection 312.5.2 (2) (1). Stability and flow will be evaluated for acceptance in accordance with Subsection 312.5.1. Joint density will be evaluated for acceptance in accordance with Subsection 312.5.2 (2) (2).

Thickness will be evaluated by the Engineer for compliance in accordance with Subsection 312.5.2 (2) (3).Acceptance for smoothness will be based on the criteria contained in Subsection 312.5.2 (2) (4). Acceptance for grade will be based on the criteria contained in Subsection 312.5.2 (2) (5).

The Engineer may at any time reject and require the Contractor to dispose of any batch of HMA which is rendered unfit for use due to contamination, segregation, incomplete coating of aggregate, or improper mix temperature. Such rejection may be based on only visual inspection or temperature measurements.

b. Acceptance criteria

(1) Mat density

Acceptance of each lot of plant produced material for mat density shall be based on the average of all of the densities taken from the sublots. If the average mat density of the lot so established equals or exceeds 96%, the lot shall be acceptable. If the average mat density of the lot is below 96%, the lot shall be removed and replaced at the Contractor’s expense.

(2) Joint density

Acceptance of each lot of plant produced HMA for joint density shall be based on the average of all of the joint densities taken from the sublots. If the average joint density of the lot so established equals or exceeds 94%, the lot shall be acceptable. If the average joint density of the lot is less than 94%, the Contractor shall stop production and evaluate the method of compacting joints. Production may resume once the reason for poor compaction has been determined and appropriate measures have been taken to ensure proper compaction.

(3) Thickness

Thickness of each course shall be evaluated by the Engineer for compliance to the requirements shown on the plans. Measurements of thickness shall be made by the Engineer using the cores extracted for each sublot for density measurement. The maximum allowable deficiency at any point shall not be more than 1/4 inch (6 mm) less than the thickness indicated for the lift. Average thickness of lift, or combined lifts, shall not be less than the indicated thickness. Where thickness deficiency exceeds the specified tolerances, the lot or sublot shall be corrected by the Contractor at his expense by removing the deficient area and replacing with new pavement.

(4) Smoothness

The final surface shall be free from roller marks. After final rolling, but not later than 24 hours after placement, the surface of each lot shall be tested in both longitudinal and transverse directions for smoothness to reveal all surface irregularities exceeding the tolerances specified. The Contractor shall furnish paving equipment and employ methods that produce a surface for each pavement lot such that the finished surface course of the pavement shall not vary more than 1/4 inch (6mm) when evaluated with a 12-foot (3.7m) straightedge. When the surface course smoothness exceeds specification tolerances which cannot be corrected by diamond grinding of the surface course, full depth removal and replacement of surface course corrections shall be to the limit of the longitudinal placement. Corrections involving diamond grinding will be subject to the final pavement thickness tolerances specified.

Transverse measurements

Transverse measurements will be taken for each lot placed. Transverse measurements will be taken perpendicular to the pavement centerline each 50 feet (15m) or more often as determined by the Engineer.

1) Testing shall be continuous across all joints, starting with one-half the length of the straightedge at the edge of pavement section being tested and then moved ahead one-half the length of the straightedge for each successive measurement. Smoothness readings will not be made across grade changes or cross slope transitions; at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Deviations on final surface course > 1/4 inch (6mm) in transverse direction shall be corrected with diamond grinding per Subsection 312.4.13 or by removing and replacing full depth of surface course.

Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

2) The joint between lots shall be tested separately to facilitate smoothness between lots. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface, with half the straightedge on one side of the joint and the other half of the straightedge on the other side of the joint. Measure the maximum gap between the straightedge and the pavement surface in the area between these two high points. One measurement shall be taken at the joint every 50 feet (15m) or more often if directed by the Engineer. Deviations on final surface course > 1/4 inch (6mm) in transverse direction shall be corrected with diamond grinding per Subsection 312.4.13 or by removing and replacing full depth of surface course. Each measurement shall be recorded and a copy of the data shall be furnished to the Engineer at the end of each days testing.

3) Longitudinal measurements. Longitudinal measurements will be taken for each lot placed. Longitudinal tests will be parallel to the centerline of paving; at the center of paving lanes when widths of paving lanes are less than 20 feet (6m); and the third points of paving lanes when widths of paving lanes are 20 ft (6m) or greater. The finished surface shall not vary more than 1/4inch (6mm) when evaluated with a 12-foot (3.7m) straightedge. Smoothness readings will not be made across grade changes or cross slope transitions; at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. Testing shall be continuous across all joints, starting with one-half the length of the straightedge at the edge of pavement section being tested and then moved ahead one- half the length of the straightedge for each successive measurement.

The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Deviations on final surface course > 1/4 inch (6mm) in longitudinal direction will be corrected with diamond grinding per Subsection 312.4.13 or by removing and replacing full depth of surface course. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding. The primary purpose of smoothness testing is to identify areas that may be prone to ponding of water which could lead to hydroplaning of aircraft. If the contractor’s machines and/or methods are producing significant areas that need corrective actions, then production should be stopped until corrective measures can be implemented. If corrective measures are not implemented and when directed by the Engineer, production shall be stopped until corrective measures can be implemented.

(5) Grade

Grade shall be evaluated on the first day of placement and then every month to allow adjustments to paving operations if measurements do not meet specification requirements. The Sub-contractor must submit the survey data to the Engineer by the following day after measurements have been taken. The finished surface of the pavement shall not vary from the gradeline elevations and cross sections shown on the plans by more than 1/2 inch (12 mm). The finished grade of each lot will be determined by running levels at intervals of 50 feet (15 m) or less longitudinally and all breaks in grade transversely (not to exceed 50 feet (15 m)) to determine the elevation of the completed pavement.

The documentation, stamped and signed by a licensed surveyor, shall be provided by the Contractor to the Engineer. The lot size shall be 2,000 square yards (1,650 square meters). When more than 15% of all the measurements within a lot are outside the specified tolerance, or if any one shot within the lot deviates 3/4 inch (19 mm) or more from planned grade, the Contractor shall remove the deficient area to the depth of the final course of pavement and replace with new material. Skin patching shall not be permitted. Isolated high points may be ground off providing the course thickness complies with the thickness specified on the plans. High point grinding will be limited to 15 square yard (12.5 sq m). The surface of the ground pavement shall have a texture consisting of grooves between 0.090 and 0.130 inches (2 and 3.5 mm) wide. The peaks and ridges shall be approximately 1/32 inch (1 mm) higher than the bottom of the grooves. The pavement shall be left in a clean condition.

The removal of all of the slurry resulting from the grinding operation shall be continuous. The grinding operation should be controlled so the residue from the operation does not flow across other lanes of pavement. Areas in excess of 15 square yard (12.5 sq m) will require removal and replacement of the pavement in accordance with the limitations noted above.

c. Density outliers

If the tests within a lot include a very large or a very small value that appears to be outside the normal limits of variation, check for an outlier in accordance with ASTM E178, at a significance level of 5%, to determine if this value should be discarded.

312.5.3 Resampling Pavement for Mat Density

a. Density outliers

Resampling of a lot of pavement will only be allowed for mat density and then, only if the Contractor requests same in writing, within 48 hours after receiving the written test results from the Engineer. A retest will consist of all the sampling and testing procedures contained in Subsections 312.5.1.

Only one resampling per lot will be permitted.

(1) A redefined mat density shall be calculated for the resampled lot. The number of tests used to calculate the redefined mat density shall include the initial tests made for that lot plus the retests.

(2) The cost for resampling and retesting shall be borne by the Contractor.

b. Outliers

Check for outliers in accordance with ASTM E178, at a significance level of 5%.

312.6 Contractor Quality Control

312.6.1 General

The Contractor shall perform quality control sampling, testing, and inspection during all phases of the work and shall perform them at a rate sufficient to ensure that the work conforms to the contract requirements, and at minimum test frequencies required by Subsection 312.6.3, including but not limited to:

a. Mix Design
b. Aggregate Grading
c. Quality of Materials
d. Proportioning
e. Mixing and Transportation
f. Placing and Finishing
g. Joints
h. Compaction
i. Surface smoothness
j. Personnel
k. Laydown plan

The Contractor shall perform quality control sampling, testing, and inspection during all phases of the work and shall perform them at a rate sufficient to ensure that the work conforms to the contract requirements, and at minimum test frequencies required by Subsection 312.6.3. As a part of the process for approving the Contractor’s plan, the Engineer may require the

Contractor’s technician to perform testing of samples to demonstrate an acceptable level of performance.

No partial measurement will be made for materials that are subject to specific quality control requirements without an approved plan.

312.6.2 Contractor testing laboratory

The lab shall meet the requirements of ASTM D3666 including all necessary equipment, materials, and current reference standards to comply with the specifications.

312.6.3 Quality control testing

The Contractor shall perform all quality control tests necessary to control the production and construction processes applicable to these specifications and as set forth in the approved Quality Control Program. The testing program shall include, but not necessarily be limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, field compaction, and surface smoothness. A Quality Control Testing Plan shall be developed as part of the Quality Control Program.

a. Asphalt content

A minimum of two asphalt content tests shall be performed per lot in accordance with ASTM D6307 or ASTM D2172 if the correction factor in ASTM D6307 is greater than 1.0. The asphalt content for the lot will be determined by averaging the test results.

b. Gradation

Aggregate gradations shall be determined a minimum of twice per lot from mechanical analysis of extracted aggregate in accordance with ASTM D5444 and ASTM C136, and ASTM C117.

c. Moisture content of aggregate

The moisture content of aggregate used for production shall be determined a minimum of once per lot in accordance with ASTM C566.

d. Moisture content of HMA

The moisture content of the HMA shall be determined once per lot in accordance with AASHTO T329

e. Temperatures

Temperatures shall be checked, at least four times per lot, at necessary locations to determine the temperatures of the dryer, the asphalt binder in the storage tank, the HMA at the plant, and the HMA at the job site.

f. In-place density monitoring

The Contractor shall conduct any necessary testing to ensure that the specified density is being achieved. A nuclear gauge may be used to monitor the pavement density in accordance with ASTM D2950.

g. Additional testing

Any additional testing that the Contractor deems necessary to control the process may be performed at the Contractor's option.

h. Monitoring

The Engineer reserves the right to monitor any or all of the above testing.

312.6.4 Sampling

When directed by the Engineer, the Contractor shall sample and test any material that appears inconsistent with similar material being sampled, unless such material is voluntarily removed and replaced or deficiencies corrected by the Contractor. All sampling shall be in accordance with standard procedures specified.

312.6.5 Control charts

The Contractor shall maintain linear control charts both for individual measurements and range (i.e., difference between highest and lowest measurements) for aggregate gradation, asphalt content, and VMA. The VMA for each sublot will be calculated and monitored by the Quality Control laboratory.

Control charts shall be posted in a location satisfactory to the Engineer and shall be kept current. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the Action and Suspension Limits applicable to each test parameter, and the Sub-contractor's test results. The Contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the Contractor's projected data during production indicates a problem and the Contractor is not taking satisfactory corrective action, the Engineer may suspend production or acceptance of the material.

a. Individual measurements

Control charts for individual measurements shall be established to maintain process control within tolerance for aggregate gradation, asphalt content, and VMA. The control charts shall use the JMF target values as indicators of central tendency for the following test parameters with associated Action and Suspension Limits:

Control Chart Limits For Individual Measurements		
Sieve	Action Limit	Suspension Limit
3/4 inch (19 mm)	±6%	±9%
1/2 inch (12 mm)	±6%	±9%
3/8 inch (9 mm)	±6%	±9%
No. 4 (4.75 mm)	±6%	±9%
No. 16 (1.18 mm)	±5%	±7.5%
No. 50 (0.30 mm)	±3%	±4.5%
No. 200 (0.075 mm)	±2%	±3%
Asphalt Content	±0.45%	±0.70%
VMA	-1.00%	-1.5%

b. Range

Control charts for range shall be established to control process variability for the test parameters and Suspension Limits listed below. The range shall be computed for each lot as the difference between the two test results for each control parameter. The Suspension Limits specified below are based on a sample size of n = 2. Should the Sub-contractor elect to perform more than two tests per lot, the Suspension Limits shall be adjusted by multiplying the Suspension Limit by 1.18 for n = 3 and by 1.27 for n = 4.

Control Chart Limits Based On Range (Based On n = 2)	
Sieve	Suspension Limit
1/2 inch (12 mm)	11%
3/8 inch (9 mm)	11%
No. 4 (4.75 mm)	11%
No. 16 (1.18 mm)	9%
No. 50 (0.30 mm)	6%
No. 200 (0.075 mm)	3.5%
Asphalt Content	0.8%

c. Corrective action

The Contractor Quality Control Program shall indicate that appropriate action shall be taken when the process is believed to be out of tolerance. The Plan shall contain sets of rules to gauge when a process is out of control and detail what action will be taken to bring the process into control. As a minimum, a process shall be deemed out of control and production stopped and corrective action taken, if:

(1) One point falls outside the Suspension Limit line for individual measurements or range; or

(2) Two points in a row fall outside the Action Limit line for individual measurements.

312.6.6 Quality control reports

The Contractor shall maintain records and shall submit reports of quality control activities daily, in accordance with the Contractor Quality Control Program.

312.7 Testing Requirements

AASHTO M156	Standard Specification for Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
ASTM C29	Standard Test Method for Bulk Density (“Unit Weight”) and Voids in Aggregate
ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C117	Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C127	Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C131	Standard Test Method for Resistance to Degradation of Small- Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM C183	Standard Practice for Sampling and the Amount of Testing of Hydraulic Cement
ASTM C566	Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
ASTM D75	Standard Practice for Sampling Aggregates
ASTM D979	Standard Practice for Sampling Bituminous Paving Mixtures
ASTM D1073	Standard Specification for Fine Aggregate for Bituminous Paving Mixtures
ASTM D1074	Standard Test Method for Compressive Strength of Bituminous Mixtures
ASTM D1461	Standard Test Method for Moisture or Volatile Distillates in Bituminous Paving Mixtures
ASTM D2041	Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures

ASTM D2172	Standard Test Method for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D2419	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
ASTM D2489	Standard Practice for Estimating Degree of Particle Coating of Bituminous Aggregate Mixtures
ASTM D2726	Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D2950	Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods
ASTM D3203	Standard Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
ASTM D3665	Standard Practice for Random Sampling of Construction Materials
ASTM D3666	Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D4125	Standard Test Methods for Asphalt Content of Bituminous mixtures by the Nuclear Method
ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D4867	Standard Test Method for Effect of Moisture on Asphalt Concrete Paving Mixtures
ASTM D5444	Standard Test Method for Mechanical Size Analysis of Extracted Aggregate
ASTM D5581	Standard Test Method for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus (6 inch- Diameter Specimen)
ASTM D6307	Standard Test Method for Asphalt Content of Hot-Mix Asphalt by Ignition Method
ASTM D6926	Standard Practice for Preparation of Bituminous Specimens Using Marshall Apparatus
ASTM D6927	Standard Test Method for Marshall Stability and Flow of Bituminous Mixtures
ASTM D6752	Standard Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Automatic Vacuum Sealing Method
ASTM E11	Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves
ASTM E178	Standard Practice for Dealing with Outlying Observations
AASHTO T030	Standard Method of Test for Mechanical Analysis of Extracted Aggregate
AASHTO T110	Standard Method of Test for Moisture or Volatile Distillates in Hot Mix Asphalt (HMA)

AASHTO T275	Standard Method of Test for Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Using Paraffin-Coated Specimens).
Asphalt Institute Handbook MS-26 Asphalt Binder	
Asphalt Institute MS-2 Mix Design Manual, 7th Edition	

312.8 Material Requirements

ASTM D242	Standard Specification for Mineral Filler for Bituminous Paving Mixtures
ASTM D946	Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction
ASTM D3381	Standard Specification for Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D4552	Standard Practice for Classifying Hot-Mix Recycling Agents
ASTM D4552	Standard Specification for Performance Graded Asphalt Binder

PART G – DRAINAGE AND SLOPE PROTECTION STRUCTURES ITEM 500 –

PIPE CULVERTS AND STORM DRAINS

500.1 Description

This item shall consist of the construction or reconstruction of pipe culverts and storm drains external to the building conveying surface water , hereinafter referred to as “conduit” in accordance with this Specification and in conformity with the lines and grades shown on the Plans or as established by the Engineer.

500.2 Material Requirements

Materials for storm drainage system shall meet the requirements specified in the following standard specifications:

Description	Location	Material	Standard
Storm drains 300mm diameter and bigger	Under taxiways and Aprons	Reinforced concrete pipe culvert (RCPC)	ASTM C76M (AASHTO M170M) Class IV, Wall B
Storm drains 300mm diameter and bigger	Under HoS and other roads	Reinforced concrete pipe culvert (RCPC)	ASTM C76M (AASHTO M170M) Class II, Wall B
Storm drains smaller than 300mm diameter	All areas	Unreinforced concrete pipe, Class 3	ASTM C14M (AASHTO M14M)

RCPC shall be have rubber gasketed joints conforming to ASTM C 443. Provide pipe in 2000 mm length minimum with circular reinforcements.

Circular reinforcement shall be full-circle type. The total area of longitudinal steel shall not be less than 0.20 percent of the concrete cross-sectional area of Wall B. Longitudinal bars shall be spaced uniformly around the pipe, and shall be continuous in each cage but shall not be spaced more than 750 mm apart.

All fittings required to complete the work shall be provided. Design and manufacture of fittings shall be governed by the same requirements as the connecting piping.

Joint mortar for concrete pipes shall consist of 1 part, by volume of Portland Cement and two (2) parts of approved sand with water as necessary to obtain the required consistency. The Portland cement shall conform to the requirements of ASTM C150, Type I. The sand shall conform to the requirements of ASTM C144. Mortar shall be used within 30 minutes after its preparation.

Rubber gaskets for rigid pipe shall conform to the requirements of ASTM C443. Poured filler for joints shall conform to the requirements of ASTM D6690.

Oakum – Oakum for joints in bell and spigot pipes shall be made from hemp (Cannavis Sativa) line or Benares Sunn fiber or from a combination of these fibers.

The oakum shall be thoroughly corded and finished and practically free from lumps, dirt and extraneous matter.

Hot poured joint sealing compound	AASHTO M 173

Bedding material shall conform to the requirements of Subsection 500.3.2, Bedding.

Backfill material shall conform to the requirements of Subsection 500.3.6, Backfilling.

Concrete for pipe cradles shall have a minimum compressive strength of 2000 psi (13.8 MPa) at 28 days and conform to the requirements of ASTM C94.

When the location of manufacturing plants allow, the plants will be inspected periodically for compliance with specified manufacturing methods, and material samples will be obtained for laboratory testing for compliance with materials quality requirements. This shall be the basis for acceptance of manufacturing lots as to quality.

Prior to and during incorporation of materials in the work, these materials will be subjected to the latest inspection and approval of the Engineer.

500.3 Construction Requirements

500.3.1 Trenches Excavation

Trenches shall be excavated in accordance with the requirement of Item 103, Structure Excavation, to a width sufficient to allow for proper jointing of the conduit and thorough compaction of the bedding and backfill materials under and around the conduit. Where feasible, trench wall shall be vertical.

The width of the trench shall be sufficient to permit satisfactorily jointing of the pipe and thorough compaction of the bedding material under the pipe and backfill material around the pipe, but it shall not be greater than the widths shown on the plans trench detail. The trench bottom shall be shaped to fully and uniformly support the bottom quadrant of the pipe.

Where rock, hardpan, or other unyielding material is encountered, the Contractor shall remove it from below the foundation grade for a depth of at least 200 mm or 12 mm for each foot of fill over the top of the pipe (whichever is greater) but for no more than three-quarters of the nominal diameter of the pipe. The excavation below grade shall be backfilled with selected fine compressible material, such as silty clay or loam, and lightly compacted in layers not over 150 mm in uncompacted depth to form a uniform but yielding foundation.

Where a firm foundation is not encountered at the grade established, due to soft, spongy, or other unstable soil, the unstable soil shall be removed and replaced with approved granular material for the full trench width. The Engineer shall determine the depth of removal necessary. The granular material shall be compacted to provide adequate support for the pipe.

The completed trench bottom shall be firm for its full length and width. Where required, in the case of crop drains, the trench shall have a longitudinal camber of the magnitude specified.

When so specified on the Plans, the excavation for conduits placed in embankment fill, shall be made after the embankment has been completed to the specified or directed height above the designed grade of the conduit.

500.3.2 Bedding

The bedding shall conform to one of the classes specified. When no bedding class is specified, the requirements for Class C bedding shall apply.

Class A bedding shall consist of a continuous concrete cradle conforming to the plan details.

Class B bedding shall consist of bedding the conduit to a depth of not less than 30 percent of the vertical outside diameter of the conduit. The minimum thickness of bedding material beneath the pipe shall be 100 mm. The bedding material shall be sand or selected sandy soil all of which passes a 9.5 mm sieve and not more than 10 percent of which passes a 0.075 mm sieve. The layer of the bedding material shall be shaped to fit the conduit for at least 15 percent of its total height. Recesses in the trench bottom shall be shaped to accommodate the bell when bell and spigot type conduit is used.

Class C bedding shall consist of bedding the conduit to a depth of not less than 10 percent of the pipe's vertical outside diameter. The foundation surface, completed in accordance with Item 103, Structure Excavation, shall be shaped to fit the conduit and shall have recesses shaped to receive the bells, if any.

For flexible pipe, the bed shall be roughly shaped and a bedding blanket of sand or fine granular material as specified above shall be provided as follows:

Pipe Corrugation Depth	Minimum Bedding Depth
10 mm	25 mm

25 mm	50 mm
50 mm	75 mm
60 mm	90 mm

For large diameter structural plate pipes the shaped bed need not exceed the width of bottom plate.

500.3.3 Laying Conduit

The conduit laying shall begin at the downstream end of the conduit line. The lower segment of the conduit shall be in contact with the shaped bedding throughout its full length. Bell or groove ends of rigid conduits and outside circumferential laps of flexible conduits shall be placed facing upstream. Flexible conduit shall be placed with longitudinal laps or seams at the sides.

Paved or partially-lined conduit shall be laid such that the longitudinal center line of the paved segment coincides with the flow line. Elliptical and elliptically reinforced conduits shall be placed with the major axis within 5 degrees of a vertical plane through the longitudinal axis of the conduit.

Inspect each pipe and fitting before and after installation; remove those found defective from site and replace with new. Provide proper facilities for lowering sections of pipes into trenches. Lay pipe with the bell ends in the upgrade direction. Adjust spigots in bells to produce a uniform space. Blocking or wedging between bell and spigots will not be permitted. Replace by one of the proper dimensions any pipe or fitting that does not allow sufficient space for proper calking or installation of joint material. At the end of each workday, close open ends of pipe temporarily with wood blocks or bulkheads. Provide batterboards not more than 7.50 meter apart in trenches for checking and ensuring that pipe invert elevations are as indicated. Laser beam may be used in lieu of batterboards for the same purpose

500.3.4 Jointing Conduit

Rigid conduits may either be of bell and spigot or tongue and groove design unless another type is specified. The method of joining conduit sections shall be such that the ends are fully entered and the inner surfaces are reasonably flush and even.

Joints shall be made with (a) Portland Cement mortar, (b) Portland Cement grout, (c) rubber gaskets, (d) oakum and mortar, (e) oakum and joint compound, (f) plastic sealing compound, or by a combination of these types, or any other type, as may be specified. Mortar joints shall be made with an excess of mortar to form a continuous bead around the outside of the conduit and finished smooth on the inside. For grouted joints, molds or runners shall be used to retain the poured grout. Rubber ring gaskets shall be installed so as to form a flexible water-tight seal. Where oakum is used, the joint shall be called with this material and then sealed with the specified material.

When Portland Cement mixtures are used, the completed joints shall be protected against rapid drying by any suitable covering material.

Flexible conduits shall be firmly joined by coupling bands.

Conduits shall be inspected before any backfill is placed. Any pipe found to be out of alignment, unduly settled, or damaged shall be taken up and re-laid or replaced.

500.3.5 Field Strutting

When required by the Plans, vertical diameter of round flexible conduit shall be increased 5 percent by shop elongation or by means of jacks applied after the entire line of conduit has been installed on the bending but before backfilling. The vertical elongation shall be maintained by means of sills and struts or by horizontal ties shall be used on paved invert pipe.

Ties and struts shall be 300 mm in place until the embankment is completed and compacted, unless otherwise shown on the Plans.

These construction specifications shall also apply in the case of re-laid conduits. In addition, all conduits salvaged for relaying shall be cleaned of all foreign materials prior to reinstallation.

500.3.6 Backfilling

Materials for backfilling on each side of the conduit for the full trench width and to an elevation of 300 mm above the top of the conduit shall be fine, readily compactible soil or granular material selected from excavation or from a source of the Contractor’s choice, and shall not contain stones that would be retained on a 50 mm sieve, chunks of highly plastic clay, or other objectionable material. Granular backfill material shall have not less than 95 percent passing a 12.5 mm sieve and not less than 95 percent retained on a 4.75 mm sieve. Oversized material, if present, shall be removed at the source of the material, except as directed by the Engineer.

When the top of the conduit is flushed with or below the top of the trench, backfill material shall be placed at or near optimum moisture content and compacted in layers not exceeding 150 mm (compacted) on both sides to an elevation 300 mm above the top of the conduit. Care shall be exercised to thoroughly compact the backfill under the haunches of the conduit. The backfill shall be brought up evenly on both sides of the conduit for the full required length. Except where negative projecting embankment-type installation is specified, the backfill material shall be placed and compacted for the full depth of the trench.

When the top of the conduit is above the top of the trench, backfill shall be placed at or near optimum moisture content and compacted in layers not exceeding 300 mm (compacted) and shall be brought up evenly on both sides of the conduit for its full length to an elevation 300 mm above the top of the conduit. The width of the backfill on each side of the conduit for the portion above the top of the trench shall be equal to twice the diameter of the conduit or 3.5 m, whichever is less. The backfill material used in the trench section and the portion above the top of the trench for a distance on each side of the conduit equal to the horizontal inside diameter and to 300 mm above the top of the conduit shall conform to the requirements for backfill materials in this Subsection. The remainder of the backfill shall consist of materials from excavation and borrow that is suitable for embankment construction.

Compaction to the density specified in Item 104, Embankment, shall be achieved by use of mechanical tampers or by rolling.

All conduits after being bedded and backfill as specified in this Subsection shall be protected by one meter cover of fill before heavy equipment is permitted to cross during construction. It shall be the Contractor's responsibility to protect installed pipes and culverts from damage due to construction equipment operations. The Contractor shall be responsible for installation of any extra strutting or backfill required to protect pipes from the construction equipment.

500.3.7 Imperfect Trench

Under this method, for rigid conduit, the embankment shall be completed as described in Subsection 500.3.6, Backfilling, to a height above the conduit equal to the vertical outside diameter of the conduit plus 300 mm. A trench equal in width to the outside horizontal diameter of the conduit and to the length shown on the plans or as directed by the Engineer shall then be excavated to within 300 mm of the top of the conduit, trench walls being as nearly vertical as possible. The trench shall be loosely filled with highly compressible soil. Construction of embankment above shall then proceed in a normal manner.

