البوتاس العربية
Arab Potash

ARAB POTASH COMPNAY

Projects and Expansions Directorate

TENDER DOCUMENT

FOR

Construction & Rehabilitation work for the body of Road in APC Plant
IFB# 202100511
"Volume 2"

SECTION 00 31 20-SITE CONDITIONS

1. PROJECT LOCATION

The project is located on the shore of the Dead Sea approximately 110 km from Amman, capital of the Hashemite Kingdom of Jordan, and 200 km north of the Red Sea port of Aqaba. Access to the plant, which is near Safi, is by road via the Mazar-Aqaba highway.

2. SITE CONDITIONS

2.1	Location	Ghor El Safi
2.2	Elevation	400m below sea level
2.3	Temperature:	
	• Maximum daily temperature (July)	46ºC
	• Average daily temperature (July)	40ºC
	• Minimum daily temperature (January):	5ºC
	• Average daily temperature (January):	13ºC
2.4	Design temperature range:	5ºC – 50Cº
2.5	Precipitation:	
	• Annual Total Precipitation:	50mm
	• Maximum One Day rainfall:	50mm
	• Maximum 15 minute rainfall:	25mm
2.6	Earthquake: (I.B.C. 2012 in reference to ASCE 7, 2010)	
	• Group: II, Site Class: D	S_s=1.13 of g
	• Seismic Category: E	S_1=0.45 of g
2.7	Wind (I.B.C 2012 refers to ASCE 7, 2010). :	
	• Reference Wind Speed (based on 3 second peak gust, ASCE7-2010)	50m/s
2.8	Wind Direction	
	• Summer	North
	• Winter	South – South West
2.9	Relative Humidity	
	• Daily average during July	37%
	• Daily Average during January	58%

Note: Relative humidity can be as high as 85%

3. SPECIAL CONDITIONS

All structures& Asphalt work are subject to severe attack from brine-laden atmosphere and deposition of aggressive materials (high chloride containing materials & dust).

END OF SECTION

Section 01 10 00- Specification Index

CLIENT NAME:	Arab Potash Company
PROJECT & SITE:	Construction & Rehabilitation work for the body of Road in APC Plant Safi, Jordan
BID NUMBER:	

ATTACHMENTS FORMING PART OF THIS SPECIFICATION:

SECTION	**REV.**	
00 31 20	0	SITE CONDITIONS
01 10 00	0	SPECIFICATION INDEX
01 11 00	0	SCOPE OF WORK
31 10 00	0	SITE CLEARING
31 20 00	0	EARTH WORK
31 11 11	0	Structural Cast in Place structural formwork
32 10 00	0	Reinforcing steel
03 30 00	0	Structural concrete
33 40 00	0	Storm water
321123	0	AGGREGATE BASE COURSE
321116.16	0	AGGREGATE SUBBASE COURSE
321216	0	ASPHALT PAVING

Feb 28, 2021	TENDER	Mohammed Dmour	0
DATE	**ISSUED FOR**	**BY**	**REV. NO.**

Mohammad Dmour	28/02/2021	N. KHASHASHNEH	28/02/2021	B. MA'AITAH	28/02/2021
PREPARED BY	**DATE**	**CHECKED BY**	**DATE**	**APPROVED BY**	**DATE**

REV. NO.:			
SECTION:			
DATE:			
BY:			

SECTION 01 11 00-SCOPE OF WORK

1. GENERAL

This Specification describes the minimum requirements for the Construction & Rehabilitation work for the body of Road in tthe Arab Potash Company (APC), located at Safi, Jordan.
The Material and designs supplied shall comply with this Specification. Compliance with this Specification does not relieve the Contractor from providing a safe, reliable, and well-designed and Construction & Rehabilitation work for the body of Road in APC Plant that will achieve the performance requirements contained in this Specification. The Contractor may provide items that are in variance with the Specifications, provided these variances are presented to the Owner/Engineer, in writing, and written approval is obtained from the Employer /Engineer.
The Contractor shall review all the general and specific technical requirements of this specification and confirm that compliance with these requirements in no way prevents the contractor from supplying material or systems that fully satisfy the system operational and performance requirements as stated in this specification. If the contractor considers that any of the specified technical requirements will prevent them from providing material or systems that will meet the specified operational and performance requirements, the contractor shall notify the Owner/Engineer in writing and propose an alternate design or specification. The contractor may use their alternate design or specification only after receiving written approval from the Owner/Engineer. Contractor is responsible to take all safety precautions during the construction.

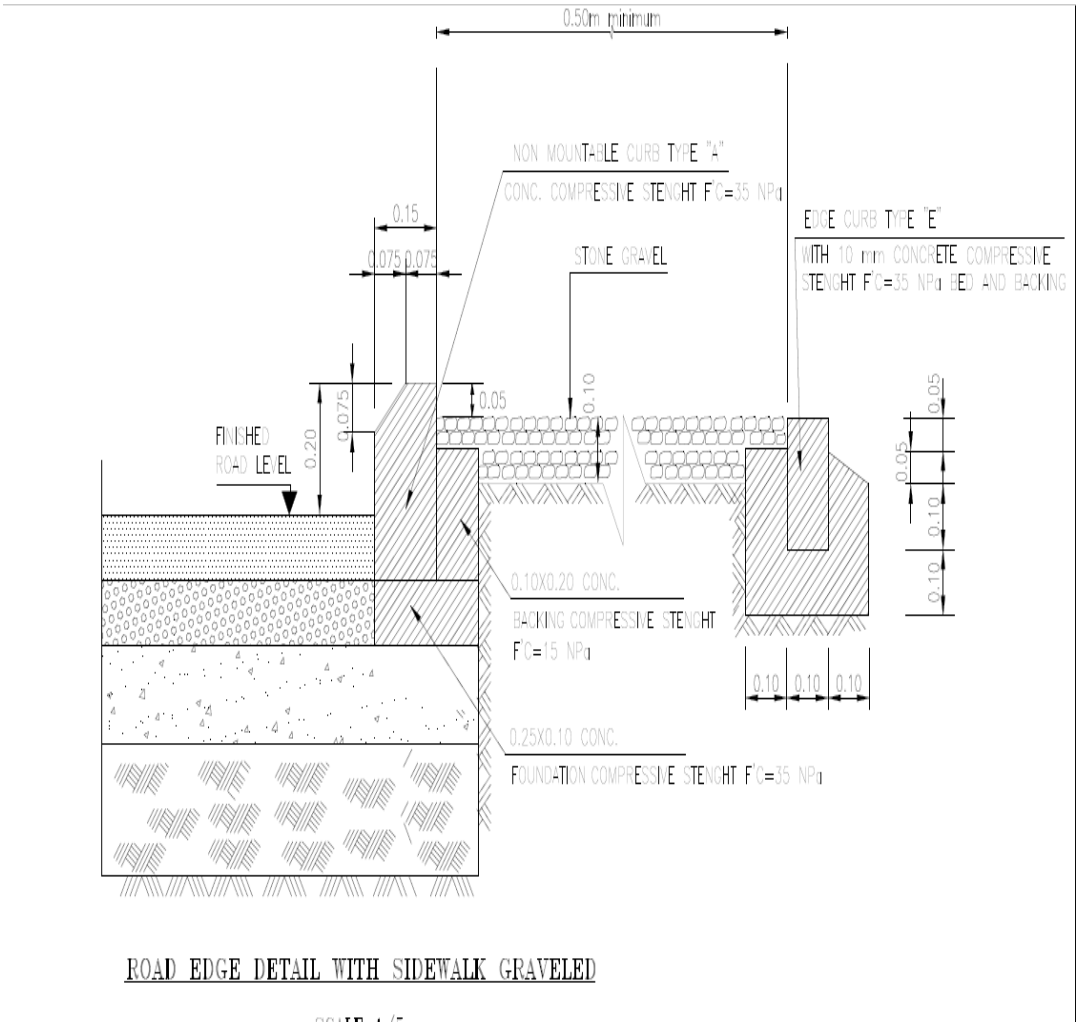
2. DESCRIPTION

The Arab Potash Company (APC) herewith referred to as the "Owner" intends employ a Construction Specialist herewith refer to as the "Vendor" or the "Contractor", to Engineer, Procure, Design, Construction & Rehabilitation work for the body of Road in tthe Arab Potash Company (APC), and shall have the following Characteristics:

1. Design, Construction & Rehabilitation work for the body of Road in APC Plant, the work includes the removal of the existing asphalt pavement and reconstruct the body of road by install one layer of binder course Asphalt with thickness 7.5cm and wearing course with thickness 5cm.according to drawing provided in the tender. moreover, any related work to adjust the existing manhole to match with new proposed design for the road work by Contractor, furthermore to provide All Reflective guidance that required to ensure safe traffic.

2. Design & Construction work for the body of Road in APC Plant, the work includes the removal of the existing asphalt pavement. and the layers of pavement below the asphalt layer in road till reach the topping layer and the reconstruction of the road according to design of profile of road which will be provide by contractor, then implementing layers (base course, sub base course, topping if needed and Asphalt layers with one layer of binder course with thickness 7.5cm and wearing course with thickness 5cm.according to drawing provided in the tender .moreover any related work to adjust the existing manhole to match with new proposed design for the road work by contractor. And provide all Reflective guidance that required to ensure safe traffic.

3. Supply and apply curb stone Class A for the road in APC plant according to project specification.



ROAD EDGE DETAIL WITH SIDEWALK GRAVELED

4. Supply and apply paint work for the road according to project Specification.
5. The storm water (underground GRP pipeline network) and manhole if required shall comply with Specifications.
6. The pavement & Backfilling materials shall comply with the Specification.
7. Thermal and moisture protection system for manhole if required shall comply with the Specifications.
8. All Specification sections included within this document shall be adhered to:

Concept design sketches are attached within this document:

1. Attached Drawing

3. WORK INCLUDED

3.1 All works shall be done in conjunction and satisfying specification section **00 31 20-SITE CONDITIONS** and all sections listed in specification section **01 10 00- SPECIFICATION INDEX**

3.2 Excavation Work: The work includes the removal of the existing asphalt pavement and the layers of paving below the top of Asphalt road till reach the topping layer.

3.3 The required work is to provide, supply, individual and compact one layer of base course (20cm) and one layer of subbase course with thickness (20 cm) after making the required compaction for the Topping layer according to the project specification and site condition , the contractor is accounted for each of these layers in cubic meters for what was implemented according to the instructions of the supervising engineer and according to the price shown in the price tables and quantities of this tender.

3.4 The binder course, the work required is to provide, supply, individual and compact a one-layer Binder asphalt course with thick (7.5 cm) after the compact the road in accordance with the project specification and according to the price shown in the price tables and quantities of this bid where the price includes.

3.5 The wearing course, the work required is to provide, supply, individual and compact a hot surface asphalt mixture (Wearing Course) thick (5 cm) after the compact the road in accordance with the project specification and according to the price shown in the price tables and quantities of this bid where the price includes (linking with the existing or removing the curbstone).

3.6 The Contractor to take into consideration that the old underground GRP pipeline is in operation mode and will not be shutdown. All contractor's activities shall be performed during the operation.

3.7 The Contractors must visit the site, in order to inspect and familiarize all the required work and inventory of the materials and equipment required to complete the work with the required quality and time and to develop the appropriate plan and mechanism of work and the amount of manpower required based on the tender documents, All work must be carried out with the approval of the engineer and the Employer and the owner of the loaded on the tender prices.

3.8 The contractor must review the engineering plans attached in the tender documents and compare them with the required work and what is in fact present, and in case of any conflict or lack of information then the contractor must provide appropriate alternatives under detailed plans for approval by the engineer/employer, well in advance of implementation.

3.9 The Contractor must submit a work plan for the installation work for the entire period of the project to be implemented so that it does not affect the progress of the production process in the factories, provided that this plan is adopted by the engineer before starting work and must update the work plan weekly and provide the engineer/employer with daily reports of the workflow.

3.10. The Contractor to submit As Built drawing for what has already been implemented on the ground in accordance with the specifications and tender documents.

3.11 The Contractor must coordinate with the employer to determine the route of the proposed line and the work shall be as instructed by the supervising engineer as required in the plans and quantity tables.

3.12 The Employer has the right to change the routes of the lines or the locations of the points of connection and separation of the proposed lines and the locations of any work required or level whether contained in the plans attached in the tender or not received and the contractor is not entitled to claim any increase in the prices of the lines of the quantities schedule or extend a period of time as a result and all the costs arising from the implementation of this work are covered within the individual prices of the items in the quantities schedule.

4. SUBMITTALS AND SCHEDULE

Contractor shall abide by the following schedule for the design and implementation of constructing underground GRP Pipeline for procurement, documents and drawing submittal which are specific for this project and shall start on the same day of contract award:

4.1 Execution and construction

the project duration will be 3 months (90 calendar days) including the design and the construction as the project must be completed immediately. any delay in the delivery of the project will be subject clause 8.0 in the condition of contract.

END OF SECTION

SECTION 31 10 00 - SITE CLEARING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Removing existing trees, shrubs, groundcovers, plants, and grass.
2. Clearing and grubbing.
3. Stripping and stockpiling topsoil.
4. Removing above- and below-grade site improvements.
5. Disconnecting, capping, or sealing, and removing site utilities.

B. Related Sections include the following:

1. Section 31 20 00 "Earthworks".

1.3 DEFINITIONS

A. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, salt and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more 50 mm in diameter; and free of subsoil and weeds, roots, toxic materials, or other non-soil materials.

1.4 MATERIAL EMPLOYERSHIP

A. Except for stripped topsoil or other materials indicated to remain Employer's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.5 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Engineer and authorities having jurisdiction.

2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

B. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining Employer's property will be obtained by Employer before award of Contract.

1. Do not proceed with work on adjoining property until directed by Engineer.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly flag trees and vegetation to remain or to be relocated.

C. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to Engineer.

3.2 UTILITIES

A. Employer will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by Contractor.

1. Verify that utilities have been disconnected and capped before proceeding with site clearing.

B. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.

1. Employer will arrange to shut off indicated utilities when requested by Contractor.

C. Existing Utilities: Do not interrupt utilities serving facilities occupied by Employer or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Engineer not less than two days in advance of proposed utility interruptions.

D. Excavate for and remove underground utilities indicated to be removed as provided in Section 31 23 00 with regards to provisions for excavation, backfill and compaction. E. Removal of underground utilities is included in project specifications.

3.3 CLEARING AND GRUBBING

A. Remove obstructions, Scrap material, trees, shrubs, grass, and other vegetation to permit installation of new construction.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding a loose depth of 200 mm and compact each layer to a density equal to adjacent original ground.

3.4 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to whatever depths is encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.

1. Remove subsoil and non-soil materials from topsoil, including trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil materials away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust.

3.5 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Sawcut faces vertically.
2. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.

3.6 DISPOSAL

A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off as instructed by the Engineer.

END OF SECTION 31 1000

SECTION 31 20 00 – EARTHWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions apply to this Section.

1.2 SUMMARY

A. This Section describes the procedures and requirements for the site grading of the Arab Potash Company (APC) storage facilities extension including:
   1. Preparing subgrades for slabs-on-grade / pavements / walks / turf and grasses
   2. Excavating and backfilling for buildings and structures
   3. Excavating and backfilling trenches for utilities and pits for buried utility structures
   4. Subbase course for concrete walks / pavements and for asphalt paving
   5. Drainage course for concrete slabs-on-grade
   6. Subsurface drainage backfills for walls and trenches

B. Related Sections include the following:
   1. Section 311000 "Site Clearing" for site stripping, grubbing, stripping [and stockpiling] topsoil, and removal of above and below grade improvements and utilities

1.3 DEFINITIONS

A. Salt: any material consisting of precipitates or deposits of Dead Sea brine.

B. Water: both brine and fresh water, except where the type of water is stated.

C. Spoil: all material excavated from the Permanent Works which is unsuitable for use in the Permanent Works, and usable material which is not incorporated as fill in the Permanent Works.

D. Rock: Rock material in beds, ledges, un-stratified masses, conglomerate deposits, and boulders of rock material

E. Post-construction level shown on the Drawings means the level to be attained on the date of completion.

F. Backfill: Soil material or controlled low-strength material used to fill an excavation or for construction of earthworks.
   1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe
   2. Final Backfill: Backfill placed over initial backfill to fill a trench

G. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

H. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving

I. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe

J. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water `

K. Excavation: Removal of materials encountered above the subgrade elevations to the lines and dimensions indicated on drawings.
   1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Engineer.
   2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Engineer. Unauthorized excavation, as well as remedial work directed by Engineer, shall be without additional compensation.

L. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface

M. Subbase Course: Aggregate layer placed between the subgrade and base course for hot mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk

N. Subgrade: Surface or elevation remaining after excavation below existing material, ground surfaces, or topsoil materials.

O. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

P. Subgrade Layer: 200 mm depth of soil material immediately below subgrade of roadways and vehicular pavements.

1.4 SUBMITTALS

A. Shop drawings showing the excavation and the backfilling areas as well as the ground levels mapped from a topographic survey along the proposed earthworks as shown in the tendered drawings. Cross sections shall be provided at stations of 25 m intervals, at any change in geometry, any abrupt changes in ground levels, or as per the Engineer's request, whichever is smaller. Work should proceed after the Engineer's approval to these drawings.

B. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:

   1. Submit to the Engineer for Approval, the source(s) of fill materials.

   2. Include test reports to demonstrate compliance with this specification

   3. Classification according to ASTM D 2487 of each on-site and borrow soil material proposed for fill and backfill, and subgrade layer.

   4. Laboratory compaction curve according to ASTM D 1557 for each on-site and borrow soil material proposed for fill and backfill, and subgrade layer. C. Proposals for the disposal of spoil materials.

D. Proposals for the location of stockpiles

E. Weekly summaries of laboratory test results.

F. Weekly progress reports summarizing the construction activities at the project site.

G. Detailed method statement, design calculations and drawings of the dewatering system for Engineer's approval prior of starting the excavation works

1.5 PROJECT CONDITIONS

A. Project Site Information: Sub-surface site investigation reports have been prepared for the project area and are available to the contractor for information only. The contractor is entirely responsible for his own assessment, interpretation, use and conclusions drawn from the information data, tests analyses and opinions contained in the reports

B. Existing Utilities: do not proceed with utility interruptions without Engineer's written permission.

C. Completely remove from site existing underground utilities as approved by Engineer. Coordinate with utility companies to shut off services if lines are active.

D. The Contractor shall be responsible for carrying out all remedial works, including any requirements to remedy incipient or actual failure, and to reinstate any failure occurring because of any temporary or permanent work construction.

E. Additional test borings and other exploratory operations may be performed by Contractor, at the Contractor's option; however, no change in the Contract Sum will be authorized for such additional exploration.

F. Existing Utilities: Locate existing underground utilities in areas of excavation work. If utilities are indicated to remain in place, provide adequate means of support and protection during earthwork operations.

G. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Employer and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

B. General: Provide borrow soil materials when sufficient satisfactory soil material is not available from excavations, the borrowing area location can be provided by owner.

C. Satisfactory soils: soil classification [Groups GW, GP, GM, SW, SP and SM according to ASTM D2487] [Groups A-1, A-2-4, A-2-5 and A-3 according to AASHTO M145], or a combination of these groups; free of rock or gravel larger than [75mm] in any dimension, debris, waste, frozen materials, vegetation and other deleterious matter.

D. Unsatisfactory soils: soil Classification [Groups GC, SC, CL, ML, OL, CH, MH, OH and PT according to ASTM D2487][Groups A-2_6, A-2_7, A-4, A-5, A-6 and A-7 according to ASSHTO M145], or a combination of these groups.

1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction
2. Unsatisfactory soils also include satisfactory soils with more than 2% organic impurities by weight.

E. Engineered Fill: Excavated or imported material to be used for fill or backfill shall meet the requirements of this specification. Backfill shall consist of well graded, clean sand and gravel meeting the following graduation requirements as shown in the Table 1 below: The plasticity index for the engineered fill materials shall not exceed 10%.

Table 1. Graduation requirements for Engineered Fill.

Sieve Size (mm)	Percentage Passing by Weight
50mm	90 - 100%
5mm	30-60%
2mm	20-50%
0.075 mm	0-15%

F. Initial Backfill for Pipe Trenches: selected fill, sand of other approved material conforming to the following:

Sieve Size (mm)	Percentage Passing by Weight	
	For pipes other than UPVC or GRP*	For UPVC pipes
20mm	100	--
5mm	25 – 100	100
1.25mm	10 – 75	25 – 75
0.315mm	5 – 30	10 – 30
0.160mm	3 – 10	3 – 10
0.080mm	0 – 5	0 – 5

* For GRP pipes: Use graded crushed stone 3.0 -8.0 mm.

F. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; with at least 95 percent passing a (37.5mm) sieve and not more than 12 percent passing a No.200 (0.075mm) sieve.

G. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; with at least 90 percent passing a (37.5mm) sieve and not more than 12 percent passing a No.200 (0.075mm) sieve.

H. Subgrade Layer: Satisfactory roadway soil materials, but conforming with the following requirements:

1. Size: 100 percent passing a 75 mm sieve and not more than 18 percent passing a 0.075 mm sieve.
2. Organic Matter: Not more than 2 percent; AASHTO T 267.
3. Maximum Dry Density: Not less than 1.7; AASHTO T 180.
4. CBR: Not less than 20 percent; AASHTO T 193.
5. Maximum Plasticity Index: 12 percent.