500.3.8 Connection to Structures

The Contractor shall note that he must deal with existing flows of water when connecting new sewers, drains and culverts to existing culverts, manholes, other drainage chambers and canals. He shall note that the existing flows of water may be influenced by tides and by other contractors working on other sections of the existing sewers, drains and culverts and shall program his works accordingly. If during the progress of the Works the Contractor encounters existing sewers and drains not shown on the Plans, he shall notify the Engineer who will issue instructions regarding the manner in which such sewers or drains are to be connected into the drainage system.

500.3.9 Particulars of Diversion of Flows

The Contractor shall be responsible for maintaining the capacity and an uninterrupted flow in existing waterways. No change in the alignment, invert levels and cross section of waterways will be permitted without having been approved by the Engineer.

The Contractor shall be responsible for temporary diversions and training of waterways as may be required during the course of the Works and for the final training into the permanent discharge point, all to the satisfaction of the Engineer. Prior to temporary diversions and training of waterways the Contractor shall provide the Engineer with independently checked calculations to demonstrate that the capacity of any diversion will perform to the requirements of this Item.

500.3.10 Unrecorded Drains and Sewers

If during the progress of the Works the Contractor encounters existing sewers and storm drains not shown on the Plans, he shall immediately notify the Engineer. The Engineer shall issue the necessary instructions to the Contractor to carry out alterations to the existing sewers, drains and/or the work under construction. The Contractor shall then submit a work proposal on rectifying the uncharted connections to the Engineer for approval. The proposal shall cover the scope, method and programme of reconnection to the new pipes or adjacent existing pipes as instructed by the Engineer. The Contractor shall only proceed with the Engineer's approval.

500.3.11 Connection to Existing Drains

The Contract includes for connections to existing drains and the Contractor shall carry out connections while providing temporary diversions to the existing drainage system in accordance with Item 500.3.8. The Contractor shall maintain any necessary temporary diversions until the connections are completed. Any such diversions and connections shall not be carried out without the prior approval of the Engineer.

The Contractor shall execute the Works with the minimum disruption or restriction of flows in existing drainage systems and shall provide adequate standby facilities during periods of disruption or restriction to safeguard against flooding.

At the commencement of Contract, the Contractor shall verify the details of the existing pipeline for connection against the details shown on the Plans or stated in the Contract Documents. He shall provide details and report immediately any discrepancy to the Engineer for consideration. This verification exercise shall be carried out for all other pipeline connections to existing drain.

500.4 Quality Assurance

500.4.1 Concrete Pipe

Preliminary Tests. All preliminary tests shall be made at the Contractor's expense. Reports covering the following tests on each size of pipe shall be submitted for review:

a) Three-edge bearing: ASTM C497, indicating load required for the 0.25mm crack and for ultimate strength.

b) Absorption ASTM C497.

The three-edge bearing test is for proof of design only. It is not required that a test be made on pipe manufactured specifically for this contract. Reports covering tests made on other pipes of the same size, class, and design as specified herein, and manufactured from materials of equivalent type and quality, may be acceptable.

Source Quality Control Tests. Control tests shall be made during the manufacture of the pipe to determine strength and absorption. Control tests shall be made by an independent testing laboratory at the expense of the Contractor.

At the option of the Engineer, strength tests may be made on cores or standard concrete cylinders. A set of two cores or four cylinders shall be taken from each day's production and every time the concrete mix is changed. One-half of the samples shall be tested at 7 days or earlier to determine when the pipe has attained sufficient strength for delivery. The remainder shall be tested at 28 days.

Absorption tests shall be made on cores taken from the pipe barrel. Cores shall be made with a diamond drill and shall be not smaller than 50 mm in diameter. One core shall be tested from each of the first three lengths of pipe of each size and class. Thereafter, cores shall be tested from 5 percent of the pipe produced, but not less than one from each day's production.

Core holes shall be repaired by cementing a properly shaped concrete plug in place with epoxy cement or by other methods acceptable to the Engineer's Representative.

The Engineer reserves the right to require sampling and testing of any pipe after delivery and to reject all pipe represented by any sample which fails to comply with the specified requirement

Standard Products. Materials shall be standard products of a manufacturer regularly engaged in the manufacture of the products and essentially duplicate items that have been in satisfactory use for at least five years prior to bid opening

500.5 Submittals

500.5.1 Drawings and Data

Drawings, specifications, schedules, and other data showing complete details of the fabrication and construction together with complete data covering all materials proposed for use, shall be submitted by the Contractor in accordance with the requirement set forth in this specification. The drawings and data shall include, but shall not be limited to: data on reinforcement, details of joints, and details of fittings and specials.

500.6 Delivery, Storage and Handling

Delivery and Storage. Inspect materials delivered to site for damage; store with minimum of handling. Store rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes and fittings free of dirt and debris.

Handling. Handle pipe, fittings and accessories in a manner to ensure delivery to the trench in sound undamaged condition. Carry, do not drag pipe to the trench.

500.7 Inspection and Quality Control

500.7.1 Field Tests and Inspection

Field inspections and field tests shall be conducted as specified in this section. The Contractor shall perform all field tests and provide labor, equipment, and incidentals required for testing. The Contractor must be able to produce evidence, when required, that each item of work has been constructed properly in accordance with the Plans and Specifications

Materials shall be inspected and accepted as to the quality before they are installed. Piping installed in trenches shall first be inspected, tested and approved by the Engineer and before these are covered or backfilled. All defects/leaks disclosed by the water test shall be remedied to the satisfaction of the Engineer and any extra costs shall be at the expense of the Contractor.

500.7.2 Pipeline Testing

The Contractor shall check each straight run of pipeline for gross deficiencies by holding a light inside the manhole; it shall show a practically full circle of light through the pipeline when viewed from the adjoining end of line

500.7.3 Leakage Tests

Test Lines for leakage by either infiltration tests or exfiltration tests. Prior to testing for leakage, backfill trench to at least the lower half of pipe. When necessary to prevent pipeline movement during testing, place additional backfill around the pipe sufficient to prevent movement, but leaving joints uncovered to permit inspection. When the water table is 600 mm or more above top of pipe at upper end of pipeline section to be tested, measure infiltration using a suitable weir or other acceptable device. When the water table is less than 600 mm above top of pipe at upper end of pipeline section to be tested, make exfiltration test by filling the line to be tested with water so that the head will be at least 1.20 meters above top of pipe at upper end of pipeline section being tested. Allow filled pipeline to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, re- establish the head and measure amount of water needed to maintain this water level during a 2-hour test period. Amount of leakage, as measured by either infiltration or exfiltration test shall not exceed 47 liters per millimeter of diameter per day per kilometer of pipeline. When leakage exceeds the amount specified, make satisfactory correction and retest pipeline section in the same manner. Correct visible leaks regardless of leakage test results.

ITEM 501 – UNDERDRAINS

501.1 Description

This item shall consist of constructing underdrains, using pipe and granular filter materials, underdrain pipe outlets, and blind drains using granular material in accordance with this Specification and in reasonably close conformity with the lines and grades shown on the Plans or as established by the Engineer.

501.2 Material Requirements

Material shall meet the requirements specified in the following specifications:

Zinc coated (galvanized) corrugated iron or steel culverts and underdrains	AASHTO M 36
Extra strength and standard strength clay pipe and perforated clay pipe	AASHTO M 65
Perforated concrete pipe	AASHTO M 175
Porous concrete pipe	AASHTO M 176
Btuminized-fiber non-pressure sewer drain and underdrainage pipe systems	AASHTO M 177
Asbestos-cement perforated underdrain pipe	AASHTO M 189

Granular Backfill Filter Material – Granular backfill filter material shall be permeable and shall meet the requirements of AASHTO M 6, except that soundness tests will not be required and minor variation in grading and content of deleterious substances may be approved by the Engineer.

When the location of manufacturing plants allows, the plants will be inspected periodically by compliance with specified manufacturing methods, and material sample will be obtained for laboratory testing for compliance with material quality requirements. This shall be the basis for acceptance of manufacturing lots as to quality.

All material shall be subjected to inspection for acceptance as to condition at the latest practicable time.

501.3 Construction Requirements

501.3.1 Pipe Installation

Trenches shall be excavated to the dimensions and grades required by the Plans or as directed by the Engineer. A minimum of 150 mm bedding layer of granular backfill material shall be placed and compacted at the bottom of the trench for its full width and length.

Sub-drainage pipe of the type and size specified shall be embedded firmly in the bedding material.

Perforated pipe shall normally, be placed with the perforations down and the pipe sections shall be joined securely with the appropriate coupling fittings or bands.

Non-perforated pipe shall be laid with the bell end upgrade and with open joints wrapped with suitable material to permit entry of water, or unwrapped as may be specified. Upgrade end sections of all sub-drainage pipe installations shall be closed with suitable plugs to prevent entry of soil materials.

After the pipe installation has been inspected and approved, granular backfill material shall be placed to a height of 300 mm above the top of pipe. Care shall be taken not to displace the pipe or the covering at open joints. The remainder of the granular backfill material shall then be placed and compacted in 150 mm maximum layers to the required height. Any remaining portion of trench above the granular backfill shall be filled with either granular or impervious material, as may be specified, and thoroughly compacted.

501.3.2 Underdrain Outlets

Trenches for underdrain outlets shall be excavated to the width and depth shown on the Plans or as otherwise directed. Pipes shall be laid in the trench with all ends firmly joined by the applicable methods and means. After inspection and approval of the pipe installation, the trench shall be backfilled in accordance with Item 103, Structure Excavation.

501.3.3 Blind Drain

Trenches for blind drains shall be excavated to the width and depth shown on the Plans. The trench shall be filled with granular backfill material to the depth required by the Plans. Any remaining upper portion of trench shall be filled with either granular or impervious material in accordance with Item 103, Structure Excavation.

ITEM 502 - MANHOLES, INLETS AND CATCH BASINS

502.1 Description

This item shall consist of the construction, reconstruction or adjustment of manholes, inlets and catch basins/catchpits in accordance with this Specification and in reasonably close conformity with the lines and grades shown on the Plans or as established by the Engineer.

502.2 Material Requirements

Plain and reinforced concrete for these structures shall meet the requirements of Item 405 of DPWH Standard Specifications for Public Works and Highways, Volume II. Other materials shall meet the following specifications:

Corrugated Metal Units – The units shall conform to Plan dimensions and the metal to AASHTO M 36. Bituminous coating, when specified, shall conform to ASTM D1187, Asphalt-base Emulsion for use as Protective Coating for Metal.

Sewer and manhole brick (Made from clay or shale)	AASHTO M 91
Building brick (Solid masonry units made from clay or shale)	AASHTO M 114

Precast concrete pipe manhole rings shall conform to the requirements of ASTM C478. Unless otherwise specified, the risers and offset cone sections shall have an inside diameter of not less than 36 inches (90 cm) nor more than 48 inches (120 cm). There shall be a gasket between individual sections and sections cemented together with mortar on the inside of the manhole.

Brick shall conform to the requirements of ASTM C32, Grade MS.

Joint Mortar – Unless otherwise indicated on the Plans, joints mortar shall be composed of one part Portland Cement and two parts fine aggregate by volume to which hydrated lime has been added in an amount equal to 10 percent of the cement by weight. All materials for mortar shall meet the requirements of Item 405 of DPWH Standard Specifications for Public Works and Highways, Volume II.

Frames, Gratings, Covers – Metal units shall conform to the plan dimensions and to the following specification requirements for the designated materials.

Metal gratings and covers which are to rest on frames shall bear on them evenly. They shall be assembled before shipment and so marked that the same pieces may be reassembled readily in the same position when installed. Inaccuracy of bearings shall be corrected by machining, if necessary. A frame and a grating or cover to be used with it shall constitute one pair.

All castings shall be uniformly coated with asphalt-based emulsion meeting the requirements of ASTM D1187, Asphalt-base Emulsion for use as Protective Coating for Metal.

Samples of the material in casting shall be taken during the casting of the units and shall be separate casting poured from the same material as the casting they represent.

Gray iron casting	AASHTO M 105
Mild to medium-strength carbon steel castings for general application	AASHTO M 103
Structural steel	AASHTO M 183
Galvanizing, where specified for these units, shall conform to the requirements of	AASHTO M 111
Reinforcing Steel	AASHTO M 31

All castings or structural steel units shall conform to the dimensions shown on the plans and shall be designed to support the designed loadings specified.

Each frame and cover or grate unit shall be provided with fastening members to prevent it from being dislodged by traffic but which will allow easy removal for access to the structure.

All castings shall be thoroughly cleaned. After fabrication, structural steel units shall be galvanized to meet the requirements of ASTM A123.

Pre-cast Concrete Units - These units shall be cast in substantial permanent steel forms. Structural concrete used shall attain a minimum 28-day compressive strength of 20.682 MPa (3000 psi). The pre-cast units shall be cured in accordance with AASHTO M 171. Water absorption of individual cores taken from such units shall not exceed 7 percent. Additional reinforcement shall be provided as necessary to provide for handling of the pre-cast units.

A sufficient number of cylinders shall be cast from the concrete for each unit permit compression tests at 7, 14 and 28 days, and to allow for at least 3 cylinders for each test. If the strength requirement is met at 7 or 14 days, the units shall be certified for use 14 days from the date of casting. If the strength is not met at 28 days, all units made from that batch or load will be rejected.

Cracks in units, honeycombed or patched areas in excess of 2,000 square millimeters, excessive water absorption and failure to meet strength requirements shall be the causes for rejection. Pre-cast reinforced concrete manhole risers and tops shall conform to the requirements of AASHTO M199.

The plants will be inspected periodically for compliance with specified manufacturing methods, and material samples will be obtained for laboratory testing for compliance with material quality requirements. This may be the basis for acceptance of manufacturing lots as the quality.

All materials shall be subjected to inspection for acceptance as to condition at the latest practicable time the Engineer has the opportunity to check for compliance prior to or during incorporation of materials into the work.

Steps or Ladder Rungs - The steps or ladder bars shall be gray or malleable cast iron or galvanized steel. The steps shall be the size, length, and shape shown on the plans and those steps that are not galvanized shall be given a coat of bituminous paint, when directed.

502.3 Construction Requirements

Concrete Structures - Concrete construction shall conform to the requirements for Item 405, Structural Concrete of DPWH Standard Specifications for Public Works and Highways, Volume II. Concrete structures shall be built on prepared foundations, conforming to the dimensions and shape indicated on the Drawings. Any reinforcement shall be placed as indicated on the Drawings and shall be approved by the Engineer before concrete is placed. All invert channels shall be constructed and shaped accurately to be smooth, uniform and cause minimum resistance to flowing water. The interior bottom shall be sloped to the outlet.

Inlet and Outlet Pipes - Inlet and outlet pipes shall extend through the walls of the structures a sufficient distance beyond the outside surface to allow for connections. They shall be cut off flush with the wall on the inside surface of the structure, unless otherwise directed. For concrete or brick structures, mortar shall be placed around these pipes to form a tight, neat connection.

Placement and Treatment of Castings, Frames, and Fittings - All castings, frames, and fittings shall be placed in the positions indicated on the Plans and shall be set true to line and elevation. If frames or fittings are to be set in concrete or cement mortar, all anchors or bolts shall be in place before the concrete or mortar is placed. The unit shall not be disturbed until the mortar or concrete has set. When frames or fittings are placed on previously constructed masonry, the bearing surface of the masonry shall be brought true to line and grade and shall present an even bearing surface so the entire face or back of the unit will come in contact with the masonry. The unit shall be set in mortar beds and anchored to the masonry as indicated on the plans or as directed by the Engineer. All units shall set firm and secure. After the frames or fittings have been set in final position, the concrete or mortar shall be allowed to harden for seven (7) days before the grates or covers are placed and fastened down.

When grade adjustment or existing structures is specified, the frames, covers and gratings shall be removed and the walls reconstructed as required. The cleaned frames shall be reset at the required elevation. Upon completion, each structure shall be cleaned of any accumulation of silt, debris, or foreign matter of any kind and shall be kept clear of such accumulation until final acceptance of the work.

Excavation and backfill shall be done in accordance with Item 103, Structure Excavation.

When structures are located within the runway safety area, the elevation of the structures shall be set to meet the grading requirements of these areas. Structures shall not exceed 3 inches (75mm) above the elevation of the surrounding areas.

Manhole, inlet and catch basin chambers shall be watertight on completion. The base slab shall be placed on 75mm minimum thick blinding. The base slab, base and benching shall be constructed of in situ concrete, vibrated and carried up to 150mm above the socket of the highest incoming pipe or as otherwise detailed. Care shall be taken when pouring the base slab to ensure that the final positions of benching and chambers are considered. The horizontal surface of the benching shall be rendered to give a fall to the channel lip, and with a non-skid finish.

Where provision is to be made for future connections of pipes to the manholes, provision shall be made in accordance with the details shown on the Plans. Junction pipes for other connections shall be filled with temporary stoppers or seals and the position of all such junctions shall be clearly defined by means of stakes or tracing wires properly worked and labelled.

Precast Concrete Structures - Precast concrete structures shall conform to ASTM C478. Precast concrete structures shall be constructed on prepared or previously placed slab foundations conforming to the dimensions and locations shown on the plans. All precast concrete sections necessary to build a completed structure shall be furnished. The different sections shall fit together readily. Joints between precast concrete risers and tops shall be full-bedded in cement mortar and shall be smoothed to a uniform surface on both interior and exterior of the structure. The top of the upper precast concrete section shall be suitably formed and dimensioned to receive the metal frame and cover or grate, or other cap, as required. Provision shall be made for any connections for lateral pipe, including drops and leads that may be installed in the structure. The flow lines shall be smooth, uniform, and cause minimum resistance to flow. The metal steps that are embedded or built into the side walls shall be aligned and placed at vertical intervals of 12 inches (300 mm). When a metal ladder replaces the steps, it shall be securely fastened into position.

Installation of Steps - -The steps shall be installed as indicated on the Plans. When the steps are to be set in concrete, they shall be placed and secured in position before the concrete is placed. When the steps are installed in brick masonry, they shall be placed as the masonry is being built. The steps shall not be disturbed or used until the concrete or mortar has hardened for at least seven (7) days. After seven (7) days, the steps shall be cleaned and painted, unless they have been galvanized. When steps are required with precast concrete structures, they shall be cast into the side of the sections at the time the sections are manufactured or set in place after the structure is erected by drilling holes in the concrete and cementing the steps in place. When steps are required with corrugated metal structures, they shall be welded into aligned position at a vertical spacing of 12 inches (300 mm). Instead of steps, prefabricated ladders may be installed. For brick or concrete structures, the ladder shall be held in place by grouting the supports in drilled holes. For metal structures, the ladder shall be secured by welding the top support to the structure and grouting the bottom support into drilled holes in the foundation.

ITEM 503 - DRAINAGE STEEL GRATING WITH FRAME

503.1 Description

This item shall consist of furnishing all materials, tools, and equipment including labor required in undertaking the proper application of steel grating with frame as shown on the Plans and in accordance with this Specification or as established by the Engineer.

503.2 Classes and Uses of Road Grates and Frames

Classes of grates that are commonly use in drainage work are sump, trench and box.

Sump grates shall be used to create a trafficable ground level entry area for surface rainwater to flow into the underground stormwater drainage system. Sump grates shall be used in paved or grassed areas that are graded to direct the surface water to a single pit or to a series of pits. Sump grates shall be plain or hinged.

Trench grates shall be used to collect surface rainwater run-off from areas that cannot be graded to direct flow into a single pit.

Box grates or road drainage shall be used to transfer road surface storm water into an underground drainage system. Normally used in conjunction with kerb entry, the addition of the grate significantly increases the hydraulic capacity of the inlet, particularly on steep slopes.

503.3 Strength Classifications and the Loading Conditions for Sump, Trench and Box Grates

Class A – Test Load 10kN

For locations trafficked only by pedestrians, wheelchairs and cyclists – inaccessible to motor vehicles by virtue of barriers, narrow passages or stepped or unpaved approaches.

Class B – Test Load 80kN

For locations normally trafficked by pedestrians and slow moving passenger cars or light agricultural tractors. These locations include areas accessible to infrequent slow moving heavy trucks. Typical locations include footpaths, ground level and multistoried car parks, suburban driveways and back yards.

Class C – Test Load 150kN

For locations trafficked by slow moving fully laden trucks such as pedestrians, malls and industrial or commercial areas.

Class D – Test Load 210kN

For locations trafficked by fast moving fully laden trucks and forklifts with wheel loads to 5.0T. This includes all public roads from residential to freeway.

Class E, F or G – Test Load 400kN, 600kN or 900kN

For locations subject to vehicles such as large forklifts, earthmoving or container handling equipment and aircraft. Typical locations include wharves, container storage areas, heavy industry or construction sites and domestic or international airports.

All loading conditions specified above are applicable to the three classes of grates depending on their specific uses and locations.

503.4 Materials Requirement

503.4.1 Steel Grating

The steel grating shall be made of fabricated mild steel provided with hot dip galvanized in accordance with ASTM A153/AASHTO M232 for superior corrosion protection. Steel grating shall be machine-made grating comprised of steel flat bars standing on edge equi-spaced from each other. To prevent them from falling over and to provide restraint in buckling, a twisted cross rod (6mm) is forge-welded1 into the top of the flat bars.

503.4.2 Steel Frame

The steel frame clear openings of drainage grates shall be 15mm larger than nominal sizes of industry standard sized pits. These pits increase in size in increments of 150mm. This shall be done to allow frames to be placed over standard panel formwork and cast in while pouring the pit walls, to speeds up installation and ensure the frame is fully embedded in the concrete.

503.4.3 Drainage Grate Sizes

The drainage grates shall be identified by their internal clear opening dimensions of the frame. For square and rectangular grates, the normal convention shall be the width x length. Metal units shall conform to the approved plan dimensions and specifications requirement for the designated materials.

Grates shall consist of 25mm to 65mm x 3mm, 4.5mm or 5mm thick flat bars with length of not more than 6.1m spaced at 30mm o.c. with 6mm twisted rod spaced at 100mm o.c.. Angular frame (L 75mm x 75mm x 9mm thick) shall be coated with hot dipped galvanized for superior corrosion protection finish and extended life. If required, I-Beam support shall be provided in the grates in accordance with the approved plan. It shall also conform to the requirements of ASTM A153 or its equivalents AASHTO M232.

503.4.4 The metal unit shall conform to ASTM A36 / AASHTO M183.

Dimension Tolerances	Thickness	+/- 0.20mm
	Width	+/- 080m
	Length	+50mm / NIL
	Straightness	6mm in each 1.5m length

503.4.5 Joint Mortar

Unless otherwise indicated on the Plans, joint mortar shall be composed of one part Portland Cement and two parts fine aggregate by volume to which hydrated lime has been added in an amount equal to 10 percent of the cement by weight. All materials for mortar shall meet the requirements of Item 405 of DPWH Standard Specifications for Public Works and Highways, Volume II. Structural concrete used shall attain a minimum 28-day compressive strength of 20.682 MPa (3000 psi).

503.5 Construction Requirements

Concrete construction shall conform to the requirements of Item 405 of DPWH Standard Specifications for Public Works and Highways, Volume II.

Metal gratings which are to rest on frames shall bear on them evenly. They shall be assembled before shipment and so marked that the same pieces may be reassembled readily in the same position when installed. Inaccuracy of bearings shall be corrected by machining, if necessary. The steel grating and its corresponding frame shall constitute one pair.

If frames or fittings are to be set in concrete or cement mortar, all anchors or bolts shall be in place before the concrete or mortar is placed. The unit shall not be disturbed until the mortar or concrete has set.

When grade adjustment or existing drainage grates is specified, the frames and steel gratings shall be removed and the walls shall be reconstructed as required. The cleaned frames shall be reset at the required elevation. Upon completion, each drainage grates shall be cleaned of any accumulations of silt, debris, or foreign matter of any kind and shall be kept clear of such accumulation until final acceptance of the work.

When frames or fittings are placed on previously constructed masonry, the bearing surface of the masonry shall be brought true to line and grade and shall present an even bearing surface so the entire face or back of the unit will come in contact with the masonry. The unit shall be set in mortar beds and anchored to the masonry as indicated on the plans or as directed by the Contractor. All units shall set firm and secure.

After the frames or fittings have been set in final position, the concrete or mortar shall be allowed to harden for seven (7) days before the grates or covers are placed and fastened down.

Excavation and backfill shall be done in accordance with Item 102, Excavation.

503.6 Acceptance Requirement

The steel grating plants will be inspected periodically for compliance with specified manufacturing and fabricating methods and bars samples will be obtained for laboratory testing for compliance with material quality requirements.

All draining grates materials shall be subjected to inspection for acceptance as to condition at the latest practicable time the Engineer has the opportunity to check for compliance prior to or during incorporation of materials into the work.

ITEM 504 - CLEANING AND RECONDITIONING EXISTING DRAINAGE STRUCTURES

504.1 Description

This item shall consist of cleaning and reconditioning existing pipes and appurtenant structures in reasonably close conformity with this Specification and as shown on the Plans.

504.2 Material Requirements

Materials used for repair or replacement under the various Pay Items shall conform the requirements of the applicable Items of this Specification.

504.3 Construction Requirements

Pipe Removed and Cleaned – The pipe shall be carefully removed and cleaned of foreign material both within the barrel and at the jointed ends.

Pipe Cleaned in Place – All foreign materials within the barrel shall be removed and disposed by methods which will prevent damage to the pipe.

If approved by the Engineer, all or part of the pipe designated to be cleaned in place may be removed, cleaned, and re-laid in accordance with the applicable Items. In such cases, the Contractor shall furnish all materials required to replace damaged pipes and joints, perform all excavation and backfill, and re-lay the pipe, all at the contract bid price for this Item.

Re-laying or Stockpiling Salvaged Pipe - Relaying of pipe selected by the Engineer to be removed and cleaned shall be done as shown on the Plans, in accordance with the appropriate Item for the kind of pipe involved. The Contractor shall furnish all jointing materials and shall replace the pipe broken by him, in sufficient lengths to complete the designated length to be relaid without added compensation. Salvaged pipe to be stockpiled shall be placed as shown on the Plans and as directed by the Engineer. No pipe which has sustained structural damage shall be placed in stockpiles. The Contractor shall dispose such damaged pipes at the approved location.

Reconditioning Drainage Structures – Structures such as manholes, inlets, and the likes, designated on the Plans or as directed by the Engineer to be reconditioned shall have all debris removed, leaks repaired, missing or broken metalwork replaced, and each structure left in operating condition.

ITEM 512 - SLOTTED DRAINS

512.1 Description

This item shall consist of the construction of steel slotted drains, cast iron slotted vane drains or concrete slotted drains in accordance with these specifications and in reasonably close conformity with the lines and grades shown on the Plans or as established by the Engineer. Typical details shall be shown on the Plans.

512.2 Material Requirements

All slotted drains shall meet the requirements shown on the Plans and specified below. All slotted drains shall meet specified hydraulic design requirements and shall support the loadings specified on the Plans.

Material shall also meet the requirements specified in the AASHTO-AGC-ARTBA Task Force 13 Report – A Guide to Standardized Highway Drainage Products.

512.2.1 Pipe

Steel slotted drain - Pipe shall be metallic coated (galvanized or aluminized type 2) corrugated steel type I meeting the requirements of ASTM A760. Pipe diameter and gauge shall be as shown on the Plans. The corrugated steel pipe shall have a minimum of two rerolled annular ends.

Cast iron slotted vane drain - Polyvinyl Chloride (PVC) pipe shall meet the requirements of ASTM D3034. Pipe diameter shall be as shown on the Plans. The pipe shall have an open slot to accept the cast iron slotted vane drain castings.

512.2.2 Grates and Castings

Steel slotted drain - Grates shall be manufactured from ASTM A36 Grade 36 steel. Spacers and bearing bars (sides) shall be 3/16 inch (5 mm) material. The spacers shall be welded to each bearing bar with four 1-1/4 inch long by 3/16 inch wide (32 mm long by 5 mm wide) fillet welds on each side of the bearing bar at spacings not exceeding 6 inches (150 mm). The grates shall be 6 inches (150 mm) high or as shown on the Plans and shall have a maximum 1-3/4 inch (45 mm) opening in the top.

Grates shall be galvanized in accordance with ASTM A123 except with a 2 ounce /square feet (0.61 kg/sq m) galvanized coating.

The grates shall be fillet welded to the corrugated steel pipe with a minimum weld one inch (25 mm) long on each side of the grate at every other corrugation. Weld areas and the heat affected zones where the slot is welded to the corrugated pipe shall be thoroughly cleaned and painted with a zinc-rich paint in accordance with repair of damaged coatings in ASTM A760.

Each 20-foot (6.1-m) length of drain delivered to the job site shall be within the following tolerances: vertical bow ±3/8 inch (9 mm), horizontal bow ±5/8 inch (16 mm), twist ±1/2 inch (12 mm).

Cast iron slotted vane drain - Castings shall meet the requirements of ASTM A48, Class 35B gray iron. Castings shall be furnished with no coatings.

Castings shall be designed to fit on open slots in 15 inch (38 cm) PVC pipe. Casting sections shall not exceed 3 feet (1 m) in length. Casting sections shall have a built- in vane configuration with bar spacings not exceeding 6 inches (150 mm). The opening at the surface shall not exceed 3-3/4 inch (95 mm), and the vane shall be constructed on a radius so that the opening shall be less than 1-1/2 inch (38 mm) at a depth of 1-1/2 inch (38 mm) as measured vertically from the surface. Casting sections shall integrally lock into the concrete by use of top and bottoms flanges and shear tabs. Castings shall accept bolts for bolting sections together and shall accept wire for fitting to pipe.

512.2.3 Concrete

Steel slotted drain – Concrete shall have a minimum compressive strength of 1,000 psi (6.9 MPa) at 28 days when tested in accordance with ASTM C39.

Cast iron slotted vane drain - Concrete shall have a minimum compressive strength of 3,000 psi (20.7 MPa) at 28-days when tested in accordance with ASTM C39.

Concrete - Plain or reinforced concrete used shall conform to the requirements of Item 405 of DPWH Standard Specification for Public Work and Highways, Volume II.

512.3 Construction Requirements

512.3.1 Excavation

The width of the trench shall be sufficient to permit satisfactory installation and jointing of the slotted drain and placing of a high slump concrete backfill material under and around the drain, but shall not be less than the external pipe diameter plus 6 inches (150 mm) on each side. The depth of the trench shall be a minimum of 2 inches (50 mm) below the invert for steel slotted drain and 6 inches (150 mm) below the invert for a cast iron slotted vane drain. The trench may be roughly shaped to the slotted drain bed.

512.3.2 Installation

Steel slotted drain shall be laid in sections joined firmly together with coupling bands, or as shown on the Plans. Cast iron drains shall be wired to the top of the PVC pipe in the slot cut to receive the castings. The top of all drains shall be held firmly in place to the proper grade, to preclude movement during the backfilling operation.

512.3.3 Joining

Slotted steel drain joints shall be firmly joined by modified hugger type bands, or as indicated, to secure the pipe and prevent infiltration of the backfill. When the slotted steel drain is banded together, the adjacent grates shall have a maximum 3 inch (75 mm) gap. Cast iron drain castings shall be bolted together.

512.3.4 Backfilling

Slotted drains shall be inspected before any backfill is placed. Damaged drains shall be aligned or replaced at the expense of the Contractor.

The trench holding the slotted drain assembly shall be backfilled with concrete that will easily flow under and around the drain and the trench wall. The opening in the top of grates and castings shall be covered to prevent unwanted material from entering the drain during the backfilling and subsequent surfacing operations.

ITEM 513 - EXTERIOR SANITARY SEWER SYSTEM

513.1 General

513.1.1 Scope

This Item consists of construction of exterior sanitary sewer system and includes but not limited to pipes, valves, fittings, manholes and appurtenances in accordance with these specifications and in reasonably close conformity with the lines and grades shown on the Plans or as established by the Engineer.

513.1.2 References

International Standard Organization (ISO)

ISO 2505/2507/2508	uPVC Gravity Sewer Pipes Test Properties
ISO 3472/3473 /3504	uPVC Gravity Sewer Pipes
ISO 3633	uPVC Fittings
ISO 161/3606/3633	Basic Dimensions & Tolerances of PVC Gravity Pipes
ISO 4435	Gravity Sewer Pipes

American Society for Testing & Materials (ASTM)

ASTM D2729/D1784	Class 12454B or 12454C Nonperforated uPVC Pipes

513.1.3 General Requirements

The Contractor shall provide sanitary sewer pipelines, fittings, appurtenances, equipment and accessories complete and operational. Pipe, fittings, appurtenances, equipment and accessories shall be new and unused unless otherwise approved by the Engineer. Excavation, trenching and backfilling for piping and related appurtenances shall be in accordance with the requirements of Item 102 and Item 500.3 of this Specification.

513.1.4 Submittals

Shop Drawings - Indicate dimensions, sizes, materials, and placement of openings and holes for sewer manholes.

Product Data - Submit data on pipe materials, fittings, and accessories. Provide manufacturers catalogue information. Provide component sizes, rough-in requirements, service sizes and finishes. Provide connection requirements.

Manufacturer's Installation Instructions - Submit installation instructions for all materials and plant.

Manufacturer's Certificate - Certify that products meet or exceed specified National Building Code, National Plumbing Code of the Philippines and other local government requirements.

513.1.5 Delivery, Storage and Handling

Protect piping systems from entry of foreign materials by providing temporary cover, completing sections of the work and isolating parts of completed system

513.2 Material Requirements

513.2.1 Gravity Sewer and Vent Pipe

Pipes and Fittings - Unless otherwise designated on Plans, all underground gravity sewer and vent pipes shall be uPVC pipes and shall comply with the following requirements:

a) For sanitary uPVC pipes and fittings of outside diameters 57mm up to 160mm shall conform to AASHTO M278 or AASHTO M 304 or ASTM D2729.
b) For uPVC pipes and fittings of outside diameter 160mm and up shall conform to ISO 4435.

Jointing and Joint Materials for uPVC Pipes –All PVC pipe joints shall be gasketed, bell-and-spigot, push-on type conforming to ASTM D 3212. Since each pipe manufacturer has a different design for push-on joints, gaskets shall be part of a complete pipe section and purchased as such. Gaskets maybe factory installed or field installed as recommended by the pipe manufacturer

Gaskets – Gaskets for PVC pipes shall be elastomeric and shall comply with ASTM F 477.

The joints in the PVC pipes shall be secured with “O” ring or solvent cement. The solvent cement for securing PVC joints shall comply with ASTM D 2564.

513.2.2 Sewer Manholes

Formed Bottom Manholes: ASTM C478, ASTM C478M; cast in place concrete masonry units laid on cast-in-place reinforced concrete foundation pad as specified. Unless otherwise specified, the risers and offset cone sections shall have an inside diameter of not less than 36 inches (90 cm) nor more than 48 inches (120 cm). There shall be a gasket between individual sections and sections cemented together with mortar on the inside of the manhole.

Brick shall conform to the requirements of ASTM C32, Grade MS.

Mortar shall consist of one part Portland cement and two parts sand. The Portland cement shall conform to the requirements of ASTM C150, Type I. The sand shall conform to the requirements of ASTM C144.

Concrete. Plain and reinforced concrete used in structures, connections of pipes with structures, and the support of structures or frames shall conform to the requirements of Item 405 Structural Concrete of DPWH Standard Specifications for Public Works and Highways, Volume II.

Cover: Standard cast iron with minimum sized pick hole, and frame. Use heavy duty cover and frame in vehicular traffic areas and shall comply with Item 502.2 of this specification.

Steps: stainless steel bar at 300 mm on centers as specified on the Plans. Installation shall comply with Item 502.3 of this specification.

513.2.3 Grease Traps

Grease trap shall be cast-in place concrete structure complying with the requirements of the local Municipal Sewage Authority. Construction shall be in accordance with these specifications, at the specified locations and conforming to the lines, grades, and dimensions shown on the Plans or as required by the Engineer.

Concrete and shall be constructed in accordance with the Plans and Specifications on Concrete Work, Item 405 of DPWH Standard Specifications for Public Works and Highways, Volume II.

513.2.4 Oil-Water Separator

Oil-water separator shall be cast-in place concrete structure complying with requirements of American Petroleum Institute (API) Publication 421 and the local Municipal Sewage Authority. Construction shall be in accordance with these specifications, at the specified locations and conforming to the lines, grades, and dimensions shown on the Plans or required by the Engineer.

Concrete and shall be constructed in accordance with the Plans and Specifications on Concrete Work, Item 405 of DPWH Standard Specifications for Public Works and Highways, Volume II.

513.3 Construction Requirements

513.3.1 Pipe Laying and Installation

Pipe laying and installation of PVC sewers shall be in accordance with ASTM D2321 and pipe manufacturer's recommendation. Testing of joints for gravity PVC sewers shall be in accordance with ASTM D3212.

Bedding Material for PVC Pipes - The bedding material for PVC pipes shall consist of coarse sands and gravels with a maximum particle size of 3/4 inches (19 mm). For pipes installed under paved areas, no more than 12% of the material shall pass the No. 200 (0.075 mm) sieve. For all other areas, no more than 50% of the material shall pass the No. 200 (0.075 mm) sieve. The bedding shall have a thickness of at least 6 inches (150 mm) below the bottom of the pipe and extend up around the pipe for a depth of not less than 50% of the pipe's vertical outside diameter.

Backfilling For PVC Pipes - The backfill shall be placed in two stages; first to the top of the pipe and then at least 12 inches (300 mm) over the top of the pipe. The backfill material shall meet the requirements of Item 500.3.6 of this specification. Bedding and other construction requirements for gravity sewers shall be in accordance with Item 500.3 of this specifications.

513.3.2 Sewerage Structures

Sewer manholes – Construct the precast concrete sewer manhole to the lines, dimensions and grades required as indicated on Plans and in accordance with Item 502.3 of this specification.

Cast-in Place Sewerage Structures – Construct cast-in place sewerage structures to the lines, dimensions and grades required as indicated on Plans and in accordance with Item 502.3 of this specification.

PART H – MISCELLANEOUS STRUCTURES

ITEM 600 - CURB AND GUTTER

600.1 Description

This Item shall consist of the construction of curb and gutter either Precast or Cast in place, made of concrete in accordance with this Specification at the location, and in conformity with the lines, grades, dimensions and design, as required by the Engineer.

600.2 Material Requirements

600.2.1 Material for Bed Course

Bed course materials as shown on the Plans shall consist of cinders, sand, slag, gravel, crushed stone, or other approved porous material of such grading that all the particles will pass through 12.5 mm (1/2 inch) sieve.

600.2.2 Concrete

Concrete shall be of the class indicated on the Plans and shall conform to the requirements of Item 405, Structural Concrete of Standard Specification for Public Work and Highways, Vol II.

600.2.3 Expansion Joint Filler

Expansion joint filler shall conform to the requirements of AASHTO M153/ Item 705.

600.2.4 Cement Mortar

Cement mortar shall consist of one part of Portland cement and two parts of fine aggregates with water added as necessary to obtain the required consistency. The mortar shall be used within 30 minutes of preparation.

600.2.5 Bonding Compound

Where bonding compound is used, it shall conform to AASHTO M200.

600.3 Construction Requirements

600.3.1 Bedding

Excavation shall be made to the required depth and the base upon which the curb and/or gutter is to be set shall be compacted to a firm and even surface. All soft and unsuitable material shall be removed and replaced with suitable material.

Bed course material shall be placed and compacted to form a bed of the required thickness as shown on the Plans.

600.3.2 Cast in Place Curb and Gutter

600.3.2.1 Placing

Forms shall conform to the requirements of Item 407 of DPWH Standard Specification for Public Work and Highways, Vol II. Metal forms shall be of an approved section.

Forms to hold the concrete shall be built and set-in-place as described in Item 407 of DPWH Standard Specification for Public Work and Highways, Vol II. Forms for at least 50 m of curb and gutter shall be in-place and checked for alignment and grade before concrete is placed. Curbs and gutters constructed on curves shall have forms of either wood or metal and they shall be accurately shaped to the curvature shown on the Plans.

Mixing, placing, finishing and curing of concrete shall conform to the requirements of Item 405 of DPWH Standard Specification for Public Work and Highways, Vol II, as modified by the requirements below.

The concrete shall be placed in the forms in layers of 100 or 125 mm each, and to the depth required. It shall be tamped and spaded until mortar entirely covers the top and surfaces of the forms. The top of the concrete shall be finished to a smooth and even surface and the edges rounded to the radii shown on the Plans. Before the concrete is given the final finishing, the surface of the gutter shall be tested with a 3-m straight-edge and any irregularities of more than 10 mm in 3 m shall be corrected.

The curb and gutter shall be constructed in uniform sections of not more than 50 m in length except where shorter sections are required to coincide with the location of weakened planes or contraction joints of the concrete pavement, or for closures, but no section shall be less than 2 m long. The sections shall be separated by sheet templates set perpendicular to the face and top of the curb and gutter. The templates shall be approximately 5 mm in thickness and of the same width as that of the curb and/or gutter and not less than 50 mm deeper than the depth of the curb and/or gutter. Templates shall be set carefully and held firmly during the placing of the concrete and shall remain in place until the concrete has set sufficiently to hold its shape but shall be removed while the forms are still in place. A preformed joint filler approved by the Engineer may be used in lieu of the sheet template mentioned above. In this event the fiber board shall be pre-cut to the shape of the curb so that its outer edge will be flushed with the abutting curb and/or gutter.

Expansion joints shall be formed at intervals shown on the Plans. Where a curb is placed next to a concrete pavement, expansion joints in the curb shall be located opposite expansion joints in the pavement.

The form shall be removed within 24 hours after the concrete has been placed. Minor defects shall be repaired with mortar containing one part of Portland Cement and two parts of fine aggregate. Plastering shall not be permitted and all rejected portions shall be removed and replaced at the Contractor's expense. The exposed surface shall be finished while the concrete is still fresh by rubbing the surfaces with a wetted soft brick or wood until they are smooth. The surfaces shall be wetted thoroughly, either by dipping the brick or wood in water, or by throwing water on the surfaces with a brush. After the concrete has been rubbed smooth using water, it shall then be rubbed with a thin grout containing one part of Portland Cement and one part of fine aggregates. Rubbing with grout shall continue until uniform color is produced. When completed, the concrete shall be covered with suitable material and kept moist for a period of 3 days, or a membrane-forming material may be applied as provided in Item 405 of DPWH Standard Specification for Public Work and Highways, Vol II. The concrete shall be suitably protected from the weather until thoroughly hardened.

After the concrete has set sufficiently, the spaces on the back of the curb which were excavated for placing the curb shall be refilled to the required elevation with suitable material which shall be tamped in layers of not more than 150 mm until consolidated.

600.3.3 Precast Curb and Gutter

600.3.3.1 Placing

The precast concrete curb and gutter shall be set in 20mm of cement mortar as specified in Subsection 600.2.4 to the line level and grade as shown on the approved Plans.

The precast curb shall not be more than 20 cm in width at the top portion and not be more than 25cm at the base. The precast curb and gutter shall be 1.0 m in length and shall be put side by side consecutively with joint in between.

Joints between consecutive curb and gutter shall be filled with cement mortar to the full section of the curb and gutter. Expansion joints shall be formed at intervals shown on the Plans. Where a curb and gutter is placed next to a concrete pavement, expansion joints in the curb and gutter shall be located opposite expansion joints in the pavement.

Minor defects shall be repaired with mortar containing one part of Portland Cement and two parts of fine aggregates. Plastering shall not be permitted and all rejected portions shall be removed and replaced at the Contractor's expense. The exposed surface shall be finished by rubbing the surfaces with a wetted soft brick or wood until they are smooth. The surfaces shall be wetted thoroughly, either by dipping the brick or wood in water, or by throwing water on the surfaces with a brush. After the concrete has been rubbed smooth using water, it shall then be rubbed with a thin grout containing one part of Portland Cement and one part of fine aggregate. Rubbing with grout shall continue until uniform color is produced.

600.3.3.2 Handling Precast Curb and Gutter

1. In preparation for the handling of precast curb and gutter, all fabricated curb and gutter of one (1) meter in length shall be provided or inserted with 2-1”Ø PVC pipes for fitting at their required locations. The PVC pipes shall be placed 25 mm from both edge during the fresh concrete is in plastic state.

2. Precast curb and gutter shall be lifted on upright position and not at the points of support and shall be the same during transporting and storage.

3. Extreme care shall be exercised in handling and moving precast curb and gutter to avoid cracking.

4. No precast curb and gutter shall be used that does not reach its final position in the forms with the required time stipulated prior to installation.

5. Precast curb and gutter shall be transferred to the construction site. Fresh curb and gutter shall not be placed against in-situ concrete which has been in a position for more than 30 minutes.

6. Precast curb and gutter may only be transported to the delivery point in truck agitators or truck mixer operating at the speed designated by the manufacturer of the equipment, provided that the consistency and workability of the mix concrete upon discharge at the delivery point is suitable for adequate placement.

ITEM 606 - PAVEMENT MARKINGS

606.1 Description

This item shall consist of placing markings on the finished pavement (exclude Airside Pavement Marking. Airside pavement marking shall refer to item 620). The work shall include the furnishing of premixed reflectorized traffic paint or reflectorized pavement marking paint conforming to the requirements of AASHTO M248, whichever is called for in the Contract, sampling and packing, preparing the surface, and applying the paint to the pavement surface, all in accordance with this Specification.

The paint shall be applied to the size, shape and location of the markings as required by the Engineer.

606.2 Premixed Reflectorized Traffic Paints

Premixed reflectorized traffic paint is a paint in which the glass beads are mixed in the paint during the process of manufacture, so that upon application and drying, the paint line is capable of retroreflection of the light beams.

Premixed reflectorized traffic paints which are available in both white and yellow are paints that provide reflective marking for concrete, bituminous, bricks or stone surface of highways, bridges, tunnels, streets, parking lots and airports.

606.2.1 Classification

Premixed reflectorized traffic paint shall be classified according to the following types based on the vehicles used:

Type I – Alkyd

Type II – Chlorinated Rubber Alkyd

606.2.2 Material Requirements

The paint shall consist of pigments, vehicles and glass beads so combined as to produce a paint that will conform to the following requirements.

a. Condition in container – The packaged material shall be free from lumps and mixed readily to a smooth homogenous state.

b. Skinning – The packaged material shall not skin within 48 hours in a ¾ filled, tightly closed container.

c. Appearance of Dried Film – The paint film shall dry to a smooth uniform finish.

d. Flexibility – The dried paint film shall not show cracking or flaking after being bent about 180 degrees over a 12.7 mm mandrel.

e. Resistance to Water – The dried paint film shall not show blistering, peeling, wrinkling and discoloration when immersed in water for 18 hours.

f. The paint shall also conform to the physical properties specified in Table 606.1.

Table 606.1 – Physical Properties

Properties	Type I and Type II	
	Minimum	Maximum
Specific Gravity	1.5	-
Drying Time, No Pick Up,		
Minutes	-	40
Consistency (Kreb Units) at 20 C	65	95

g. Premixed reflectorized traffic paint composition shall conform to the requirements given in Table 606.2.

Table 606.2 – Composition Requirements

Paint Composition	Requirements			
	Type I		Type II	
	Minimum	Maximum	Minimum	Maximum
Total Dry Solids, percent By weight	60	-	60	-
Titanium Dioxide, Rutile Percent by weight	16.0	-	16.0	-
Medium Chrome Yellow, Percent by weight	12.0	-	12.0	-
Extenders, percent by wt., White Yellow	 -	 13.0 17.0	 - -	 13.0 17.0
Non-volatile Content (based on the vehicle) percent by weight	40	-	41	-
Glass Beads, percent by Weight	31.0	35.0	31.0	35.0

h. Glass Spheres or Beads Requirements:

Quantity: The amount of glass beads to be mixed with the paint shall be 500 grams per liter of paint.

Beads Diameter: The percentage of beads that will pass through the US Standard Sieves shall be as follows:

Sieve No. (um)	Mass Percent Passing
70 (212 – um) – 0.850	100
80 (186 – um) – 0.600	85-100
140 (106 – um) – 0.300	15-55
230 (63 – um) – 0.150	0-10

Index of Refraction: The index of refraction of the beads shall be within the range of 1.50 to 1.60 when tested by the liquid immersion method at 29oC.

Appearance: The glass beads shall be transparent, colorless and the sum of particles that are fused, plane, angular and colored and contains bubble shall not exceed 20 percent

606.2.3 Construction Requirements

The painting of lane markers and traffic strips shall include the cleaning of the pavement surfaces, the application, protection and drying of the paint coatings, the protection of pedestrians, vehicular or other traffic, the protection of all parts of the road structure and its appurtenances against disfigurement by spatters, splashes or smirches of paints or of paint materials, and the supplying of all tools, labor and traffic paint necessary for the entire work.

The paint shall not be applied during rain or wet weather or when the air is misty, or when in the opinion of the Engineer, conditions are unfavorable for the work. Paint shall not be applied upon damp pavement surfaces, or upon pavement which has absorbed heat sufficient to cause the paint to blister and produce a porous film of paint.

The application of paint shall preferably be carried out by a machine specially made for this purpose but where brushes are used, only round or oval brushes not exceeding 100 mm in width will be permitted. The paint shall be so applied as to produce a uniform, even coating in close contact with the surface being painted.

Traffic paint shall be applied to the pavement at the rate of 0.33 L /m2 and shall dry sufficiently to be free from cracking in from 15 to 30 minutes.

All markings shall present a clean cut, uniform and workmanlike appearance. Markings that fail to have a uniform, satisfactory appearance either by day or night, shall be corrected by the Contractor in a manner acceptable to the Engineer and at no cost to the Government.

606.2.4 Sampling

The paint shall be sampled in accordance with PNS484/ISO1512 or other Philippine Standard Method of Sampling Paints and Varnishes.

606.2.5 Test Methods

The paints shall be tested in accordance with the methods specified in PNS 461 or other Philippine Standard Method of Tests for Paints and Varnishes.

606.2.6 Packing, Packaging and Marking

The paints shall be packed, packaged and marked in accordance with PNS 140.

ITEM 608 – TOPSOIL

608.1 Description

This Item shall consist of topsoil furnished, transported and spread, or topsoil removed from designated areas, hauled and spread, in accordance with this Specification at the location shown on airfield drawing package or as required by the Engineer.

608.2 Material Requirements

Topsoil furnished shall consist of fertile friable soil of loamy character without admixture of undesirable subsoil, refuse or foreign materials. It shall be obtained from well-drained arable land and shall be reasonably free from roots, hard clay, coarse gravel, stones, coarse sand, noxious seeds, sticks, brush, litter and other deleterious substances. Topsoil shall be capable of sustaining healthy plant life and shall be subject to the approval of the Engineer.

Topsoil shall contain not less than five (5) percent organic matter as determined by loss or ignition of samples oven-dried to constant weight.

608.3 Construction Requirements

608.3.1 Sources of Material

Topsoil shall be obtained as specified in Item 102, Excavation, or from other approved sources. The Sub-contractor shall notify the Engineer at least five days before he intends to start topsoil stripping operations. After inspection and approval by the Engineer and prior to stripping any topsoil, the Contractor shall remove noxious weeds and tall grass, brush roots and stones larger than 50 mm in diameter.

608.3.2 Placing

The topsoil shall be evenly spread on the areas and to the line and level shown on the Plans and compacted with a light roller to a depth of not less than 100 mm. Spreading shall not be done when the ground topsoil is excessively wet, or otherwise in a condition detrimental to such work. The roadway surfaces shall be kept clean during hauling and spreading operations.

After spreading has been completed, large clods, stones, roots, stumps and other loose-lying materials shall be raked up and removed. Any erosion, irregularities of grade or other incidental damage to the surface of the topsoil shall be repaired and/or restored to the Engineer's satisfaction.

ITEM 620 - TAXIWAY AND APRON MARKING

620.1 Description

This item shall consist of the preparation and painting of numbers, markings, and stripes on the surface of taxiways and aprons, in accordance with these specifications and at the locations shown on the airfield drawing package, or as directed by the Engineer:

The scope of works also include removing existing marking present within the marking boundary shown on airfield drawing package. The Contractor shall confirm the extent of removal with the Engineer prior to the initial application of markings.

The terms “paint” and “marking material” as well as “painting” and “application of markings” are interchangeable throughout this specification.

620.2 Materials Acceptance

The Contractor shall furnish manufacturer’s certified test reports for materials shipped to the project. The certified test reports shall include a statement that the materials meet the specification requirements. The reports can be used for material acceptance or the Engineer may perform verification testing. The reports shall not be interpreted as a basis for measurement. The Contractor shall notify the Engineer upon arrival of a shipment of materials to the site. All material shall arrive in sealed containers 55 gallons or smaller for inspection by the Engineer. Material shall not be loaded into the equipment until inspected by the Engineer.

620.3 Materials

Paint shall be in accordance with the requirements this section. The colours and paints for the markings shall be conformed to ICAO Annex 14 Volume 1 Appendix 1 Section 3 Specifications, or Alternatively The Australian Standard AS2700-1996, entitled “Colour standards for general purposes” in accordance with the follow:

1. Yellow – AS2700-1966 Y14 – Stand lead in lines, stop bars, nose wheel markings, and stand designators. Markings shall be painted with two coats of traffic line.

2. Red – AS2700-1966 R13- Hatched box markings at interstand clearways, tug boxes, fuel hydrant points and wing tip clearance lines. Markings shall be painted with two coats.

3. Yellow – AS2700-1966 Y14 – Taxi lane and taxiway centerlines. Markings shall be painted with two coats of NCA – High opacity airport line markings.

4. Black – AS2700-1966 N61 – Contrasting black surround. The width of surround colour must ensure an adequate visibility contrast. The width of surround on either side of the marking must not be less than half the line width.

620.4 Construction Methods

Markings shall be installed in accordance with manufacturer's instructions and each coat shall comply with the manufacturers recommended dry file thickness.

All markings shall be accurately set out prior to the application of the paint markings stop bar locations to be confirmed by the Engineer.