6. The top 150 mm subgrade material should not contain more than 0.2% total sulphate content and 0.05% total chloride content.

I. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; except with 100 percent passing a (25mm) sieve and not more than 8 percent passing a No.200 (0.075mm) sieve.

J. Drainage Course: Narrowly graded mixture of washed crushed stone, crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading size 57; with 100 percent passing a (37.5mm) sieve and 0 to 5 percent passing a No.8 (2.36mm) sieve.

K. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading size 67; with 100 percent passing a (37.5mm) sieve and 0 to 5 percent passing a No.8 (2.36mm) sieve. L. Sand: ASTM C33; fine aggregate, natural, or manufactured sand.

M. Impervious fill: clayey gravel and sand mixture capable of compacting to a dense state.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

B. Preparation of subgrade for earthwork operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface is specified in Section 31 10 00 "Site Clearing".

C. Protect and maintain erosion and sedimentation controls during earth moving operations

3.2 DEWATERING

A. Prevent, as specified, surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow run off water to accumulate in excavations. Do not use excavated trenches for temporary drainage.
2. Install a dewatering system, whenever required, to keep subgrades dry and convey ground water away from excavations. Maintain until dewatering is no longer required.
3. Maintains the groundwater level at least 0.5 m below the final excavation levels.
4. The Contractor will be responsible for designing, constructing, installing, building, and maintaining all necessary temporary water containment facilities, channels, and diversions; furnishing, installing, and operating all necessary pumps, piping, and other facilities and equipment; and removing all such temporary works and equipment after their intended function is no longer required.
5. The Contractor should submit a detailed method statement, design calculations and drawings of the dewatering system for Engineer’s approval prior of starting the excavation works.

3.3 EXCAVATION, GENERAL

A. Before any excavation or earthworks is commenced, the site of the excavation or earthworks shall be surveyed by the Contractor in a manner and to the extent required by the Engineer. Drawings recording the survey shall be signed by the Contractor and the Engineer as a true record and the Contractor shall then supply two prints to the Engineer.

B. Such record shall not be altered in any way unless such alterations are agreed and signed by both the Contractor and the Engineer.

C. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include soil materials, and obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials, replace with satisfactory soil materials.

D. Classified Excavation: Excavate to subgrade elevations. Material to be excavated will be classified as earth.

1. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; together with soil, boulders, and other materials not classified as unauthorized excavation.

E. Temporary excavations: The Contractor shall be responsible for ensuring that the slopes of all temporary excavations and natural slopes affected by the Temporary Works are maintained in a stable condition. Temporary excavations deeper than 1200mm shall have their sides battered to no steeper than 1.0 vertical to 1.5 horizontal, or as directed by the Engineer. Alternatively, if steeper side slopes are necessary, the sides shall be adequately supported by shoring and bracing as needed. Do not form stockpiles of excavated material close to edge of excavations.

3.4 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus (25mm) with due allowance for any lean concrete or engineered fill. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

B. Excavations for footings and foundations: do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base receive other work.

C. Excavation for underground tanks, basins, and mechanical or electrical utility structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus (25mm). Do not disturb bottom of excavations intended as bearing surfaces.

3.5 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.6 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 300 mm higher than top of pipe or conduit, unless otherwise indicated.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

1. For pipes and conduit less than 150 mm in nominal diameter and flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
2. For pipes and conduit 150 mm or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe circumference. Fill depressions with tamped sand backfill.
3. Excavate trenches 150 mm deeper than elevation required or other unyielding bearing material to allow for bedding course.

3.7 SUBGRADE INSPECTION

A. Notify the Engineer when excavations have reached required subgrade.

B. If the Engineer determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

C. Proof-roll subgrade below the building slabs and pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction**,** repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to (5 km/h).
2. Proof-roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than (13.6 tones).
3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Engineer, and replace with compacted backfill as directed.

D. Reconstruct subgrades damaged by rain, accumulated water, or construction activities, as directed by Engineer, without additional compensation.

3.8 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under slab on Grade by extending bottom elevation of concrete slab on grade to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of (17.2 MPa), may be used when approved by Engineer.

1. Fill unauthorized excavations under other construction or utility pipe as directed by Engineer.

3.9 STORAGE OF SOIL MATERIALS

A. The Contractor may choose to form stockpiles of fill materials. Where stockpiling is adopted, separate stockpiles of different materials shall be formed according to the known characteristics of the material, which shall be recorded by tests made during the formation of the stockpiles.

B. The Contractor shall submit his proposals for the location of stockpiles to the Engineer. The Contractor shall leave the residues or the sites of such stockpiles in stable and tidy condition to the approval of the Engineer.

C. Stockpile soil materials away from edge of excavations.

3.10 PLACING OF FILL

Fill placement shall comply with the following requirements:

1. Fill materials shall be placed to the lines and levels shown on the Drawings and in such a way that the as-placed materials are uniform and homogeneous.

2. Fill materials shall be placed only on approved foundations or on approved previous layers of fill. If the surface of the previous layer is too smooth for proper bonding with the next layer or too dry it shall be scarified and watered.

3. Each layer shall normally be constructed across the full width of the zone, and lengths suited to the operation of the equipment.

4. Suitable markers for each zone of fill indicating coordinates, profile, level and thickness of layers being placed at any time, shall be installed at intervals not greater than 50m.

5. All permanently exposed surfaces shall be trimmed and finished to a uniform profile and appearance.

3.11 UTILITY TRENCH BACKFILL

A. Places backfill on subgrades free of mud.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Backfill trenches excavated under footings and within 450 mm of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings.

D. Provide 100-mm- thick, concrete-base slab support for piping or conduit less than 750 mm below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 100 mm of concrete before backfilling or placing roadway subbase.

E. Place and compact initial backfill of satisfactory soil, free of particles larger than 25 mm in any dimension, to a height of 300 mm over the utility pipe or conduit.
   1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

F. Backfill voids with satisfactory soil while installing and removing shoring and bracing.

G. Place and compact final backfill of satisfactory soil to final subgrade elevation.

H. When Backfilling to pipes with concrete beds and surrounds:
   1. do not start backfilling within 24 hours of placing concrete,
   2. do not use heavy compactors,
   3. Prevent traffic loads within 72 hours of placing concrete.

3.12 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontals so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows:

   1. Under grass and planted areas, use satisfactory soil material.
   2. Under walks and pavements, use satisfactory soil material.
   3. Under steps and ramps, use engineered fill.
   4. Under slabs-on-grade, use engineered fill.
   5. Under footings and foundations, use engineered fill. C. Place soil fill on subgrades free of mud.

3.13 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.

   1. Do not place backfill or fill soil material on surfaces that are muddy.
   2. Remove and replace or scarify and air dry otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.14 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Places backfill and fill soil materials in layers not more than (200 mm) in loose depth for material compacted by heavy compaction equipment, and not more than (100 mm) in loose depth for material compacted by hand-operated tampers.

B. Places backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:

   1. Under structural foundations, slabs-on-grade, steps, and pavements, scarify and re-compact top 300mm of existing subgrade and each layer of backfill or fill soil material at 95percent.
   2. Under walkways, scarify and re-compact top 150 mm below subgrade and compact each layer of backfill or fill soil material at 90 percent.
   3. Under lawn or unpaved areas, scarify and re-compact top 150 mm below subgrade and compact each layer of backfill or fill soil material at 90 percent.
   4. For utility trenches, compact each layer of initial and final backfill soil material at 90 percent.

3.15 SUBGRADE LAYER

A. Subgrade Layer in Cut:

1. Where 200 mm depth of existing subgrade under roadways and vehicular pavements is composed of satisfactory material conforming to the requirements specified for subgrade layer, scarify to a depth of 200mm, remove vegetable and other deleterious matter, and stones larger than 75 mm.

2. Where 200 mm depth of existing subgrade under roadways and vehicular pavements is composed of unsatisfactory material, excavate, and replace with material conforming to the requirements specified for subgrade layer.

B. Place and compact subgrade layer under roadways and vehicular pavements in two layers to the required elevations as follows:

1. Uniformly moisten or aerate subgrade layer before compaction, to within 2 percent of optimum moisture content.

A. Do not place subgrade layer material on surfaces that are muddy, frozen, or contain frost or ice.

2. Compact to 100 percent modified maximum density according to AASHTO T 180.

3.16 FIELD QUALITY CONTROL

A. Testing of materials, density testing and inspection of excavation and filling shall be carried out by an independent testing agency engaged by the Contractor. All testing and sampling to be under the supervision of a qualified soils technician.

B. Testing shall include sieve analyses, in-situ density testing and in-situ moisture content tests.

C. The testing agency will test compaction of soils in place according to ASTM D 1556, and ASTM D 2167 as applicable. Tests will be performed at the following locations and frequencies:

D. Frequencies of tests:

1. Sieve Analysis of Fill Materials: One analysis for every 500 m^3 or wherever there is a change of source of materials or if the consistency of the material from a given source changes

2. Carry out in-situ density tests in accordance with ASTM D 1556 and ASTM D 2167 for every 500 m^2 of engineered fill layer placed (but not less than three) and at least one density test per foundation. More tests may be required if the Engineer deems it necessary. Make available all test results and records to Engineer for his approval.

3. Where fill is to be placed on undisturbed surfaces, one in-situ density test shall be performed for each 500 m^2 of site area involved.

E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required; re-compact and retest until specified compaction is obtained.

3.17 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by Engineer; reshape and re-compact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.18 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Employer's property.

B. Disposal: Transport surplus satisfactory soil to designated storage areas on the Employer's property. Stockpile or spread soil as directed by Engineer.

1. Remove waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Employer's property.

END OF SECTION 31 20 00

SECTION 031113 - STRUCTURAL CAST-IN-PLACE CONCRETE FORMING

1.GENERAL

1.1 RELATED DOCUMENTS

Drawings and general provisions of the Contract, including Conditions of Contract and Division 1 Specification Sections, apply to this Section.

1.2 REFERENCES

1.2.1 American Concrete Institute (ACI):

A. *ACI 117 Specifications for Standard Tolerances for Concrete Construction and Materials*

B. *ACI 347R Guide to Formwork for Concrete*

C. *ACI SP-4 Formwork for Concrete*

1.2.2 American National Standards Institute (ANSI):

A. *ANSI Q9001 Quality Systems – Model for Quality Assurance in Design, Development, Production, Installation, and Servicing*

B. *ANSI Q9002 Quality Systems – Model for Quality Assurance in Production, Installation, and Servicing*

1.2.3 American Society for Testing and Materials (ASTM):

A. *ASTM D412 Standard Test Methods for Vulcanized Rubber & Thermoplastic Elastomers – Tension*

B. *ASTM D624 Standard Methods for Tear Strength of Conventional Vulcanized Rubber & Thermoplastic Elastomers*

C. *ASTM D 1751 Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (No extruding and Resilient Bituminous Types*

D. *BS 743 Specification for Materials for Damp Proof Courses*

1.3 SUBMITTALS

1.3.1 Formwork Shop Drawings: Prepare shop drawings for formwork indicating fabrication and erection of forms for specified finish concrete surface. Show form construction including jointing, especial form joints or reveals, location and pattern of form tie placement. Prepare formwork drawings by or under the supervision of a qualified professional engineer detailing fabrication, assembly, and support of formwork. The Engineer's review is for general architectural applications and features only. Design and engineering of formwork for structural stability and efficiency are the Contractor's responsibility.

A. *Shoring and Reshoring: Indicate proposed schedule and sequence of stripping formwork, shoring removal, and installing and removing reshoring.*

1.4 QUALITY ASSURANCE

1.4.1 Quality System: Comply with ISO 9001/9002 Quality System as a minimum. Incorporate all the standard procedures supplied by the Engineer and the Employer.

1.4.2 Codes and Standards: Comply with 2001 Manual of Concrete Practice Parts 1, 2, 3, 4 & 5, and CRSI "Manual of Standard Practice" except where more stringent requirements are shown or specified.

1.4.3 The Contractor shall operate a Quality Assurance System in accordance with ANSI Q9002. This Quality Assurance Manager shall be responsible for the preparation of a Quality Plan for approval of the operations specified in this Section. The Quality Plan shall include, among other things, the list and schedule of the Quality Control audits that the Quality Assurance Manager or his designee shall make.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Deliver, handle and store formwork materials in a manner to prevent weathering, warping, or damage detrimental to the strength of the materials or to the surface to be formed. Do not contaminate formwork surfaces which will be in contact with concrete with foreign matter. Handle and erect fabricated formwork to prevent damage.

2.PRODUCTS

2.1 FORM-FACING MATERIALS

2.1.1 Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.

2.1.2 Chamfer Strips: Wood, metal, PVC, or rubber strips, 20 mm by 20 mm, unless otherwise indicated.

2.2 FORM MATERIALS

2.2.1 Forms for Exposed Finish Concrete: Plywood, metal, metal-framed plywood faced, or other acceptable panel-type materials to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on Drawings.

A. *Use overlaid plywood complying with U.S. Product Standard PS-1 "A-C or B-B High Density Overlaid Concrete Form," Class I.*

B. *Use plywood complying with U.S. Product Standard PS-1 "B-B (Concrete Form) Plywood," Class I, Exterior Grade or better, mill-oiled and edge-sealed, with each piece bearing legible inspection trademark.*

2.2.2 Forms for Unexposed Finish Concrete: Plywood, lumber, metal, or another acceptable material. Provide lumber dressed on at least two edges and one side for tight fit.

2.2.3 Forms for Textured Finish Concrete: Units of face design, size, arrangement, and configuration to match the Engineer's control sample. Provide solid backing and form supports to ensure stability of textured form liners.

2.2.4Forms for Cylindrical Columns and Supports: Metal, glass-fiber-reinforced plastic, or paper or fiber tubes that will produce smooth surfaces without joint indications. Provide units with sufficient wall thickness to resist wet concrete loads without deformation.

2.2.5 Pan-Type Forms: Glass-fiber-reinforced plastic or formed steel, stiffened to support weight of placed concrete without deformation.

2.2.6 Carton Forms: Biodegradable paper surface, treated for moisture-resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.

2.2.7 Form Release Agent: Provide commercial formulation form release agent with a maximum of 350 g/L volatile organic compounds (VOCs) that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

A. *Formulate form release agent with rust inhibiters for steel facing materials.*

2.2.8 Form Ties: Factory-fabricated, adjustable-length, removable or snap-off metal form ties designed to prevent form deflection and to prevent spalling of concrete upon removal. Provide units that shall leave no metal closer than 38 mm to the plane of the exposed concrete surface. No permanent metallic part shall have less concrete cover than the reinforcement. Provide ties that, when removed, will not leave holes larger than 25 mm in diameter in the concrete surface. Furnish ties with integral water-barrier plates to walls indicated to receive damp-proofing or waterproofing.

2.2.9 Void Forms: Biodegradable paper surface, treated for moisture resistance structural sufficient to support weight of plastic concrete and other superimposed loads.

2.2.10 Chamfer Strips: Wood, metal, PVC, or rubber strips 20 mm x 20 mm, size as indicated on drawing.

3.EXECUTION

3.1 FORMWORK

3.1.1 Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until concrete structure can support such loads. Design of formwork shall be the sole responsibility of the Contractor.

3.1.2 Construct formwork so that concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.

3.1.3 Limit concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:

A. *Class A, 4 mm.*

B. *Class B, 6 mm.*

C. *Class C, 10 mm.*

D. *Class D, 25 mm.*

3.1.4 Construct forms tight enough to prevent loss of concrete mortar.

3.1.5 Make form joints tight to prevent leakage of mortar. Honeycombing of concrete will not be accepted. Clean all edges and contact surfaces before erection.

A. *Locate horizontal form joints for exposed columns 2400 mm above finished floor elevation.*

3.1.6 Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical. Kerf wood inserts for forming keyways, reglets, recesses, and the like, for easy removal.

A. *Do not use rust-stained steel form-facing material.*

3.1.7 Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.

3.1.8 All props, struts, braces, etc. are to rest on adequate sole pieces. The Contractor shall satisfy the Engineer that the temporary works are strong enough to afford the required support using the permissible stresses for the material employed as given in the appropriate standards. All supporting members are to remain in position until the newly constructed work is able to support its designed and applied loads.

3.1.9 Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

3.1.10 Chamfer exterior corners and edges of concrete receiving applied waterproofing membranes.

3.1.11 Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

3.1.12 Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

3.1.13 Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

3.1.14 Coat contact surfaces of forms with form release agent, according to the manufacturer's written instructions, before placing reinforcement.

3.1.15 Where it is required to use internal ties and spacers, their type, spacing and use shall be to the, approved of the Engineer. In no circumstances shall these ties protrude out of the finished

concrete, all ties must be cut back into the structural concrete and the surface made good to satisfy the requirements of the minimum spacing and cover.

3.2 EMBEDDED ITEMS

3.2.1 Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use Setting Drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

A. *Install anchor bolts, accurately located, to elevations required.*

B. *Install reglets to receive top edge of foundation sheet waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions.*

C. *Install dovetail anchor slots in concrete structures as indicated.*

3.3 REMOVING AND REUSING FORMS

3.3.1 General: Formwork, for sides of beams, walls, columns, and similar parts of the Work, that does not support weight of concrete may be removed after cumulatively curing at not less than 10 deg.C (50 deg. F) for 24 hours after placing concrete provided concrete is hard enough to not be damaged by form-removal operations and provided curing and protection operations are maintained.

3.3.2 The Engineer shall be notified when the Contractor intends to remove any formwork at least 6 hours prior to starting the process.

3.3.3 Leave formwork, for beam soffits, joists, slabs, and other structural elements that supports weight of concrete in place until concrete has achieved the following:

A. *At least 70 percent of 28-day design compressive strength*

B. *Determine compressive strength of in-place concrete by testing representative field- or laboratory-cured test specimens according to ACI 301.*

C. *Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.*

3.3.4 Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form release agent.

3.3.5 When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by the Engineer.

3.4 SHORES AND RESHORES

3.4.1 Comply with ACI 318M, ACI 301, and recommendations in ACI 347R for design, installation, and removal of shoring and reshoring.

3.4.2 In multistory construction, extend shoring or reshoring over a sufficient number of stories to distribute loads in such a manner that no floor or member will be excessively loaded or will induce tensile stress in concrete members without sufficient steel reinforcement.

3.4.3 Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excessive stress or deflection.

END OF SECTION 31113

SECTION 032100 - REINFORCING STEEL

GENERAL

1.1 RELATED DOCUMENTS

Drawings and general provisions of the Contract, including Conditions of Contract and Division 1 Specification Sections, apply to this Section.

1.2 REFERENCES

1.2.1 American Concrete Institute (ACI):

A. *ACI 117 Specifications for Standard Tolerances for Concrete Construction and Materials*

B. *ACI 315 Standard Practice for Detailing Reinforced Concrete Structures*

C. *ACI 318 Building Code Requirements for Reinforced Concrete*

1.2.2 American National Standards Institute (ANSI):

A. *ANSI Q9001 Quality Systems – Model for Quality Assurance in Design, Development, Production, Installation, and Servicing*

B. *ANSI Q9002 Quality Systems – Model for Quality Assurance in Production, Installation, and Servicing*

1.2.3 American Society for Testing and Materials (ASTM):

A. *ASTM A 82 Standard Specification for steel wire*

B. *ASTM A 184 Fabricated Concrete reinforcement.*

C. *ASTM A 185 Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement*

D. *ASTM A 496 Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement*

E. *ASTM A 497 Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete*

F. *ASTM A 615M Standard Specification for Deformed and Plain Billet- Steel Bars for Concrete Reinforcement*

G. *ASTM A 706M Standard Specification for Low-Alloy Steel Deformed and Plain Bars*

H. *ASTM A 775/A775M Standard Specification for Epoxy-Coated Reinforcing Steel Bars*

I. *ASTM A 780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings*

J. *ASTM A 820 Standard Specification for Steel Fibers for Fiber-Reinforced Concrete*

1.2.4 British Standards:

A. *BS 4449 Specification for Carbon Steel Bars for the Reinforcement of Concrete*

B. *BS 4483 Steel Fabric for the Reinforcement of Concrete*

C. *BS 8666 Specification for Scheduling, Dimensioning, Bending and Cutting of Steel Reinforcement for Concrete*

1.2.5 Commercial Standards (CS):

A. *Concrete Plant Manufacturers Bureau - Concrete Plant Standards* Concrete

1.2.6 Reinforcing Steel Institute (CRSI):

A. *CRSI Manual of Standard Practice*

1.3 SUBMITTALS

1.3.1 Steel Reinforcement Shop Drawings: Details of fabrication, bending, and placement, prepared according to ACI 315, "Details and Detailing of Concrete Reinforcement." Include material, grade, bar schedules, stirrup spacing, bent bar diagrams, arrangement, and supports of concrete reinforcement. Include special reinforcement required for openings through concrete structures and where special conditions occur.

1.3.2 Welding Certificates: Copies of certificates for welding procedures and personnel.

1.3.3 Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names, and addresses of architects/engineers and owners, and any other information required by the Engineer.

1.3.4 Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials:

A. *Steel reinforcement and reinforcement accessories:*
A copy of the manufacturer's test certificate for ultimate strength, elongation, and cold bending, together with the chemical analysis of the steel shall be submitted to the Engineer for each consignment of reinforcing steel delivered to the Project site.