The surface of the pavement shall be thoroughly swept and cleaned before application of the paint. Immediately before application of the paint, the surface shall be dry and free from dirt, grease, oil, laitance, or other foreign material that would reduce the bond between the paint and the pavement.

Use of any chemicals or impact abrasives during surface preparation shall be approved in advance by the Engineer. After the cleaning operations, sweeping, blowing, or rinsing with pressurized water shall be performed to ensure the surface is clean and free of grit or other debris left from the cleaning process.

The painting shall be performed only when the surface is dry and when the surface temperature is at least 45°F (7°C) and rising and the pavement surface temperature is at least 5°F (2.7°C) above the dew point or meets the manufacturer's recommendations. Markings shall not be applied when the wind speed exceeds 10 mph unless windscreens are used to shroud the material guns.

At least 24 hours prior to remarking existing markings, the existing markings must be removed such that 90% of the existing markings are removed with low (3,500-10,000 psi) water blaster. After water blasting, the surface shall be cleaned of all residue or debris either with sweeping or blowing with compressed air or both.

Prior to the initial application of markings, the Contractor shall certify in writing that the surface has been prepared in accordance with the paint manufacturer's requirements, that the application equipment is appropriate for the type of marking paint and that environmental conditions are appropriate for the material being applied. This certification along with a copy of the paint manufacturer's surface preparation and application requirements must be submitted and approved by the Engineer prior to the initial application of markings.

620.5 Equipment

Equipment shall include the apparatus necessary to properly clean the existing surface, a mechanical marking machine, a bead dispensing machine, and such auxiliary hand-painting equipment as may be necessary to satisfactorily complete the job.
The mechanical marker shall be an atomizing spray-type or airless-type marking machine suitable for application of traffic paint. It shall produce an even and uniform film thickness at

the required coverage and shall apply markings of uniform cross- sections and clear-cut edges without running or spattering and without over spray.

ITEM 621 – SODDING

621.1 Description

This item shall consist of soil preparation, seeding at the areas shown on the airfield drawing package or as directed by the Engineer in accordance with these specifications.

621.2 Seed

The species and application rates of grass, legume, and cover-crop seed furnished shall be those stipulated herein. Seed shall conform to the requirements of local airport standard.

Seed shall be furnished separately or in mixtures in standard containers labeled in conformance with the Agricultural Marketing Service (AMS) Seed Act and applicable state seed laws with the seed name, lot number, net weight, percentages of purity and of germination and hard seed, and percentage of maximum weed seed content clearly marked for each kind of seed. The Contractor shall furnish the Engineer duplicate signed copies of a statement by the vendor certifying that each lot of seed has been tested by a recognized laboratory for seed testing within six (6) months of date of delivery. This statement shall include: name and address of laboratory, date of test, lot number for each kind of seed, and the results of tests as to name, percentages of purity and of germination, and percentage of weed content for each kind of seed furnished, and, in case of a mixture, the proportions of each kind of seed. Wet, moldy, or otherwise damaged seed will be rejected.

621.3 Lime

Lime shall be ground limestone containing not less than 85% of total carbonates, and shall be ground to such fineness that 90% will pass through a No. 20 mesh sieve and 50% will pass through a No. 100 mesh sieve. Coarser material will be acceptable, providing the rates of application are increased to provide not less than the minimum quantities and depth specified in the special provisions on the basis of the two sieve requirements above. Dolomitic lime or a high magnesium lime shall contain at least 10% of magnesium oxide. Lime shall be applied as per seed product recommendation. All liming materials shall conform to the requirements of ASTM C602.

621.4 Fertilizer

Fertilizer shall be standard commercial fertilizers supplied separately or in mixtures containing the percentages of total nitrogen, available phosphoric acid, and water- soluble potash. They shall be applied at the rate and to the depth specified, and shall meet the requirements of applicable state laws. They shall be furnished in standard containers with name, weight, and guaranteed analysis of contents clearly marked thereon. No cyanamide compounds or hydrated lime shall be permitted in mixed fertilizers.

The fertilizers may be supplied in one of the following forms:

(1) A dry, free-flowing fertilizer suitable for application by a common fertilizer spreader;

(2) A finely-ground fertilizer soluble in water, suitable for application by power sprayers; or

(3) A granular or pellet form suitable for application by blower equipment.

(4) Fertilizers shall be shall be spread as per seed product recommendation.

621.5 Soil for repairs.

The soil for fill and top soiling of areas to be repaired shall be at least of equal quality to that which exists in areas adjacent to the area to be repaired. The soil shall be relatively free from large stones, roots, stumps, or other materials that will interfere with subsequent sowing of seed, compacting, and establishing turf, and shall be approved by the Engineer before being placed.

Topsoil requirements are detailed in Item 608.

621.6 Construction Methods

Advance preparation and cleanup. After grading of areas has been completed and before applying fertilizer and ground limestone, areas to be seeded shall be raked or otherwise cleared of stones larger than 2 inches (50 mm) in any diameter, sticks, stumps, and other debris that might interfere with sowing of seed, growth of grasses, or subsequent maintenance of grass-covered areas. If any damage by erosion or other causes has occurred after the completion of grading and before beginning the application of fertilizer and ground limestone, the Contractor shall repair such damage include filling gullies, smoothing irregularities, and repairing other incidental damage.

An area to be seeded shall be considered a satisfactory seedbed without additional treatment if it has recently been thoroughly loosened and worked to a depth of not less than 100 mm as a result of grading operations and, if immediately prior to seeding, the top 3 inches (75 mm) of soil is loose, friable, reasonably free from large clods, rocks, large roots, or other undesirable matter, and if shaped to the required grade.

When the area to be seeded is sparsely sodded, weedy, barren and unworked, or packed and hard, any grass and weeds shall first be cut or otherwise satisfactorily disposed of, and the soil then scarified or otherwise loosened to a depth not less than 100mm. Clods shall be broken and the top 3 inches (75 mm) of soil shall be worked into a satisfactory seedbed by discing, or by use of cultipackers, rollers, drags, harrows, or other appropriate means.

621.7 Dry application method.

Lime shall be applied separately and prior to the application of any fertilizer or seed and only on seedbeds that have previously been prepared as described above. The lime shall then be worked into the top 3 inches (75 mm) of soil after which the seedbed shall again be properly graded and dressed to a smooth finish.

Following advance preparations and cleanup fertilizer shall be uniformly spread at the rate that will provide not less than the minimum quantity stated in Subsection 621.4.

Grass seed shall be sown at the rate specified in Subsection 621.2 immediately after fertilizing. The fertilizer and seed shall be raked within the depth range stated in the special provisions. Seeds of legumes, either alone or in mixtures, shall be inoculated before mixing or sowing, in accordance with the instructions of the manufacturer of the inoculant. When seeding is required at other than the seasons shown on the plans or in the special provisions, a cover crop shall be sown by the same methods required for grass and legume seeding.

After the seed has been properly covered, the seedbed shall be immediately compacted by means of an approved lawn roller, weighing 40 to 65 pounds per foot (60 to 97 kg per meter) of width for clay soil (or any soil having a tendency to pack), and weighing 150 to 200 pounds per foot (223 to 298 kg per meter) of width for sandy or light soils.

621.8 Wet application method.

The Contractor may elect to apply seed and fertilizer (and lime, if required) by spraying them on the previously prepared seedbed in the form of an aqueous mixture and by using the methods and equipment described herein. The rates of application shall be as specified in the special provisions.

The spraying equipment shall have a container or water tank equipped with a liquid level gauge calibrated to read in increments not larger than 50 gallons (190 liters) over the entire range of the tank capacity, mounted so as to be visible to the nozzle operator. The container or tank shall also be equipped with a mechanical power- driven agitator capable of keeping all the solids in the mixture in complete suspension at all times until used.

The unit shall also be equipped with a pressure pump capable of delivering 100 gallons (380 liters) per minute at a pressure of 100 lb / sq inches (690 kPa). The pump shall be mounted in a line that will recirculate the mixture through the tank whenever it is not being sprayed from the nozzle. All pump passages and pipe lines shall be capable of providing clearance for 5/8 inch (16 mm) solids. The power unit for the pump and agitator shall have controls mounted so as to be accessible to the nozzle operator.

There shall be an indicating pressure gauge connected and mounted immediately at the back of the nozzle.

The nozzle pipe shall be mounted on an elevated supporting stand in such a manner that it can be rotated through 360 degrees horizontally and inclined vertically from at least 20 degrees below to at least 60 degrees above the horizontal. There shall be a quick-acting, three-way control valve connecting the recirculating line to the nozzle pipe and mounted so that the nozzle operator can control and regulate the amount of flow of mixture delivered to the nozzle. At least three different types of nozzles shall be supplied so that mixtures may be properly sprayed over distance varying from 20 to 100 feet (6 to 30 m). One shall be a close-range ribbon nozzle, one a medium-range ribbon nozzle, and one a long-range jet nozzle. For case of removal and cleaning, all nozzles shall be connected to the nozzle pipe by means of quick-release couplings.

In order to reach areas inaccessible to the regular equipment, an extension hose at least 50 feet (15 m) in length shall be provided to which the nozzles may be connected.

Lime, if required, shall be applied separately, in the quantity specified, prior to the fertilizing and seeding operations. Not more than 220 pounds (100 kg) of lime shall be added to and mixed with each 100 gallons (380 liters) of water. Seed and fertilizer shall be mixed together in the relative proportions specified, but not more than a total of 220 pounds (100 kg) of these combined solids shall be added to and mixed with each 100 gallons (380 liters) of water.

All water used shall be obtained from fresh water sources and shall be free from injurious chemicals and other toxic substances harmful to plant life. Brackish water shall not be used at any time. The Sub-contractor shall identify to the Engineer all sources of water at least two (2) weeks prior to use. The Engineer may take samples of the water at the source or from the tank at any time and have a laboratory test the samples for chemical and saline content. The Contractor shall not use any water from any source that is disapproved by the Engineer following such tests.

All mixtures shall be constantly agitated from the time they are mixed until they are finally applied to the seedbed. All such mixtures shall be used within two (2) hours from the time they were mixed or they shall be wasted and disposed of at approved locations.

Lime, if required, shall be sprayed only upon previously prepared seedbeds. After the applied lime mixture has dried, the lime shall be worked into the top 3 inches (75 mm), after which the seedbed shall again be properly graded and dressed to a smooth finish.

Mixtures of seed and fertilizer shall only be sprayed upon previously prepared seedbeds on which the lime, if required, shall already have been worked in. The mixtures shall be applied by means of a high-pressure spray that shall always be directed upward into the air so that the mixtures will fall to the ground like rain in a uniform spray. Nozzles or sprays shall never be directed toward the ground in such a manner as might produce erosion or runoff.

Particular care shall be exercised to ensure that the application is made uniformly and at the prescribed rate and to guard against misses and overlapped areas. Proper predetermined quantities of the mixture in accordance with specifications shall be used to cover specified sections of known area.

Checks on the rate and uniformity of application may be made by observing the degree of wetting of the ground or by distributing test sheets of paper or pans over the area at intervals and observing the quantity of material deposited thereon.

On surfaces that are to be mulched as indicated by the plans or designated by the Engineer, seed and fertilizer applied by the spray method need not be raked into the soil or rolled. However, on surfaces on which mulch is not to be used, the raking and rolling operations will be required after the soil has dried.

621.9 Maintenance of seeded areas.

The Contractor shall protect seeded areas against traffic or other use by warning signs or barricades, as approved by the Engineer. Surfaces gullied or otherwise damaged following seeding shall be repaired by regarding and reseeding as directed. The Contractor shall mow, water as directed, and otherwise maintain seeded areas in a satisfactory condition until final inspection and acceptance of the work.

When either the dry or wet application method outlined above is used for work done out of season, it will be required that the Contractor establish a good stand of grass of uniform color and density to the satisfaction of the Engineer. A grass stand shall be considered adequate when bare spots are one square foot (0.01 sq m) or less, randomly dispersed, and do not exceed 3% of the area seeded.

PART I – MATERIALS DETAILS

ITEM 700 - HYDRAULIC CEMENT

700.1 Portland Cement and Masonry Cement

Cement shall conform to the requirements of the following cited Specifications for the type specified or permitted.

Type	Specifications
Type I, II, or V	ASTM C150
Type IP, IS, IL	ASTM C595
Types GU, HE, HS, MH, LH	ASTM C1157

The chemical requirements for all cement types specified should meet suitable criteria for deleterious activity. Low alkali cements (less than 0.6% equivalent alkalies, the low reactivity option in ASTM C595, or Option R in ASTM C1157) shall be specified when no other mitigating measures are added.

Total Alkalies (Na2O and K2O) of the cement secured for the production of concrete shall be independently verified in accordance with ASTM C114.

Unless otherwise permitted by the Engineer, the product of only one mill of any one brand and type of Portland Cement shall be used on the project.

The Contractor shall provide suitable means of storing and protecting the cement against dampness. Cement which, for any reason, has become partially set or which contains lumps of caked cement will be rejected. Cement salvaged from discarded or used bags shall not be used.

ITEM 701 - CONSTRUCTION LIME (HYDRATED)

701.1 General

Hydrated lime shall conform to the requirements of PHILSA I-1-68 or ASTM C207-76 and shall be of the following type:

Type N	- Normal hydrated lime for masonry purposes.
Type S	- Special hydrated lime for masonry purposes.
Type NA	- Normal air-entraining hydrated lime for masonry purposes.
Type SA	- Special air-entraining hydrated lime for masonry purposes.

Type N and S are suitable for use in mortar, in scratch and brown coats of cement plaster, for stucco and for addition to Portland Cement concrete.

Type NA and SA are air-entrained hydrated limes that are suitable for use in any of the above uses where air-entrainment are desired.

Type S and SA hydrated lime develop high, early plasticity and higher water retentivity and by a limitation on their unhydrated oxide content.

It is the intent of this Specification to use either the Type N or S for soil stabilization and as filler requirement to bituminous plant mixtures. It is expected to provide pavements with greater resistance to the detrimental effects of water, especially flooding during the rainy season.

701.2 Chemical Requirements

Hydrated lime for construction purposes shall conform to the following standard chemical requirements.

	%
Calcium and Magnesium oxides (Non-volatile basis), min. %	60
Carbon dioxide (as received basis), max. %	
If sample is taken at the place of manufacture	5
If sample is taken at any other place	7
Unhydrated oxides (as received basis) for Type S and SA, max. %	8

701.3 Physical Requirements

Hydrated lime for construction purposes shall conform to the following standard physical requirements:

a. Percentage Residue

The residue retained on a 0.600 mm (No. 30) sieve shall not be more than 0.57% and not more than 15% on a 0.075 mm (No. 200) sieve.

b. Plasticity

The putty made from Type S, special hydrate, or type SA, special air- entraining hydrate, shall have plasticity figure of not less than 200 when tested within 30 minutes after mixing with water.

c. Water Retention

Hydrated lime mortar made with Type N (normal hydrated lime) or Type NA (normal air-entraining lime), after suction for 60 seconds, shall have a water retention value of not less than 75 percent and not less than 85% for Type S and SA, when tested in a standard mortar made from the dry hydrate or from putty made from the hydrate which has been soaked for a period of 16 to 24 hours.

701.4 Grading Requirement

Hydrated lime for construction purposes shall conform to the following grading requirements:

Sieve Designation		Mass Percent Passing
Standard mm	Alternate US Standard	
0.850 0.075	(No. 20) (No. 200)	100 85 – 100

ITEM 702 - BITUMINOUS MATERIALS

702.1 Asphalt Cements

Asphalt cement shall conform to the requirements of AASHTO M226.

702.2 Liquid Asphalts

Liquid asphalt shall conform to the requirements of the following specifications: Rapid Curing

Liquid Asphalts	-	AASHTO M81
Medium Curing Liquid Asphalts	-	AASHTO M82

702.3 Emulsified Asphalts

Emulsified asphalts shall conform to the requirements of the following specifications:

Emulsified Asphalt (Anionic)	-	AASHTO M140 (ASTM D 977)
Emulsified Asphalt (Cationic)	-	AASHTO M208

702.4 Acceptance Procedures for Bituminous Materials

702.4.1 General

Bituminous materials will be accepted at the source of shipment subject to the following conditions:

a. The supplier shall conduct laboratory tests of all materials intended for shipment to the Government and certify that the materials meet the Contract Specifications.

b. Before loading, the producer shall examine the shipping container, remove all remnants of previous cargoes which night contaminate the material to be loaded and certify that it was clean and free of contaminating material and loaded.

c. The Contractor shall furnish with each shipment two copies of the delivery ticket. The delivery tickets shall contain the following information:

Consignees ______________________	Destination _______________________
Project Number __________________	Date _____________________________
Grade __________________________	Loading Temp. ____________________
Net Liters _______________________	Specific Gravity ___________________
	At 15.50C (600F)

Net Weight ____
Identification No. (Truck, Car, Tank, etc.) ____________________________________

d. The Contractor or the supplier as his agent, shall deliver to the Engineer or his representative a certification signed by an authorized representative of the supplier to cover the quality and quantity of material and the condition of container for each shipment. The certification shall be essentially in the following form and may be stamped, written or printed on the delivery tickets.

"This is to certify that this shipment of ______________ (tonnes/litres) or _________________ of asphalt meets all Contract Specification requirements of the DPWH, and the shipping container was clean and free from contaminating material when loaded.

Producer __________________________
Signed ____________________________

Failure to sign the certification will be a cause to withhold use of the material until it can be sampled, tested and approved.

702.4.2 Quality Control Reviews

Quality control reviews will be conducted by the Government, or an authorized representative at the point of production, at frequencies prescribed by the DPWH, to determine the reliability of the producer's certifications.

If this review indicates that the certifications are not reliable, the acceptance of bituminous materials by certification will be discontinued and the contents of each shipping container will be sampled at point of delivery, tested and accepted prior to incorporation into the work. This procedure will be followed until the engineering determination is made that the supplier's quality control and testing procedures are such that material meeting Contract Specifications is being consistently produced.

702.4.3 Alternate Acceptance Procedures for Asphalt Materials

Where required by the Special Provisions, the following alternate acceptance plan for asphalt material will apply in lieu of (a) and (b) above. The Contractor shall provide deliver tickets and certifications as set out in (a), above.

Acceptance samples of bituminous materials shall be obtained in accordance with AASHTO T40, Sampling Bituminous Materials, at the applicable point of acceptance as defined herein:

a. Bituminous materials used in direct application on the road. Acceptance samples shall be obtained under the supervision of the Engineer from the conveyances containing the bituminous material at the point of delivery. Single samples shall be taken of each separate tank load of bituminous material delivered, at the time of discharge, into distributors or other conveyances on the project.

b. Bituminous materials initially discharged into storage tanks on the project. Acceptance samples shall be obtained from the line between the storage tank and the distributor of the bituminous mixing plant after each delivery. A single acceptance sample shall be taken after sufficient period of circulation of such bituminous material has taken place to insure samples representative of the total materials then in the storage tank.

   As soon after sampling as practicable, the acceptance sample shall be delivered by the Engineer to the nearest authorized laboratory for tests to determine compliance.

702.4.4 Requirements for Bituminous Materials containing Anti-stripping Additives

a. All the foregoing requirements of Item 702 shall apply for the type of bituminous material involved.

b. Additionally, the Contractor or the supplier as his agent, shall furnish the Engineer or his representative along with and the time of delivery of the initial shipment of fortified bituminous material to the project, and thereafter with the subsequent shipments when ordered by the Engineer, 1 litre (1 quart) sealed sample of the bituminous material taken at the time of loading at the refinery and prior to introduction of the additive, along with a separate 0.5 liter (1 pint) sample of the anti-stripping additive involved.

702.5 Application Temperatures

Bituminous materials for the several application indicated in the Specifications shall be applied within the temperature ranges indicated in Table 702.1.

Table 702.1 – Application Temperatures

Type and Grade Of Material	Application Spray (Min./Max.)	Temperature Range (0C) Mix (Min./Max.)
RT 1-2-2	15.5 – 54	15.5 – 54
RT 4-5-6	29 – 65.5	29 – 65.5
RT 7-8-9	65.5 – 107	65.5 – 107
RT 10-11-12	79 – 121	79 – 121
RTCB 5-6 30	15.5 – 48.9	15.5 – 48.9

MC 30	21 – 62.8	15.5 – 40.5
RC-MC 70	40.5 – 85	32 – 68
RC-MC 250	60 – 107	51.7 – 93
RC-MC 800	79 – 129	71 – 107
RC-MC 3000	106.7 – 143	93 – 126.7
All Emulsions	10 – 71	10 – 71
Asphalt Cement (All Grades)	204 Max.	As required to achieve viscosity of 75 – 150 seconds to achieve a Kinematic Viscosity of 150-300 mm2/s (150-300) centi-stokes

Table 702.1 shall apply unless temperatures ranges applicable to specific lots of material delivered to the job are supplied by the producer.

702.6 Material for Damp-proofing and Waterproofing Concrete and Masonry Surfaces

Material shall conform to the requirements of the following specifications:

a.	Primer for use with asphalt	AASHTO M116
b.	Primer for use with tar	AASHTO M121 (ASTM D43)
	Or	
	It may be a liquid water-gas tar conforming to the following requirements:	
	Specific gravity, 25°/25°C	1.030 – 1.100
	Specific viscosity at 40°C (Engler), not more than	3.0
	Total distillate, mass percent 300°, not more than	50.0
	Bitumen (soluble in carbon disulphide), not less than	98.0 percent
	Water not more than	2.0 percent
C.	Tar for mop or seal coats: Coal tar pitch (heated to free flowing but not to exceed 149°C (300°F)	ASSHTO M118, Type B (ASTM D 450)
	Or	
	Tar applied at about 27°C (80°F)	AASHTO M52, RTCB 5 or 6
	Rubberized tar (heated to free flowing but not to exceed 121°C (250°F)	ASTM D2993

d.	Asphalt for mop coat	AASHTO M115
e.	Waterproofing fabric	ASSHTO M117 (ASTM D1668)
	Fabric shall be waterproofed with tar or asphalt in agreement with the material specified for prime and mop coats.	
f.	Mortar materials shall conform to Section 705.5 except that the mortar shall be uniformly mixed to spreading consistency in the proportion of 1 part Portland Cement to 3 parts fine aggregate.	
g.	Asphalt plank	AASHTO M46 (ASTM D517)
	Unless otherwise shown on the plans, planks shall be 30 mm thick and may be from 150 to 300 mm in width but all pieces for one structure shall be of the same width except such "closers" as may be necessary. The lengths shall be such as to permit the laying of the planks to the best advantage on the surface to be covered but shall not be less than 0.9 nor more than 2.5 m.	
h.	Asphalt roll roofing	ASTM D224, 65 pound grade

702.7 Membrane Material for Waterproofing Bridge Decks

Bridge deck waterproofing membrane shall be mesh-reinforced self-sealing rubberized asphalt preformed membrane and shall have the following properties:

Thickness Permeance-Perms Kg/Pa.s.m2 (grains/sq.ft./hr./in.Hg)	1.65 mm (655 mils) 57.213 x 10-11 (0.10)	ASTM E96 Method B
Tensile strength	344.5 kPa (50 lb/in)	ASTM D 882 modified for 25.4 mm (1 inch) opening
Puncture resistance (mesh)	90.8 kg (200 lb)	ASTM E154
Pliability – 6.35 mm (1/4") mandrel 1800 bend at –8.30C (-150F)	No cracks in rubberized asphalt	ASTM D146
Primer and mastic shall be as recommended by the manufacturer and shall be compatible with the membrane.		

702.8 Tars

Tars shall conform to the requirements of AASHTO M52.

702.9 Dust Oils

Dust oils and clarified dust oil shall conform to the following requirements:

General Requirements	ASTM METHOD	Dust Oil			Clarified Dust Oil
		Light	Medium	Heavy	
Flash Point, °C (Open tag.), min.	D 1310	51.6	51.6	51.6	93.3
Viscosity at 38°C (100°F) Kinematic, CS	D 2170	40-70	90-15	145-200	20-100
Water, % maximum	D 95	2.0	2.0	2.0	2.0
Asphaltenes %	*D2006	3.0-6.0	4.0-7.0	5.0-8.0	0.5-0
Saturates % minimum	*D2006	25	25	25	10
Distillation					
Total Distillate to 288°C (550°F), Max. %	**D402	35	30	30	5
Test on residue from Distillation to 288°C (550°F)					
Viscosity at 1000°T, Kinematic, CS	D 2170	75-250	200-630	540-1500	20-150
Solubility in Trichloroethylene, % Min.	***2042	97.0	97.0	97.0	97.0

ITEM 703 – AGGREGATES

703.1 Fine Aggregate for Concrete and Incidentals

703.1.1 Concrete

Fine Aggregate for concrete shall conform to the requirements of AASHTO M6, with no deleterious substances in excess of the following percentages:

Clay lumps	3.0
Coal and lignite	1.0
Material passing 0.075 mm sieve	4.0
Other substances – as shown in Special Provisions	

Lightweight aggregate, if required or permitted by the Special Provisions, shall meet the pertinent requirements of AASHTO M195.

703.1.2 Granular backfill filter material for underdrains and filler for paved waterways shall be permeable and shall meet the requirements of AASHTO M6, except that soundness tests will not be required and minor variations in grading and content of deleterious substances may be approved by the Engineer.

703.1.3 Aggregate for minor concrete structures shall be clean, durable, uniformly graded sand and gravel, crushed slag or crushed stone, 100 percent of which will pass a 37.5 mm (1-1/2 inches) sieve and containing not more than 5 percent passing the 0.075 mm (No. 200) sieve.

703.2 Coarse Aggregate for Portland Cement Concrete

Coarse aggregate for concrete shall meet the requirements of AASHTO M80. Lightweight aggregate, if required or permitted by the Special Provisions, shall conform to the requirements of AASHTO M195, for the grading specified.

703.3 Aggregate for Portland Cement Treated and Stabilized Base Course

The crushed and uncrushed granular material shall consist of hard durable stones and rocks of accepted quality, free from an excess of flat, elongated, soft or disintegrated pieces or other objectionable matter. The method used in obtaining the aggregate shall be such that the finished product shall be as consistent as practical.

All materials passing the 4.75 mm (No. 4) mesh produced in the crushing operation of either the stone or gravel shall be incorporated in the base material to the extent permitted by the gradation requirements. The plasticity index shall not be less 4 nor more than 10.

703.4 Aggregate for Untreated Subbase, Base or Surface Courses

Aggregate shall consist of hard, durable particles or fragments of crushed stone, crushed slag or crushed or natural gravel. Materials that break up when alternately wetted and dried shall not be used.

Coarse aggregate is the material retained on the 2.00 mm (No. 10) sieve and shall have a percentage of wear of not more than 50 for subbase and not more than 45 for Base and Surface Courses as determine by AASHTO Method T96.

Fine aggregate is the material passing the 2.00 mm (No. 10) sieve and shall consist of natural or crushed sand and fine mineral particles. The fraction passing the 0.075 mm (No. 200) sieve shall not be greater than 0.66 (two-thirds) of the fraction passing the 0.425 mm (No. 40) sieve. For base courses, the fraction passing the 0.425 mm (No. 40) sieve shall have a liquid limit not greater than 25 and a plasticity index not greater than 6, while for subbase course, the liquid limit shall not be greater than 35 plasticity index not greater than 12.

For surface courses, the fraction passing the 0.425 mm (No. 40) sieve shall have a liquid limit not greater than 35 and a plasticity index not less than 4 or greater than 9.

All materials shall be free from vegetable matter and lumps or balls of clay.

When crushed aggregate is specified, not less than 50 mass percent of the particles retained on the 4.75 mm (No. 4) sieve shall have at least one fractured face.

Gradation of each designated size of aggregate shall be obtained by crushing, screening and blending processes as may be necessary.

Materials otherwise meeting the requirements of this Section will be acceptable whenever such materials produce a compacted course meeting applicable density requirements as specified in Subsections 200.3.3 and 202.3.3.

703.5 Aggregate for Bituminous Concrete

703.5.1 Coarse Aggregate

Coarse aggregate retained on the 2.36 mm (No. 8) sieve shall be crushed stone, crushed slag or crushed or natural gravel and unless otherwise stipulated, shall conform to the quality requirements of AASHTO M79–74.

When crushed gravel is used, it shall meet the pertinent requirements of Section 2.1 and 3.1 of AASHTO M62–74 and not less than 50 mass percent of the particles retained on the 4.75 mm (No. 4) sieve shall have at least one fractured face. The coarse aggregate shall be of such gradation that when combined with other required aggregate fractions in proper proportion, the resultant mixture will meet the gradation required under the composition of mixture for the specific type under contract. Only one kind shall be used on the project except by permission of the Engineer.

703.5.2 Fine Aggregate

Fine aggregate passing the 2.36 mm (No. 8) sieve shall consist of natural sand, stone, stone screenings or slag screenings or a combination thereof and unless otherwise stipulated shall conform to the quality requirements of AASHTO M29 (ASTM D1073). Fine aggregate shall be of such gradation that when combined with other required aggregate fractions in proper proportion, the resultant mixture will meet the gradation required under the composition of mixture for the specific type under contract.

703.5.3 Open-Graded Asphalt Concrete Friction Course

Aggregate shall conform to Subsections 703.5.1 and 703.5.2 above and the following requirements. Relatively pure carbonate aggregates or any aggregates known to polish shall not be used for the coarse aggregate fraction (material retained on the 2.36 mm (No. 8) sieve. In addition, the coarse aggregate fraction shall have at least 75 mass percent of weight of particles with at least two fractured faces and 90 mass percent with one or more fractured faces, except that lightweight aggregates need not meet this requirement. The abrasion loss (AASHTO T96) shall not exceed 40 mass percent.

703.5.4 Lightweight Aggregate (except slag)

Lightweight aggregate (except slag), if required or permitted by a Special Provisions, shall be manufactured by the rotary kiln process. The material shall consist of angular-fragments uniform in density and reasonably free from flat, elongated or other deleterious substances. The material shall show an abrasion loss of less than 45 mass percent when tested in accordance with AASHTO T96. The dry mass per cubic metre shall not exceed 1080 kg (67 pcf). After testing through five cycles of the magnesium sulfate soundness test, the loss shall not exceed ten (10) mass percent.

703.6 Aggregate for Bituminous Plant Mix Surfacing

Aggregate shall be uniformly graded from coarse to fine. Target values for the intermediate sieve sizes shall be established within the limits shown in Table 703.1.

The Contractor shall submit the proposed target values in writing to the Engineer for approval. The target gradation is subject to confirmation testing in accordance with Section 310.2 before approval by the Engineer. Any changes in the target gradation are subject to confirmation testing in accordance with Section 310.2, unless otherwise approved in writing by the Engineer. No target gradation adjustment will be permitted during the span of a lot.

Table 703.1 – Range of Gradation Target Values

Sieve Designation mm	Mass percent passing square mesh sieves, AASHTO T 11 and 27, exclusive of mineral filler
	Range
25 (1 inch)	100
19 (3/4 inch)	100
4.75 (No. 4)	50-60
2.36 (No. 8)	38-48

No intermediate sizes of aggregate shall be removed for other purposes without written consent of the Engineer.

If crushed gravel is used, not less than 50 mass percent of the material retained on the 4.75 mm (No. 4) sieve shall be particles having at least one fractured face.

That portion of the composite material passing a 4.75 mm (No. 4) sieve shall have a sand equivalent of not less than 35, as determined by AASHTO T176, Alternate Method No. 2.

The aggregate shall show a durability index not less than 35 (coarse and fine) as determined by AASHTO T210.

The material shall be free of clay balls and adherent films of clay or other matter that would prevent thorough coating with the bituminous material.

703.7 Aggregate for Hot Plant-Mix Bituminous Pavement

The provisions of Subsections 703.5.1, 703.5.2 and 703.5.3 shall apply. The several aggregate fraction for the mixture shall be sized, graded and combined in such proportions that the resulting composite blend meets one of the grading requirements of Table 703.2 as specified in the Schedule.

The gradings to be used will be shown in the Special Provisions, adjusted to reflect variations in aggregate densities.

The ranges apply to aggregates with bulk specific gravity values that are relatively constant throughout a grading band. When such values vary from sieve to sieve, such as with lightweight aggregates, the ranges for each sieve size shall be adjusted to reflect the variations.

703.8 Aggregate for Cold Plant-Mix Bituminous Pavement

The provisions of Subsections 703.5.1 and 703.5.2 shall apply.

703.8.1 Aggregate for Pavement

The several aggregate fractions for the mixture shall be sized, graded and combined in such proportions that the resulting composite blends meet the respective grading requirements of Table 703.3 adjusted to reflect variation in aggregate densities.

703.8.2 Aggregate for Top Dressing

The material for the top dressing shall consist of dry sand, stone screenings or slag screenings so graded that at least 95 mass percent shall pass the 4.75 mm (No. 4) sieve and not more than 40 percent shall pass the 0.300 mm (No. 50) sieve.

Table 703.2 – Gradation Ranges-Hot Plant Mix Bituminous Pavements
(Mass percent passing square sieves, AASHTO T11 and T27)

Sieve Designation, mm	GRADING						
	A	B	C	D	E	F	G
37.5(1-1/2 inch)	100	-	-	-	-	-	-
25 (1 inch)	95-100	100	100	-	-	-	-
19 (3/4 inch)	75-95	95-100	95-100	100	-	100	-
12.5 (1/2 inch)	-	68-86	68-86	95-100	100	-	100
9.5 (3/8 inch)	54-75	56-78	56-78	74-92	95-100	-	95-100
4.75 (No. 4)	36-58	38-60	38-60	48-70	75-90	45-65	30-50
2.36 (No. 8)	25-45	27-47	27-47	33-53	62-82	33-53	5-15
1.18 (No. 16)	-	18-37	18-37	22-40	38-58	-	-
0.600 (No. 30)	11-28	11-28	13-28	15-30	22-42	-	-
0.300 (No. 50)	-	6-20	9-20	10-20	11-28	10-20	-
0.074 (No. 200)	0-8	0-8	4-8	4-9	2-10	3-8	2-5

703.9 Aggregate for Road Mix Bituminous Pavement

Aggregates for road mix bituminous pavement construction shall be crushed stone, crushed slag, or crushed or natural gravel which meet the quality requirements of AASHTO M62-74 or M63-74 for the specified gradation, except that the sodium sulfate soundness loss shall not exceed 12 mass percent.

When crushed gravel is used, at least 50 mass percent of the particles retained on the 2.00 mm (No. 10) sieve shall have at least one fractured face. Gradation shall conform to Grading F of Table 703.2.

703.10 Aggregate for Cover Coats, Surface Treatments and Bituminous Preservative Treatment

Cover aggregate for type 2 seal coat (Item 303) shall consist of sand or fine screenings, reasonably free from dirt or organic matter.

Aggregates for type 3 seal coat (Item 303) surface treatments or bituminous preservative treatment shall be crushed stone, crushed slag or crushed or natural gravel. Only one type of aggregate shall be used on the project unless alternative types are approved. Aggregates shall meet the quality requirements of AASHTO M78-74.

When tested in accordance with AASHTO T182, (ASTM D1664) aggregate shall have a retained bituminous film above 95 mass percent.

Aggregates which do not meet this requirement may be used for bituminous surface treatments and seal coats provided a water-resistant film.

Lightweight aggregate, if required or permitted by the Special Provisions, shall meet the pertinent requirements of Subsection 703.5.4.

When crushed gravel is used, not less than 50 mass percent of the particles retained on the 4.75 mm (No. 4) sieve shall have at least one fractured face. Aggregates shall meet the gradation requirements called for in the Bid Schedule.

Table 703.3 – Gradation Requirements-Cold Plant Mix Bituminous Pavement (Mass percent passing square mesh sieves, AASHTO T27)

Sieve Designation		Bottom (Binder) Course	Wearing (Surface) Course
Standard, mm	Alternate US Standard		
37.5	1-1/2”	100	-
25	1”	85-100	-
19	¾”	40-70	100
12.5	½”	10-35	95-100
4.75	No. 4	4-16	15-40
2.36	No. 8	0-5	10-25
0.600	No. 30	-	4-13
0.300	No. 50	-	0-5

Table 703.4 – Gradation Requirements for Cover Coats (Mass percent passing square mesh sieves, AASHTO T27)

Sieve Designation	Grading designation with corresponding size No. from AASHTO M43 (ASTM D448) modified

Std. mm	Alt US Std	A (No.5)	B (No.6)	C (No.7)	D (No.8)	E (No.9)	F (No.10)
37.5	1-1/2”	100	-	-	-	-	-
25	1”	90-100	100	-	-	-	-
19	¾”	-	90-100	100	-	-	-
12.5	½”	0-10	-	90-100	100	-	-
9.5	3/8”	-	0-15	-	85-100	100	100
4.75	No.4	-	-	0-15	-	85-100	85-100
2.36	No.8	-	-	-	0-10	-	-
0.075	No.200	0-2	0-2	0-2	0-2	0-2	0-10

703.11 Blotter

Aggregate for blotter material shall conform to the gradation requirements of AASHTO M43 (ASTM D448), size 2.00 mm (No. 10). The aggregate shall be free from vegetable or other deleterious materials.

Table 703.5 – Gradation Requirements for Bituminous Surface Treatments (Mass percent passing square mesh sieves, AASHTO T 27)

Sieve Designation		Grading designation with corresponding size No. from AASHTO M43 (ASTM D448) modified					
Std. mm	Alt US Std	A (No.5)	B (No.6)	C (No.7)	D (No.8)	E (No.9)	F (No.10)
37.5	1-1/2”	100	-	-	-	-	-
25	1”	90-100	100	-	-	-	-
19	¾”	20-25	90-100	100	-	-	-
12.5	½”	0-10	20-55	90-100	100	-	-
9.5	3/8”	0-5	0-15	40-70	85-100	100	100
4.75	No. 4	-	0-5	0-15	10-30	85-100	85-100
2.36	No. 8	-	-	0-5	0-10	10-40	60-100
0.150	No. 100	-	-	-	-	-	0-10

Table 703.6 – Gradation Requirements for Bituminous Preservative Treatment

Sieve Designation		Mass percent passing square mesh Sieves, AASHTO T27	
Standard mm	Alternate US Standard	Grading A	Grading B
19	¾”	-	100
9.5	3/8”	100	-
4.75	No. 4	45-80	45-80
2.36	No. 8	28-64	28-64
0.075	No. 200	0-12	0-12

703.12 Bed Course Material

Bed course material for sidewalks, paved waterways and curbing shall consist of cinders, sand, slag, gravel, crushed stone or other approved material of such gradation that all particles will pass through a sieve having 37.5 mm (1-1/2 inches) square openings.

Bed course material for slope protection shall be a porous, free-draining material consisting of sand, gravel, cinders, slag, crushed stone or other approved free- draining material. This material shall be uniformly graded and of such size that 100 percent of the material will pass through a sieve having 37.5 mm (1-1/2 inches) square opening.

703.13 Sheathing Material

Sheathing material shall conform to either (a) or (b) below:

a. Sound, durable particles of gravel, slag or crushed stone meeting the following gradation:

Sieve	Mass percent passing
75 mm (3”)	100
4.75 mm (No. 4)	0 – 10
0.075 mm (No. 200)	0 – 2

b. Clean noncementitious sand meeting the requirements of Subsection 703.1.2.

703.14 Aggregates for Subgrade Modification

The material shall consist of hard, durable particles or fragments of slag, stone or gravel, screened or crushed to the required size and grading. The material shall be visually free from vegetable matter and lumps or balls of clay and shall meet the requirements for one of the gradings given in Table 703.7 whichever is called for in the Bid Schedule.

That portion of the material passing a 0.425 mm (No. 40) sieve shall have a plasticity index of not over 6, as determined by AASHTO T90.

Table 703.7 – Grading Requirements-Aggregates for Subgrade Modification

Sieve Designation		Mass percent passing square mesh sieves using AASHTO T27		
Standard Mm	Alternate US Standard			
75	3”	100	-	-

37.5	1-1/2”	-	100	-
25	1”	-	-	100
4.75	No. 4	30 – 70	30 – 70	40 – 80
0.075	No. 200	0 - 15	0 - 15	5 – 20

Crushed slag shall consist of clean, tough, durable pieces of blast furnace slag, reasonably uniform in density and quality and reasonably free from glassy pieces.

703.15 Aggregates for Salt Stabilization

Aggregates for salt stabilized base course shall consist of hard durable particles or fragments of slag, stone or gravel, screened or crushed to the required size and grading.

That portion of the material passing a 0.425 mm (No. 40) sieve shall have a plasticity index of not over 6, as determined by AASHTO T90.

The material shall be visually free from vegetable matter or lumps or balls of clay and shall meet the requirements for one of the gradings given in Table 703.8 as called for in the Bid Schedule.

Table 703.8 – Gradation Requirements for Aggregates for Salt Stabilized Base Course

Sieve Designation		Mass percent passing square mesh sieves, AASHTO T11 and T27	
Standard, mm	Alternate US Standard	Grading A	Grading B
75	3”	-	-
50	2”	-	100
37.5	1-1/2”	-	70 – 100
25	1”	100	-
19	¾”	70 – 100	50 – 80
9.5	3/8”	50 – 80	40 – 70
4.75	No. 4	35 – 45	30 – 60
2.00	No. 10	25 – 50	20 – 50
0.425	No. 40	15 – 30	10 – 30
0.075	No. 200	7 - 15	7 – 15

* Gradation varies with top size of material and should be based on size of largest material used. For instance, if largest size is 50 mm (2 inches), gradation should be under heading B; if 25 mm (1 inch), under A.

703.16 Aggregates for Emulsified Asphalt Treated Base Course

Aggregate shall consist of coarse aggregate of crushed gravel, crushed slag or crushed stone, composed of hard, durable particles or fragments and a filler of finely crushed stone, sand, slag or other finely divided mineral matter. The portion of the material retained on a 4.75 mm (No. 4) sieve shall be known as coarse aggregate and that portion passing a 4.75 mm (No. 4) sieve shall be known as fine aggregate. The material shall meet one of the grading requirements of Table 703.9.

Table 703.9 Grading Requirements for Aggregates for Emulsified Asphalt Treated Base
(Mass percent passing square mesh sieves, AASHTO T 11 & T 27)

Sieve Designation		Grading A	Grading B	Grading C
Standard, mm	Alternate US Standard			
37.5	1-1/2”	100	100	-
25	1”	95-100	95-100	-
19	¾”	-	50-85	100
9.5	3/8”	-	-	95-100
4.75	No. 4	-	26-59	65-100
2.00	No. 10	0-9	17-48	-
0.425	No. 40	-	-	12-35
0.075	No. 200	0-2	2-10	3-12

If crushed gravel is used, not less than 65 mass percent of the coarse aggregate particles retained on a 4.75 mm (No. 4) sieve shall be particles having at least one fractured face.

Coarse aggregate shall have a percent of wear of not more than 35 at 500 revolution, as determined by AASHTO T 96.

The aggregate shall show a durability factor not less than 35 (coarse and fine) as determined by AASHTO T 210 (Production of Plastic Fines in Aggregates).

The material shall be free of clay balls and adherent films of clay or other matter that would prevent thorough coating with bituminous material.

ITEM 703A - MINERAL FILLER

703A.1 Description

Mineral filler shall consist of finely divided mineral matter such as rock dust, slag dust, hydrated lime, hydraulic cement, fly ash or other suitable mineral matter. It shall be free from organic impurities and at the time of use, shall be sufficiently dry to flow freely and shall be essentially free from agglomerations.

703A.2 General Requirements

703A.2.1 Filler material for bituminous bases or pavements shall meet the requirements of AASHTO M17, Mineral Filler for Bituminous Paving Mixtures.

703A.2.2 Physical Requirements

Mineral filler shall be graded within the following limits:

Sieve	Maximum Perfect Passing
0.600 mm (No. 30)	100
0.300 mm (No. 50)	95 – 100
0.075 mm (No. 200)	70 – 100

The mineral filler shall have a plasticity index not greater than 4. Plasticity index limits are not appropriate for hydraulic lime and cement.

703A.3 Methods of Sampling

703A.3.1 Materials in Bulk

Sampling from bins, piles or cars – A sampling tube that takes a core not less than 25 mm (1 inch) in diameter may be used to obtain sample portions from one or more location as required to obtain a field sample of at least 5 kg (10 lb). Sample portions may be taken from holes dug into the material at 5 or more locations to provide a field sample of at least 5 kg (10 lb).

Sampling from conveyors – Sample portions shall be taken at regular intervals during the time of movement of the materials in the unit being sampled to provide a field sample of at least 5 kg (10 lb).

703A.3.2 Materials in Packages

From the unit to be sampled, select at least one percent of the packages at random for sampling, but in no case shall fewer than 5 packages be selected. Take a sample portion from a hole dug into the top of each package selected for sampling. A sampling tube may be used that takes a core not less than 25 mm (1 inch) diameter. Insert the tube into the package to substantially sample the entire length of the package. Combine the sample portions taken to obtain a field sample of at least 5 kg (10 lb).

703A.4 Shipping Samples

Mineral filler shall be shipped in a clean, moisture-proof container and packaged securely to prevent the loss of material during handling. Reduce the field sample to a minimum size of 2.5 kg (5 lb) to submit for testing, using the method of quartering.

703A.5 Methods of Test

The properties enumerated in this Specification shall be determined in accordance with the following AASHTO Method of Test:

Gradation	AASHTO T37
Plasticity Index	AASHTO T90

ITEM 705 - JOINT MATERIALS

705.1 Joint Fillers

Poured filler for joints shall conform to the requirements of AASHTO M173. Preformed fillers for joints shall conform to the requirements of ASTM D1751 or ASTM D1752, Type II or III as specified, and shall be punched to admit the dowels where called for on the Plans. The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint, unless otherwise specified by the Engineer. When the use of more than one piece is required for a joint, the abutting ends shall be fastened securely and held accurately to shape by stapling or other positive fastening means satisfactory to the Engineer.

705.2 Joint Mortar

Pipe joint mortar shall consist of one part Portland Cement and two parts approved sand with water as necessary to obtain the required consistency. Portland Cement and sand shall conform respectively to Section 700.1 and 703.1. If shown in the Special Provisions, air entrainment conforming to Section 708.2 shall be provided. Mortar shall be used within 30 minutes after its preparation.

705.3 Rubber Gaskets

Ring gaskets for rigid pipe shall conform to the requirements of AASHTO M198. Continuous flat gaskets for flexible metal pipe shall conform to the requirements of ASTM D1056 with grade SCE 41 used for bands with projections or flat bands and grade SCE 43 for corrugated bands. Gaskets thickness for bands with projections or flat bands shall be 12.5 mm (1/2 inch) greater than the nominal depth of the corrugation and shall be 9.5 mm (3/8 inch) for corrugated bands.

705.4 Oakum

Oakum for joints in bell and spigot pipe shall be made from hemp (Cannabis Sativa) line, or Benares Sunn fiber, or from a combination of these fibers. The oakum shall be thoroughly corded and finished and practically free from lumps, dirt and extraneous matter.

705.5 Mortar for Masonry Beds and Joints

705.5.1 Composition

Unless otherwise indicated on the Plans, masonry mortar shall be composed of one part Portland Cement or air-entraining Portland Cement and two parts fine aggregate by volume to which hydrated lime has been added in an amount equal to ten (10) mass percent of the cement. In lieu of air-entraining cement, Portland Cement may be used with an air-entraining admixture in accordance with the applicable provisions of Item 405 of Standard Specification for Public Work and Highways.

For masonry walls not exceeding 1.8 m (6 feet) in height, a mortar composed of one part masonry cement and two parts fine aggregate by volume maybe substituted for the above mixture of Portland Cement, lime and fine aggregate. For other construction, masonry cement may be used if and as shown on the Plans.

705.5.2 Materials

Either Type I or Type IA air-entraining Portland Cement, conforming to AASHTO M85 may be used, except that when the contract contains an item for concrete under Item 405 of Standard Specification for Public Work and Highways, the Contractor may use the same type as is used for that work.

Masonry cement shall conform to the requirements of AASHTO M150–74 (ASTM C91).
Fine aggregate shall conform to the requirements of AASHTO M45 (ASTM C144). Hydrated lime shall meet the requirements for Residue, Popping and Pitting, and Water retention shown for Type N lime in Section 701.3 (ASTM C207). Water shall conform to the requirements of Item 714, Water.

Air-entraining agents shall conform to the requirements of Section 708.2 AASHTO M154 (ASTM C260).

705.6 Copper Water Stops or Flashings

Sheet copper for water stops of flashings shall meet the requirements of AASHTO M 138 (ASTM B152) for Type ETP, light cold-rolled, soft anneal, unless otherwise specified in the Special Provisions.

705.7 Rubber Water Stops

Rubber water stops may be molded or extruded and have a uniform cross-section, free from porosity or other defects, conforming to the nominal dimensions shown on the Plans. An equivalent standard shape may be furnished, if approved by the Engineer.

The water stop may be compounded from natural rubber, synthetic rubber or a blend of the two, together with other compatible materials which will produce a finished water stop meeting the requirements of Table 705.1. No reclaimed material shall be used. The Contractor shall furnish a certificate from the producer to show the general compositions of the material and values for the designated properties. The Contractors shall also furnish samples, in length adequate for making designated tests, as ordered by the Engineer.

705.8 Plastic Water Stops

Plastic water stops shall be fabricated with a uniform cross-section, free from porosity or other defects, to the nominal dimensions shown on the Plans. An equivalent standard shape may be furnished, if approved by the Engineer.

The material from which the water stop is fabricated shall be a homogenous, elastomeric, plastic compound of basic polyvinyl chloride and other material which, after fabrication, will meet the requirements tabulated herein. No reclaimed material shall be used. The Contractor shall furnish a certificate from the producer, showing values for the designated properties in Table 705.2. The Contractor shall furnish samples, in lengths adequate for making designated tests, as ordered by the Engineer.

Table 705.1 – Required Properties and Test Methods-Finished Rubber Water Stop

Property	Federal Test Method Standard No. 601	Requirement
Hardness (by shore durometer)	3021	60-70
Compression set	3311	Maximum 30 percent
Tensile strength	4111	Minimum 17.23 MPa (2,500 psi)
Elongation at Breaking	ASTM D 412	Minimum 450 percent
Tensile stress at 300 percent elongation	4131	Minimum 6.20 MPa (900 psi)
Water absorption by mass	6631	Minimum 5 percent
Tensile strength after aging	7111	Minimum 80 percent original

Table 705.2 – Required Properties and Test Methods-Finished Plastic Water Stop

Property	ASTM	
	Method	Requirements
Tensile strength	D 638	Minimum 9.646 MPa (1,400 psi)
Elongation at breaking	D 638	Minimum 260 percent
Hardness (shore)	D 2240	60 – 75
Specific gravity	(Federal test Method No. 406-5011)	Maximum – 0.02 from manufacturer's value
Resistance to alkali	D 543	Maximum weight change: - 0.10 percent to + 0.25 percent
Water absorption (48 hrs)	D 570	
Cold bending	(1)	No cracking

Property	ASTM	
	Method	Requirements
Volatile loss	D 1203	Not more than manufacturer’s value
7 days using 10% NaOH	-	Maximum hardness Change ±5 (shore), Maximum tensile strength decrease: 15%

The cold bend test will be made by subjecting a 25 x 150 x 3 mm (1 x 6 x 1/8 inch) strip of plastic water stop to a temperature of –28.80C (-200F) for 2 hours. The strip will immediately thereafter be bent 180 degrees around a rod of 6.35 mm (1/4 inch) diameter by applying sufficient force to hold the sample in intimate contact with the rod. The sample will then be examined for evidence of cracking. At least three individual samples from each lot will be tested and the result reported.

705.9 Hot Poured Pipe-Joint Sealing Compound

It shall meet the requirements of Federal Specification SS-S-169 for the type and class specified.

705.10 Pipe-Joint Packing Compound

Packaging compounds for use with sealing compounds specified in Section 705.9 shall be of appropriate sizes and shall meet the requirements of Federal Specification HH-P-117.

705.11 Preformed Plastic Sealing Compound

For concrete pipe joints, it shall meet the requirements of Federal Specification SS- S-210.

ITEM 706 - CONCRETE, CLAY, PLASTIC AND FIBER PIPE

706.1 Non-Reinforced Concrete Pipe

This pipe shall conform to the requirements of AASHTO M86M (ASTM C14M) for the specified internal diameters, wall thickness, length, straightness and strength classes as shown on the Plans.

706.2 Reinforced Concrete Pipe

This pipe shall conform to the requirements of AASHTO M170M or AASHTO M242M (ASTM C655) for specified internal diameters, wall thickness, length, reinforcement and strength classes as shown on the Plans.

Reinforced elliptically shaped pipe conforming to the requirements of AASHTO M207M (ASTM C507) shall be furnished where specified. Unless otherwise specified, pipe wall design and use of elliptical reinforced concrete arch culvert pipe shall meet the requirements of AASHTO M206M (ASTM C506).

Precast reinforced concrete and sections shall conform to the requirements of the cited specifications to the extent which they apply. Reinforced concrete D-load pipe shall meet the requirements of AASHTO M242M (ASTM C655).

706.3 Perforated Concrete Pipe

This pipe intended to be used for underdrainage shall conform to the requirements of AASHTO M175M (ASTM C 444M) for the specified types, internal diameters and slot length and spacing.

706.4 Concrete, Clay Drain and Perforated Clay Tile

The concrete drain tile with internal diameter from 100mm to 900mm that are intended to be used for surface and subsurface drainage shall conform to the requirements of AASHTO M178M (ASTM C412M) for the specified internal diameter, wall thickness, length, shape, strength and absorption.

Clay drain and perforated clay drain tile shall conform to the requirements of ASTM C 4 for the specified sizes and strength.

706.5 Porous Concrete Pipe

This non-reinforced concrete pipe for use in underdrains shall conform to the requirements of AASHTO M176M (ASTM C654) for the specified internal diameters, strength and porosity or rate of infiltration tests.