1.3.5 Minutes of preinstallation conference.

1.4 QUALITY ASSURANCE

1.4.1 Quality System: Comply with ISO 9001/9002 Quality System as a minimum. Incorporate all the standard procedures supplied by the Engineer and the Employer.

1.4.2 Codes and Standards: Comply with 2001 Manual of Concrete Practice Parts 1, 2, 3, 4 & 5, and CRSI "Manual of Standard Practice" except where more stringent requirements are shown or specified.

1.4.3 The Contractor shall operate a Quality Assurance System in accordance with ANSI Q9002. This Quality Assurance Manager shall be responsible for the preparation of a Quality Plan for approval of the operations specified in this Section. The Quality Plan shall include, among other things, the list and schedule of the Quality Control audits that the Quality Assurance Manager or his designee shall make.

1.4.4 Materials and installed work may require testing and retesting at any time during progress of Work. Tests, including retesting of rejected materials for installed Work, shall be done at the Contractor's expense.

1.4.5 Welding: Qualify procedures and personnel according to AWS D1.4, "Structural Welding Code--Reinforcing Steel."

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Deliver, store, and handle steel reinforcement, welded wire and accessories to prevent excessive rusting, fouling, contamination from dirt, grease and other bond reducing or foreign matter, bending and damage.

A. *Avoid damaging coatings on steel reinforcement.*

B. *Maintain identification after bundles are broken.*

PRODUCTS

2.1 STEEL REINFORCEMENT

2.1.1 Reinforcing Bars: ASTM A 615M, Grade 60 (420 MPa) specified yield strength with maximum carbon content of 0.3%, AC1318 or BS 4449 grade B500B deformed, uncoated. One test per 5000 m length delivered to site.

2.1.2 Deformed-Steel Welded Wire Fabric: ASTM A 496

2.1.3 Only new material shall be furnished. On receipt and at time of installation, material shall be free of loose rust and loose mill scale, deleterious amounts of salts and coatings that reduce or destroy bond. Tight rust and mill scale or surface irregularities are acceptable if the weight and dimensions, including height of deformations and tensile properties, of a test specimen that has been wire-brushed by hand, are not less than those required by the applicable Standards.

2.1.4 Reinforcement shall be accurately bent, cut, or formed to the dimensions and configuration shown on Drawings and within the tolerances specified in ACI 315. Reinforcement shall be bent cold using pin sizes in accordance with ACI 318. Bars may be preheated only if prior approval has been requested and received. Reinforcement shall not be rebent or straightened without prior approval.

A. *Reinforcement having a reduced section, kinks, visible transverse cracks at bends, or otherwise damaged in any way shall not be used. Galvanized steel shall not be used for reinforcement.*

B. *Reinforcement shall not be welded unless specifically shown on Drawings or permitted as an exception and then only after approval of the welding method appropriate to the grade of steel and the type of welding rod to be used.*

2.2 REINFORCEMENT ACCESSORIES

2.2.1 Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete or fiber-reinforced concrete of greater compressive strength than concrete, and as follows:

A. *For concrete surfaces exposed to view where legs of wire bar support contact forms, use CRSI Class 1 plastic protected or CRSI Class 2 stainless-steel bar supports.*

B. *Other reinforcement supports shall consist of concrete spacer blocks made of the same materials, to the same specified requirements and with the same inherent properties as the parent material with the exception that the maximum aggregate size shall be appropriate for the thickness of cover to the reinforcement.*

2.2.2 Add other products for dowels or dowel sleeves if required. These include circular and rectangular plastic dowel sleeves, square dowels, and plastic-surfaced or reinforced-paper-covered dowels.

2.2.3 Joint Dowel Bars: Plain-steel bars, ASTM A 615M, Grade 60 (420 MPa). Cut bars true to length with ends square and free of burrs.

2.2.4 Mechanical Splices (Couplers) of deformed high yield steel bars are to consist of two seamless steel sleeves and interconnecting high tensile steel stud with plastic protection caps for threaded section of sleeve. To be tested and the test to exceed 135% of the specified yield strength of grade 60 bar.

2.3 FABRICATING REINFORCEMENT

2.3.1 Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.3.2 The Engineer shall have access to the fabrication shop for inspection. The Contractor shall inform the Engineer in advance when fabrication will commence and the anticipated durations of fabrication operations.

EXECUTION

3.1 STEEL REINFORCEMENT

3.1.1 General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.

A. *Avoid cutting or puncturing vapor retarder/barrier and waterproofing membranes during reinforcement placement and concreting operations. Repair damages before placing concrete.*

3.1.2 Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.

A. *Shop- or field-weld reinforcement according to AWS D1.4, where indicated.*

3.1.3 Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

3.1.4 Install welded wire fabric in longest practicable lengths on bar supports spaced to minimize sagging. Lap edges and ends of adjoining sheets at least one mesh spacing. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Lace overlaps with wire.

3.1.5 Shipping and Storage:

A. *Reinforcement shall be handled and shipped in a manner to avoid bending or other damage to the bars. Bars shall be bundled, separated in sizes and clearly marked by diameter size preferably for one placement, in accordance with the placement schedule and as follows:*

- Bars for separate buildings or large structures shall not be bundled together. Bars for small structures may be bundled together but each bar or group of bars that have the same piece mark shall be tagged and coded.

- *Metal tags or approved equal shall be provided and labeled with legible markings.*
- *All bundles shall be tagged at each end. Tags shall show piece marks corresponding to the mark numbers on the placement drawings and on the bar list.*

-Bars shall be bundled in the largest size practical for handling and shipping.

B. *Reinforcement shall be stored 1m above ground on platforms, skids or other approved supports and suitably spaced. Contact with the soil shall be avoided. Proper drainage and protection from the elements shall be provided to minimize corrosion.*

3.1.6 Clean reinforcement of loose rust and mill scale, earth, ice, and other materials that reduce or
3.1.7 destroy bond with concrete.

Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement on concrete blocks of a size to give the correct cover to the reinforcement. Concrete spacer blocks shall be made of the same materials, to the same specified requirements and have the same inherent properties as the parent material, but with the exception that the maximum aggregate size shall be appropriate for the thickness of cover to the reinforcement.

A. *Where cathodic protection is utilized, reinforcement shall be isolated from the electrical grounding system.*

B. *Chairs made of reinforcement shall be used to support the top mats of slab reinforcement and they shall be so dimensioned as to be stable during concreting operations. The chairs shall themselves be supported on concrete blocks as specified above.*

3.1.8 Place reinforcement to maintain minimum coverages as indicated for concrete protection. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement operations. Ties at intersections shall be made with 1.5 mm diameter annealed wire with wire ends directed into concrete, not toward exposed concrete surfaces.

3.1.9 Concrete Cover:

A. *Concrete cover to reinforcement shall be as indicated on Drawings:*

B. *Cover to reinforcement shall be checked before any concrete is cast. The bending of reinforcement at a cold joint is not permitted. Concrete cover shall be checked with a cover meter as soon as formwork is removed.*

3.1.10 All lap splices shall be in accordance with ACI 318 class B tension lap splice unless otherwise shown on Drawings. All reinforcement bars shall be developed in accordance with ACI 318 unless otherwise shown on Drawings. Welded wire fabric shall be lapped 1.5 mesh plus the extension on the wires unless otherwise shown on Drawings.

3.2 QUALITY CONTROL AND TESTING

3.2.1 General:

A. *Testing Laboratory:*

Employ an independent testing agency to perform tests and to submit test reports. Be responsible for taking, identifying and delivering to the test laboratory all test samples called for in this Specification. The testing laboratory shall be responsible for the testing. Collect all test results and deliver them to the Engineer in the format and detail as specified.

B. *Testing Laboratory Qualifications: The testing laboratory shall be accredited by NAMAS or an equivalent National Standard and shall have a Quality System in accordance with ANSI Q9001.*

END OF SECTION 032100

SECTION 03 30 00-STRUCTURAL CONCRETE

1. DESIGN REQUIREMNT

1.1 This performance specification is for the design and construction of structural Concrete slab on grade and beams. The Contractor shall submit design calculation notes including 3 D and 2 D analysis models (with soft copies) showing design of concrete slab on grade, design drawings, specifications,

1.2 The Contractor shall design and construct the Slab on Grade to suit the specified location and should investigate and work within all site constraints and conditions.

1.3 The Contractor shall employ experienced Engineers in the design and construction works and shall submit such personnel to the Owner's/Engineer's approval.

1.4 The Contractor shall have reasonable familiarity with the entire process or operation involved.

2. IMENSIONS AND FINISHES

2.1 Width, span, and height can be considered as per the indicative sketches initially for pricing. Exact and for Construction dimensions are the responsibility of contractor/Designer and shall be coordinated with potash slab on grade included but not limited to:

2.1.1 Ramps, exits, and entrances

2.2 The Engineer is to approve all type of finishes.

3. DESIGN STANDARDS AND SPECIFICATIONS

The Concrete structures shall be designed and executed in accordance with the specific and general requirements mentioned below:

3.1 ACI 318M-14, Building Code Requirements for Structure Concrete.

3.2 ACI 350-06 and ACI 224R-01 for water retaining structures.

3.3 ACI 315-99 for details and detailing of concrete reinforcement.

3.4 International building code 2009.

3.5 ASCE/SEI 7-10 for live, wind and earthquake loadings.

3.6 ASTM standards in building codes.

4. DESIGN

4.1 The design shall be performed by an approved professional engineer experienced in this type of structures.

4.2 The structure shall be designed for the following (not limited to the below):

4.2.1 Dead loads: in addition to the structure self-weight, Super-imposed dead load (SDL) shall account for the flooring,

4.2.2 Live and roof live Loads including dust loads: As per the ASCE 7-10.

4.2.3 Wind Load: As per the ASCE 7-10, the maximum gust winds a 10 above ground 50 m/s, exposure "C".

4.2.4 Seismic Load: As per ASCE 7-10, site class D, maximum considered earthquake response accelerations S_s=1.13 of g, S_1=0.45 of g.

4.2.5 Temperature: Structure shall be designed to accommodate a temperature differential of 30°C.

4.2.6 Construction loads

4.7 The design of the structure shall be in accordance with the "ACI318–14".

4.8 *(Whenever applicable):* The following deflection limits shall be adopted:

4.8.1 Deflection criteria for Gravity Loads
Total immediate deflection L/360

4.8.2 Sustained deflection after attachment L/480
Of non- Structural components likely to be
Damaged by deflection

4.8.3 Sustained deflection after attachment of L/240
Non-Structural components unlikely to be
Damaged by deflection

4.9 *(Whenever applicable):* Overall building movements and individual member designs are set within the deflection limits in the following table:

Lateral Deflection (under wind loads)	**H/500 (H being the height of the building)**
Story drift	ΔM < 0.02 x Story height (ΔM = Cd Δmax/Ie , Δmax being the design level response displacement, Cd is Design amplification factor as per table 10.2 in SBC Code, Ie is importance factor)
Building separation	$\Delta M = \sqrt{(\Delta M1^2 + \Delta M2^2)}$ ΔM1 and ΔM2 being the maximum inelastic response displacements for two adjacent buildings

4.10 *(Whenever applicable):* Expansion joints in the building structures:

Expansion joints in the building structures shall be considered where necessary. This is so in order to relief temperature and shrinkage stresses.

4.11 Thermal and Moisture Proofing of Structure Shall be conforming to SBS membrane; 4 mm thickness.

4.11.1 Proper Protection shall be considered as per geotechnical investigation where soil aggressiveness and design water table are encountered.

4.11.2 Chemical Coatings shall be applied to all concrete internal surfaces of water retaining structures.

4.11.3 Chemical hardener shall be applied to all concrete internal surfaces where potash is stored or piled.

4.12 Control of Crack Width

The table below presents reasonable crack widths under service loads that are adopted in the design of reinforced concrete members subject to various exposure conditions.

Exposure Condition	**Crack Width**
Dry air or protective membrane	0.41mm (0.016 in)
Humidity, moist air, soil	0.30 mm (0.012 in)
Deicing Chemicals	0.18 mm (0.007 in)
Seawater and seawater spray, wetting and drying	0.15 mm (0.006 in)
Water-retaining structure	0.10 mm (0.004 in)

A crack width of 0.2mm shall be used for structures subjected to groundwater or reservoirs/tanks.

4.13 Concrete Cover: The minimum concrete cover to be considered in the design is shown in the below table which is according to ACI 318-14:

Concrete exposure	Member	Reinforcement	Specified cover, mm
Cast against and permanently in contact with ground	All	All	75
Exposed to weather or in contact with ground	All	Dia. 19 through Dia. 57 bars	50
		Dia. 16 bar, MW200 or MD200 wire, and smaller	40
Not exposed to weather or in contact with ground	Slabs, joists, and walls	Dia. 43 and Dia. 57 bars	40
		Dia. 36 bar and smaller	20
	Beams, columns, pedestals, and tension ties	Primary reinforcement, stirrups, ties, spirals, and hoops	40

4.14 Geotechnical Investigation

4.14.1 Full soil investigation shall be performed to provide all soil parameters needed in the design. This shall include but not limited to the below:

- Design bearing stress
- Soil aggressiveness level
- Design water table
- Soil properties (angle of friction, soil density, subgrade modulus, etc).

4.14.2 The minimum foundation embedment depth shall be according soil investigation.

4.14.3 The top 300-mm of the ground surface at the slab on grade level should be scarified, wetted, and re-compacted to a dry density not less than 95% of the maximum dry density as determined by modified proctor compaction test (ASTM D 1557).

4.14.4 All soft spots or unsuitable materials located at the foundation level should be removed and replaced by compacted well graded material.

4.14.5 Where an open excavation cannot be carried out, adequate excavation supports and protection systems should be installed and monitored, in order to safely support the sides of the excavation and any existing adjacent surcharge, without disturbing the underlying soils or causing any damage.

4.14.6 Surface and ground water should be prevented from entering excavations, from ponding on prepared subgrades, and from flooding the project site.

4.14.7 The bearing capacity of soil shall be tested by contractor as per latest international, local and project specifications and codes.

4.14.8 All subsurface structures should be protected by isolating the structure with appropriate full tanking membrane.

4.14.9 Soil replacement shall be performed as per geotechnical specifications below all slab on grade The Contractor/Designer shall submit a clear basis of design report to the Engineer's / Owner's approval prior to launching detailed design activities.

4.15 Structural Systems:

The design shall be based on functional, economical, durable, and efficient system. Concrete dimensions and reinforcement details shall meet the requirements of both design limit states, namely the strength demand at ultimate limit state and the serviceability requirements at service limit state. Detailed structural drawings/specification shall be submitted according to the design.

5. GEOTECHNICAL DESIGN CRITERIA:

The criteria governing the geotechnical analysis of the different structure components aim to provide a safe design and maintain the serviceability. The serviceability of the building is guaranteed by adequate settlement predictions and ground deformation analysis. Then, appropriate values of ground deformation moduli are given to the structural engineer to assess the effects of forced deformations and differential settlements. This is an iterative procedure which converges to certain values of ground deformation moduli by trading values of contact stresses calculated by the structural engineer and values of settlement calculated by the geotechnical engineer. The serviceability requirements shall respect the limiting values recommended by the standard codes with regards to angular distortion and tilt (1:300). The safety of the foundation system different components is assessed by comparing the capacity according to the Codes of Practice with the loads calculated by structural engineers.

GENERAL

1.1 RELATED DOCUMENTS

Drawings and general provisions of the Contract, including Conditions of Contract and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

1.2.1 This Section specifies cast-in-place concrete, concrete materials, mix design, placement procedures, and finishes.

1.2.2 Cast-in-place concrete includes, but is not limited to, the following:

A. *Foundations and footings (spread, combined, raft, strips, etc.)*
B. *Slabs-on-grade.*
C. *Walls.*
D. *Structural framing members.*
E. *Equipment pads and bases.*
F. *Suspended slabs.*
G. *Stairs.*
H. *Columns.*
I. *Others.*
J. *Pedestals*
K. *Ramps*
L. *Trenches*
M. *Others*

1.3 DEFINITIONS

1.3.1 Cementitious Materials: Portland cement alone or in combination with one or more of fly ash, ground granulated blast-furnace slag, and silica fume.

1.4 REFERENCES

1.4.1 American Association of State Highway and Transportation Officials (AASHTO):

A. *AASHTO M182 Standard Specification for Burlap Cloth Made from Jute or Kenaf*

B. *AASHTO T26 Standard Method of Test for Quality of Water to be used in Concrete*

1.4.2 American Concrete Institute (ACI):

A. *ACI 117 Specifications for Standard Tolerances for Concrete Construction and Materials*

B. *ACI 301 Specifications for Structural Concrete for Buildings*

C. *ACI 304 Guide for Measuring, Mixing, Transporting, and Placing Concrete*

D. *ACI 305 Hot Weather Concreting*

E. *ACI 309 Guide for Consolidation of Concrete*

F. *ACI 315 Standard Practice for Detailing Reinforced Concrete Structures*

G. ACI 318 Building Code Requirements for Reinforced Concrete

H. *ACI 347 Formwork for Concrete*

I. *ACI 504R Guide to Joint Sealants for Concrete Structures*

1.4.3 American National Standards Institute (ANSI):

A. *ANSI Q9001 Quality Systems – Model for Quality Assurance in Design, Development, Production, Installation, and Servicing*

B. *ANSI Q9002 Quality Systems – Model for Quality Assurance in Production, Installation, and Servicing*

1.4.4 American Society for Testing and Materials (ASTM):

A. *ASTM A 82 Standard Specification for Steel Wire Reinforcement, Plain, for Concrete*

B. *ASTM A 185 Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement*

C. *ASTM A 307 Standard Specification for Carbon Steel Bolts and Studs, 415 MPa Tensile Strength*

D. *ASTM A 496 Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement*

E. *ASTM A 497 Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete*

F. *ASTM A 615M Standard Specification for Deformed and Plain Billet- Steel Bars for Concrete Reinforcement*

G. *ASTM A 706M Standard Specification for Low-Alloy Steel Deformed and Plain Bars*

H. *ASTM A 775/A775M Standard Specification for Epoxy-Coated Reinforcing Steel Bars*

I. *ASTM A 780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings*

J. *ASTM A 820 Standard Specification for Steel Fibers for Fiber-Reinforced Concrete*

K. *ASTM C 31 Standard Practice for Making and Curing Concrete Test Specimens in the Field*

L. *ASTM C 33 Standard Specification for Concrete Aggregates*

M. *ASTM C 39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens*

N. *ASTM C 40 Standard Test Method for Organic Impurities in Fine Aggregates for Concrete*

O. *ASTM C 42 Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete*

P. *ASTM C 88 Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate*

Q. *ASTM C 94 Standard Specification for Ready-Mixed Concrete*

R. *ASTM C 114 Standard Test Methods for Chemical Analysis of Hydraulic Cement*

S. *ASTM C 117 Standard Test Method for Materials Finer Than 75-Micrometer (No. 200) Sieve in Mineral Aggregates by Washing*

T. *ASTM C 127 Standard Test Method for Density, Relative Density (Specific Gravity) and Absorption of Coarse Aggregate*

U. *ASTM C 128 Standard Test Method for Density, Relative Density Specific Gravity) and Absorption of Fine Aggregate*

V. *ASTM C 131 Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine*

W. *ASTM C 142 Standard Test Method for Clay Lumps and Friable Particles in Aggregates*

X. *ASTM C 143 Standard Test Method for Slump of Hydraulic Cement Concrete*

Y. *ASTM C 150 Standard Specification for Portland Cement*

Z. *ASTM C 171 Standard Specification for Sheet Materials for Curing Concrete*

AA. *ASTM C 172 Standard Practice for Sampling Freshly Mixed Concrete*

BB. *ASTM C 186 Standard Test Method for Heat of Hydration of Hydraulic Cement*

CC. *ASTM C 191 Standard Test Method for Time of Setting of Hydraulic Cement by Vicat Needle*

DD. *ASTM C 192 Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory*

EE. *ASTM C 219 Standard Terminology Relating to Hydraulic Cement*

FF. *ASTM C 227 Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)*

GG. *ASTM C 289 Standard Test Method for Potential Reactivity of Aggregates (Chemical Method)*

HH. *ASTM C 295 Standard Guide for Petrographic Examination of Aggregates for Concrete*

II. *ASTM C 309 Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete*

JJ. *ASTM C 311 Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland-Cement Concrete*

KK. *ASTM C 330 Standard Specification for Lightweight Aggregates for Structural Concrete*

LL. *ASTM C 494 Standard Specification for Chemical Admixtures for Concrete*

MM. *ASTM C 586 Standard Test Method for Potential Alkali Reactivity of Carbonate Rocks for Concrete Aggregates (Rock Cylinder Method)*

NN. *STM C 595 Standard Specification for Blended Hydraulic Cements*

OO. *ASTM C 618 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete*

PP. *ASTM C685 Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing*

QQ. *ASTM C 881 Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete*

RR. *ASTM C 920 Standard Specification for Elastomeric Joint Sealants*

SS. *ASTM C 989 Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars*

TT. *ASTM C1059 Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete*

UU. *ASTM C 1064 Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete*

VV. *ASTM C 1077 Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation*

WW. *ASTM C 1105 Standard Test Method for Length Change of Concrete Due to Alkali-Carbonate Rock Reaction*

XX. *ASTM C 1116 Standard Specification for Fiber-Reinforced Concrete and Shotcrete*

YY. *ASTM D 209 Standard Specification for Lampblack Pigment*

ZZ. *ASTM D 512 Standard Test Methods for Chloride Ion in Water*

AAA. *ASTM D 516 Standard Test Method for Sulfate Ion in Water*

BBB. *ASTM D 1751 Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types*

CCC. *ASTM D 3963/D 3963M Standard Specification for Fabrication and Jobsite Handling of Epoxy-Coated Steel Reinforcing Bars*

DDD.