706.6 Vitrified Clay Lined Reinforced Concrete Pipe

Designs for fully lined or half lined pipes of the specified strength classes shall be submitted by the manufacturer for approval. The application requirements of AASHTO M170M and AASHTO M65 shall govern. Liner or liner elements, shall be clay of first quality, sound, thoroughly and perfectly burned without warps, cracks or other imperfections and fully and smoothly salt glazed.

706.7 Perforated Vitrified Clay Pipe

This pipe intended to be used for underdrainage shall conform to the requirements of ASTM C700 for pipe with full circular cross-section, for the specified diameters and strength class. When specified, the bell shall have integral spacer lugs to provide for an annular opening and self-centering feature.

706.8 Vitrified Clay Pipe

This pipe intended to be used for the conveyance of sewage and storm water shall conform to the requirements of ASTM C 700 for pipe with full cross-section, for the specified diameters and strength class.

Pipe and fittings for sewers of 150mm to 600mm diameter shall be extra-strength vitrified clay pipe conforming to the applicable requirements.

706.9 Cradle Invert Clay Pipe

This pipe shall conform to the applicable requirements of ASTM C 700 and ASTM C 1208M.

706.10 Asbestos Cement Pipe

This pipe intended to be used in conveyance of drainage works shall conform to the applicable requirements of ASTM C 428 and ASTM C 508 for the specified diameters and strength classes.

706.11 Perforated Asbestos Cement Pipe

This pipe intended to be used in conveyance of drainage works shall conform to the applicable requirements of ASTM C 508 and ASTM C 428 for the specified diameters.

706.12 Reinforced Concrete Arch Culvert, Storm Drain and Sewer Pipe

This pipe shall conform to the requirements of AASHTO M206M (ASTM C506M).

706.13 Reinforced Concrete Elliptical Culvert, Strom Drain and Sewer Pipe

This pipe shall conform to the requirements of AASHTO M207M (ASTM C507M).

706.14 Reinforced Concrete D-load Culvert, Storm Drain and Sewer Pipe

This pipe shall conform to the requirements of AASHTO M242M (ASTM C655M).

706.15 Plastic and Polyethylene Corrugated Drainage Pipe or Tubing

This pipe shall conform to the requirements of AASHTO M252.

706.16 High Density Polyethylene Pipe

This pipe shall conform to the requirements of ASTM F 714 and shall be based upon the DIPS, outside diameter sizing system. The dimensions ratio (DR) of pipe to be installed shall also be either shown on the Plans or as directed by the Engineer.

706.17 Precast Reinforced Concrete Box Sections for Culverts, Storm Drains and Sewers

These sections shall conform to the requirements of AASHTO M259M and ASTM C 789M.

706.18 Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings

This pipe shall conform to the requirements of ASTM D2751.

706.19 Acrylonitrile-Butadiene-Styrene (ABS) Composite Sewer Pipe

This pipe shall conform to the requirements of AASHTO M264 (ASTM D2680).

706.20 Polyvinyl Chloride (PVC) Sewer Pipe and Drain Pipe

This pipe shall conform to the applicable requirements of AASHTO M 278 or AASHTO M304 (ASTM D2729) and ISO 4435.

706.20.1 General Requirements

A. Pipes

For sanitary uPVC pipes and fittings of outside diameter 57mm up to 160mm shall conform to AASHTO M 278 or AASHTO M 304 or ASTM D 2729.
For uPVC pipes and fittings of outside diameter 160mm and up shall conform to ISO 4435.

B. Joints

All joints shall be elastomeric ring and should be machine installed fixed seal made of EPDM rubber bonded with stiff PP ring unless approved otherwise by the Engineer.

Double sockets or slip on sockets maybe used adjacent to structures of special fittings.

Solvent welded fittings maybe used for buried fittings if assembled in the manufacturer's workshop under the supervision of the Engineer's Representative. Solvent shall be as per the pipe anufacturer's recommendation.

Solvent welded fittings maybe used for exposed piping, if approved by the Engineer.

ITEM 707 - METAL PIPE

707.1 Cast Iron Pipe

This pipe shall conform to the requirements of AASHTO M64 or ASTM A716 for the specified diameters and strength classes. Unless otherwise specified, either smooth, corrugated or ribbed pipe may be furnished. Pipe of diameter in excess of 1.2 m (48 inches) shall conform to ANSI Standard for Cast Iron Pit Cast Pipe for specified diameter and strength class.

707.2 Corrugated Iron or Steel Pipe and Pipe Arches

707.2.1 Riveted Pipe and Pipe Arches

The conduit shall conform to the requirements of AASHTO M36 and M218 for the specified dimensions and thicknesses.

707.2.2 Welded Pipe and Pipe Arches

Corrugated steel pipe and pipe arches fabricated by resistance spot welding shall comply with the applicable requirements of AASHTO M36 and M218.

707.2.3 Helical Pipe

Unperforated helically corrugated pipes shall conform to sizes shown on the Plans and with the applicable requirements of AASHTO M36 and M218.

707.2.4 Special sections, such as elbows and fabricated flared and sections, shall conform to the applicable requirements of AASHTO M36 and M218.

Coupling bands shall conform to AASHTO M 36 and M 218, except that use of bands with projections (dimple bands) will be limited to end sections and to pipe laid on grades under 10 percent.

Bands of special design that engage factory reformed ends of corrugated pipe may be used.

Steel sheets of the required compositions may be furnished with commercially produced corrugation dimensions other than those specified in AASHTO M 36 and M 246, if shown on the Plans or approved by the Engineer.

707.3 Bituminous Coated Corrugated Iron or Steel Pipe and Pipe Arches

These conduits, coupling bands and special sections, shall conform to the requirements of AASHTO M190 coating Type A, B or C as specified. Coupling bands shall be fully coated with bituminous material.

Special sections, such as elbows and other sections shall conform to the applicable requirements of AASHTO M190. Coating and invert paving shall be of the type specified. Flared end sections shall conform to the requirements of AASHTO M243 for the coating specified.

The Engineer may waive the imperviousness test for coated pipe if no separation of coating from metal is observed.

When asbestos bonded bituminous coating is specified, these requirements shall equally apply and in addition, the special process of embedding asbestos fiber in the molten metallic bonding medium shall be used to bond the bituminous coating. Asbestos-bonded corrugated metal pipe shall be fabricated in accordance with AASHTO M36 using asbestos-bonded sheets shall be coated with a layer of asbestos fibers pressed into the molten zinc bonding medium. Immediately after the metallic bond has solidified, the asbestos fibers shall be thoroughly impregnated with a bituminous saturant. The finished sheets shall be uniformly coated and free from blisters. After fabrication, the culvert sections shall be treated as specified for either Type A, B or C, as called for in the Bid Schedule, in accordance with AASHTO M190. Coupling bonds shall be fully coated with bituminous material conforming to the requirements of AASHTO M36 and M190, Type A. The use of bands with projections (dimple bands) will be limited to end sections and to pipe laid on grades under 10 percent.

707.4 Corrugated Iron or Steel Pipe for Underdrains

This pipe shall conform to the requirements of AASHTO M 36 and M 218 for the specified diameters and types. Galvanized metal part-circle pipe may be used if permitted by the Special Provisions and shown in the Bid Schedule.

707.5 Bituminous Coated Iron Steel Pipe for Underdrains

This pipe shall conform to the requirements of AASHTO M36 and M218 and shall be coated with bituminous material to meet the requirements of AASHTO M190, Type A coating, except that the minimum coating thickness shall be 0.75 mm (0.03 inch). Coupling bands shall be fully coated. The specified minimum diameter of perforations shall apply after coating. The Engineer may waive the imperviousness test if no separation of coating from the metal is observed.

707.6 Corrugated Aluminum Alloy Culvert Pipe

This shall conform to the requirements of AASHTO M196 and M197.

707.7 Corrugated Aluminum Alloy Pipe for Underdrains

This pipe shall conform to the requirements of Section 707.6.

707.8 Bituminous Coated Corrugated Aluminum Alloy Culvert Pipe

This pipe shall conform to the requirements of Section 707.6 and shall be coated with bituminous material conforming to the requirements of AASHTO M190. Coating and invert paving shall be of the type specified.

707.9 Bituminous Coated Corrugated Aluminum Alloy Pipe Underdrain

This pipe shall conform to the requirements of Section 707.6 and shall be coated with bituminous material conforming to the requirements of AASHTO M190, type of coating as specified.

707.10 Structural Plate for Pipe, Pipe Arches and Arches

These conduits and bolts and nuts for connecting plates shall conform to the requirements of AASHTO M167.

707.11 Full Bituminous Coated Structural Plate Pipe, Pipe Arches and Arches

These conduits shall conform to the requirements of Section 707.10 and shall be coated with bituminous material conforming to the requirements of AASHTO M243, type coating as specified.

707.12 Aluminum Alloy Structural Plate for Pipe, Pipe Arches and Arches

These conduits and the bolts and nuts for connecting plates shall conform to the requirements of AASHTO M219.

707.13 Full Bituminous Coated Aluminum Alloy Structural Plate Pipe, Pipe Arches and Arches

These conduits shall conform to the requirements of Section 707.12 and shall be coated with bituminous materials conforming to the requirements of AASHTO M190, type of coating as specified.

707.14 Precoated, Galvanized Steel Culverts and Underdrains

These conduits shall conform to the requirements of AASHTO M245 and M246.

707.15 Slotted Pipe

Slotted pipe shall be the angle slot pipe or the grate slot type. The type of slotted pipe to be installed shall be at the option of the Contractor.

Slot angles for the angle slot drain shall conform to the requirements of ASTM S36. Grate assemblies for the grate slot drain shall conform to ASTM A36 or A576. Slot angles and grate slot assemblies shall be galvanized in accordance with the provisions of Subsection 712.07, Frames, Gratings, Covers and Ladder Rungs, of the Standard Specification Federal Highway Projects FP-79.

Flashing shall be commercial quality and shall be galvanized with G165 coating designation conforming to the provisions in ASTM A525. Bolts and nuts shall conform to the provisions of ASTM A307. Structural tubing spacers shall conform to the provisions in ASTM A501. Said bolts, nuts and spacers shall be galvanized in accordance with the provisions of AASHTO M111.

ITEM 708 - CHEMICAL ADMIXTURES FOR CONCRETE

708.1 Description

This Item specifies the classification, sampling, testing, packing and marking of concrete admixtures. It also specifies the physical requirements for concrete with each type of chemical admixtures.

Admixtures

A material, other than water, aggregates and hydraulic cement (including blended cement) that is used as an ingredient of concrete and is added to the batch in controlled amounts immediately before or during mixing to produce some desired modification to the properties of the concrete.

708.2 Types of Chemical Admixtures for Concrete

The concrete chemical admixture shall be classified as follows and shall conform to the requirements of AASHTO M194.

a. Type A – Accelerating Admixtures

   An admixture that accelerates the time of setting and early strength development of concrete.

b. Type B – Retarding Admixtures

   An admixture that delays the time of setting of concrete.

c. Type C – Water-reducing Admixtures

   An admixture that reduces the quantity of mixing water required to produce concrete of a given consistency.

d. Type D – Water-reducing High Range, Admixtures

   An admixture that decreases the quantity of mixing water required to produce concrete of a given consistency by 12 percent or greater.

e. Type E – Water-Reducing and Accelerating Admixtures

   An admixture that decreases the quantity of mixing water required to produce concrete of a given consistency and hastens the time of setting and early strength development of concrete.

f. Type F – Water-Reducing and Retarding Admixtures

An admixture that decreases the quantity of mixing water required to produce concrete of a given consistency and delays the time of setting of concrete.

g. Type G – Water-Reducing, High Range, and Retarding Admixtures

An admixture that decreases the quantity of mixing water required to produce concrete of a given consistency of 12 percent or greater and delays the time of setting of concrete.

708.3 Air-Entraining Admixtures

Air-entraining admixtures shall conform to the requirements of AASHTO M154 (ASTM C260).

708.4 Physical Requirements

The concrete in which each of the types of chemical admixtures are used shall conform to the physical requirements given in Table 708.1.

Table 708.1 – Physical Requirements of Chemical Admixtures for Concrete[A]

PHYSICAL PROPERTY	Type A	Type B	Type C	Type D	Type E	Type F[B]	Type G[B]
Water Content, percent of control, maximum							
Time of setting, allowable deviation from control, hour							
Initial Minimum	-	1.0 later	1.0 earlier	1.0 later	1.0 earlier	-	1.0 later
Maximum	1.0 earlier nor 1.5 later	3.5 later	3.5 earlier	3.5 later	3.5 earlier	1.0 earlier nor 1.5 later	3.5 later
Final : Minimum	-	-	1.0 earlier	-	1.0 earlier	-	-
Maximum	1.0 earlier nor 1.5 later	3.5 later	-	3.5 later	-	1.0 earlier nor 1.5 later	3.5 later

Compressive Strength, percent of control minimum:[C]							
1 day	-	-	-	-	-	140	125
3 days	110	90	125	110	125	125	125
7 days	110	90	100	110	110	115	115
28 days	110	90	100	110	110	110	110
6 months	100	90	90	100	100	100	100
1 year	100	90	90	100	100	100	100
Flexural Strength, percent of control, minimum:[C]							
3 days	100	90	110	100	110	110	110
7 days	100	90	100	100	100	100	100
28 days	100	90	90	100	100	100	100
Length Change, maximum shrinkage (Alternative requirements)[D]							
Percent of control	135	135	135	135	135	135	135
Increase over Control	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Relative durability factor minimum	80	80	80	80	80	80	80

A. The values in the table include allowance for normal variation in test results.

The objects of the 90% compressive strength for Type B admixture is to require a level of performance comparable to that of the reference concrete.

B. It is recommended that whenever practicable, tests may be made using cement, pozzolan, aggregates, air-entraining admixture, and the mix proportions and batching sequence when used in non-air-entraining and air- entrained concrete because the specific effects produced by chemical admixtures may vary with the properties and proportion of the other ingredients of the concrete. For instance, types "F" and "G" admixtures may exhibit such higher water reduction in concrete mixtures having higher cement factors than 307 +- 3 kg/m3. Mixtures having a high range water reduction generally display a higher rate of slump loss. When high range admixtures are used to impart increased workability (15 cm to 20 cm slump), the effect may be of limited duration, reverting to the original slump in 30 to 60 min depending on factors normally affecting rate of slump loss.

C. The compressive and flexural strength of the concrete containing the admixture under test at any test age shall be not less 90% of that attained at any previous test age. The objective of this limit is to require that the compressive or flexural strength of the concrete containing the admixture under test shall not decrease with age.

D. The percent of control limit applies when length change of control is 0.030% or greater; increase over control limit applies when length change of control is less than 0.030%.

E. This requirement is applicable only when the admixtures is to be used in air- entrained concrete.

When the admixture is to be used in Prestressed concrete, the chloride content of the admixture shall be stated and whether or not chloride has been added during its manufacture.

708.5 Sampling

708.5.1 The chemical admixtures for concrete shall be sampled either by grab or composite sampling. A grab sample is one obtained in a single operation. A composite sample is one obtained by combining three or more grab samples.

708.5.2 Liquid Admixtures

708.5.2.1 The grab samples taken for quality tests shall represent a unit shipment or a single production lot. Each grab sample shall have a volume of at least 0.5L (1 pint), a minimum of 3 grab samples shall be taken.

708.5.2.2 Liquid admixtures shall be agitated thoroughly immediately prior to sampling. Grab samples shall be taken from different locations and thoroughly mixed to form the composite sample and the resultant mixture sampled to provide for at least 4 litres for complete set.

708.5.2.3 Admixtures in bulk storage tanks shall be sampled equally from the upper, intermediate and lower levels by means of drain cocks in the sides of the tanks or a weighed sampling bottle fitted with a stopper that can be removed after the bottle is lowered to the proper depth.

708.5.3 Non-liquid Admixtures

708.5.3.1 The grab samples taken shall represent not more than 2 Mg (2 tons) of admixture and shall have a mass of at least 1 kg (2 lb). A minimum of four grab samples shall be taken.

708.5.3.2 Composite samples shall be prepared by thoroughly mixing the grab samples selected and the resultant mixture sampled to provide at least 2.3 kg (5 lb) for complete test.

708.6 Testing

Procedures for Proportioning of Concrete Mixtures, Tests and Properties of Freshly Mixed Concrete, Preparation of Test Specimens, Test Specimens of Hardened Concrete and Tests on Hardened Concrete shall be in accordance with AASHTO M194.

The Concrete containing the admixtures shall be tested in accordance with ASTM C39, ASTM C138, ASTM C192, and ASTM C617.

708.7 Packing

The liquid admixtures shall be packed in 4, 20 or 200 litre containers made of steel, plastic or other suitable packing materials. These containers shall be properly sealed.

The non-liquid admixtures or concrete shall be packed in 25-kilogram containers made of steel, plastic, or other suitable packing materials. These containers shall be properly sealed.

708.8 Marking

Each container shall be marked with the following information:

a. Name, form and type of the product;

b. Net mass or volume;

c. Name and address of manufacturer and recognized trademark, if any;

d. Manufacturer's batch number and date of manufacture

e. Made in the Philippines and,

f. Required handling procedures

ITEM 710 - REINFORCING STEEL

710.1 Description

Reinforcing steel shall conform to the requirements of the following Specifications:

Deformed Billet-Steel Bars for Concrete Reinforcement	AASHTO M31 (ASTM A615)
Deformed Steel Wire for Concrete Reinforcement	AASHTO M225 (ASTM A496)
Welded Steel Wire Fabric for Concrete Reinforcement	AASHTO M55 (ASTM A185)
Cold-Drawn Steel Wire for Concrete Reinforcement	AASHTO M32 (ASTM A82)
Fabricated Steel Bar or Rod Mats for Concrete Reinforcement	AASHTO M54 (ASTM A184)
Welded Deformed Steel Wire Fabric of Concrete Reinforcement	AASHTO M221 (ASTM A497)
Plastic Coated Dowel Bars	AASHTO M254 Type A
Low Alloy Steel Deformed Bars for Concrete Reinforcement	ASTM A206

Bar reinforcement for concrete structures, except No. 2 bars shall be deformed in accordance with AASHTO M42, M31 and M53 for Nos. 3 through 11.

Dowel and tie bars shall conform to the requirements of AASHTO M31 or AASHTO M42 except that rail steel shall not be used for tie bars that are to be bent and re-straightened during construction. Tie bars shall be deformed bars. Dowel bars shall be plain round bars. They shall be free from burring or other deformation restricting slippage in the concrete. Before delivery to the site of the work, a minimum of one half (1/2) the length of each dowel bar shall be painted with one coat of approved lead or tar paint.

The sleeves for dowel bars shall be metal of an approved design to cover 50 mm (2 inches), plus or minus 6.3 mm of the dowel, with a closed end, and with a suitable stop to hold the end of the sleeve at least 25 mm (1 inch) from the end of the dowel bar. Sleeves shall be of such design that they do not collapse during construction.

Plastic coated dowel bar conforming to AASHTO M254 may be used.

710.2 Prestressing Reinforcing Steel

Prestressing reinforcing steel shall conform to the requirements of the following Specifications:

High-tensile wire	AASHTO M204 (ASTM A421)
High-tensile wire strand or rope	AASHTO M203 (ASTM A416)

High-tensile alloy bars as follows:

High-tensile-strength alloy bars shall be cold stretched to a minimum of 895.7 MPa (30,000 psi). The resultant physical properties shall be as follows:

Minimum ultimate tensile strength	1000 MPa (145,000 psi) followed by stress relieving
Minimum yield strength, measured by the 0.7 percent extension under load method shall not be less than	895.7 MPa (130,000 psi)
Minimum modulus of elasticity	25,000,000
Minimum elongation in 20 bar diameters after rupture	4 percent
Diameters tolerance	+0.762 mm – 0.254 mm (+0.03”-0.01”)

If shown on the Plans, type 270 k strand shall be used, conforming to AASHTO M203.

ITEM 714 – WATER

714.1 Description

This Item covers criteria for acceptance of Questionable Water either natural or wash water for use in concrete. Water used in mixing or curing shall be potable, clean, free of oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to the finished product, except that non-potable water, or water from concrete production operations, may be used if it meets the requirements of ASTM C1602.

714.2 Requirements

The mixing water shall be clear and apparently clean. If it contains quantities or substances that discolor it or make it smell or taste unusual or objectionable, or cause suspicion, it shall not be used unless service records of concrete made with it (or other information) indicated that it is not injurious to the quality, shall be subject to the acceptance criteria as shown in Table 714.1 and Table 714.2 or as designated by the purchaser.

When wash water is permitted, the producer will provide satisfactory proof or data of non-detrimental effects if potentially reactive aggregates are to be used. Use of wash water will be discontinued if undesirable reactions with admixtures or aggregates occur.

Table 714.1 – Acceptance Criteria For Questionable Water Supplies

	Limits
Compressive strength, min. %	
- Control at 7 days	90
Time of Setting deviation from control	from 1:00 earlier to 1:30 later
Time of Setting (Gillmore Test)	
- Initial	No marked change
- Final Set	No marked change
Appearance	Clear Color
Colorless Odor	Odorless
Total Solids	500 parts/million max. PH value
4.5 to 8.5	

Table 714.2 – Chemical Limitation for Wash Water

	Limits
Chemical Requirements, Minimum Concentration	
Chloride as C1(-1) expressed as a mass percent of cement when added to the C1(-1) in the other components of the concrete	

mixtures shall not exceed the following levels:

1. Prestressed Concrete	0.06 percent
2. Conventionally reinforced concrete in a moist environment and exposed to chloride	0.10 percent
3. Conventionally reinforced concrete in a moist environment but not exposed to chloride	0.15 percent
4. Above ground building construction where the concrete will stay dry	No limit for corrosion
Sulfate as SO4, ppmA	3000
Alkalies as (Na2O + 0.658 K2O), ppm	600
Total Solids, ppm	50000

A Wash water reused as mixing water in concrete may exceed the listed concentrations of sulfate if it can be shown that the concentration calculated in the total mixing water, including mixing water on the aggregate and other sources, does not exceed that stated limits.

Water will be tested in accordance with, and shall meet the suggested requirements of AASHTO T26.

Water known to be of potable quality may be used without test.

PART J – AIRFIELD LIGHTING ITEM 800 - HIGH MAST FLOODLIGHT SYSTEMS (HML)

800.1 Description

This section specifies the performance requirements for high mast floodlight systems for the new Taxiways and Aprons. The scope of works are summarized as follow:

- Provide High Mast Lighting and associated cables, ducts and draw-pits for 10 new Code C Aprons and 2 new MARS Aprons.

- Modification to existing HML locate at north-east of stand C5R may be required subject to the performance of the existing light.

- Working including detail design for the mast foundations. The proposed pavement joint layout shall be taken into consideration on the location of the HMLs.

- Works including provide temporary modifications demanded by the construction affecting the power circuit feeders and related control systems wiring due to local or remote demolition, rewiring, testing and calibration of the High Mast Lighting.

- Work includes all materials and incidentals, including all of the necessary work to place the High Mast Lighting in operational condition as a completed unit to the satisfaction requirements.

- An indicative HML lighting and ducting layout can be found in airfield drawing package. The Contractor shall review the drawing and provide a detailed dimensional layer. The HML and ducting layout shall consider the location of the airfield utilities and joint arrangement.

All the new HML lights, cables, joining kits and control system shall be procured by the Contractor to ensure compatibility of equipment across the airfield.

The new HML control system is proposed connecting to the Airport Operation Control Centre.

800.2 References

The following is a listing of the publications referenced in this Section:

- CAAP DOTC "Manual of Standards for Aerodromes", updated on September 2012, first issued on May 2008
- ICAO Annex 14 Volume I "Aerodrome Design and Operations (Sixth Edition)", updated on July 2013 and first issued on 1990
- ICAO Aerodrome Design Manual Part 4 "Visual Aids", updated on 2004

- FAA Advisory Circular AC 150/5340-30 “Design and Installation Details for Airport Visual Aids”, updated on 7/21/2014
- FAA Advisory Circular AC 150/5370-10G “Standards for Specifying Construction of Airport.
- NFPA 70 National Electrical Code
- NFPA 101 Life Safety Code
- AASHTO LTS 2 Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals
- ASTM A 36 Structural Steel
- ASTM A 123 Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
- ASTM A 143 Practice for Safeguarding Against Embrittlement of Hot Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
- ASTM A 153 Zinc Coating (Hot Dip) on Iron and Steel Hardware
- ASTM A 615 Deformed and Billet Steel Bars for Concrete Reinforcement
- ASTM A 572 High Strength Low Alloy Columbium Vanadium Steel of Structural Quality
- AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings.
- ASTM A 595 Steel Tubes, Low Carbon, Tapered for Structural Use
- Other relevant FAA Advisory Circulars;
- Other relevant ICAO Manuals.
- National Fire Protection Association (NFPA)

800.3 Design and Performance Requirements

The Contractor shall ensure Apron floodlighting must be located so as to provide adequate illumination on all the apron service areas that are intended for use at night.

If an apron taxiway is not provided with taxiway lighting, then it must be illuminated by the apron floodlighting in accordance with ICAO Annex 14 and CAAP DOTC “Manual of Standards for Aerodromes” requirements.

Apron floodlights must be located and shielded and mounted at a height of 25m so that there is a minimum of direct or reflected glare to pilots of aircraft in flight and on the ground, air traffic controllers, and personnel on the apron.

An aircraft parking position must receive, as far as practicable, apron floodlighting from two or more directions to minimize shadows.

Apron floodlighting poles or pylons must not penetrate the obstacle limitation surfaces.

The Contractor shall provide the locations of floodlight as per ICAO requirements. The Contractor can reduce the number of floodlight if it is still possible to fulfil requirements stated in this specification and associated design codes. The Contractor should get the approval from the Engineer in advance to change the floodlight location. The characteristics of apron floodlighting stated in Clause 9.15.4 of CAAP DOTC “Manual of Standards for Aerodromes” shall be followed.

The following summarizes the High Mast Floodlight systems performance requirements.

(1) Illuminance

The HML shall be designed to meet the following performance requirements for the apron stand intended for large aeroplane

Aspect			**Requirement**
Parking Position	(a)	Maintained average horizontal illuminance at ground level	Minimum 20 lux
	(b)	Uniformity	Average to minimum of not more than 4 to 1
	(c)	Maintained average vertical illuminance at 2m above the apron	Minimum 20 lux in relevant parking direction
Other Apron Area	(a)	Maintained average horizontal illuminance at ground level	50 per cent of the average illuminance on the aircraft stands
	(b)	Uniformity	Average to minimum of not more than 4 to 1

(2) Spacing

Referring to FAA Advisory Circular AC 150/5360-13 “Planning and Design Guidelines for Airport Terminal Facilities” Clause 52, the floodlights are typically mounted at a maximum spacing of 60m.

(3) Glare

Referring to Section 13.3.7 of ICAO Aerodrome Design Manual Part 4, the apron floodlights should be located and shielded to avoid direct of reflected glare to control tower or landing aircraft.