ASTM E 154 Standard Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover

EEE. *ASTM E 329 Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials used in Construction*

FFF. *ASTM E 548 Standard Guide for General Criteria Used for Evaluating Laboratory Competence*

GGG. *ASTM E 1155M Standard Test Method for Determining FF Floor Flatness and FL Floor Levelness Numbers (Metric)*

HHH. *ASTM E 1745 Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs*

1.4.5 British Standards:

A. *BS 812 Testing Aggregates*

B. *BS 882 Specification for Aggregates from Natural Sources for Concrete*

C. *BS 1881 Methods of Testing Concrete*

D. *BS 1881, Part 5 Testing Concrete: Methods of Testing Hardened Concrete for Other than Strength*

E. *BS 1881, Part 122 Testing Concrete: Method for Determination of Water Absorption*

F. *BS 1881, Part 116 Testing Concrete: Method for Determination of Compressive Strength of Concrete Cubes*

G. *BS 1199 and 1200 Specification for Building Sands from Natural Sources*

H. *BS 4027 Specification for Sulfate-Resisting Portland Cement*

I. *BS 4449 Specification for Carbon Steel Bars for the Reinforcement of Concrete*

J. *BS 4483 Steel Fabric for the Reinforcement of Concrete*

K. *BS 5328 Methods for Specifying Concrete Including Ready-Mixed Concrete*

L. *BS 8007 Code of Practice for Design of Concrete Structures for Retaining Aqueous Liquids*

M. *BS 8110 Structural Use of Concrete Part 1 (1997): Code of Practice for Design and Construction, Part 2 (1985): Code of Practice for Special Circumstances, Part 3 (1985): Design Charts for Singly Reinforced Beams, Doubly Reinforced Beams and Rectangular Columns*

N. *BS 8666 Specification for Scheduling, Dimensioning, Bending and Cutting of Steel Reinforcement for Concrete*

O. *EN 197 Part 1: Cement. Composition, Specifications and Conformity Criteria for Common Cements*

P. *DIN 1048 Part 5 Testing of Hardened Concrete*

1.4.6 Commercial Standards (CS):

A. *Concrete Plant Manufacturers Bureau - Concrete Plant Standards*

B. *National Ready-Mixed Concrete Association (NRMCA) - Check List*

1.4.7 Concrete Reinforcing Steel Institute (CRSI):

A. *CRSI Manual of Standard Practice*

1.4.8 Corps of Engineers (CE):

A. *CE CRD-C119 Test for Flat and Elongated Particles*

B. *CE CRD-C300 Curing Compound*

C. *CE CRD-C513 Rubber Water stops*

D. *CE CRD-C572 PVC Water stops*

1.4.9 National Standard of Canada:

A. *CAN/CSA A23.5 - M86 Supplementary Cementing Materials*

1.5 SUBMITTALS

1.5.1 Product Data: For proprietary materials and items, including reinforcement and forming accessories, admixtures, patching compounds, water stops, joint systems, curing compounds, dry-shake finish materials, and others as requested by the Engineer.

1.5.2 Design Mixes: For each concrete mix. Include alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

1.5.3 Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names, and addresses of architects/engineers and owners, and any other information required by the Engineer.

1.5.4 Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials.

1.5.5 Material Certificates: Signed by manufacturers and contractor certifying that each of the following items complies with specified requirements:

A. *Cementitious materials and aggregates.*

B. *Admixtures:*
Material certificates in lieu of material laboratory test reports when permitted by the Engineer. Material certificates shall be signed by the manufacturer and the Contractor, certifying that each material item
complies with specified requirements. Provide certification from admixture manufacturers that chloride content complies with specified requirements.

C. *Water stops.*

D. *Curing materials.*

E. *Floor and slab treatments.*

F. *Bonding agents.*

G. *Adhesives.*

H. *Vapor retarders.*

I. *Epoxy joint filler.*

J. *Joint-filler strips.*

K. *Repair materials*

L. *Concrete Protective System.*

1.5.6 Samples: Samples of materials as requested by the Engineer, with names, sources, and descriptions, including, but not limited to, the following:

A. *Color finishes.*

B. *Normal-weight aggregates.*

C. *Reglets.*

D. *Waterstops.*

E. *Vapor retarder/barrier.*

F. *Form liners.*

G. *Joint fillers.*

H. *Sealants.*

1.5.7 Minutes of preinstallation conference.

1.5.8 Transit Mix Delivery Slips

A.

Keep a record showing time and place of each casting of concrete, together with transit mix delivery slips at job site, according to the following.

B. *Before unloading each truck at the site, the Contractor shall provide a delivery ticket containing the following information:*

- name and location of the batch plant date and serial number of the ticket
- designation of the work (name and location) compressive strength of concrete
- quantity of concrete

- truck number, load number and cumulative total time - batched
-specified slump and air content admixture dosage
-water/cement ratio cement content
-maximum size of aggregate weights of fine and coarse aggregate
-indication that all ingredients are as previously certified or approved temperature of mix

1.5.9 After discharge of the concrete provide the following information on the delivery ticket:

A. *time that the discharge of the load was started and completed amount of water added*
B. *after batching (must be signed by the Engineer) amount of admixture added after*
C. *batching*

1.5.10 Make record available to the Engineer for inspection.

1.5.11 Upon completion of the Work, deliver a copy of record and delivery slips to the Engineer.

1.6 QUALITY ASSURANCE

1.6.1 Quality System: Comply with ISO 9001/9002 Quality System as a minimum. Incorporate all the standard procedures supplied by the Engineer and the Employer.

1.6.2 Codes and Standards: Comply with 2001 Manual of Concrete Practice Parts 1, 2, 3, 4 & 5, and CRSI "Manual of Standard Practice" except where more stringent requirements are shown or specified.

1.6.3 Concrete Quality Control Engineer: Appoint a full-time Concrete Quality Control Engineer (CQCE) to ensure that concrete is properly produced, placed, cured and protected. The CQCE shall be equivalent to a Member of the Institute of Concrete Technology (MICT) and shall be responsible

for the maintenance and submission of all specified records. The CQCE shall not report to his own company's site construction management but to his own company's management and to the Engineer. The CQCE shall set standards of quality and insist that these standards be followed, prepare a Quality Control Program for the inspection and testing of concrete and the maintenance of all reports and records to meet the specified requirements and requirements of the Engineer.

A. *The CQCE shall be authorized to:*

Postpone concreting operations until outstanding requirements are corrected.
Reject materials or workmanship that do not conform to this Specification.
Prevent the use of equipment that could cause improper construction relative to this Specification.
Stop any work that is not being done in accordance with specified requirements.
Report within 24 hours and provide records to and as required by the Engineer upon discovery of non-compliance.

1.6.4 Qualifications of Workmen:

A. *Use only properly trained and experienced journeyman concrete finishers for finishing of concrete floor surfaces.*

B. *In acceptance or rejection of concrete floor finishes, no allowance will be made for lack of skill on the part of finishers.*

1.6.5 The Contractor shall operate a Quality Assurance System in accordance with ANSI Q9002. This Quality Assurance Manager shall be responsible for the preparation of a Quality Plan for approval of the operations specified in this Section. The Quality Plan shall include, among other things, the list and schedule of the Quality Control audits that the Quality Assurance Manager or his designee shall make.

1.6.6 Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products complying with ASTM C 94/C94M requirements for production facilities and equipment.

1.6.7 Engage an independent testing agency acceptable to the Engineer to perform material evaluation tests and qualified according to ASTM C 1077 and ASTM E 329 to conduct the testing indicated, as documented according to ASTM E 548 and to design concrete mixes.

A. *Personnel conducting field tests shall be qualified as ACI concrete field testing technician, Grade 1 according to ACI CP-1 or an equivalent certification program.*

1.6.8 Materials and installed work may require testing and retesting at any time during progress of Work. Tests, including retesting of rejected materials for installed Work, shall be done at the Contractor's expense.

1.6.9 Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, each aggregate from one source, and each admixture from the same manufacturer.

1.6.10 Mockups: Before casting concrete that is exposed to view on surfaces of the completed structure or building, cast a mockup for each exposed element, including slabs if applicable, to demonstrate typical joints, surface finish, texture, color, tolerances, quality of materials and standard of workmanship in the completed Work.

A. *Revise size of mockups in subparagraph below if required.*

B. *Build mockups in the location and of the size indicated or, if not indicated, as directed by the Engineer.*

C. *Notify the Engineer seven days in advance of dates and times when mockups will be constructed.*

D. *In the presence of the Engineer, damage parts of exposed surfaces as selected by the Engineer, and demonstrate materials and techniques proposed for repairs to match adjacent undamaged surfaces.*

E. *Obtain the Engineer's approval of mockups before starting cast-in-place concrete elements exposed to view.*

F. *If the Engineer determines that any mockup does not meet requirements, demolish and remove from the site and cast another until the mockup is approved.*

G. *Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.*

H. *Demolish and remove mockups when directed.*

1.6.11 Preinstallation Conference: Conduct conference at Project site to comply with requirements as follows:

A. *At least 35 days prior to submitting design mixes, conduct a meeting to review detailed requirements for preparing concrete design mixes and to determine procedures for satisfactory concrete operations. Review requirements for submittals, status of coordinating work, and availability of materials. Establish preliminary work progress schedule and procedures for materials inspection, testing, and certifications. Require representatives of each entity directly concerned with cast-in-place concrete to attend conference, including, but not limited to, the following:*

Contractor's superintendent.
- Agency responsible for concrete design mixes.
- Agency responsible for field quality control.
- Ready-mix concrete producer.

Concrete subcontractor.

- Primary admixture manufacturers.

1.7 DELIVERY, STORAGE, AND HANDLING

1.7.1 To ACI 301, Clause 2.50.

A. *Cement that has been in storage for more than 6 months shall be tested for suitability for use and subject to the approval of the Owner's Engineer.*

1.8 TOLERANCES

To ACI 117, and as follows:

1.8.1 Alignment

A. *The dimensions, by which any beam, wall or column may be out of position in plan, shall not exceed 5 mm. Foundation deviation may not exceed 15 mm.*

1.8.2 Plumb

A. *The dimensions by which any column or wall is out of plumb in any direction shall not exceed 5 mm in any 3 meters of height, with a maximum of 20 mm in the total height of the construction.*

1.8.3 Levels

A. *The dimension by which any beam or slab is out of level, either up or down, shall not exceed 3 mm. In floor slabs. Where the concrete forms the final floor surface, then the maximum permissible departure from a 3 m straight edge resting in contact with the floor shall be 5 mm.*

1.8.4 Cross Sectional Dimensions

A. *The difference between the finished cross sectional dimensions of any member, after striking the formwork, and the dimensions shown on the drawings, shall not exceed 3 mm. Members framing into an intersection shall maintain their lines vertically and horizontally to an accuracy of 3 mm.*

1.8.5 Bulging and Local Irregularities

A. *The permissible deviation for bulging and local irregularities in the surface of elements shall not exceed 3 mm in 3 meters.*

1.8.6 Reinforcement Cover Tolerances

A. *The permissible deviation for cover to reinforcement shall be 5 mm from that specified. The permissible deviation for the location of reinforcement shall be 25 mm, provided the permissible deviation for cover is not exceeded.*

1.8.7 Pedestals under Baseplates

A. *Top of concrete for pedestals which are to receive base plates for steel columns or posts shall be cast to the levels shown on the drawings, within a tolerance of +0 mm, -15 mm.*

1.8.8 Anchor Bolts Placing

A. *Centre to center of any two bolts within same anchor bolt group 3mm.*

B. *Centre to center of adjacent anchor bolt groups, 6 mm maximum accumulation per 35 m along a column line, but not to exceed a total of 20 mm.*

C. *Centre of any anchor bolt group to the column line through that group, 6 mm.*

PRODUCTS

2.1 CONCRETE MATERIALS

2.1.1 Portland cement: ASTM C 150, Type I or BS EN 197-1 Type CEM I 42.5N, to be used in the superstructure concrete mixes.

2.1.2 Triple Blend Cement: ASTM C 150, Type I or BS EN 197-1 Type CEM I 42.5N, with C3A content between 5% to 8% shall be used in reinforced substructure concrete mixes, in combination with Silica fume to ASTM C1240 (5% to 10% of cementitious weight) and either Fly ash to ASTM C618 (25% to 35% of cementitious weight) or GGBS to ASTM C989 (50% to 60% of cementitious weight).

2.1.3 Sulphate Resisting Cement: ASTM C 150, Type V or BS EN 197-1 Type CEM I/SR 42.5N, to be used for plain/unreinforced substructure concrete and for concrete elements in contact with sewage.

2.1.4 Silica Fume: ASTM C 1240, amorphous silica. The approved supplier shall provide documentation to establish the following:

A. *That the silica fume complies with ASTM C1240 standard requirements.*

B. *The silica fume results from the production of silicon or ferro-silicon alloys containing at least 85 percent silicon.*

C. *That source of supply shall remain the same for the construction period of the project.*

D. *That the supply shall be adequate to meet the anticipated peak requirement.*

E. *Chemical analyses to give the percentages of the following materials:*

SiO_2	C	SO_3
CaO	Fe_2O_3	K_2O
Al_2O_3	Na_2O	MgO

Loss on ignition.
Percentage of particles greater than 44 mm.
Specific surface area and method of test, together with corresponding particle size.

F. *Delivery of silica fume to the concrete batching plant shall be in dry powder form, with a bulk density between 400 and 720 kg/cu. m.*

G. *Manufacturer's test certification shall be supplied for each delivery of silica fume and shall confirm that the silica fume complies with the above requirements and shall be submitted by the Contractor no later than the day of delivery of the silica fume.*

H. *The Engineer shall have the right to call for tests, the cost of which are to be borne by the Contractor, on each delivery of silica fume, if necessary to establish or confirm that the silica fume meets the above requirements.*

2.1.5 Select supplementary cementing materials from subparagraphs below, if permitted. Blending of fly ash or slag with Portland cement is accomplished at mixing plant. Fly ash or slag, may slow rate of concrete strengthening, and affect color uniformity.

A. *Fly Ash: ASTM C 618, Class F.*

B. *Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.*

2.1.6 Normal-Weight Aggregates: Aggregates shall be from approved sources and shall conform to the requirements of ASTM C 33 and BS EN 12620. Petrographic analyses shall be made in accordance with ASTM C 295. Aggregates for exposed concrete shall be from a single source and shall not contain substances that cause spalling. Only aggregates not susceptible to alkali aggregate reaction shall be used. The Contractor shall supply samples of the materials for approval by the Engineer and each aggregate source shall be subject to monitoring by the Engineer. Grading of aggregate shall be to the completion of ASTM C33 or BS EN 12620.

A. *Coarse Aggregate: Coarse aggregate size shall be 20 mm nominal and those retained on a 5mm sieve and shall consist of crushed or uncrushed gravel or crushed stone and shall be selected, recrushed, finish screened and washed with water meeting the requirements of Paragraph 2.1.G as necessary to comply with the following:*

Frequency of Tests	Test Description	Standard	Limit
1 per 30 days	Los Angeles Abrasion Loss (Grading A or B)	ASTM C 131	25% maximum
1 per 30 days	Ratio of Los Angeles Abrasion Loss at 100 & 500 Revolutions (100/500 Revolutions Value)	ASTM C 131 Note 6	0.25% maximum
1 per day	Clay Lumps and Friable Particles	ASTM C 142	1.0% maximum
1 per day	Material Finer than 75 Microns	ASTM C 117	1.0% maximum
1 per 7 days	Water Absorption	ASTM C 127	2.0% maximum
1 per 3 days	Chlorides as Cl	BS EN 1744-1	0.03% maximum
1 per 3 days	Sulfates as SO3	BS EN 1744-1	0.3% maximum
1 per 30 days	Magnesium Sulfate Soundness Loss (5 cycles)	ASTM C 88	10.0% maximum
1 per 3 days	Flakiness Index	BS EN 933-3	25% maximum
1 per 3 days	Elongation Index	BS 812	25% maximum
1 per source	Reactive Silica	ASTM C 227	Per Appendix X1.3.7 of ASTM C 33
1 per 7 days	Specific gravity		Minimum 2.6
1 per each batch	Moisture Content		
1 in 7 days	Light Weight Pieces	ASTMC 123/C123M	0.5% Maximum
1 in 3 days	Sieve Analysis	ASTM C136	As per ASTM C33 Requirements
1 in 30 days	Drying Shrinkage	EN 12620 CL 5.7 EN 1367.4	0.045% maximum

Additionally, limits specified in Paragraph 2.9.H for the total salt content of concrete shall not be exceeded.

B. *Fine Aggregate: Fine aggregate, those passing a 5mm sieve, shall consist of crushed gravel, crushed stone, or natural sand with rounded or sub-rounded particles and shall be washed as necessary to comply with the following:*

Frequency of Tests	Test Description	Standard	Limit
1 per day	Clay Lumps and Friable Particles	ASTM C 142/C14 2M	1.0% maximum
1 per day	Material Finer than 75 Microns	ASTM C 117	maximum 3% for natural sand and 5% for crushed sand with no plastic fines
1 per 7 days	Water Absorption	ASTM C 128	2.0% maximum
1 per 3 days	Chlorides as Cl	BS EN 1744-1	0.06% maximum
1 per 3 days	Sulfates as SO3	BS EN 1744-1	0.30% maximum
1 per 7 days	Organic Impurities	ASTM C 40/C40 M	Lighter than Standard Color
1 per day	Sand equivalent	ASTM D2419	75% minimum
1 per day	Light weight pieces	ASTM C 123/C123M	0.5% maximum
1 per source	Reactive Silica	ASTM C227	Per Appendix X1.3.7 of ASTM C 33/C33M
1 in 3 days	Sieve analysis	ASTM C136	As per ASTM C33/C33M requirements
1 per 30 days	Drying Shrinkage	EN 12620 cl. 5.7 EN 1367-4	0.045% maximum

- Additionally, limits specified in Paragraph 2.9.H for the total salt content of concrete shall not be exceeded.

C. *Shell Content: The maximum permissible shell content of aggregates shall not exceed the following for specified nominal aggregate sizes:*

Nominal Aggregate Size (mm)	**Maximum Permissible Shell Content % by Weight of Dry Aggregate**
40	**2**
20	**5**
10	**10**

D. *Certification: Obtain from each proposed source of supply Test Certification to confirm that the aggregates comply with the above requirements. The following information shall be provided:*

Quarry location.
Aggregate type.
Petrographic analysis report.
Grading curve.
Shape and surface texture.
Flakiness index.
10 percent fines value.
Impact test.
Shell content.
Chloride and sulfate content.
Relative density.
Water absorption value and moisture content.
Silt, clay, and dust content.
Results of reactive silica tests.
Organic impurities (fine aggregate only).

E. *Testing:*

When a source of supply for each aggregate type has been established, samples of materials delivered to Project site shall be taken for testing in accordance with BS 812 as follows:

- Tests for clay, silt and dust, and sieve analysis shall be carried out for every 20 tons of fine aggregate and every 40 tons of coarse aggregate. Chemical analyses shall be carried out on every 100 tons of aggregate.

- The Engineer shall have the right to call for additional samples at any time for testing of aggregates delivered to the Project site or of aggregates at the source of supply in order to confirm that the aggregates meet the above requirements.

F. *Transportation: During transportation to the Project site, all aggregates shall be protected from wind-borne contaminants. If these contaminants are present at time of delivery to the Project site, then the aggregates shall be washed with water meeting the requirement of Paragraph 2.1.G. Transport vehicles shall be cleaned of*

G. *possible contamination due to previous use.*

Storage: Aggregates shall be stored (under shade) on hard concrete floors or other approved materials having sufficient slope to ensure adequate drainage of aggregate before being used for concrete and each size and type shall be stored in separate heaps without intermixing. Storage shall prevent contamination of the aggregates by foreign material including windblown dust. Fine and coarse aggregates shall be separated by permanent substantial partitions. Methods of storing, shading and cooling aggregates shall be approved by the Engineer.

2.1.7 Water: Water used for mixing concrete, ice production, washing and cooling aggregates, and curing concrete shall be free from impurities, oil, acid, salts, alkali, organic matter, and other potentially deleterious substances in accordance with AASHTO T26 and when tested in accordance with ASTM D 512 and ASTM D 516. Additionally, the limits specified in Paragraph 2.9.H for the total salt content of the concrete shall not be exceeded. The chloride content shall not exceed 500 ppm.

A. *Once a source of satisfactory supply has been established, further tests shall be made daily with a portable electrical conductivity probe calibrated against the satisfactory supply. If the conductivity exceeds that of the satisfactory supply, then further chemical tests shall be performed.*

2.2 ADMIXTURES

2.2.1 Admixtures containing Chlorides shall not be used.

2.2.2 General: No admixture shall be used in the concrete without the Engineer's written approval and under no circumstances shall admixtures containing chlorides or other corrosive agents be allowed. Admixture compatibility with the type of cement used shall be proven.

2.2.3 The Contractor shall perform a trial batch and casting to substantiate the manufacturer’s claims of workability, retardation, and air entrainment (0 to 1.0 percent maximum), as specified in Article 2.14. Admixtures shall comply with the following standards: ASTM C494/C494 M, EN 934 and EN 480. Also, admixture shall comply with EN 12878 for pigments of cement.

2.2.4 Air-Entraining Admixture: No air entraining agent shall be used.

2.2.5 Admixtures shall be incorporated into the mix design strictly in accordance with the manufacturer’s written instructions.

2.2.6 High-Range Water-Reducing Admixture (Superplasticizer): ASTM C 494, Type G.

A. *If necessary, and only with the Engineer’s approval, a naphthalene sulphonate retarding superplasticizer shall be used to increase workability of the concrete and retard the initial set.*

B. *Products: To produce fluid concrete with a slump value at least 200 mm, easily flowing, but at the same time free from segregation and having the same water/cement ratio as that of a no slump concrete with admixture. The product shall result in concrete that*

remains workable for a minimum of 3 hours at +20 deg.C (68 deg.F) and for a minimum of 1 hour at +40 deg. C (104 deg. F).

C. *Obtain from the retarding superplasticizer supplier, details of the material for review by the Engineer and confirmation that it is in accordance with specified requirements. Confirmation shall be obtained that the retarding superplasticizer is compatible with any pozzolan that is used.*

D. *Glare-Reducing Agent: For landscape concrete paving, provide material for reducing glare. Comply with ASTM D 209.*

2.2.7 Water-Reducing Admixture (Plasticizer): ASTM C 494, Type A.

2.2.8 Water-Reducing and Accelerating Admixture: ASTM C 494, Type E.

2.2.9 Water-Reducing and Retarding Admixture: ASTM C 494, Type D.

2.2.10 Third Generation admixtures, Polycarboxylate Ether, shall be used in concrete containing silica fume or if self-consolidating concrete is required

2.2.11

Corrosion-Inhibiting Admixture: The concrete mix shall contain commercially formulated, anodic inhibitor or a mixed cathodic and anodic inhibitor based on Amines and Alcohol with a minimum dosage of 10 l/m3. The inhibitor must be capable of forming a protective barrier and absorbed on the reinforcement surface of concrete for protecting steel bars and minimizing chloride reactions with steel reinforcement in concrete.

2.2.12

Corrosion inhibitors must be certified by international and reputable standards institutes and shall not have any negative effects on concrete physical properties. They must possess a long and good work record in the Middle East and must be tested by suitable corrosion durability model to suit project requirement of minimum corrosion initiation period of 15 years.

2.3 WATERSTOPS

2.3.1 Water stops: Provide flat, dumbbell-type water stops at construction joints and other joints as indicated. Water stops shall be sized to suit joints.

A. *Flexible PVC Water stops: CE CRD-C 572, for embedding in concrete to prevent passage of fluids through joints. Factories fabricate corners, intersections, and directional changes.*

- Profile: Ribbed with center bulb.

2.4 VAPOR RETARDERS, CURING COMPOUNDS AND FINISH

2.4.1 Vapor Retarder: ASTM E 1745, Class C, of one of the following materials; or polyethylene sheet, ASTM D 4397, not less than 0.25 mm thick:

A. *Nonwoven, polyester-reinforced, polyethylene coated sheet; 0.25 mm thick.*

B. *Three-ply, nylon- or polyester-cord-reinforced, laminated, high-density polyethylene sheet; 0.18 mm thick.*

2.4.2 Related Materials:

A. *Polyethylene sheet not less than 8 units thick.*

B. *Water resistant barrier consisting of heavy Kraft papers laminated together with glass fiber reinforcement and over coated with black polyethylene on each side.*

2.4.3 Fine-Graded Granular Material: Clean mixture of crushed stone, crushed gravel, and manufactured of natural sand; ASTM D 448, Size 10, with 100 percent passing a 4.75 mm sieve and 10 to 30 percent passing a 0.15 mm sieve; meeting deleterious substance limits of ASTM C 33 for fine aggregates.

2.4.4 Granular Fill: Clean mixture of crushed stone or crushed or uncrushed gravel; ASTM D 448, Size 57, with 100 percent passing a 38 mm sieve and 0 to 5 percent passing a 2.36 mm sieve.

2.4.5 Sand Cushion: Clean, manufactured, or natural sand.

2.4.6 Absorptive Cover: Burlap cloth made from jute or kenaf weighing approximately 0.29 kg/sq. m and complying with AASHTO M182, Class 2.

2.4.7 Moisture-Retaining Cover (Impervious Sheeting): One of the following, complying with ASTM C 171:

A. *Waterproof paper.*

B. *Polyethylene film.*

C. *Polyethylene-coated burlap*

2.4.8 curing Compound: Curing Compound shall be a non-degradable Pliolite Resin in accordance with ASTM C 309, Type I, Class B. It shall in addition to curing, act as both a sealer and primer coat for most subsequent coatings. The Contractor shall obtain confirmation from the supplier of the curing compound that it is compatible with the final applied finishes and meets the above requirements.

2.4.9 Evaporation Control: Monomolecular film-forming compound applied to exposed concrete slab surfaces for temporary protection from rapid moisture loss.

2.4.10 Underlayment Compound: Free-flowing, self-leveling, pumpable, cement-based compound for applications from 25 mm thick to feathered edges. The underlay shall be applied in passes not thicker than 6 mm at any interval.

2.4.11 Colored Wear-Resistant Finish: Packaged dry combination of materials consisting of Portland cement, graded aggregate, coloring pigments, and plasticizing admixture. Use coloring pigments that are finely ground nonfading mineral oxides interground with cement. Color shall be as selected by the Engineer from manufacturers' standards, unless otherwise indicated.

2.5 FLOOR AND SLAB TREATMENTS

2.5.1 Sprinkle-On Floor Hardener: factory blend of selected non-metallic aggregates, Portland cement and additives, to be sprinkled on surface of green concrete (within 2 - 3 hours of casting) to give an extremely hard-wearing, skid-resistant, durable, grease and oil-resistant topping for concrete floors:

A. *28-day compressive strength:* *70 N/mm2*

B. *hardness, Moh's scale:* *>7*

C. *rate of application: in accordance with manufacturer's recommendations*

D. *abrasion resistance:* *ASTM C 944* *>80% compared to controlled concrete*

2.5.2 Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to the following:

A. *Master Builders Technologies/Degussa; Mastertop300 (synthetic aggregate) 6-7kg/m2*

2.6 CURING MATERIALS

2.6.1 Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.

2.6.2 Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 305 g/sq. m when dry.

2.6.3 Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

2.6.4 Water: Potable.

2.6.5 Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C 309, Type 1, Class B.

2.7 RELATED MATERIALS

2.7.1 Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber.

2.7.2 Epoxy Joint Filler: Two-component, semirigid, 100 percent solids, epoxy resin with a Shore A hardness of 80 per ASTM D 2240.

2.7.3 Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

2.7.4 Epoxy-Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class and grade to suit requirements, and as follows:

A. *Type II, non-load bearing, for bonding freshly mixed concrete to hardened concrete.*

B. *Types I and II, non-load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.*

C. *Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.*

2.7.5 Reglets: Fabricate reglets of not less than 0.55 mm thick galvanized steel sheet. Temporarily fill or cover face opening of Reglet to prevent intrusion of concrete or debris.

2.7.6 Dovetail Anchor Slots: Hot-dip galvanized steel sheet, not less than 0.85 mm thick, with bent tab anchors. Temporarily fill or cover face opening of slots to prevent intrusion of concrete or debris.

2.7.7 Foam Backing Rod: For use with joint filler and joint sealer. Round closed cell foam, extruded polyethylene, Shore A hardness of 20, tensile strength of 140 to 200 kPa, oversized 30-50%, compatible with sealant and primer, non-adhering to sealant.

2.8 REPAIR MATERIALS

2.8.1 Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 3 mm and that can be feathered at edges to match adjacent floor elevations.

A. *Cement Binder: ASTM C 150, Portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.*

B. *Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.*

C. *Aggregate: Well-graded, washed gravel, 3 to 6 mm or coarse sand as recommended by underlayment manufacturer.*

D. *Compressive Strength: Not less than 30 MPa at 28 days when tested according to ASTM C 109M.*

2.8.2 Repair Topping: Traffic-bearing, cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 6 mm.

A. *Cement Binder: ASTM C 150, Portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.*

B. *Primer: Product of topping manufacturer recommended for substrate, conditions, and application.*

C. *Aggregate: Well-graded, washed gravel, 3 to 6 mm or coarse sand as recommended by topping manufacturer.*

D. *Compressive Strength: Not less than 40 MPa at 28 days when tested according to ASTM C 109M.*

2.9 CONCRETE MIXES

2.9.1 Prepare design mixes for each type and strength of concrete determined by laboratory trial mix, as follows:

A. *Proportion normal-weight concrete according to ACI 211.1 and ACI 301.*

2.9.2 Use a qualified independent testing agency acceptable to the Engineer for preparing and reporting proposed mix designs for the laboratory trial mix basis.

A. *Do not use the same testing agency for field quality control.*

2.9.3 Submit written reports to the Engineer of each proposed mix for each class of concrete at least 30 days prior to start of Work. Do not begin concrete production until proposed mix designs have been reviewed and approved by the Engineer.

2.9.4 Design mixes to provide normal-weight concrete with the following properties unless otherwise indicated on Drawings:

A. *Blinding Concrete: Proportion normal-weight concrete mix as follows:*

Compressive Strength (28 Days): 15 MPa.

Maximum W/C ratio: 0.6.

Maximum Slump: 100 mm. Slump for concrete mixes with admixture shall range from 160mm to 200mm.

Cyclopean concrete: plums of broken stone spalls or boulders free from sharp or angular edges and ranging in size from 100 to 300mm to be soaked in water prior to incorporation in cyclopean concrete. Plums are to be evenly placed and comprise maximum 50% of total volume of concrete in position and with minimum cover of 70mm.

B. *All Reinforced concrete Elements: Proportion normal-weight concrete mix as follows:*

- Compressive Strength on Cylinder (28 Days): 40 MPa

- Minimum cementitious content: 380 kg/m3

- Maximum water to cementitious ratio: 0.4.

- Maximum Slump: 100 mm

- Maximum Slump for Concrete Containing High-Range Water-Reducing Admixture: 160 mm to 200mm after admixture is added to concrete with 50 to 100 mm slump.

- Silica fume in combination with other cementitious additives such as fly ash or GGBS shall be added to the substructure concrete, to meet the specified permeability test requirements.

2.9.5 All concrete below ground shall have protective coating .

2.9.6 Blinding/mud mat concrete shall contain sufficient SRC cement to obtain the specified design strength.

2.9.7 Water-Cement Ratio: The free water-cement ratio shall not exceed 0.40. Where cementitious additives are used, the water-cement ratio shall be the water content divided by the cement plus cementitious content. The water-cement ratio shall be continuously checked at the mixer with due allowance made for water contained in the aggregates. Under no circumstance shall water be added between the mixer and the place of concrete placement. The Engineer may require that the water-cement ratio be checked during tests performed on fresh concrete samples taken at the time of placement as specified.

2.9.8 Slump Limits: The slump of concrete mixes shall be such that the concrete can be transported, placed into the forms, and compacted without segregation as specified. If no superplasticizer is required, the slump at time of placement shall be 50-75 mm as measured in accordance with ASTM C 143. In accordance with Article 3.5, the concrete shall always exhibit a mobility that enables this placement to be affected with the minimum amount of difficulty.

2.9.9 Total Salt Content:

A. *Chlorides: The total chloride content (sum of both acid soluble and water soluble chlorides) of the concrete from all sources, expressed as chloride ion, shall not exceed 0.15 percent by weight of dry cement, inclusive of cementitious content when tested in accordance with BS 1881.*

B. *Sulfates: The total sulfate content of the concrete from all sources, expressed as SO3, when tested in accordance with BS 1881, shall not exceed 3 percent by weight of dry cement, inclusive of cementitious content.*

2.9.10 Initial Setting Time:

A. *The initial setting time shall be not less than one hour after the production concrete is discharged into the form. With a maximum time between mixing and placing concrete of one hour, the total time between mixing and initial set shall be a minimum of 2 hours. There shall be a maximum setting time of 6 hours.*

B. *When trial mixes are made to determine the workability of the concrete, the initial setting time of the cement paste shall be determined using the method defined in ASTM C 191 but at the maximum allowable temperature and with same proportions of pozzolan and retarding superplasticizer as specified in this Specification.*

2.9.11 Test Mixes - Structural Grade Concrete: When the proposed workability, proportions of aggregates and superplasticizer, and strength for each grade of concrete have been established, test concrete shall be produced for approval by the Engineer. The following shall be performed for each grade of concrete:

A. *Six separate test mixes shall be made and cured in accordance with ASTM C 192 and tested in accordance with ASTM C 39.*

B. *The 36 cylinders for each grade of concrete shall be tested for compressive strength at 28 days and the mean strength and standard deviation established for each grade.*

C. *The test mixes shall be accepted provided that:*

The mix proportions and workability are in accordance with this Specification.
The standard deviation for each grade is 3.5 MPa or less.
The mean strength for structural concrete exceeds the specified design strength by 6 MPa.

2.9.12 Test Mixes - Blinding or Mud mat Concrete:

A. *Concrete for blinding or mud mat shall be a designed mix with the specified design strength of 15 MPa. The trial mix proportions shall be left to the discretion of the Contractor. Once they have been chosen, three separate test mixes shall be made with those proportions and three 150 mm test cylinders shall be made from each mix for testing at 28 days. The trial mix proportions, and water/cement ratio shall be approved if the average strength of the nine cylinders is not less than 20 N/sq. mm.*

B. *No production test shall be made for this grade of concrete, but the Engineer will monitor the mix proportions and water/cement ratio.*

2.9.13 Adjustment to Concrete Mixes: Mix design adjustments may be requested when characteristics of materials, job conditions, weather, test results, or other circumstances warrant. Laboratory test data for revised mix design and strength results shall be submitted to and approved by the Engineer before using in the Work.

2.9.14 Absorption Test: The absorption of the hardened concrete from the trial mixes for structural grades shall be tested as a measure of the concrete's ability to resist the ingress of aggressive salts. No absorption tests shall be required for blinding or mudmat concrete. Absorption tests shall be in accordance with modified BS 1881: Part 122, tested at 28-days as follows:

A. *After trial mixes have been accepted, three 150 mm cylinders shall be cast from each grade of concrete and immersed in water at 20 deg. C (68 deg. F) for 7 days.*

B. *At the end of the curing period, 75 mm diameter core specimens shall be cut along the longitudinal axis of each cylinder to a depth of 75 mm.*

C. *The specimens shall be dried in an oven at 105 deg. C (221 deg. F) for 72 hours.*

D. *The specimens shall be cooled in a dry airtight vessel for 24 hours, weighed, and than immediately immersed in a tank containing water at 20 deg. C (68 deg.F) with the longitudinal axis of the cores horizontal, and with 25 mm depth of water over the specimens.*

E. *The specimens shall be immersed for 30 minutes, then removed, shaken, surface dried, and reweighed. The water absorption shall be calculated as the increase in mass resulting from immersion, expressed as a percentage of the dry mass.*

F. *If the cores lengths differ from 75 mm, a correction factor (graph given in BS 1881) shall be applied.*

G. *The mean of the corrected absorption figure for each concrete grade shall be calculated and the absorption of the concrete mixes shall be acceptable if the mean absorption is less than 1.5 percent at 30 minutes. The mean absorption figure and the lowest absorption figure shall be recorded for each grade and used for comparison purposes with absorption tests carried out on cores cut from in-situ concrete, as scheduled.*

2.9.15 Permeability Tests:

A. *BE EN 12390-8 Depth of Penetration shall be carried out as a measure of water permeability on concrete before the mix design or manufacturing method are approved. The tests shall be carried out in accordance with BS EN at age 28 days and the maximum value of penetration shall not exceed the following limits:*

In-situ construction: Less than 10 mm.

B. *The chloride permeability of the concrete shall be determined using cores taken from the prototype samples, in accordance with AASHTO T277 "Rapid Determination of the Chloride Permeability of Concrete". The following limits shall not be exceeded at 28 days:*

In-situ construction: 1000 coulombs.

C. *The concrete will be deemed to comply with the permeability requirements of this specification if all test results comply with the limits indicated in paragraphs 1 and 2.*

D. *If any of the BS EN and the rapid chloride permeability test results of unprotected surfaces of a sample failed to meet the above requirements, then all the concrete work represented by such sample shall be deemed not to comply with the permeability requirements.*

E. *If, in the opinion of the Engineer, the concrete that has failed to meet the permeability requirements of this Specification is likely to cause durability problems, three cores shall be cut from the area represented by failed samples for additional BS EN and rapid chloride permeability testing. The actual location shall be decided by the Engineer.*

2.9.16 Test Construction:

A. *Test Foundation: A test foundation footing and plinth shall be cast on grade to the details provided by the Engineer in accordance with specified requirements. This shall be performed before any permanent works are constructed. The concrete shall be cured for the period required in Article 3.9, after which an epoxy coating shall be applied to that part of the plinth which would normally be above ground and a protection coating applied to the remainder of the plinth and the footing, all in accordance with Section 071353.*

B. *Test Floor Slab: A 3 m by 4 m test area of 150 mm thick floor slab constructed of above ground reinforced concrete in accordance with this Specification shall be cast on grade and given a Class U4 finish as specified in Paragraph 3.7.E. The concrete shall be cured for the period specified in Article 3.9.*

2.9.17 Cementitious Materials: Limit percentage, by weight, of cementitious materials other than Portland cement in concrete as follows:

A. *Fly Ash: 35 percent.*

B. *Ground Granulated Blast-Furnace Slag: 60 percent.*

C. *Silica Fume: 10 percent.*

2.9.18 Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.

2.9.19 Admixtures: Use admixtures according to the manufacturer's written instructions.

A. *Use water-reducing admixture or high-range water-reducing admixture (superplasticizer) in concrete, as required, for placement and workability.*

B. *Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.*

C. *Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs and parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.40.*

D. *Use Third generation admixture, Polycarboxylate Ether, if silica fume is used in the concrete or if self-consolidated concrete is required*

E. *Use corrosion-inhibiting admixture in concrete mixes where indicated.*

All to be as required and approved by the Engineer, for placement and workability. Use admixtures in accordance with the manufacturer's instructions. Ensure that the correct quantity of admixture is always used. The equipment to be used for dispensing and the method of incorporating the admixture into the concrete shall be subject to approval. The dispensing unit shall be translucent so that the operator can see the discharge of the admixture.

2.10 CONCRETE MIXING

2.10.1 General: Concrete production shall be in accordance with ACI 304. A checklist for concrete production shall be produced, such as that used by the NRMCA or approved equal.

A. *Batching of materials shall be by weight. All weighing equipment shall be calibrated and documentation shall be provided to establish that the accuracy is continuously maintained in accordance with the requirements of ACI 304. Batching scale accuracy shall be in accordance with the Concrete Plant Standards of the Concrete Plant Manufacturers Bureau, or approved equal.*

B. *Furnish the necessary equipment and establish accurate procedures for determining the quantities of free moisture in the aggregates. Moisture determinations shall be made daily and whenever there is an apparent change in the moisture content. The moisture content shall be recorded. The moisture of aggregates shall be utilized in adjusting the weight of aggregate added to the mix. The water added to the mix shall be similarly adjusted.*

2.10.2 Job-Site Mixing: All concrete mixed on Project site shall be in a batch mixer of approved size and design complying with ACI 304 and producing a uniform distribution of the materials throughout the mixed concrete in accordance with ASTM C 94 uniformity test. The contents of the drum shall be completely discharged before re-charging. After all the materials are in the mixer, mixing shall continue until the whole of the materials are uniformly distributed and the mass is of uniform color and consistency. In the case of concrete that contains silica fume with a density between 400-720 kg/cu. m, the mixing time shall be 50 percent greater than the requirement for concrete without silica fume.

A. *Whenever mixing is to be suspended for half an hour or longer, the drum of the mixer shall be thoroughly washed out with clean water. Provide a competent operator who shall be in continuous control of the mixer. No retempering of concrete, which has partially hardened, by the addition of cement, aggregate, or water shall be allowed*

B. *Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mix type, mix time, quantity, and amount of water introduced.*

2.10.3 Ready-Mixed Concrete:

A. *Ready-Mixed concrete shall comply with the requirements. of ASTM C 94 or EN 206 and as follows:*

Concrete shall be centrally mixed off site and transported in an agitator truck. Truck mixing shall not be permitted.
The plant and trucks shall be certified as meeting the requirements of the NRMCA Check List, or approved equal.
Details and information regarding the supplier proposed by the contractor shall be submitted to the Engineer for approval.
The sewer of ready mixed concrete shall not subsequently be charged without further approval of the Engineer.

B. *When air temperature is between 30 deg.C (82 deg.F) and 32 deg.C (90 deg. F), delivery time from the time water is added to the mix until it is placed in its final position in the form shall not exceed 60 minutes. When air temperature is above 32 deg.C (90 deg. F), delivery time shall not exceed 45 minutes.*

C. *Before discharging concrete at the point of delivery, provide the Engineer with a delivery ticket for each batch of concrete containing the following information as a minimum:*

- Name or number of off-site concrete depot.
- Serial number for ticket.
- Date.
- Time of dispatch.
- Truck number.
- Name of Supplier.
- Grade or mix description of concrete.
- Type of cement.
- Cement content.
- Water/cement ratio.
- Nominal maximum size of aggregate.
- Source of aggregate, maximum size, weight of fine and coarse aggregate.
- Type or name of admixture, if included.
- Quantity of concrete in cubic meters.