In order to minimize direct and indirect glare, the mounting height of the floodlights should be at least two times the maximum aircraft eye height of pilots of aircraft regularly using the airport

(4) Shadow Effect

An aircraft parking position must receive light from two or more directions, as practicable, to minimize the effect of shadow due to obstacles by arrangement and aiming of the floodlights. In case of unavoidable shadow, some apron services may require supplementary lighting such as portable lighting.

(5) Masts and Foundations

The HMLs are installed at two sides of each aircraft stands in order to prevent shadow effect on the apron. The spacing shall be determined by the Contractor in accordance with the listed references code. The floodlights are recommended to be mounted at 25m height which can be minimized glare to the pilots inside cockpit.

The masts shall include means of maintenance access to serve the luminaires, preferably by a mechanism for lowering a ring or equal device holding the luminaries by electrically operated power tools and with the provision to operate manually.

According to ICAO Annex 14, an independent un-switched off ICAO Type A low intensity omni-directional fixed "red" obstruction lighting should be installed at the highest point of each HML to provide enough safety requirements for aircraft. The Obstruction light shall comply with the specification requirements stated in FAA AC 150/5370-10G Item L-119 "Airport Obstruction Lights".

Place the concrete in one continuous pour without construction joints. If any twisting, racking, or other movement of the anchor bolts out of plumb, projection, or pattern, or any damage to the threads exists the Engineer will reject the entire base.

The Contractor shall provide the design and specification documents to the Engineer if other foundation type such as Caisson and Pile type are to be considered.

The foundations will be painted in obstacle marking colours in accordance with ICAO Annex 14. The HML foundation shall be designed to fit with the proposed bay.

The high mast floodlight systems shall be furnished, supplied, installed, adjusted and tested in accordance with this Section.

The high mast floodlight poles shall be designed in accordance with the references listed in clause 800.2, the local Building Code and the provisions of the AISC Specifications. In case of conflict, the more stringent requirement shall govern. The poles shall be designed for vibration and fatigue using two million vibration cycles. All structural details shall be checked for fatigue resistance by applying governing fatigue loading, computing nominal stress ranges at the details and assuring that the stress ranges are less than the constant amplitude fatigue limits for the particular details.

The design wind load shall be the pressure of the wind based on a wind velocity of 90 m.p.h. (and shall include a 30 percent gust factor) on the pole with all appurtenances required, including but not limited to lowering ring, luminaries, pole and base.

Physical properties of poles shall be such that horizontal linear displacement due to the transverse load application is not greater than 5% of the structure height or the limitations set by vibration or fatigue analysis.

Structural design calculations of floodlight poles assemblies, including anchor bolts, bases, and lowering devices shall be signed and sealed by a Professional Engineer licensed in the Philippines where the installation will take place.

800.4 Power Supply

The system reliability can be maintained to minimize the downtime due to failure of power supply networks. In order to ensure that the apron area remains operational during an event of power outage, it is recommended to provide uninterruptible power supply (UPS) to alternate masts.

Feeder pillar shall be provided for distribution of power for apron flood lighting system. Feeder pillar shall be of floor mounting, free standing type, suitable for outdoor installation, dust, vermin and weather proof construction with suitable IP protection.

The calculated load from a computer-aided lighting calculation software need to be increased by 40% which is 30% for counteract the lower efficiency of adopting white light source and 10% for contingency.

800.5 Existing Services

A number of services currently cross the existing pavements, cables and drains. The Contractor has stated that it is to be assumed that the existing services will be removed or diverted within the working boundary.

The Contractor shall hold responsibility for existing information detailing the location and depth of the existing services. The Contractor is recommended to confirm the location of existing services prior to commencement of the works on site.

All redundant electrical equipment at the spectacles is to be removed as part of these works.

800.6 Quality Assurance

Entities manufacturing high mast floodlight equipment, and components specified herein, shall have a minimum of five years of manufacturing experience and shall demonstrate prior experience on at least two projects involving complexities similar to those required under this Contract.

Electrical equipment for which there are a nationally recognized standards shall be safety tested and bear the conformance labelling of the third party inspection authority certifying that the electrical equipment is listed as suitable for the purpose specified.

Electrical equipment shall be manufactured and installed in compliance with applicable articles of NFPA 70, NFPA 101 and all local codes.

800.7 Delivery, Storage and Handling

Deliver materials in the manufacturer's original, unopened, protective packaging. Wet or damp wrapping shall be removed, and disposed of, to prevent staining finish. Store materials in manufacturer's original protective packaging in a manner to prevent soiling and physical damage, prior to installation.

Maintain protective covering until installation is complete and remove such coverings as part of final clean-up.

Handle in a manner to prevent damage to finished surfaces. Touch up any damage to finishes to match adjacent surfaces.

800.8 Spare Parts

Unless otherwise approved by the Engineer, provide 10% (or minimum of one) spare winch assemblies.

Unless otherwise approved by the Engineer, provide 10% (or minimum of 12) replacement lamps for each type of lamp installed.

Unless otherwise approved by the Engineer, provide 5% (or minimum of 2) replacement ballasts for each type of ballast installed.

800.9 Submittals

See Appendix "800 A" for submittals requirements.

800.10 Product References

(1) Manufacturers

Subject to compliance with requirements of this Section, provide high mast floodlight systems of manufacturers.

(2) Materials

Materials for high mast floodlight systems is recommended be as specified below:

Pole shaft shall consist of round and multi sided tapered steel tubes. Pole sections over 12.5 inches in diameter shall be fabricated of ASTM A572, Grade 65 material with minimum yield strength of Fy = 65ksi. Sections 12.5 inches and under in diameter shall be fabricated of ASTM A595, Grade A steel modified to 55,000 psi minimum yield strength. Shaft shall be hot dip galvanized after fabrication in accordance with ASTM A123 and A143.

(3) Anchor Base Plate

Fabricated from hot rolled weldable, low carbon steel conforming to ASTM A572, Grade 42 shall be circumferentially welded to the pole top and bottom. The material shall possess a minimum yield strength of Fy = 42 ksi. Base Plate shall be hot dip galvanized after fabrication in accordance with ASTM A123 and A143.

(4) Anchor Bolt Assemblies

Fabricated from low carbon high strength steel alloy conforming to ASTM A615 possessing a minimum yield strength of Fy = 75 ksi. Each anchor bolt shall be provided with two (2) hex nuts and two (2) flat washers and two (2) levelling shims. The threaded end of each anchor bolt and each hex nut and washer shall be hot dip galvanized in accordance with ASTM A153 without hydrogen embrittlement.

(5) Bracket Arms

Fabricated from 2" schedule 40 pipe shall conform to ASTM A513.

Lighting Fixture Housings Fabricated from copper free aluminium Alloy 360.1 with 0.4% copper content.

Any products specification deviated from this section shall seek approval from the Engineer.

800.11 Construction Features

(1) General

The Contractor to provide a detailed dimensional drawing to show the locations, sizes and types of high mast floodlight pole.

(2) Pole

Shaft shall be tapered steel tubing. All shaft steel shall be full gauge without laminations. All sections of the shaft shall have a uniform taper from top to bottom and shall be full length longitudinally welded. Weld shall be as per AASHTO LTS 2, AWS D1.1 & D1.5, whichever will govern. All welds shall be inspected by methods described in AASTO LTS 2. The Engineer may request the Contractor to perform additional testing as directed by the Engineer.

The overall height dimension as shown on the HML typical details and submit to the Engineer for approval.

Pole shaft shall be secured to the ground by base plate with anchor bolts.

All transverse welds and all base plate welds shall be 100 percent penetration. Longitudinal welds shall be 60 percent minimum penetration. The longitudinal weld in slip joint area shall be reinforced. Inspection shall consist of ultrasonic testing for all 100 percent penetration welds, visual and magnetic particle for all others.

Overall pole height shall not deviate from the specified height plus or minus

1 percent. Sweep and camber shall be maximum of 1/8 inch per 5 feet. Twist shall be a maximum of 10 degrees overall.

The handhole shall be located 6 inches above the base plate and shall be approximately 14 inches by 36 inches outside dimensions and shall have a suitable hinged door and quarter turn lock.

Welded splices or connections shall be in accordance with AWS D 1.1. In material where the yield point is increased by cold working or other physical means, the strength of the welds themselves shall be based upon the properties of the base metal prior to working.

A grounding lug shall be welded adjacent to the equipment handhole inside the pole, and shall be suitable for connection with #4/0 AWG bare copper cable as shown on the Contract Drawings

Resistance of all joints in pole shall not exceed that of parent material. Lightning rod assembly shall be bronze and mounted on top of pole. Rod shall be 2 inch diameter lead coated solid copper and shall have a terminal as shown on the Contract Drawings.

Each anchor bolt shall be threaded as required, and have a 90 degree hook. Anchorage shall be based on the more stringent of AISC and AASHTO codes. Anchor bolts shall be provided with a full size bolt circle template.

The foundation and anchorage system shall be designed for loads equal to, or greater than, the maximum loads that the pole is designed for. The geotechnical criteria shall be stated in order to determine the type of footing to be used (i.e. spread footing).

(3) Lowering Device (Where applicable)

(a) Power Unit

The power unit shall be a drill type tool with a heavy duty reversing motor with the stalled torque at least twice that required to operate the device. The motor shall drive the winch through the torque limiter coupling to limit the lifting force exerted on the cables. The torque limit shall be factory pre-set. There shall be a backup shear pin designed to shear at torque level between 50% and 100% over the torque limiter setting. Provide five extra pins with each power unit. The motor shall be controlled by the switch connected by a 20 foot remote cord.

The motor shall be provided with a support frame which can be mechanically connected to the winch assembly.

The portable power unit shall be provided with a portable enclosed and encapsulated transformer to step down the voltage from the value specified by the manufacturer to 120V to operate the power unit. The transformer shall be provided with carrying handle. All electrical connections shall be prewired outdoor type twist lock caps and plugs.

Utilize the unit in the erection of the floodlight pole assemblies and upon completion of said work deliver the unit, in good operating condition, to a designated location.

Unless otherwise approved by the Engineer, provide one power unit per ten poles installed.

(b) Winch and Gear Reducer Assembly

The winch shall be designed for power operation. The winch shall have a strength at least five (5) times the lifted load with the number of layers of cable with which it will be used. The winch shall be supported from both ends and stainless steel keepers shall be provided to ensure the uncoiled cable will properly rewrap onto the drum.

The worm gear reducer shall have a minimum of 30 to 1 reduction ratio and include an internal drag brake on the worm shaft to prevent free spooling of the winch drum.

The drum shall be capable of winding 150 feet of cable and shall be factory pre wound with stainless steel 7x19 aircraft cord of 1/4 inch diameter and sufficient length to maintain at least eight (8) complete wraps on the drum after the device has been lowered to its lowest position.
A disconnecting type clevis assembly shall be crimped on the end of the drive cable at the factory, and an adapter plate for connecting the reducer onto the drive mounting plate shall be provided with each reducer assembly.

The winch shall be welded to a removable mounting plate connected to the pole structure with four (4) stainless steel bolts and with welded bottom lip to release stress from the bolt connections.

All hardware shall be hot dip galvanized according to ASTM A153.

(c) Transition Clevis Assembly

The transition clevis assembly shall be fabricated of A36 quality steel and shall be hot dipped galvanized.

A transition clevis assembly shall be used to properly attach winch cable to the three (3) hoisting cables and the main electrical power cord. To prevent the cables from untwisting while loaded, which would result in a reduction of tensile strength of the cable, the clevis shall not allow either the winch cable or any of the hoisting cables to independently rotate.

The underside of the transition plate shall contain three compression springs Type S54. The springs shall be internally supported by a galvanized eye-bolt assembly for connection to the main drive cable. Each springloaded eye bolt shall have its corresponding 7x19 stainless steel woven aircraft hoisting cable of 3/16" diameter attached to it by means of factory installed crimps.

(d) Headframe Assembly

The headframe shall be attached to the pole by means of a steel slip fitter and secured by stainless steel screws. The assembly shall be made of a minimum A36 quality steel and hot dip galvanized per ASTM A123.

The headframe shall encompass six (6) hoisting cable sheaves with the minimum diameter of six (6) inches. The cable grooves shall be machined to eliminate any rough surface on which cable shall ride. Oil impregnated sintered bronze bushing shall be pressed into the steel sheave hub and shall ride on stainless steel shafts.

Sheaves shall be housed inside side plates with stainless steel cable keepers. Each sheave shall utilize a keeper bolt arrangement to prevent cables from jumping the sheave.

The headframe shall include three (3) symmetrically located latching devices. The latches shall contain no moving parts and shall remove all loading from the suspension and drive cables.   The latches and hardware shall be A36 quality steel and shall be galvanized. Each latch shall be strong enough to support three (3) times the weight of the entire ring and the maximum number of luminaires.

Indicator flags shall turn automatically during locking process, providing a signal visible from the ground that latch is securely locked.

The power cable shall ride over a roller assembly. The assembly shall consist of multiple rollers installed between two (2) vertical side plates. To prevent abrasion of the cable as it travels through the headframe, the rollers shall be made of resin. The rollers shall be located on a radius on both ends of the assembly to support power cable in at least a seven (7) inch bending radius. A keeper bar shall be positioned at both ends of the assembly to keep the cord in its track during pole erection and normal operation.

All suspension cables shall be pre strung in the factory through the head assembly.

The entire headframe assembly shall be covered by the birdproof aluminium free cover hood. The hood shall fit the cable sheaves in such a manner as to prevent the cables from jumping the sheave. The hood shall be attached to the frame by means of stainless steel screws and self-locking nuts.

(e) Luminaire Ring Assembly

The ring shall be made of a minimum seven (7) gauge A36 quality steel channel and shall be hot dip galvanized. The ring shall have welded to it sufficient quantity of 2" diameter galvanized steel pipe tenons for attachment of the luminaires.

The luminaire tenon shall be pre wired, with power cord running from the tenon to the junction. The ring shall contain three stainless steel locating pins, each with a stainless steel sleeve.

The ring assembly shall be furnished with spring loaded iris guide arms or other centering device which will center the luminaire ring while ascending or descending the pole. The centering device shall be capable of keeping the ring concentric about the pole in winds up to 30 mph.

(f) Wiring

Each ring shall be furnished with the necessary length of 4#10 Type "SO" electrical power cords. All cables shall be attached to the ring assembly at a NEMA Type IV weather tight copper free aluminium wiring compartment through water tight cable connectors. A factory prewired 600V terminal block shall be provided in the wiring chamber. A weather-tight twist lock power inlet shall be provided on the chamber to allow the testing of the luminaires while in the lowered position.

A circuit breaker assembly shall be mounted to the winch plate to serve as disconnecting means for the lowering device. Prewired to the breaker assembly shall be a weather tight twist lock connector to alternately supply the power to the portable power unit and to the test inlet on the lowered luminaire ring.

Strain relief shall be provided at both ends of the main power cable with the use of the properly sized cable clamps. The hole in the headframe plate through which the power cable passes shall be dressed with a stainless steel bushing.

(4) Luminaires

Each high mast floodlight pole shall be furnished with the luminaires appropriate for the floodlight application. Provide luminaires as specified on Item 800.1 and in accordance with associated design codes.

(5) Paint

Each pole shall be primed and painted in accordance with the requirements specified in the in accordance with ICAO Annex 14.

(6) Duct and Manholes

The Duct Bank and Conduits shall comply with the specification requirements stated in FAA AC 150/5370-10G Item L-110 “Airport Underground Electrical Duct Backs and Conduits” and item L-115 “Electrical Manholes and Junction Structure”.

800.12 Execution

(1) Installation

(a) Foundation

The Contractor shall provide the foundations drawing. Concrete shall be in accordance with the Part E Item 311 “Portland Cement Concrete Pavement”

(b) Excavation and Backfill

Excavation and backfill for foundation shall be in accordance with the Part C Item 102 “Excavation” and other associated items.

(c) Install anchoring hardware in accordance with the manufacturer's instructions and the specified anchor bolt template.

(d) Dissimilar Metals

"Dissimilar metals" shall mean those metals which are incompatible with one another in the presence of moisture, as determined from their relative positions in the Electrochemical Series, or from test data.

Where dissimilar metals come in contact, paint the joint both inside and out with approved coating to exclude moisture from the joint, or provide a suitable insulating barrier separating the metals.

(e) Assemblies

Assemble luminaires, furnished under this section, in accordance with the manufacturer's instructions. Provide and install any additional boxes, brackets, required for a complete installation.

Provide stainless steel safety tether for each luminaire. Connect safety tether to the luminaire and the ring assembly.

(2) Inspection

Upon completion of the installation, the lighting fixtures and lighting equipment shall be in operating order and condition and wiring shall be neatly arranged and the finish free from defects. At the time of final inspection, all fixtures shall be fully lamped and be complete with the required lenses, reflectors, and other components necessary for the specified functioning of the fixtures. All fixtures and equipment shall be clean and free from dust or paint spots. Any reflectors, glassware, or other parts broken prior to the final inspection shall be replaced.

(3) Adjustments

Luminaires shall be carefully aimed in accordance with an approved computer generated plot so as to provide a required foot candle distribution. Adjust floodlights during the hours of darkness under the supervision of the Contractor. Notify the Engineer at least 48 hours before the aiming.

800.13 Appendix A Submittal Requirements

Submit the following in accordance with the specification and performance requirements:

A. Shop Drawings

1. Manufacturer's established installation procedure manuals for each type of specified high mast floodlight pole, lowering device and lighting fixture.

2. For each high mast type: Clearly illustrate assembly methods, luminaire mounting hardware, detailed dimensions, anchor bolt size and templates, lowering device details, materials, finishes and electrical components.

3. For each lighting fixture type: Submit independent testing laboratory photometric report, and performance data in IESNA format

4. Luminaire, ballast and lamp and optical assembly description and manufacturer's complete catalog number

5. Luminaire schematic drawing with basic dimensions

6. Isolux (isofootcandle) Curves for Apron area

7. Lumen Utilization Curves for Apron area

8. Zonal Lumen Summary Table

9. Input Watts

10. Luminaire Efficiency

11. For each ballast type: Submit manufacturer's data with ballast description, catalog number, lamp type, input voltage, input wattage, ballast factor, power factor, minimum starting temperature, operating temperature and wiring diagram.

12. Photoelectric Control Devices: Submit manufacturer's data for ambient light sensors and contactors.

13. Drawings

The Contractor shall provide drawings show:

a. Locations, number and orientation of high mast floodlight poles and luminaires.

b. Specify requirements for complete high mast floodlight pole assembly:

c. Pole type, size, height and construction features.

d. Lowering device construction features and appurtenances.

e. Luminaires.

f. Spare parts.

g. Wiring diagrams and grounding details.

B. Calculations

1. For each high mast floodlight system type specified on the Contract Drawings submit calculations verifying that total weight and Effective Projected Area (EPA) of the selected high mast with accessories and appurtenances do not exceed manufacturers Maximum Recommended Total Load. Structural design calculations of floodlight poles assemblies, including anchor bolts, bases, and lowering devices shall be signed and sealed by a Professional Engineer licensed in the State where the installation will take place.

2. Submit:

a. Test results of the welds.

b. Results of vibration and fatigue analysis.

c. Structural computation of lowering device.

d. If the splice design is based on the results of an independent outside entity, the complete test design shall be submitted.

e. The design computations and drawings for any necessary dampers.

f. Structural steel, reinforcing steel and concrete.

3. Submit computer generated lighting calculations.

End of Appendix “A”

ITEM 801 – TAXIWAY LIGHT AND ILLUMINATED AIRFIELD SIGNS

801.1 Description

A. This section includes the minimum specification requirements for supply, installations, testing and commissioning of Airfield lighting equipment including but not limited to constant current regulators, lighting fixtures, isolation transformers, transformer mountings, Airfield lighting cables and illuminated airfield signs.

All the new AGL lights, primary and secondary cables, joining kits and AGL pots shall be procured through the Engineer to ensure compatibility of equipment across the airfield.

Any works required to the existing airport operation control centre located below the ATC tower and the system design is not included in this package and will be managed separately.

801.2 AGL Performance Requirements

The AGL works included in Tender stage, as a performance specification, requiring detailed design of the AGL works to be carried out by the Contractor. The preliminary design of the AGL works and specification required compliance with ICAO Annex 14.

The design and installation of all equipment shall comply with all relevant instructions and regulations statutory or otherwise current at the date of tender and in particular with the following:

- FAA AC 150/5340-30G Design and Installation Details for Airport Visual Aids
- FAA Advisory Circular AC 150/5345-41: Specification for Airport Light Base and Transformer Housings, Junction Boxes, and Accessories.
- FAA Advisory Circular AC 150/5345-46A: Specification for Runway and Taxiway Light Fixtures
- FAA AC 150/5340-24 Runway and Taxiway Edge Lighting System
- FAA Advisory Circular AC 150/5370-10G “Standards for Specifying Construction of Airport.
- PI 29/2005 "Installation, commissioning and maintenance of AGL cable circuits
- The Electricity at Work Regulations 1989
- Aerodrome Design Manual Pt. 4 - Visual Aids

- Aerodrome Design Manual Pt. 5 - Electrical Systems
- M & E Specification 42.
- CDM Regulations
- Any related British Standards and Codes of Practice.
- BS EN 61821 Electrical Installations for lighting and beaconing of aerodromes - Maintenance of aeronautical ground lighting constant current series circuits
- BS EN 61823 Electrical installations for lighting and beaconing of aerodromes – AGL series transformers
- [BS 7430] – BS 7430: 1991 – Code of Practice for Earthing.
- [BS 6651] – BS 6651: 1992 – Code of Practice for the Protection of Structures against Lightning.
- [BS 3224 Part 5] – BS 3224: Part 5: 1988 – Lighting Fittings for Civil Land Aerodromes – Specification for Inset Lighting Units.
- [HSWN 97/16] Health & Safety Warning Notice 97/16 – Aviation Ground Lighting –Simon Parmeko Constant Current Regulators.
- [HSWN 03/02] Health & Safety Warning Notice 03/02 – Aeronautical Ground Lighting (AGL) Asbestos in seating (or base) gaskets.

Only AGL equipment may be used that is in compliance with ICAO Annex 14, and National and International Standards, where the bespoke system integration or homogeneous assembly design, including the use of installation materials, is underwritten by system designer, or if no system designer, the installer.
The Contractor will include manufacturer’s details for all equipment offered with the tender return. This will include confirmation that all equipment offered is in compliance with the relevant standards. Where possible, copies of certification / approval documents will be included. Warranty Certificates shall also be included in the materials proposed to be used.
AGLS subcontractor must have experience in similar scope of work in at least two projects or must have professional assistance and/or supervision from the manufacturer or supplier during the execution of the work. In the absence of a specialty license to install the lighting system, the contractor may opt to employ the supplier’s consultant experts to monitor and inspect during the installation and witness commissioning of the equipment.

801.3 Light Spacing

According to CAAP DOTC Section 9.12.14, the spacing of taxiway edge light should be determined in accordance with the Figure 9.12-1. The maximum spacing on a straight section of taxiway is 50m and uniformly distributed in longitudinal direction.

For the edge lights on curved section, the taxiway edge lights must continue around the edge of the curve to tangent point on the other taxiway. The spacing will be determined based on the radius of the curve. Curved edges should have at least three edge lights with uniform spacing as per FAA AC 150/5340-30.

801.4 Light Characteristic

CAAP and FAA advisory circular stated that medium intensity taxiway lights should be used for taxiway edge lights.

As per FAA AC 150/5340-30H and CAAP Manual of Standards for Aerodromes, the taxiway edge lights should be fixed omni-directional lights with blue colour. The lights should be visible up to at least 75o above the horizontal and at all angles in azimuth necessary to provide guidance to the pilot of an aircraft on the taxiway. The intensity of taxiway edge lights should be 2 cd from 0o to 6o vertical and 0.2 cd at any vertical angle from 6° to 75°.

801.5 Ducts and Draw-pits

The new duct and pit system for the T2 apron area are designed to serve the new taxilane edge lights. Spare ducts, draw-pits and earth-pits are proposed at the taxilanes centreline for future development. The pits will be surrounded by isolation joint to prevent pavement cracking induced from corners of pit. The AGL pit shall be constructed at the corner of a concrete pavement bay, if practicable, to reduce quantity of isolation joint used and complexity of construction.

As there are only few number of lights to be installed, the new AGL development is recommended connecting to extension of existing circuits. The Contractor shall verify the feasibility of such arrangement.

The recommended drawpits spacing is at every 60m interval and earthing pit at every 200m.

The Duct Bank and Conduits shall comply with the specification requirements stated in FAA AC 150/5370-10G Item L-110 “Airport Underground Electrical Duct Backs and Conduits” and item L-115 “Electrical Manholes and Junction Structure”

801.6 Use of Reflectors

Reflectors are permitted to enhance taxiway lighting systems installed on short taxiway sections, curves and intersections. Contractor shall refer to Retro- reflective AC 150/5345-39, FAA Specification L-853, Runway and Taxiway Retro- reflective Markers.

801.7 System Design

The Contractor shall coordinate the lighting system design with the existing and future airport plans. A typical edge lighting layout and ducting arrangement can be found in airfield drawing package. The Sub-contractor shall review the proposed layout and provide detailed design drawings showing the dimensional layout of the lighting system prior to construction.

Lighting Fixtures.

The lighting fixtures installed in the edge lighting systems are either base-mounted. Base mounts are used for either elevated fixtures or in-pavement fixtures. Base mounting provides additional protection for this equipment and makes the equipment more accessible for maintenance. Base-mounted fixtures must be installed using series circuits only and are recommended for MITL. The Contractor shall provide cost information for the system to the Engineer for confirmation.

Electrical Power

(Series vs. Parallel Circuits). Series powered circuits with isolation transformers are recommended for the taxiway edge MITL lighting systems.

Series circuits may also be interleaved, considering requirements for equipment such as regulators and adjacent lamp monitoring during design of the system.

The Contractor shall refer to International Civil Aviation Organization (ICAO), Aerodrome Design Manual, Document 9157-AN/901, Part 5, Electrical Systems.

For additional technical information about airport lighting circuit interleaving. The power cable shall comply with the specification requirements stated in FAA AC

150/5370-10G Item L-108 “Underground Power Cable for Airports”. Underground cable for airfield lighting facilities (taxiway lights and signs) shall conform to the requirements of AC 150/5345-7, Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits latest edition.

Power Source and Monitoring.
Series powered airport lighting circuits are powered by constant current regulators

(CCRs). The regulators and the associated monitoring system are described in AC

150/5345-10, Specification for Constant Current Regulators and Regulator Monitors. System design is not included in this package and will be managed by the Contractor separately.

Lighting System	Type	Mounting	Fixture	Power System	Number of Steps
MITL	Inset	Base	L-852T	Series	3
	Elevated	Base	L-861T	Series or Parallel	3

Brightness Steps.

The edge light intensity shall design to meet the medium intensity systems requirements. The MITL system shall be installed using a series circuit and powered by an L-828 or L-829 regulator, have three brightness steps as follows:

		Lamp Current	
	Percent Brightness	**Series**	**Parallel**
Step 3	100	6.6A	120V
Step 2	30	5.5A	85V
Step 1	10	4.8A	60v

Equipment and Materials.

All equipment and material shall be complied with ICAO Annex 14 and FAA Advisory Circulars.