- Certifying that chlorides and sulfate contents are within specified limits and
- stating their values.
- Amount of concrete in cubic meter.

EXECUTION

3.1 PREPARATION

3.1.1 General: Remove wood scraps and debris from areas in which concrete will be placed. Clean areas thoroughly to ensure proper placement and bonding of concrete.

3.1.2 Notification: Notify the Engineer and the independent testing agency at least 24 hours prior to any concreting operation proceeding. Approval by the Engineer to place concrete shall be contingent on formwork, and reinforcing steel placement, and evidence that casting may be placed without stopping.

3.1.3 Bonding New Concrete to Existing: Surfaces shall be thoroughly cleaned of all foreign material prior to depositing fresh concrete. For hardened concrete surfaces, laitance shall be removed and the aggregate partially exposed. The surfaces shall be thoroughly wetted immediately before placing the new concrete.

3.2 VAPOR RETARDERS

3.2.1 Vapor Retarder: Place, protect, and repair vapor retarder sheets according to ASTM E 1643 and manufacturer's written instructions.

3.2.2 Fine-Graded Granular Material: Cover vapor retarder with fine-graded granular material, moisten, and compact with mechanical equipment to elevation tolerances of plus 0 mm or minus 20 mm.

3.2.3 Granular Fill: Cover vapor retarder with granular fill, moisten, and compact with mechanical equipment to elevation tolerances of plus 0 mm or minus 20 mm.

A. *Place and compact a 15 mm thick layer of fine-graded granular material over granular fill.*

3.2.4 General: Place vapor retarder/barrier sheeting in position with longest dimension parallel with direction of pour.

3.2.5 Lap joints 150 mm and seal with manufacturer's recommended mastic or pressure-sensitive tape. Cover vapor retarder/barrier with sand cushion and compact to depth indicated.

3.3 JOINTS

3.3.1 General: Construct joints true to line with faces perpendicular to surface plane of concrete.

3.3.2 Construction Joints:

A. *Locate and install construction joints so that they do not impair strength or appearance of the structure and are acceptable to the Engineer. Unless otherwise shown or approved, provide, and locate construction joints in accordance with ACI 301. Where construction joints are indicated in construction documents, no deviation shall be allowed without the approval of the Engineer. Additional joints shall be kept to a minimum and must be approved by the Engineer. The joint surface shall be roughened to remove laitance without disturbing the coarse aggregate by pressure jetting with air and water or by wire brushing. The joint shall be clean prior to placing fresh concrete. The new concrete shall be well worked against the old concrete to ensure a good joint.*

B. *The use of expanded metal or other perforated material is prohibited in construction joints.*

C. *Place construction joints perpendicular to main reinforcement. Continue reinforcement across construction joints except as indicated otherwise. Do not continue reinforcement through sides of strip placements.*

D. *Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.*

E. *Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders.*

F. *Space vertical joints in walls as indicated, or as required by the Engineer.*

G. *Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.*

H. *Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.*

3.3.3 Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of concrete thickness, as follows:

A. *Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint to a radius of 3 mm. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.*

B. *Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 3 mm wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.*

3.3.4 Isolation Joints in Slabs-on-Grade: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.

A. *Terminate full-width joint-filler strips not less than 12 mm or more than 25 mm below finished concrete surface where joint sealants, specified in Division 7 Section "Joint Sealants," are indicated.*

B. *Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together. Unless otherwise indicated Drawing, Joint sealing shall be in accordance with ACI 504r*

3.4 WATERSTOPS

3.4.1 Flexible Water stops: Install in construction joints as indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed water stop during progress of Work. Field-fabricate joints in water stops according to manufacturer's written instructions.

3.5 CONCRETE PLACEMENT

3.5.1 General: Comply with ACI 301, ACI 304, and ACI 318.

3.5.2 Inspection: Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast in. Notify other trades to permit installation of their work. Concrete shall not be placed until the condition of the reinforcement, other embedded items, and the formwork has been inspected and approved by the Engineer.

3.5.3 Transportation: Concrete, after being discharged from the mixer, shall be transported as rapidly as possible to its final position in the Work by agitator trucks, which shall prevent adulteration, segregation, loss of workability or contamination of the ingredients. The containers that convey the concrete shall be kept clean and free from hardened or partially hardened concrete.

A. *The addition of water at the point of discharge is prohibited and trucks shall have the water tank completely disconnected from the drum.*

The use of chutes, spouts, skips and pumps shall be permitted if approval is obtained. Under no circumstances shall any aluminum pipe or other conveying equipment

B. *containing aluminum be allowed to contact fresh concrete when it is conveyed to its point of placement.*

C. *Method of pouring and pouring sequence shall be submitted by the Contractor to the Engineer's approval.*

3.5.4 Placing Concrete in Forms: Deposit concrete in forms continuously or in horizontal layers no deeper than 450 mm and in a manner to avoid inclined construction joints. Where placement consists of several layers, place each layer while the preceding layer is still plastic to avoid cold joints. If a section cannot be placed continuously, provide construction joints as specified. Deposit concrete to avoid segregation at its final location.

A. *Concrete shall not be dropped into place from a height exceeding 1.5 m nor through dense reinforcing steel, which could cause segregation of the coarse aggregate. Structural concreting against open excavation will not be permitted as the concrete cannot be coated afterwards.*

B. *When vertical lifts of concrete are interrupted or delayed for more than one hour, the surface of the unfinished concrete shall be thoroughly cleaned and washed with cement grout immediately before fresh concrete is added and the first layer of new concrete placed shall not exceed 150mm depth and particular care shall be taken with compaction of this new layer to ensure good bond.*

C. *Method of pouring and pouring sequence shall be submitted by the Contractor to the Engineer's approval.*

3.5.5 Do not add water to concrete during delivery, at Project site, or during placement.

3.5.6 Deposit concrete continuously or in layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as specified. Deposit concrete to avoid segregation.

3.5.7 Deposit concrete in forms in horizontal layers no deeper than 600 mm and in a manner to avoid inclined construction joints. Place each layer while preceding layer is still plastic, to avoid cold joints.

A. *Consolidate placed concrete with mechanical vibrating equipment. Use equipment and procedures for consolidating concrete recommended by ACI 309R.*

B. *Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations no farther than the visible effectiveness of the vibrator. Place vibrators to rapidly penetrate placed layer and at least 150 mm into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mix constituents to segregate.*

3.5.8 Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.

A. *Consolidate concrete during placement operations so that concrete is thoroughly worked around reinforcement and other embedded items and into corners.*

B. *Maintain reinforcement in position on chairs during concrete placement.*

C. *Screed slab surfaces with a straightedge and strike off to correct elevations.*

D. *Slope surfaces uniformly to drains where required.*

E. *Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, free of humps or hollows, before excess moisture or bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.*

3.5.9 Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by low temperatures.

3.5.10 Compaction and Vibration: Full compaction of the concrete shall be achieved throughout the entire depth of the layer. It shall be thoroughly worked against the formwork and around the reinforcement and successive layers shall be thoroughly bonded together. Air bubbles formed during the mixing and casting shall be expelled particular care shall be taken where sloping formwork is used.

A. *Consolidate placed concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping. Use equipment and procedures for consolidation of concrete complying with ACI 309.*

B. *Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations no farther than the visible effectiveness of the machine. Place vibrators to rapidly penetrate placed layer and at least 150 mm into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion, avoid over vibration and limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mix to segregate.*

3.5.11 Placing Concrete Slabs: Deposit and consolidate concrete slabs in a continuous operation, within limits of construction joints, until completing placement of a panel or section. Consolidate concrete during placement operations so that concrete is thoroughly worked around reinforcement, other embedded items and into corners. Bring slab surfaces to correct level with a straightedge and strike off. Use bull floats or darbies to smooth surface free of humps or hollows. Do not disturb slab surfaces prior to beginning finishing operations. Maintain reinforcing in proper position during concrete placement.

3.5.12 Hot-Weather Placement: When hot weather conditions exist that would impair quality and strength of concrete, place concrete complying with ACI 305 and as specified.

A. *Cool ingredients before mixing to maintain concrete temperature at time of placement to below 32 deg.C (90 deg. F). Mixing water may be chilled or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is the Contractor's option.*

B. *Concrete temperature shall not exceed 32 deg. C (90 deg.F) and the temperature differential shall not exceed 25 deg. C (68 deg. F).*

C. *No concreting operation shall be carried out at ambient temperature of 40 deg. C (104 deg. F) or more.*

D. *Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedding in concrete.*

E. *Fog spray forms, reinforcing steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without puddles or dry areas.*

F. *Use water-reducing retarding admixture when required by high temperatures, low humidity, or other adverse placing conditions, as acceptable to the Engineer.*

G. *Shade mixing plant and trucks, aggregates, water tank, and cement silo.*

H. *Paint white the mixing plant, trucks, water tank, and cement silo.*

I. *Insulate the water tank and supply piping.*

J. *Provide necessary shades over and around the concrete being poured to prevent sun rays from coming into direct contact with the surface of the concrete and the formwork for a period of about 7 days (minimum from the time of pouring concrete).*

K. *Concrete placing shall be completed as quickly as possible to reduce transit time.*

L. *Curing of exported concrete shall be immediately carried out.*

3.6 FINISHING FORMED SURFACES

3.6.1 Rough-Formed Finish (Class F1): Provide a rough-formed finish on formed concrete surfaces not exposed to view in the finished Work or concealed by other construction. Concrete surface texture is that imparted by form-facing material used, with tie holes and defective areas repaired and patched, and fins and other projections exceeding 7 mm in height rubbed down or chipped off. This finish class is not applicable to elements where backfill is to be placed against the concrete.

3.6.2 Smooth-Formed Finish (Class F2): Provide a smooth-formed finish on formed concrete surfaces exposed to view or to be covered with a coating material applied directly to concrete, such as waterproofing, damp-proofing, veneer plaster, painting, or another similar system. This is an as-cast concrete surface obtained with selected form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch defective areas with fins and other projections completely removed and smoothed. No ledges shall be permitted at the position of joints in the formwork.

3.6.3 Smooth-Rubbed Finish (Class F3): Provide smooth-rubbed finish not later than 1 day after form removal on scheduled concrete surfaces that have received smooth-formed finish treatment. Moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.

3.6.4 Grout-Cleaned Finish (Class F4): Provide grout-cleaned finish on scheduled concrete surfaces that have received smooth-formed finish treatment.

A. *Combine one part Portland cement to one and one-half parts fine sand by volume, and a 50:50 mixture of acrylic or styrene butadiene-based bonding admixture and water to form the consistency of thick paint. Blend standard Portland cement and white Portland cement in amounts determined by trial patches so that final color of dry grout shall match adjacent surfaces.*

B. *Thoroughly wet concrete surfaces apply grout to coat surfaces, and fill small holes. Remove excess grout by scraping and rubbing with clean burlap. Keep damp by fog spray for at least 36 hours after rubbing.*

3.6.5 Cork-Floated Finish: Wet concrete surfaces and apply a stiff grout. Mix one part Portland cement and one part fine sand with a 1:1 mixture of bonding agent and water. Add white Portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Compress grout into voids by grinding surface. In a swirling motion, finish surface with a cork float.

3.6.6 Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

3.7 FINISHING FLOORS AND SLABS

3.7.1 General: Comply with recommendations in ACI 302.1R for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.

3.7.2 Scratch Finish (U1): Apply scratch finish to monolithic slab surfaces receiving concrete floor topping or mortar setting beds for tile, Portland cement terrazzo, and other bonded applied cementitious finish flooring material, and where indicated. After placing slabs, finish surface to tolerances of F(F) 15 (floor flatness) and F(L) 13 (floor levelness) measured in accordance with ASTM E 1155M. Slope surfaces uniformly to drains where required. After leveling, roughen surface before final set with stiff brushes, brooms, or rakes.

3.7.3 Nonslip Broom Finish (U2): Apply a nonslip broom finish to exterior concrete platforms, steps, ramps, and elsewhere as indicated. Immediately after float finishing, slightly roughen concrete surface by brooming with fiber-bristle broom perpendicular to main traffic route. Coordinate required final finish with the Engineer before application.

3.7.4 Float Finish (U3): Apply float finish to monolithic slab surfaces receiving trowel finish and other finishes as specified; slab surfaces to be covered with membrane or elastic waterproofing, membrane or elastic roofing, or sand-bed terrazzo; and where indicated. After screeding, consolidating, and leveling concrete slabs, do not work surface until ready for floating. Begin floating, using float blades or float shoes only, when surface water has disappeared, or when concrete has stiffened sufficiently to permit operation of power-driven floats, or both. Consolidate surface with power-driven floats or by hand-floating if area is small or inaccessible to power units. Finish surfaces to tolerances of F(F) 18 (floor flatness) and F(L) 15 (floor levelness) measured in accordance with ASTM E 1155M. Cut down high spots and fill low spots. Uniformly slope surfaces to drains. Immediately after leveling, refloat surface to a uniform, smooth, granular texture.

3.7.5 Trowel Finish (U4): Apply a trowel finish to monolithic slab surfaces exposed to view and slab surfaces to be covered with resilient flooring, carpet, ceramic or quarry tile, paint, or another thin film finish coating system. This finish is also applicable to tops of buried foundations since they have to be subsequently coated.

A. *After floating, begin first trowel-finish operation using a power-driven trowel. Begin final troweling when surface produces a ringing sound as trowel is moved over surface. Consolidate concrete surface by final hand-troweling operation, free of trowel marks, uniform in texture and appearance, and finish surfaces to tolerances in accordance with ASTM E1155M of the following:*

- Specified overall values of flatness, F(F) 35; and levelness, F(L) 25; with -- minimum local values of flatness, F(F) 24; and levelness, F(L) 17; for slabs-on-grade.
- Specified overall values of flatness, F(F) 30; and levelness, F(L) 20; with minimum local values of flatness, F(F) 24; and levelness, F(L) 15; for suspended slabs.

B. *Grinds smooth any surface defects that would telegraph through applied floor covering system.*

C. *Finish and measure surface so gap at any point between concrete surface and an unleveled freestanding 3 m long straightedge, resting on two high spots and placed anywhere on the surface, does not exceed the following:*

5 mm.

3.7.6 Trowel and Fine Broom Finish (U5): Where ceramic or quarry tile is to be installed with thin-set mortar, apply a trowel finish as specified, then immediately follow by slightly scarifying the surface with a fine broom.

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3.7.7 Colored Wear-Resistant Finish (U6): Apply a colored wear-resistant finish to monolithic slab surface indicated.

A. *Apply dry shake materials for the colored wear-resistant finish at a rate of 5 kg/sq. m unless a greater amount is recommended by material manufacturer.*

B. *Cast a trial slab approximately 3 m square to determine actual application rate, color, and finish, as acceptable to the Engineer.*

C. *Following placement, vibrating, and leveling, float the concrete with a wooden float to "open" the surface and allow the excess moisture and air to escape.*

D. *Once the sheen has disappeared, apply floor hardener as a dry shake onto the wet surface. Apply approximately one-half of the material and then float into the surface with a wooden float.*

E. *Following the first float, apply the balance of the material and float in the same fashion.*

F. *Once the surface is firm enough to take foot traffic, use a power float to finish the surface to a smooth and non-slip finish.*

G. *After floating, apply a trowel finish as specified. Cure slab surface with a curing compound recommended by the dry shake material manufacturer. Apply the curing compound immediately after the final finishing.*

3.7.8 Broom Finish: Apply a broom finish to exterior concrete platforms, steps, and ramps, and elsewhere as indicated.

A. *Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route. Coordinate required final finish with the Engineer before application.*

3.7.9 Slip-Resistive Aggregate Finish: Before final floating, apply slip-resistive aggregate finish where indicated and to concrete stair treads, platforms, and ramps. Apply according to manufacturer's written instructions and as follows:

A. *Uniformly spread 12 kg/10 sq. m of dampened slip-resistive aggregate over surface in one or two applications. Tamp aggregate flush with surface, but do not force below surface.*

B. *After broadcasting and tamping, apply float finish.*

C. *After curing, lightly work surface with a steel wire brush or an abrasive stone, and water to expose slip-resistive aggregate.*

3.8 MISCELLANEOUS CONCRETE ITEMS

3.8.1 Filling In: Fill in holes and openings left in concrete structures, unless otherwise indicated, after work of other trades is in place. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete Work.

3.8.2 Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

3.8.3 Equipment Bases and Foundations: Provide machine and equipment bases and foundations as shown on Drawings. Set anchor bolts for machines and equipment at correct elevations, complying with diagrams or templates of manufacturer furnishing machines and equipment.

3.8.4 Steel Pan Stairs: Provide concrete fill for steel pan stair treads, landings, and associated items. Cast-in inserts and accessories as shown on Drawings. Screed, tamp, and trowel-finish concrete surfaces.

3.8.5 Tolerance and concrete dimensions for in-situ concrete members shall, under no circumstances, exceed the permissible ones as indicated in the ACI.

3.9 CONCRETE PROTECTION AND CURING

3.9.1 General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and with recommendations in ACI 305R for hot-weather protection during curing.

3.9.2 Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 1 kg/sq. m x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

3.9.3 Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing by one or a combination of the following methods:

3.9.4 Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces, by one or a combination of the following methods:

A. *Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:*

Water. Continuous water-fog spray.

-Absorptive cover, water saturated, and kept continuously wet. Cover concrete - surfaces and edges with 300 mm lap over adjacent absorptive covers.

B. *Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 300 mm, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.*

Retain subparagraphs below to suit Project.

-Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.

-Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.

-Cure concrete surfaces to receive floor coverings with either a moisture-retaining cover or a curing compound that the manufacturer recommends for use with floor -coverings.

C. *Curing Compound: Shall be to the Engineer's approval applied uniformly in continuous operation by power spray or roller according to the manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.*

D. *Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.*

3.9.5 Curing Methods: Cure concrete by curing compound, by moist curing, by moisture-retaining cover curing, or by combining these methods, as specified below.

A. *Horizontal Surfaces: Horizontal surfaces shall be saturated with water and then treated with curing compound. Apply curing compound as soon as final finishing operations are complete (within 2 hours and after surface water sheen has disappeared). Apply uniformly in continuous operation by power spray or roller according to manufacturer's directions. Recoat areas subjected to heavy rainfall within 3 hours after initial application. The surfaces shall then be bonded and flooded with*

water or draped with wet burlap together with a perforated soaker hosepipe, covered with white impervious sheeting held firmly in place along all edges and kept continuously wet for the duration of the curing period.

B. *Vertical Surfaces: Vertical timber formwork shall be draped with wet burlap as soon as concrete is placed. Vertical surfaces shall be treated with curing compound as soon as formwork is removed, draped with wet burlap, covered with white impervious*

sheeting held firmly in place along all edges and kept continuously wet for the duration of the curing period. Care shall be taken to avoid drying winds.

C. *Impervious Sheeting: Impervious sheeting shall be in accordance with ASTM C 171.*

D. *Curing Compound: Curing compound shall be white and in accordance with CE CRD-C300. It shall be a water-based wax emulsion for concrete above grade, which will not be subsequently coated. Otherwise the curing compound shall be compatible with the coating. Obtain confirmation from the supplier of the curing compound that it meets the above requirements.*

3.10 LIQUID FLOOR TREATMENTS

3.10.1 Penetrating Liquid Floor Treatment: Prepare, apply, and finish penetrating liquid floor treatment according to manufacturer's written instructions.

A. *Remove curing compounds, sealers, oil, dirt, laitance, and other contaminants and complete surface repairs.*

B. *Do not apply to concrete that is less than seven days old.*

C. *Apply liquid until surface is saturated, scrubbing into surface until a gel forms; rewet; and repeat brooming or scrubbing. Rinse with water; remove excess material until surface is dry. Apply a second coat in a similar manner if surface is rough or porous.*

3.10.2 Sealing Coat: Uniformly apply a continuous sealing coat of curing and sealing compound to hardened concrete by power spray or roller according to manufacturer's written instructions.

3.11 JOINT FILLING

3.11.1 Prepare, clean, and install joint filler according to manufacturer's written instructions.

A. *Defer joint filling until concrete has aged at least six months. Do not fill joints until construction traffic has permanently ceased.*

3.11.2 Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joint clean and dry.

3.11.3 install semi-rigid epoxy Joint Filler full depth in saw-cut Joint and at least 50 deep in formed Joint, Over fill joint and trim joint filler flush with top of joint after hardening

3.12 CONCRETE SURFACE REPAIRS

3.12.1 Concrete exposed by the removal of formwork shall be inspected by the Engineer before any remedial work, subsequent coating or other treatment that would hinder the proper inspection of the concrete is carried out. Any concrete not complying with this requirement shall be liable for rejection.

3.12.2 Concrete not meeting the specified requirements shall be removed and rebuilt without delay unless the Engineer approves that a repair may be satisfactorily effected. This agreement shall not preclude the subsequent rejection of the repaired work by the Engineer. The proposed method for removal and replacement of defective work shall be submitted to the Engineer for approval for each concrete placement before the removal commences.

3.12.3 All repairs approved by the Engineer shall be performed by a subcontractor specialized in the repair of concrete in the Middle East and prepared to guarantee the work. Any repair method submitted for approval shall produce a result that is as impermeable as the original concrete. Subsequent tests on the repaired concrete shall be carried out at the discretion of the Engineer in order to establish the quality of the repair, particularly at the joint between the original and the repaired concrete.

3.12.4 Defective Concrete: Repair and patch defective areas when approved by the Engineer. Remove and replace concrete that cannot be repaired and patched to the Engineer's approval.

3.12.5 Patching Mortar: Mix dry pack patching mortar, consisting of one part Portland cement to two and one-half parts fine aggregate passing a 1.2 mm sieve, using only enough water for handling and placing.

3.12.6 Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.

A. *Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 13 mm in any dimension in solid concrete but not less than 25 mm in depth. Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with patching mortar before bonding agent has dried. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.*

B. *Repair defects on surfaces exposed to view by blending white Portland cement and standard Portland cement so that, when dry, patching mortar will match surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.*

C. *Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by the Engineer.*

3.12.7 Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.

A. *Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pockets, crazing and cracks in excess of 0.25 mm wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.*

B. *After concrete has cured at least 14 days, correct high areas by grinding.*

C. *Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete.*

D. *Correct other low areas scheduled to receive floor coverings with a repair underlayment. Prepare, mix, and apply repair underlayment and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface. Feather edges to match adjacent floor elevations.*

E. *Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of 6 mm to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.*

F. *Repair defective areas, except random cracks and single holes 25 mm or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose steel reinforcement with at least 20 mm clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mix as original concrete except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.*

G. *Repair random cracks and single holes 25 mm or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.*

3.12.8 Perform structural repairs of concrete, subject to the Engineer's approval, using epoxy adhesive and patching mortar.

3.12.9 Repair materials and installation not specified above may be used, subject to the Engineer's approval.

3.13 GROUTING

3.13.1 Preparation: Concrete foundation top shall be cleaned of dirt, laitance, oil and grease. Anchor bolt boxes and sleeves shall be cleaned of all polystyrene and other deleterious material. The surface of the concrete shall be thoroughly wetted just prior to grouting but shall contain no excess water, particularly in the bolt boxes and sleeves.

3.13.2 Materials:

A. *Type G1: For interior bases protected from weather and saline bearing waters and not subject to heavy or vibratory loads, grout shall consist of one part Portland cement to two parts well graded sand by volume. Sand shall comply with Paragraph 2.1. A retarding superplasticizer may be used if necessary to obtain the correct fluidity in high ambient temperatures.*

B. *Type G2: For all heavily loaded structural column bases and equipment bases subjected to vibratory loads, a proprietary non-shrink, non-metallic high strength grout especially formulated for high-temperature work.*

C. *Type G3: For all other exterior work exposed to potential saline ingress, proprietary general purpose non-shrink grout, especially formulated for high temperature work.*

3.13.3 Placement:

A. *The manufacturer's recommendations shall be followed for proprietary grouts. The temperature of the grout at time of placement shall not exceed 25 deg.C (77 deg. F) and the temperature of the elements in contact with the grout shall not exceed 40 deg.C (104 deg. F) . To obtain the required temperatures, it may be necessary to do the following:*

- Shield the materials from the direct rays of the sun.
- Mix materials with flaked ice.
- Cool base plates with water but ensure that anchor bolt pockets are free from water.
- Require certification of plant and trucks to meet requirements of the NRMCA Check List or approved equal.

B. *Grout strength shall not be less than 30 N/sq. mm at 28 days. Document to Engineer that this strength is being achieved. Grouting shall not proceed until the steel work or equipment has been leveled and plumbed with the bases being supported in the meantime by steel packers and shims.*

C. *Completely fill anchor bolt sleeves with grout before placing grout under base plates. The gravity grouting method shall be used wherein the flowable self-leveling grout is poured on one side of a base until it flows out at the opposite side. Packers and shims used to level bases shall be removed after the grout has set and the resulting pocket repaired with similar grout.*

3.14 WATER-RETAINING CONSTRUCTION

3.14.1 General: Water-retaining construction shall comply with this Specification.

3.14.2 Joints: Joints shall be designed and constructed in accordance with ACI 504R. Details and positioning of joints, together with the materials to be used, shall be shown on the Drawings.

A. *Water stops shall be in accordance with Paragraph 2.3.A. Jointing of water stops shall be made by welding in an approved fashion. Lapping of water stops at joints and the use of adhesives for jointing purposes shall not be permitted unless specifically authorized. Water stops shall not be perforated or damaged. Concrete shall be carefully placed and compacted to ensure dense impervious concrete, particularly around the ribs of water stops. At all joints the concrete shall be placed up to the centerline of the water stop. All starters to walls of watertight construction shall be cast using hung formwork so that the concrete in the starters is placed simultaneously with the concrete in the slab.*

3.14.3 Testing: In addition to the testing required, further tests to determine the water tightness of the structure shall be performed in accordance with BS 8007. The structure shall be filled with fresh water to the designed level and after a period to allow for absorption of water, the faces remote from the liquid shall be inspected for leaks over a 7-day period. Any defects shall be repaired by an approved method, which could involve demolition and rebuilding, or lining of the structure.

3.15 QUALITY CONTROL AND TESTING

3.15.1 General:

A. *Testing Laboratory:*

Employ an independent testing agency, approved by the Engineer to perform tests and to submit test reports.
Be responsible for taking, identifying, and delivering to the test laboratory all test samples called for in this Specification. The testing laboratory shall be responsible for the testing. Collect all test results and deliver them to the Engineer in the format and detail as specified.

B. *Testing Laboratory Qualifications: The testing laboratory shall be accredited by NAMAS or an equivalent National Standard and shall have a Quality System in accordance with ANSI Q9001.*

3.15.2 Quality Control - Testing on Fresh Concrete:

A. *Compressive Strength Test for Structural Concrete:*

Sampling, curing, and testing shall be performed using the relevant procedures in ASTM C 31, ASTM C 39, and ASTM C 172.

- Samples for production concrete cylinders shall be taken at the point of placement at the average rate of one per 25 cu. m of concrete placed, with a minimum of one sample taken every day that the mix is used. A sample shall consist of four 150
cylinders molded and stored for laboratory-cured test specimens except when field-cured test specimens are required. One cylinder is for testing at 7 days after casting, two for testing at 28 days after casting, and one reserved for later testing if required.
If frequency of testing provides fewer than 5 strength tests for
given class of concrete, conduct testing from at least 5 randomly selected batches or from each batch if fewer than 5 are used.
When total quantity of a given class of concrete is less than 25 cu. m, the Engineer may waive strength testing if adequate evidence of satisfactory strength is provided.
When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing the in-place concrete.
Samples shall be collected and tested for all absorption and permeability testing, from all classes of concrete, as specified under Clause 2.9 L and 2.9.M, frequency of which shall be directed by the Engineer.

Records: Records shall be kept of the mix details and position in the works of all batches of concrete and of all samples taken for cylinders and other specimens and of their test results. A copy shall be supplied to the Engineer within 24 hours after recording/testing. Records shall contain, but not be limited to, the following information:

Date, time, location, and volume of pour.

Ambient temperature and humidity.

Concrete temperature (at time of placement).

Cement type and manufacture.

Concrete type and class.

Aggregate type and source.

Admixture details.

Water/cement ratio.

Identification of test cylinder.

Name of concrete testing service.

Date and time of sampling.

Method of compaction.

Date of testing and results of test.

Age of sample in days, weight in grams, density in kg/cu. m.

Crushing load in newtons and crushing strength in N/sq. mm.

Signatures of person preparing cylinder and of person crushing cylinder.

Results of testing.

- For the 28-day tests, the concrete will be deemed to comply with the specified design strength if the average strength determined from all sets of 3

consecutive tests is at least equal to the specified design strength and no individual strength test falls below the specified design strength by more than 3.5 N/sq. mm. Any concrete not complying with the specified design strength shall be at risk for removal and replacement at the Contractor's expense.

- The 28-day cylinder crushing results shall be grouped consecutively in groups of 40 and each group shall have a standard deviation less than 3.5 N/sq. mm. If the standard deviation is greater than or equal to 3.5 N/sq. mm, then concrete production shall be investigated by the Engineer and further tests on trial mixes may be required.

- Tests shall be carried out at 7 days to establish a relationship between the 7-day and 28-day strengths. This relationship shall be used to interpret future test results to predict the corresponding 28-day strength. The Engineer shall be advised without delay of any 7-day test result indicating that the corresponding 28-day strength will likely fail to meet the specified strength so that any necessary action can be taken to minimize the effect of such possible failure.

B. *Compressive Strength Test for Blinding or Mud mat Concrete: There shall be no production tests on blinding or mud mat concrete. The Engineer will require compressive strength tests if it is believed that the characteristic strength is below 10 N/sq. mm. Characteristic strength is defined as that value of the cube strength below which 5 percent of all possible test results would be expected to fall. If the tests confirm that the characteristic strength is less than 15 N/sq. mm, then the Engineer will require revisions to the mix design to ensure that the concrete meets the specified requirements.*

C. *Measurement of Concrete Temperature: Temperature measurements shall be in accordance with ASTM C 1064. Concrete temperature shall be measured 50 mm below the surface prior to and at the point of placement and recorded on the pour card for each pour. There shall be one test hourly when air temperature is 4 deg.C (39 deg. F) and below and when air temperature is 27 deg.C (81 deg. F) and above, and one test for each set of compressive-strength specimens. Concreting shall stop if the temperature of the concrete does not meet the requirements of Paragraph 3.5.L*

D. *Cement Content and Water/Cement Ratio: Samples of freshly mixed concrete shall be chosen by the Engineer at least once per month from each structural grade and determination made of cement content and water/cement ratio in accordance with BS 1881. If the cement content is less than 90 percent of the requirement in Paragraph 2.9.F or the water/cement ratio greater than 110 percent of the requirement in Paragraph 2.9.H then there shall be an investigation to establish the cause and the Engineer may reject the casted concrete for the pour from which the samples were taken. The Engineer may request an analysis of fresh concrete from any pour. No analysis of freshly mixed concrete is required for blinding or mud mat concrete.*

E. *Salt Content: The total concentration of sulfates and chlorides in fresh concrete shall be measured at least once a week for all structural grades of concrete. Tests shall be in accordance with BS 1881. Concentrations of each ion shall not exceed the limits specified in Paragraph 2.9.H. If these limits are exceeded, the concrete pour from which the samples were taken shall be rejected and further tests performed on the*

casted concrete in accordance with Paragraph 3.15.C to determine the total extent of the problem.

F. *Slump: Slump tests shall be performed in accordance with ASTM C 143. There shall be a minimum of one test at the point of discharge for each day's pour for each type of concrete. Additional tests shall be performed when concrete consistency appears to have changed*

3.15.3 Quality Control - Testing on Hardened Concrete:

A. *General: The Engineer may request samples to be taken and tests carried out on any hardened structural grade concrete as specified below if he suspects that the concrete does not meet the specified requirements. If the tests confirm that the concrete does not meet the requirements of this Specification, then the Engineer may require the concrete to be removed at the Contractor's expense. If the tests confirm that the concrete meets the requirements of this Specification, then the cost of taking the samples shall not be at the Contractor's expense.*

B. *Compressive Strength Tests: The Engineer may request cores to be drilled from a particular pour. 100 mm diameter cores shall be drilled as requested, in accordance with ASTM C 42, and sent for crushing. If the cores from that pour have an average compressive strength less than 85 percent of the characteristic strength or any individual core has a compressive strength less than 75 percent of the characteristic strength, it shall be evidence that the concrete from which it was taken is not in accordance with the specified requirements.*

C. *Concrete Cover: The Engineer may check the concrete cover over the reinforcement with a cover meter. Any indication that the cover is generally less than the requirements specified in Section 032100 shall be checked by limited surface concrete removal. If it is confirmed that the actual cover is generally less than specified, then the concrete shall be removed at the Contractor's expense. In the case of localized lack of cover and where appearance is not important, a repair shall be effected by removal of the inadequate cover and the cutting back of concrete for 50 mm behind the reinforcement. Resurfacing of the concrete with the specified cover shall be carried out as a repair by a specialist subcontractor as specified in Article 3.12.*

D. *Absorption: A sample of three 75 mm diameter cores, 75 mm long, shall be taken from hardened concrete if directed by the Engineer and tested in accordance with Paragraph 2.9.M. Should the absorption of any core exceed by more than 1 percent the highest approved test result, then the concrete from which it was cut shall be removed. No absorption test shall be required for blinding or mudmat concrete.*

E. *Permeability Tests: Sample of three 75 mm diameter cores, 75 mm long, shall be taken from hardened concrete if directed by the Engineer and tested in accordance with Paragraph 2.9.L. Should the permeability of any core exceed the highest approved test result, then the concrete from which it was cut shall be removed. No permeability test shall be required for blinding or mudmat concrete.*

F. *Salt Content: Engineer may request samples to be taken from two 20 diameter drillings into the concrete surface, spaced 75 mm apart. Each drilling shall proceed in 25 mm increments for a total depth of 100 mm and the dust from the 4 samples in each hole shall be sent for sulfate and chloride content analysis in accordance with BS 1881. Should the tests show that the limits specified in Paragraph 2.9.H are exceeded, the concrete shall be removed.*

G. *Nondestructive Testing: Impact hammer, son scope, or other nondestructive device may be used but shall not be used as the sole basis for acceptance or rejection.*

H. *Additional Tests: The testing agency shall make additional tests of in-place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure, as directed by the Engineer. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed.*

END OF SECTION

SECTION 334000 - STORM DRAINAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes storm drainage outside the building. And the storm water (GRP Piping) material shall be suitable for the media flowing inside below table shows the chemical analysis for the return brine considering variation of ±15% for values.

DESCRIPTION	% KCl	% NaCl	% $MgCl_2$	% $CaCl_2$	% H_2O	Density
HLP Carnallite Thickener Brine	1.61	1.24	26.36	4.19	66.60	1.307

1.**3 DEFINITIONS**

GRP: Glass Reinforced Plastic.

1.**4 PERFORMANCE REQUIREMENTS**

Gravity-Flow, No Pressure-Piping Pressure Ratings: At least equal to system test pressure.

1.**5 SUBMITTALS**

Product Data: Submit manufacturer's technical product data and installation instructions for system materials and products.

Shop Drawings: Include plans, elevations, details, and attachments for the following:

- Drainage pipe network, including pipe diameters and gradients.
- Manholes and other structures, including invert levels, frames, covers, and grates.

- Coordination Drawings: Show manholes and other structures, pipe sizes, locations, and elevations. Include details of underground structures and connections. Show other piping in same trench and clearances from sewerage system piping. Indicate interface and spatial relationship between piping and proximate structures.

- Coordination Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1-meter equals 500 meters (1:500) and vertical scale of not less than 1 meter equals 50 meters (1:50). Indicate underground structures and pipe. Show types, sizes, materials, and elevations of other utilities crossing system piping.

- As-Built Drawings: At project close-out, submit record drawings of installed pipework and products, in accordance with requirements of the Specification, Division 1.

- Maintenance Data: Submit maintenance data and parts lists for system materials and products. Include this data, product data, Shop Drawings, and submit drawings in maintenance manual; in accordance with requirements of the Specification, Division 1.

- Certificate of Compliance.

Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

- Do not store plastic structures, pipe, and fittings in direct sunlight.

- Protect pipe, pipe fittings, and seals from dirt and damage.

- Handle pipes, precast concrete manholes and other structures according to the manufacturer's written instructions.

- Manufacturer's recommendations on handling, repairing, laying, jointing, anchoring, cutting and other works for pipes and fittings are to be strictly followed.

1.7 PROJECT CONDITIONS

- Site Information: Perform site survey and verify existing utility locations.

- Locate existing structures and piping to be closed and abandoned.

- Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

- Notify Engineer not less than two days in advance of proposed utility interruptions.

- Do not proceed with utility interruptions without Engineer's written permission.

1.8 QUALITY ASSURANCE TESTING

Testing on GRP Pipes: The following tests shall be carried out on manufactured pipes. Details of testing program to be submitted to the Engineer for review and approval prior to commencement of pipe manufacture. The manufacturer quality control scheme shall be to BS 5750 or ISO 9002. Guidance on assessment of conformity shall be to CEN/TS 14632. At least the following tests shall be carried out and reported for approval:

- Longitudinal strength to ASTM D 3262.
- Hydraulic test to ASTM D 3517.
- Stiffness to ASTM Method D 2412 or ISO 7685.
- Wall thickness to EN ISO 3126.
- Diameter to EN ISO 3126.
- Hardness to ASTM 2583.
- Loss of ignition to ASTM D 2584.
- Hoop tensile to ASTM D 3517.

1.9 COORDINATION

- Coordinate connection to drainage main with concerned authorities.

PART 2 - PRODUCTS

2.1 PIPES AND FITTINGS

Glass Reinforced Plastic (GRP) Pipe and Fittings

1. Pipes and fittings to BS 14364, or AWWA C950.

- Pipe and fittings shall include a corrosion resistant liner, a structural wall and a resin rich exterior surface

- The liner shall have a nominal thickness of 1.0 mm. The liner surface shall be reinforced with "C" glass. The remainder of the liner thickness shall be reinforced with an acid resistant chopper "E" glass strand or mat.

- The pipe structural wall shall consist of glass reinforcement, and fine silica sand, all impregnated with resin. The fine silica sand shall be added to the structural layer to achieve the design thickness for the required stiffness specified such that the overall hoop flexural modulus (E) for pipe is not less than 24 GN/M2. Silica sand and filler content shall not exceed 50%.

-Pipes shall be provided with a resin rich outer layer reinforced with one layer of "C" glass veil. The exterior layer shall have a minimum thickness of 0.2 mm. The layer shall resin be rich and reinforced with one layer of C glass.

-The resin used for the corrosion resistant liner of the pipe and fittings shall be high grade polyester resin (isophthalic or better) type. For the structural wall and exterior layer of the pipe a high grade isophthalic polyester resin shall be used. No dark pigments shall be used in the pipe or fittings.

-All glass reinforcements except for the inner and outer surfaces of the pipe and fittings shall be of the "E" type. Surface reinforcement shall be of the "C" glass type.

-Pipes shall be designed for a life of not less than 50 years. Submit calculations for initial and long term deflection with Truck loads, Buckling, Vacuum, Pressure Class, and Strain in accordance with Appendix "A" of AWWA, C-950 or equivalent. The maximum calculated long term deflection should not exceed 3 percent. Copies of the design calculations shall be submitted to the Engineer for approval.

-Stiffness: Minimum 5,000 N/m2. Suitability of stiffness shall be verified for the various trench and pipe laying conditions and as recommended by the manufacturer.

- Longitudinal Strength: To BS 14364 Table 13 or ASTM D 3262 Table 7.

- Hoop Strength: To ASTM D 3517 Table 8.

- Strain Corrosion Resistance: Tests are to be carried out as per ASTM D 3681 or BS 14364 strain corrosion value at 50 years to equal or exceed 0.7 percent.

- Markings: To BS 14364 Clauses 4.3 and 6.7.

- Joints: GRP double socket couplings with rubber rings to BS EN 681: Parts 1 and 2, BS EN 682 and BS 7874. Allowable angular deflection to BS 14364 Clause 4.7.3.1.

2.2 MANHOLES

- Normal-Traffic Precast Concrete Manholes: ASTM C 478M, precast, reinforced concrete, of depth indicated, with provision for rubber gasketed joints.

- Diameter: 1200 mm minimum, unless otherwise indicated.

- Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.

- Base Section: 150 mm minimum thickness for floor slab and 100 mm minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.

- Riser Sections: 100 mm minimum thickness, and lengths to provide depth indicated.

- Top Section: Eccentric-cone type. Top of cone of size that matches grade rings.

- Gaskets: ASTM C 443M, rubber.

- Grade Rings: Include two or three reinforced-concrete rings, of 150 to 225 mm total thickness, that match 610 mm diameter frame and cover.

- Pipe Connectors: ASTM C 923M, resilient, of size required, for each pipe connecting to base section.

- Cast-in-Place Concrete Manholes: Construct of reinforced-concrete bottom, walls, and top; designed according to ASTM C 890 for A-16, heavy-traffic and/or extra heavy traffic, structural loading; of depth, shape, dimensions, and appurtenances indicated.

- Ballast: Increase thickness of concrete, as required to prevent flotation.

- Grade Rings: Include two or three reinforced-concrete rings, of 150 to 225 mm total thickness, that match 610 mm diameter frame and cover.

- Manhole Frames and Covers: Ductile iron to BS EN 124 or equivalent, epoxy coated, solid top. Suitable lifting device for manhole covers to be provided at a rate of one for every 10 covers. Frames to be bolted to manhole to ensure proper fixity. Wording on cover is to be as approved on Site. Types to be as follows:

- For roadways: Class D400 heavy duty non-rock type for wheel loads up to 11.5 tons. Minimum test load 400 kN.

- For sidewalks: Class B125, light duty. Minimum test load 125 KN.

2.3 CATCH BASINS/GULLIES

- Normal-Traffic, Precast Concrete Catch Basins and gullies: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for rubber gasketed joints.

- Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (100-mm) minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.

- Riser Sections: 4-inch (100-mm) minimum thickness, 48-inch (1220-mm) diameter, and lengths to provide depth indicated.

- Top Section: Eccentric-cone type, unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.

- Gaskets: ASTM C 443 (ASTM C 443M), rubber.