A. TAXIWAY EDGE INSET LIGHTS (LED type)

1. The light shall be fitted with powerful coloured Light Emitting Diodes.

2. Average LED life of 100,000 hrs at full intensity and shall include a long-life fitting. The fitting has a low projection height without any negative slope in front of the prism. This gives the same performance in dry and rainy conditions.

3. The light shall resist all stresses imposed by impact, rollover and static loads of the modern in-present aircrafts without damage to light, aircraft or vehicle tyres.

4. The LED fitting shall function normally and compatible with the used remote lamp control.

5. The whole fitting and mounting system are to be fully corrosion proof. All screws, washers, nuts and hardware are to be made with

plain stainless steel. The total height of the fixture above grade is not to exceed 12mm.

6. The inset lights should be designed for use in harsh environments. The electronic components are encapsulated in waterproof polyurethane, well protected from wear and tear.
7. There should be inbuilt over-voltage surge and lightning protection provided.

B. TAXIWAY EDGE LIGHTS ELEVATED (LED TYPE)

1. The average LED life of 100,000 hrs at full intensity and shall include a long-life fitting and more than 180,000hrs under typical operating conditions which significantly reduces ongoing maintenance costs and periodic re-lamping expenses.
2. The elevated lights shall be UV-resistant polycarbonate outer lens option minimizes risk of lens damage if fixture is knocked over.
3. The elevated lights should be rugged low-profile design reduces damage due to jet blast.
4. Aluminum casting, stainless steel hardware and protected with aviation yellow powder coat finish. Locking ring is protected with aviation blue powder coat finish.
5. The elevated lights should withstand wind velocities up to 300km/hr.

C. RUNWAY GUARD LIGHT (WIGWAG) LED

1. Average LED life of 100,000 hrs at full intensity and shall include a long-life fitting and more than 180,000hrs under typical operating conditions which significantly reduces ongoing maintenance costs and periodic re-lamping expenses.

2. Runway guard light is a runway holding position elevated flashing, high intensity light to be used in night and day and to provide ICAO photometric performances, for use in CAT I conditions.

3. The average luminous intensity is to be at least 3000cd in yellow light for a minimum beam coverage as follows;

   Horizontal : +,- 8˚
   Vertical : +,- 8˚

4. Two light sources surrounded by a low luster black face plate and independent visors, to reduce the amount of incident sunlight in order to maximize the contrast during on-off cycle.

5. Two 65W, 6.6A LED lamp life at full intensity.

6. The fixtures shall be fabricated from corrosion-resistant materials and all exterior surfaces shall be painted in aviation yellow for added protection and visibility.

7. The mounting system shall include a flexible steel tether and grooved column that will ensure that the fixture is frangible that will prevent the fixture from being blown into neighboring taxiways or runways in case the column breaks.

8. The flash rate shall be in alternating flashes of 45 to 50 flashes per minute per lamp.

9. The light beam shall be adjustable of 0 to 20˚ vertically and +,- 20˚ horizontally.

10. The light in each unit of ICAO Configuration A shall be illuminated alternately.

11. The unit is to be continued working on one lamp if the other lamp is out of service.

12. The fixture shall be installed on a light base housing using a heavy duty base plate that shall be designed to withstand the high bending moments induced in the fixture.

D. AIRFIELD GUIDANCE SIGNS

1. The airfield guidance signs shall be internally illuminated which fully comply with latest ICAO Annex 14 and FAA.

2. The signage shall consist of a rigid, self-carrying and low mass aluminum housing with a poly-carbonate panel. The legend shall be applied inside and no paint shall be used in order to limit damage and aging to a minimum.

3. The frangibility shall be in accordance with ICAO requirements and must withstand wind velocity up to 300km/h.

4. The lamp shall be LED. Coordinate to winning supplier for the number of LED modules to be use.

5. CAT I holding position signs shall be located on each side of the runway-holding position marking facing the direction of the approach to the critical area.

6. Information signs shall wherever practicable be located on the left side of the taxiway.

7. A mandatory instruction sign shall consist of an inscription in white on a red background. The height of a mandatory sign shall be 800mm.

8. An information sign other than location sign shall consist of an inscription in black on a yellow background. The height of an information sign shall be 600mm.

9. As per site conditions guidance signs should have bird spikes to prevent birds waste to enter on the signs panel.

10. Re-lamping shall be performed without the need for any special tools without having to open large wind loaded panels.

11. Electrical power supply to the sign shall be 6.6A series circuit. The protection degree of the sign shall be minimum IP54 or better.

12. The forms of characters, i.e., letters, numbers, arrows, and symbols shall conform to those shown in ICAO Annex 14, Volume 1, 7th Edition 2016, Appendix 4.

13. The average luminance of the sign shall be calculated by establishing grid points as shown in Figure A4-1 in ICAO Annex 14, Volume 1, 7th Edition, 2016 Appendix 4.

14. The perpendicular distance of Taxiway Guidance Signs from the runway and taxiway shall be in accordance with Table 5-5 of ICAO Annex 14 Vol. 1 7th Edition 2016.

E. AIRFIELD LIGHTING CABLES

Airfield Lighting cables are to comply with ICAO Aerodrome Design Manual Part 5 and FAA specification L-824 type C. Two types of AFL cables shall be use primary series cables and secondary cables.

Airfield Lighting Primary Series cables

1. AFL Primary series cables is used to connect the Constant Current Regulators (CCR) to the primary windings of isolating transformers. Primary cable shall be single core, screened MV(5KV) cable and its construction shall be as follows;

    a. Conductor stranded 7wires tinned copper conductor, minimum cross section $6mm^2$

    b. Extruded semi-conductive layer

    c. Cross-linked polyethylene (XLPE) insulation with minimum thickness of 2.3mm.

    d. Brass tape screen

    e. Black polyethylene or PVC sheath, ozone resistant with termite repellant.

    f. Supplied on non-returnable wooden drums in length of 3000m.

2. Junction kits between the primary series cables and the isolation transformers are to be done by connector kits in accordance with FAA specification L-823.

3. The connector kit is designed to fulfilled the following requirements;

   a. To ensure the electrical continuity of the screen.
   b. To earth the screen.
   c. To ensure the continuity of the primary series loop.

4. The construction of connector kit is to consist of one plug and one receptacle. The kit consist of:

   a. One male and one female connector to be crimped on the series cable conductor.
   b. One male and one female connector body.
   c. Connection accessories for the cable screen.

F. Airfield Lighting Secondary Cables

1. AFL Secondary cable is used to connect the airfield lighting fixture to the secondary windings of series isolating transformers or to the remote control unit connecting to the transformer . Secondary cables shall be two-cores cable (for running into ducts) or two single core wires (for running into saw-cuts) of 1KV nominal voltage.

   a. Conductor stranded minimum cross section $4mm^2$ copper conductor.

   b. Polyvinyl-Chloride (PVC) insulation.

   c. Supplied on non-returnable wooden drums in length of 4000m.

   d. The connector kit for secondary cable to be supplied separately, and to be complied with the ICAO requirements and FAA specifications.

   e. Cable joints in secondary cables shall not be permitted.

The secondary connector kits shall fulfill the following reqts:

The secondary connector kits shall comply with the latest edition of FAA AC 150/5345-26.

- The connectors shall be made from the same thermoplastic elastomeric materials as the opposite connector of the lights or series transformers.
- The pins and sockets shall be made respectively from nickel and tin plated copper, partially annealed to be crimped to the cable conductors.
- The secondary connector kits shall be fully watertight.
- Current rating 20A and Voltage rating 600V.

G. LIGHT BASES

For this project there are two bases to be use deep base and shallow base. Bases are divided into two categories, those subjected to load bearing and those non-load bearing bases. Load bearing bases are generally used for inset lights when the fittings are subject to aircraft loading. Non-load bearing bases are generally used for elevated lights. They are installed in the shoulders and thus normally not subject to any other load than the light they bear. They nevertheless resist accidental rollover by any aircraft or by any ground vehicle in their normal path. The deep base will be use for the elevated lights which will be installed on the straight section of the taxiway. The shallow base will be installed on all curved sections of the taxiway.

The installation of bases requires great care for the initial positioning. The bases are supporting lights and these lights have very narrow positioning tolerance. A temporary plywood is to be provided to protect the top flange during transportation and erection. The base covers are to be supplied with stainless steel mounting screws and O-ring gaskets to ensure water tightness of the assembly.

Shallow light bases for mounting flush lights are to be tempered, anodized with aluminum alloy coating against corrosion suitably size for the type of light installed and provided with necessary cable entry, glands and grommets and suitable resin filler.

H. ADHESIVE COMPOUNDS THREE COMPONENT FOR SEALING INSET LIGHTS IN PAVEMENT.

The sealing of inset lights in pavements require adhesive compounds. It is three component made of inert filler, resin and activator.

a. Application. Adhesive shall be applied on a dry, clean surface, free of grease, dust and other loose articles.
   The method of mixing and application shall be strict accordance with the manufacturer recommendation.

b. Curing. When pre-warmed at 25˚C mixed and placed in accordance with manufacturer direction, the materials shall cure at 20˚C without the application of external heat.

c. Caution. Installation and use shall be in accordance with manufacturer recommended procedures. Avoid prolonged or repeated contact with skin. In case of contact wash with soap and flush with water.

d. The Contractor shall furnish the vendor certified test report for each batch of material delivered at project. The report shall certify that the material meets specification requirements and is suitable for use with fine aggregates or high grade sand. The report shall be delivered to the Engineer before permission is granted for use of material.
   In addition the contractor shall obtain a statement from the supplier or manufacturer which guarantees the material for one year.

I. ISOLATION TRANSFORMER

Isolation transformer are to be manufactured in accordance with FAA 150-5345-47b and are to comply with ICAO Aerodrome Design Manual Part 5. Transformers are to be located in manholes of taxiways as shown in the drawings.

a. The isolating transformer should consist of primary and secondary circuit around magnetic core and is suitable for the primary operating voltage of 5000V.

b. The primary and secondary circuits should be isolated electrically. The winding should be tightly wound and secured prior to molding to reduce the possibility of turns becoming loose. The core of the isolating transformer should remain unsaturated in normal load conditions, but its state would change to saturated if one of the lamps connected is blown. This will maintain integrity of the system.

c. Transformers shall be designed to operate indefinitely under load, short circuit, or open circuit conditions in the secondary with rated current and rated frequency in the primary. The transformer shall have sufficient capacity to allow for lamp ageing, secondary lead losses and contact losses.

d. Isolating transformers are to be completely molded or encapsulated in a thermo-plastic elastomer. The primary side is to be equipped with 2 single core $6mm^2$ primary cables (5KV) each 0.6m long, with one male and one female plug and the secondary side is to be equipped with a $2x4mm^2$ secondary cable (1KV) of 1.2m length with a two pole female plug. The following operating conditions shall apply to the isolating transformers:

Rated voltage	: 5000V
Rated frequency	: 60HZ
Rated current	: 6.6A
Rated power	: 15W, 45W, 65W, 100W, 200W
Operating temperature	: -55 to 65˚C

e. Earthing is to be provided by connecting the earthing, lead of the transformer to a welded earthing terminal inside the base, as requested by ICAO Aerodrome Design Manual Part 5.

J. CONSTANT CURRENT REGULATORS

1. The CCR construction and performance shall comply to the following :

   ICAO Aerodrome Design Manual Part 5 para. 3.2.1.4 to 3.2.1.6
   FAA 150-5345-10f
   IEC 61822 edition 2 2009-05

2. The constant current regulator is to be microprocessor controlled and of solid state using Thyristors in series with the output transformer for automatic current regulation against load and mains voltage variations.

3. The CCR operational parameters are to be adaptable and modifiable through the password protected operator display or through a portable PC with a dedicated software.

4. The built-in microprocessor shall allow for comprehensive monitoring and diagnosis of the CCR, and adaptation of user defined optional parameters. It shall allow also for remote control and monitoring via field bus system or multi-wire.

5. The manufacturer shall provide all communication message descriptions to allow integration with Airfield Lighting Control and Monitoring System.

6. The CCR shall be equipped with a built-in HV-Cutout easily accessible and protected with a key. The cut-out shall isolate the series circuit from the CCR output and provides grounding and insulation resistance measurement functions.

7. The on-board controller shall monitor the following;

    a. The supply voltage variations
    b. Output current monitoring for over-current
    c. Output current monitoring for open circuit
    d. Output current monitoring for asymmetry.

8. The CCR is to be provided with series circuit insulation monitoring, which will measure the insulation resistance of the series circuit versus ground with both the regulator on and off. A stabilized DC voltage is to be applied between series circuit and ground, irrespective of the operating voltage. The measurement range for the insulation resistance module shall be 0 to 500Megaohms. It shall be possible to set two threshold values for the generation earth fault warning or alarm.

9. The CCR shall be circuit selector compatible, and lamp addressable units without having to replace or modify any parts of the hardware of the CCR. The CCR shall be able to respond to circuit changes within 15cycles. Provision is to be made to indicate a ground fault on the circuit while permitting the circuit to operate normally when only a single ground fault occurs.

10. The CCR shall include an open circuit protective device to lock the regulator when there is open circuit on the secondary. The device shall be reset by push button located on the display panel of CCR. The over-current protective device shall trip the primary when over-current exceeds the 6.6A current by 5%. The device shall operate within 5 seconds after an over-current of 5% and within 1 second after an over-current of 25%. The device

shall reset within 2 seconds after the control switch is turned off and re-energized

11. The CCR shall be indoor type, solid state, using back-to-back coupled thyristors in series with the output transformer for automatic current correction against load and mains variations. They are to be air-cooled naturally ventilated. Use of forced air ventilation is not permitted. Regulators are to be KVA rated as indicated, 230 volts, 60 Hz input power. Output current is to be 6.6A as indicated CCR are to be provided with internal DC voltage for control power and are to be interfaced with remote control and monitoring from the control consoles. Regulators shall have proper EMI shielding and shall not generate any kind of electro-magnetic interference causing disturbance to the surrounding equipment.

12. Output current is to be maintained with up to 30% of secondary of isolating transformers open circuited. A compensator shall set the thyristor-firing angle to adjust the output current to a reference value. The reference value shall vary with the selected brightness step.

13. Power factors are to be guaranteed at not less than 0.9 for 2.5 kVA to 30kVA units. The CCR shall have 20% space capacity for future additional load.

14. Ambient operating conditions of units are to be from - 10°C to + 55°C.

15. CCR shall include of the following:

    Circuit breaker.
    Alpha numeric LCD display to indicate
    Output current [RMS]
    Output voltage [RMS}
    Input Power Factor.
    Input Voltage.
    Input Current [RMS]
    Efficiency
    Output Load [kVA]
    Thyristor Conduction angle
    Leakage Resistance Value
    Series Circuit Identification.
    Brightness step [% Illumination]
    Number of failed lamps
    Display and LCD test.
    Hours Run Counter [Total + Individual Steps]

• 2 Levels of Leakage resistance thresholds.

LED's for CCR on, I-fault, earth-fault, Lamp fault and local operation.
Reset button.
Remote, off, brightness step 1 to 5 selectors.
Open circuit protection device.
Over current protection device.
Adjustable operational parameters via the CCR front panel.
communication interface.
Input terminals, output terminals.
Auxiliary fuses, diagnostic connector, earth terminal, lightning arrestors, power transformer.

16. CCR are to be provided with user configurable 3-step or 5-step brightness steps. The current shall be digitally adjustable for all intensity steps over full current range 1.3 A (RMS) to 6.6 A (RMS).

17. For ease of maintenance, all modules within the CCR are easily accessible for servicing or replacement without the use of special tools.

18. The output current regulation shall be ±1 % of 6.6A under the following conditions:
Load variation between 0 % & 100%
Supply voltage variation of -15 % to +15 %
Supply frequency variation of ± 5 %.

19. The taps on the output winding shall allow for matching the regulator output capacity to the actual series circuit load. For precise adaptation to any secondary load.

20. The CCR is to include the necessary interface modules for the remote control signaling and monitoring system as described elsewhere.

21. The CCR shall be provided with Lamp Fault Detection and Earth Fault Detection.

22. Supplier shall provide the software and the necessary tools required for set up and maintenance procedures.

23. The CCR shall be able to handle non-linear load with no restrictions on the performance of the CCR.

24. The access to the settings of the CCR parameters shall be password protected.

25. The CCR shall undergo detailed functional testing at factory in presence of Consultant and CIAC representatives before being sent to the site.

26. CCR Unit is to be a self contained, metal clad, floor standing unit with lifting lugs, and two cross pieces for floor mounting and with lockable doors. All monitoring and control functions are to be front mounted.

K. SERIES CIRCUIT CUT-OUT

1. The series circuit cut-out is used to isolate safely the series circuit from the Constant Current Regulator during maintenance or testing operations; and also to allow periodical isolation resistance measurement of series circuit to ground without disconnecting the series primary cable.

2. The CCR shall be provided with cut out for each series circuit in accordance with CCR rating and circuit load.

3. The series circuit cut-out shall be 20A current capacity and 5kV A.C. working voltage. The cut-outs shall have 3 positions "Operation", "Maintenance", and "Test".

L. GROUNDING OF AGL INSTALLATIONS

1. Ground conductor for secondary circuits are to be connected to grounding terminals inside airfield lighting fixtures, using an insulated green/yellow PVC grounding wire of 4 mm2 cross section, connected to an grounding bar installed in the manholes.

2. An grounding counterpoise wire of 22 mm2, PVC insulated green/yellow is to interconnect all grounding bars inside manholes and is to be ground to grounding rod every 150m. The grounding conductor is to be pulled in 50mm UPVC duct over the top row of ducts at 150 mm over the ductbank and positioned centrally over airfield lighting cables.

3. Airfield lighting cable shields of primary are to be connected to the grounding terminals in every manhole by 2.5mm² and airfield isolating transformer leads using an insulated PVC wire (Green/Yellow) of 6mm2 cross-section.

801.10 Airfield Earthing

The Contractor shall provide and install additional supplementary earth pits at every 200m along the length of each earth circuit conductor. The quantity of rods at each location will be sufficient to provide at least 5Ω resistance to earth. The main earth will be connected to the earth rods at these locations and labelled "electrical earth, do not disconnect". Earth cables will be laid in the same duct as the AGL series circuit cables they are protecting.

801.11 Liaison with Others

The Contractor is advised that during the course if the works the Airport building and associated airfield will remain fully operational 24 hours a day, 7 days a week. It is essential therefore that the Contractor liaises closely with all appropriate parties.

The airport authorities are to be consulted on the detailed daily program and agreement obtained to ensure no conflict with operational movement. The primary source of contact will be the Engineer. A system of permits to work will be operated to ensure that any work on the AGL system is coordinated and approved by the Engineer.

801.12 Contractor Operatives

A proportion of the works requires the Contractor to carry out installations next to the area of live taxiways/aprons.

All operatives working in these areas will hold the relevant Airport permits and have the necessary radio training. The Sub-contractor will allow in his tender for appropriate training for all staff. All staff will have previous experience of working in the areas of live taxiways/aprons evidence of this will be provided with the tender return.

The Contractor is to provide its own experienced Approved Persons conversant with but not limited to ICAO and FAA requirements to advise the contract manager on site requirements.

801.13 Safe Working Procedures

The Contractor will adhere to a safe working procedure at all times and comply with the airport Safety Rules and Procedures. Work in the active areas of an airport may be subject to some hazards. Assessments shall be carried out by the Contractor for each type of task to identify risks and any necessary procedures to minimize them. Where risks are, other than trivial, risk assessments shall usually lead to the production of a method statement setting out procedures to be followed. The five steps of risk assessment are:

- Look at the hazards
- Decide who might be harmed and how
- Evaluate the risk arising from the hazard and decide whether existing precautions are adequate or more should be done.
- Record the findings
- Review the assessment from time to time and revise if necessary.

The Contractor shall prepare all work programmes which will be agreed in advance with the Engineer. In giving estimates of outage times it is beneficial to allow for contingencies and therefore give best and worst case scenarios. The Contractor shall endeavour to always start at the agreed time as a delayed start does not necessarily imply that a corresponding later finish time will be acceptable. Some electrical accidents occur during fault finding after a breakdown when pressure for continued operation could result in electricians taking risks. To anticipate this, a plan should be established for proper fault finding procedures, which are always implemented during breakdown maintenance.

Where the task may impact on the activities of other organisations it is essential that the Contractor liaises with them to ensure that no unforeseen hazards exist.

The Electricity at Work Regulations 1989 applies to work on AGL, as well as all other electrical installations. Compliance with the requirements of these regulations is essential to ensure safe working practices.

801.14 Submittals

1. Acceptance inspection and testing plan, including procedures for airfield lighting equipment inspection and testing to ensure proper installation and operation.

2. Technical Data: Submit data for approval, including catalogues, detailed literature, manufacturer’s name, catalogue number, rating, specification overall dimensions and special features, as applicable for each item.

3. List of recommended spare parts, consumable items and maintenance special tools to be provided after completion of project.

4. The final drawings are indicative showing the requirements for the airfield lighting layouts and the related civil works, it shall be the Contractor’s responsibility to check the drawings verify at site the actual conditions and related civil works to satisfy the system performance required by the airfield equipment supplier.

5. Contractor shall arrange for testing of the equipment at the Supplier factory to be witnessed by the Client and Consultant representatives team. The team will inspect major components of airfield lighting equipment like ccr’s, lights and guidance signs.

6. Contractor to submit site acceptance sheets based on supplier recommendations for accepting the equipment on site.

7. Contractor to submit a safety assessment document for all equipment supplied under the project.

8. Contractor to provide complete technical information deemed necessary by the Client/Engineer, for the equipment/system including software used for commissioning, testing or troubleshooting.

9. AGL contractor shall provide the complete database of the installed AGL equipment, fixtures, circuits, etc. with extensive technical details.

10. The contractor shall provide one complete set of special tools and test equipment required for the installation, testing, commissioning and maintenance of the supplied equipment to CIAC. These tools shall include, but not limited to the following;

    - Installation jig for 8inch shallow base,
    - Light unit lifting tool

11. The proposed AGL lighting fixtures are LED type.

801.15 Functional Tests

Installation shall comply with FAA AC 150/5340 24 and shall be done in accordance with fixture manufacturer's installation procedures. The AGL Contract shall perform functional test to demonstrate the reliability of the electrical installation as per FAA AC 150/5340-24 requirements.

The Contractor is to supply all necessary equipment and appliances for a complete testing and commissioning.

1. The CCR's shall be tested after the completion of the installation to the designed ambient condition and full load rating.

2. All lighting power and control circuits are continuous and free from short circuits.

3. The insulation resistance to earth of all un-earthed series circuits is not less than 80 megaohms.

801.16 MANUFACTURER SUPPORT

Warranty

The AGL equipment manufacturer shall warrant against defects in workmanship and hardware for the equipment specified in this section and in a minimum period of 1 year from the date of completion of the project.

1.2 Technical Support

The AGL equipment manufacturer shall provide the following minimum technical support during warranty period.

a. Technical Phone assistance
b. Answering emails
c. Technical support via telephone 24/7 throughout the year.
d. Onsite Technical field support as required.

1.3 Spare Parts

The AGL contractor shall provide sufficient spare parts and consumable items for 1year of operation including the warranty period. A list of recommended spare parts shall be submitted during bid submission period. The spare parts shall be delivered to CIAC warehouse after carrying out all the required material inspection tests. The spare parts/consumable items shall be handed over to CIAC prior to the completion of Site Acceptance tests.

1.3.1 Spare parts/consumables shall include, but not limited to the following:

- Led lamp, led electronics, driver, back cover leads (all different wattages)
- Filter gaskets
- Non-sealed prism
- LED assembly
- Sealed prism
- 6.6A converter assembly
- VAC converter assembly
- Valve for water tightness test

- Runway Guard lights
- Taxiway edge lights
- Guidance Signs

- Series isolating transformers (of all different wattages)
- CCRs power supply
- Accessories for CCRs
- Primary cable connector kits
- Secondary cable connector kits

Note: The spare items shall have the same specifications of the original items mentioned in this specification.

II- PRODUCTS AND SYSTEMS

1. APPROVED MANUFACTURERS
   a. Eaton (USA)
   b. Honeywell (Germany)
   c. Hella (Germany)
   d. ADB Safegate (Belgium)
   e. Youyang (Korea)
   f. OCEM (Italy)

PART K – WATER SUPPPLY SYSTEM FOR AIRCRAFT FIRE AND RESCUE PROTECTION

1. Selection of water source
   - Public (municipal) water system
   - Man made reservoir
   - Natural reservoir

2. Standards for distribution system
   - Minimum Hydrant spacing is 300ft (90m) but not more than 500ft (150m)

   Does not include – Water supply system

Item 900 - Fire Hydrant System

Applicability: Support Aircraft Rescue operation in Airport

Guide for water requirements for Fire Protection

- Airport Terminals
- Airport hanger
- Air cargo terminal
- Fuel Farm

Ref: NFPA 419 Guide for Master Planning Airport and water Supply System for Fire Protection

Layout:
Along periphery of aprons used for aircraft parking, passenger loading and unloading. Not under terminal, maintenance facility ,embankments, heavy traffic areas, runways, taxiways. Hydrant location shall be identified with a reflective sign at least 15ft above their position.

Materials:
Pipes – Black iron pipes atleast 6'' for the main line coated with approved material for rust protection
Fire Hydrant - 4' hose nozzle and shall be in conformance with NFPA No. 194

System Readiness & Maintenance

a. Oversight. Responsibility for assuring proper operation,
maintenance, and testing of an ARFF vehicle fill source and the associated distribution system should rest with a single agency or authority. Depending on the actual source, and/or its physical location, that authority could be airport management, a private water company, or the local municipal utilities department.

b. Operational Checks. Periodic testing of subsystem components as well as the total water supply system is essential to both prove the operational readiness of the system and to train new personnel or maintain the currency of those responsible for system operation under emergency conditions.
In addition, key ARFF officials should be fully familiar with the operation of

any portion of the water supply system under airport jurisdiction. The following schedule of operational checks is recommended:

(1) Initiate and maintain a leak detection program to detect and repair leaks that may develop in any portion of the buried water system that lies near the air operations surfaces. Undetected leaks could result in pavement undermining and subsequent collapse.

(2) Perform a turnover test for both the primary and the spare fire water pumps at least once a week. Conduct full flow tests at least once per year. Run up each internal combustion engine (including any spares) used to drive fire water pumps weekly for at least one-half hour.

(3) Flush test all hydrants annually. Operate all main and subsystem valves in the water supply system through at least one full cycle (open/close/open or close/open/close) at least once annually.

(4) Conduct a daily inspection of all subsystem isolation valves to insure that inadvertent system outages do not go undetected in the event that unauthorized valve closures occur.

(5) Conduct a full flow test immediately after any significant change, modification or repair has been made to the airport ARFF water supply system; or, to any of the major subsystems. This test is needed to insure that the original design parameters have not been degraded or that the anticipated improvements have been attained.

c. System Outage Reporting. Airport management should develop and implement an operating procedure that assures ARFF service notification of any reduction in the ARFF water supply capability, either in pressure or volume.

Reference specs : FAA (AC 150/5220-4B)