- Grade Rings: Include two or three reinforced-concrete rings, of 6- to 9-inch (150- to 229-mm) total thickness that matches 24-inch- (600-mm-) diameter frame and grate.

- Steps: ASTM C 478 (ASTM C 478M), individual steps or ladder. Omit steps for catch basins less than 60 inches (1500 mm) deep.

- Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section.

- Cast-in-Place Concrete, Catch Basins: Construct of reinforced concrete; designed according to ASTM C 890 for structural loading; of depth, shape, dimensions, and appurtenances indicated.

- Bottom, Walls, and Top: Reinforced concrete.

- Channels and Benches: Concrete.

- Steps: Manufactured from deformed, 1/2-inch (13-mm) steel reinforcement rod complying with ASTM A 615/A 615M and encased in polypropylene complying with ASTM D 4101. Include pattern designed to prevent lateral slippage off step. Cast or anchor into sidewalls with steps at 12- to 16-inch (300- to 400-mm) intervals. Omit steps for manholes less than 60 inches (1500 mm) deep.

- Frames and Grates: ASTM A 536, Grade 60-40-18 or BS/EN Class D400, ductile iron designed for heavy-duty service. Include flat grate with small square or short-slotted drainage openings.

- Size: 24 by 24 inches (600 by 600 mm) minimum, unless otherwise indicated.

- Grate Free Area: Approximately 50 percent, unless otherwise indicated.

2.4 CONCRETE

General: Reinforced cast-in-place or precast concrete according project specification.

- Channels and Benches: concrete according to project specification.

2.5 PROTECTIVE COATINGS

- Externally with three layers of bituminous coating that shall be applied by brush in accordance with manufacturer's instructions. Minimum thickness shall be 600 microns.

- Internally with four coats of coal tar epoxy paint, 70% epoxy and 30% coal tar. The coating shall be applied by brush in accordance with manufacturer's instructions. Minimum thickness shall be 1000 microns.

2.4 LOOSE RIPRAP

Stones shall be sound, dense, hard and durable rock fragments free from weathering, cracks, seams, brick or concrete; and any other deleterious material and can be placed / dumped as specified. Individual pieces are to be clean, angular and neither elongated nor flat, the longest dimension not exceeding twice the shortest dimension.

PART 3 - EXECUTION

3.1 EARTHWORK

- Excavating, trenching, and backfilling are specified in Section 310000 "Earthwork."

3.2 PIPING APPLICATIONS

- General: Include watertight, silt tight, or soiltight joints, unless watertight or silttight joints are indicated.

- Refer to Part 2 of this Section for detailed specifications for pipe and fitting products. Use pipe, fittings, and joining methods according to applications indicated.

3.3 INSTALLATION, GENERAL

- General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical.

- Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.

- Use manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

- Install two flexible joints. Install the first joint at 1 diameter distance maximum from outside face of manhole and the second joint at not more than the following distances away from the first joint:

1. Pipelines not exceeding 450 mm diameter: 1.0 m.

2. Pipelines over 450 mm and not exceeding 800 mm diameter: 1.6 m.

3. Pipelines over 800 mm diameter: 2.5 m.

- Install piping and connect to building's storm drains, of sizes and in locations indicated. Terminate piping as indicated.

1.Install gravity-flow piping pitched down in direction of flow, at minimum slope of 1 percent, unless otherwise indicated.

- Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or a combination of both.

- Extend storm drainage piping and connect to building's storm drains, of sizes and in locations indicated. Terminate piping as indicated.

- Install stormwater drainage pipes according to manufacturer’s recommendations.

3.4 PIPE INSTALLATION

General: Join and install pipe and fittings according to installations indicated.

- GRP Pipe and Fittings: Install according to AWWA C950 and to the manufacturer's recommendations.

- System Piping Joints: Make joints using system manufacturer's couplings, unless otherwise indicated.

- Join piping made of different materials or dimensions with couplings made for this application. Use couplings that are compatible with and that fit both systems' materials and dimensions.

- Install with top surfaces of components, except piping, flush with finished surface.

- Follow manufacturer's instructions regarding placement of bedding and backfilling, cleanliness of joint surfaces, lubricant used, correct location of components, provision of correct gaps between end of spigot and back of socket, maximum permissible deflection of joints for detachable couplings and flexible joints, provision of flexible joints for connections to pipes built into structures.

- Refer to Section 3.10 "Drainage system installation" for basic piping joint construction and installation.

3.5 MANHOLE INSTALLATION

General: Install manholes, complete with appurtenances and accessories indicated.

- Form continuous concrete channels and benches between inlets and outlet.

- Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 75 mm above finished surface elsewhere, unless otherwise indicated.

- Install precast concrete manhole sections with gaskets according to ASTM C 891.

- Construct cast-in-place concrete manholes as indicated.

3.6 CATCH-BASIN/GULLY INSTALLATION

- Constructs catch basins to sizes and shapes indicated.

- Set frames and grates to elevations indicated.

3.7 STORM DRAINAGE INLET AND OUTLET INSTALLATION

- Construct inlet head walls, aprons, and sides of reinforced concrete, as indicated.

- Construct riprap of broken stone, as indicated and specified.

- Install outlets that spill onto grade, anchored with concrete, where indicated.

- Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.

- Construct energy dissipaters at outlets, as indicated.

3.8 CONCRETE PLACEMENT

Place cast-in-place concrete according to ACI 318 and ACI 350R or equivalent.

3.9RIPRAP CONSTRUCTION

The surfaces upon which grouted riprap is to be placed shall be excavated, formed, compacted to the required lines, grades, and sections as shown on the Drawings or as directed.

3.10 DRAINAGE SYSTEM INSTALLATION

- Assemble and install components according to manufacturer's written instructions.

- Install with top surfaces of components, except piping, flush with finished surface.

- Assemble channel sections to form slope down toward drain outlets. Use sealants, adhesives, fasteners, and other materials recommended by system manufacturer.

- Embed channel sections and drainage specialties in 4-inch (100-mm) minimum concrete around bottom and sides.

3.11 STORMWATER DISPOSAL SYSTEM INSTALLATION

Excavate trenches of width and depth and install system and backfill according to manufacturer's written instructions and drawings.

3.12 TAP CONNECTIONS

- Make connections to underground structures so finished Work complies as nearly as practical with requirements specified for new Work.

3.13 FIELD QUALITY CONTROL

- Clear interior of piping and structures of dirt and superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed.

- Place plug in end of incomplete piping at end of day and when work stops.

- Flush piping between manholes and other structures to remove collected debris, if required by authorities having jurisdiction.

- Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (600 mm) of backfill is in place, and again at completion of Project.

- Submit separate reports for each system inspection.

- Defects requiring correction include the following:

- Alignment: Less than full diameter of inside of pipe is visible between structures.

- Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.

- Crushed, broken, cracked, or otherwise damaged piping.

- Infiltration: Water leakage into piping.

- Exfiltration: Water leakage from or around piping.

- Replace defective piping using new materials and repeat inspections until defects are within allowances specified.

- Reinspect and repeat procedure until results are satisfactory.

- Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

- Do not enclose, cover, or put into service before inspection and approval.

- Test completed piping systems according to Section 334000 Clause 2.1 A 10.

- Schedule tests and inspections by Engineer with at least 24 hours' advance notice.

- Submit separate reports for each test.

- Leaks and loss in test pressure constitute defects that must be repaired.

- Replace leaking piping using new materials and repeat testing until leakage is within allowances specified.

- Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects as follows:

- Field testing generally:

- Provision of test equipment: All items for test have to be provided on site before the test i.e. pressure gauges, instruments, water etc.

- Carry out tests in the presence of the Engineer's Representative.

- Test sections: Test gravity sewers in sections between manholes.

- Test plug: Secure end of main and test plug by struts.

- Apply pressure by manually operated test pump or, in the case of large diameter mains, by power driven test pump, if approved.

- Examine exposed joints and repair visible leaks.

- Failure: should a test fail, locate leak and replace or make good defective pipe or replace and make good faulty joint. Retest main.

- Records: keep test records in an approved form. Hand original copy to the Engineer immediately after completion of test.

- Non-pressure lines not exceeding 1000 mm diameter are to be air tested before backfilling and hydrostatic tested after backfilling.

- Non-pressure lines over 1000 mm diameter are to be visually inspected from the inside and tested at joints by hydraulic individual joint test.

- Non-pressure lines: Carry out infiltration tests where crown of pipe at high part of length under test is more than 1.2 m below water table.

- Hydrostatic Testing of Non-pressure Pipelines:

- Procedure is to be as described for pressure pipelines.

- Test pressure: 1.0 m head of water above pipe soffit at highest point and not greater than 6 m head of water at lowest point of section under test. If maximum head is exceeded, test section in stages.

- Test period 30 minutes.

- Allowable leakage: 2 litres/Km length/metre diameter/30 minutes.

- Air Testing of Pipelines:

- Test procedure to BS EN 1610.

- Infiltration Test for Gravity Pipes:

- Timing: Carry out test after total backfilling of length under test.

- Plug effectively all inlets to system as directed.

- Measure residual flow by approved method i.e. weir or other.

- Infiltration limits: The following limits are not to be exceeded:

- 1) Pipelines not exceeding 700 mm: 0.02 liters/hour/100 linear meters/mm diameter.

- Pipelines over 700 mm: 0.03 liters/hour/100 linear meters/mm diameter.

- Failure: Test will be deemed to have failed if allowable infiltration water is exceeded. Locate source of excessive infiltration by approved means i.e. traversing light and mirrors or inflated rubber plug etc. and make good. Repeat test until successful.

- Visual Inspection Test:

- Timing: Carry out test after total backfilling of length under test.

- Limit of length to be tested at one time is three full- length pipes unless otherwise approved.

- Apparatus: Use rubber tired bogies which do not damage lining of pipe and an adequate supply of electric lamps.

- Check joints by means of feelers to ensure rubber rings are correctly located.

- Check pipe barrel for visible cracks.

- Deflection Tests for GRP Pipes:

- Conduct: Deflection tests for GRP pipes as required by the Engineer at 3 stages. Deflection shall be measured at the spigot end at mid point and at the socket end.

- Stage 1: At completion of primary backfill (deflection at this stage should be below 0.5%).

- Stage 2: At final backfill (Maximum allowable deflection 2.5%).

- Stage 3: 6 months after final backfill (maximum allowable deflection 4.0%).

- Pipes not passing the deflection tests at stage 2 or stage 3 will be removed and replaced.

- Cleaning and Inspection of sewers:

- Cleaning: Clean pipeline of silt and debris after backfilling pipe trenches and completing manholes, hatch boxes etc. but before surfaces are permanently reinstated and make ready for inspection by the Engineer's Representative.

- Inspection: Pipelines of 700 mm diameter and over are, where practicable, to be inspected from the inside and when necessary a suitable trolley is to be provided for this purpose.

- Inspection: Pipelines less than 700 mm diameter which cannot be inspected from the inside, are to be inspected by passing a cylinder of diameter 25 mm less than the internal diameter of the pipe and length not

- less than the internal diameter of the pipe through each pipeline.

-Testing of manholes: Plug manhole inlets and outlets, fill manhole with water and allow to stand for at least 24 hours or such longer period to allow for complete absorption. Re-top with water. Allowable leakage over 24 hours is not to exceed 1 percent of total volume of manhole, otherwise make good and retest.

End of section

SECTION 321116.16 - AGGREGATE SUBBASE COURSE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

Drawings and general provisions of the Contract, including General and Particular Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

This Section includes aggregate for subbase course composed of crushed aggregates constructed on the prepared underlying course in accordance with the Specification and shall conform to the lines, grades, dimensions, and typical cross section shown on the Drawings.

Related Sections include the following:

Section “Earth Moving” for subgrade preparation, grading, and subbase course
Section "Aggregate Base” for aggregate base course.
Section “Asphalt Paving”.

1.3 DEFINITIONS

Aggregate Subbase Course: Subbase course composed of mineral aggregate uniformly blended and mixed with water.

Subgrade: Compacted soil layer immediately below the subbase course.

Subgrade Layer: 200 mm depth of soil material immediately below subgrade.

Test Section: 2000 m² of compacted Aggregate subbase course, constructed for the purpose of verification of Contractor’s means, methods and equipment, and subject to approval by the Engineer, prior to commencement of the Work.

Lot of Compacted Material: 500 m² of compacted subbase course.

Utilities include on-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.4 SUBMITTALS

Product Data: For each type of manufactured material and product indicated.

Samples: For the following:

- 100-kg samples, sealed in airtight containers, of each proposed aggregate material.

- Design Mixes: For subbase course mix. Include alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

-Provide compressive strength test results and moisture-density curves.

Qualifications Data: For forms and persons specified in “Quality Assurance” Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects/engineers and owners, and any other information required by Engineer.

Material Test Reports: Form a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of aggregate materials

- Classification according to ASTM 2487.
- Laboratory compaction curve according to AASHTO T180 (Method D).

Material Certificates: Certificates signed by manufacturers certifying that each material complies with requirements.

Field Records for the Following:

-Test Section
-Verification of compliance of subgrade, in accordance with specified requirements, prior to placement of subbase course.
-Laboratory reports; laboratory density test results for each lot.
-Field reports; in - place density test results for each lot.

Photographs or videotape, sufficiently detailed, of existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by earthwork operations.

Minutes of preinstallation conference.

Daily Progress Reports: Include location of all construction joints.

1.5 QUALITY ASSURANCE

Codes and Standards: Comply with the Provisions of the Egyptian code for Urban and Rural roads, except where different requirements are specified or shown on the drawings.

Installer Qualifications: Engage an experienced installer who has completed aggregate subbase course similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

Manufacturer Qualifications: Engage a firm experienced in manufacturing similar to that indicated for this Project and with a record of successful in-service performance.

Testing Agency Qualifications: Demonstrate to Engineer's satisfaction, based on Engineer's evaluation of criteria, that the independent testing agency has the experience and capability to satisfactorily conduct the testing indicated in access with standards without delaying the Work.

Regulatory Requirements: Conform to applicable standards of authorities having jurisdiction for asphalt paving work.

Pre-installation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section “Project Management and Coordination”.

1.6 PROJECT CONDITIONS

-Provide a minimum 48-hour notice to the Engineer, and receive written notice to proceed, before interrupting any service, facility or utility operated or occupied by the Employer or others.
-Protect subbase coarse from rain, wind and sun, indentation, and physical damage.
-Finished portions of the subbase course that are used by equipment in the construction of an adjoining section shall be protected to prevent marring or damaging the completed work.

- Project Site Information: The Contractor is entirely responsible for his own assessment, interpretation, use, and conclusions drawn from the information, data, tests, analyses, and opinions contained in any Site Investigation report discussed or related to the project conditions.

-Whenever needed, additional test borings and other exploratory operations shall be conducted at the Contractor’s own cost and expense.

Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earthwork operations.

Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from employers and authorities having jurisdiction.
Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

Notify utilities companies and authorities having jurisdiction for area where Project is located before commencing earthwork operations.

Existing Utilities: Do not interrupt utilities serving facilities on or adjacent to Project site unless permitted in writing by Engineer and then only after arranging to provide temporary utility services according to requirements.

Notify Engineer not less than two days in advance of proposed utility interruptions.
Do not proceed with utility interruptions without Engineer's written permission.

Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

PART 2 - PRODUCTS

2.1 AGGREGATE

Aggregate: Shall be either natural gravel, crushed stone or crushed gravel. The fine aggregate shall consist of screenings obtained from crushed stone, gravel, or sand. Aggregate may be washed, if directed, to remove excessive quantities of clay, silty clay or salts.

Crushed Stone: Shall consist of hard, durable particles or fragments of stone, free from dirt or other objectionable matter, and shall contain no more than 8% of flat, elongated, soft, or disintegrated pieces.

Crushed Gravel: Shall consist of hard durable stones, rocks, and boulders crushed to specified sizes and shall be free from excess flat, elongated, soft or disintegrated pieces, dirt, or other objectionable matter.

The method used in production of crushed gravel shall be such that the finished product shall be as uniform as practicable. The crushing of the gravel shall result in a product, which shall have at least 90% by weight of particles with at least one fractured face. All stones, rocks, and boulders of inferior quality occurring in the pit shall be wasted.

Any material passing 4.75 mm (No. 4) sieve and produced in the crushing process shall be incorporated in the subbase material up to the gradation limits required for the subbase coarse aggregate.

The Crushed Aggregate: Shall meet the requirements of one of the gradations shown in Table 1 when tested in accordance with AASHTO T-11 and T-27

TABLE 1: REQUIREMENTS FOR GRADATION OF AGGREGATE

Sieve Designation (Square openings)	Percent by weight passing
50 mm (2 in)	100
25 mm (1 in)	75-95
9.5 mm (3/8 in)	40-75
4.75 mm (No.4)	30-60
2.00 mm (No. 10)	20-45
0.425 mm (No.40)	15-30
0.075 mm (No.200)	5-20

The amount of the fraction of material passing the No. 200 mesh sieve shall not exceed one half the fraction passing the No. 40 mesh sieve.

The percentage of wear shall not exceed 45% after 500 revolutions, when tested in accordance with AASHTO T 96 (Los Angeles Abrasion Test).

The crushed aggregate subbase course material shall have a 4-day soaked CBR of not less than 30 when compacted at 100% of modified proctor AASHTO (T180) and tested in accordance with AASHTO T 193.

When tested for soundness in accordance with AASHTO T 140, the material shall not show signs of disintegration and the loss by weight shall not exceed 12 % in the case of the sodium sulphate test and 18% in the case of the magnesium sulphate test.

The portion of aggregate, including any blended material, passing the 0.425 mm (No. 40) mesh sieve shall have a liquid limit (LL) of not more than 25 and plasticity index (PI) of not more than 6 when tested in accordance with AASHTO T 89 and T 90.

If additional fine material is required to correct the aggregate gradation, or for adjusting the LL or PI of the fraction passing the 0.425 mm (No. 40) sieve, it shall be uniformly blended and mixed with the aggregate material at the crushing plant or by an approved plant. Reworking of the material in situ to obtain the specified gradation will not be permitted. Additional fine material for these purposes shall be obtained from the crushing of stone, gravel, or natural material. The crushed aggregate subbase course material shall have chloride content of less than 3.5 per cent and sulphate content of less than 2.0 per cent when tested in accordance with BS 812.

PART 3 - EXECUTION

3.1 OPERATION AT SOURCES OF SUPPLY

All work involved in clearing and grubbing of quarries and pits, including the handling of unsuitable material, shall be performed at own expense. The subbase material shall be obtained from approved sources. The material shall be handled in a manner that shall secure a uniform and satisfactory product.

3.2 EQUIPMENT

Equipment: Used to handle, place, spread, moisten, compact and finish subbase course shall be on the site in very good working condition, and approved by Engineer before construction is permitted to start.

3.3 SURFACE PREPARATION

Aggregate Subbase Course: Shall be placed directly on completed subgrade, preparation and the subgrade surface shall be as specified in section 312000.

3.4 MIXING AND SPREADING

Subbase Course Material: May be premixed with water, in a pugmill mixing plant or on site. The amount of water added, as determined, shall be such that the material will be uniform and within the specified moisture content range at the time of compaction.

The Engineer may allow other methods of mixing provided such methods(s) do not reduce the standard of work. Demonstrate, in the presence of Engineer, ability to attain the requirement given in this Specification.

Premixed Material: Shall be placed on the subgrade in a uniform layer not less than 75 mm nor more than 200 mm of compacted thickness.

Subbase Course Material: Shall be placed to the required width using a self-propelled spreader or motor grader, and shall be delivered such that it is ready for compaction without further shaping.

Material: Shall not be handled in such a way as to cause segregation. If the spreader causes segregation in the material, or leaves ridges or other objectionable marks on the surface which cannot be readily eliminated or prevented by adjustment of the spreader operation, the use of such spreader shall forthwith be discontinued and it shall be replaced by a spreader capable of spreading the material in a proper manner.

Segregated Material: Shall be removed and replaced with well graded material. "Skin" patching will not be permitted. Only minor surface manipulation and watering to achieve the required surface tolerances will be permitted during the compaction process.

Hauling or placement of material will not be permitted when, in the judgement of Engineer, the weather or surface conditions are such that hauling operations will cause cutting or rutting of subgrade or cause contamination of the subbase course material.

3.5 COMPACTION

Compaction: Plan the sequence of operations so that the least amount of water will be lost by evaporation from uncompleted surfaces. If placing of succeeding layer of material in delayed to the extent that additional water is required to prevent ravelling or excessive drying, the application of such water shall be carried out in an approved manner and at own expense.

Subbase Course: Material shall be compacted by means of approved compaction equipment, progressing gradually from the outside towards the centre, with each succeeding pass uniformly overlapping the previous pass.

Rolling: Continue until the entire thickness of each subbase layer is thoroughly and uniformly compacted to 100% AASHTO T 180 maximum density.

Final rolling of the completed course shall be by means of an approved self-propelled roller. Rolling shall be accompanied by sufficient blading, to ensure a smooth surface, free from ruts or ridges and having the proper shape.
When additional water is required, it shall be applied in an approved manner.

Areas Inaccessible to Normal Compaction: Compacted by use of portable mechanical tampers until the required standard of compaction is achieved, or to the satisfaction of Engineer.

Each Layer: Completely compacted and approved prior to delivery of materials for the following layer.

Prior to placing a following layer, the surface shall be made sufficiently moist as directed, to ensure proper bond between the layers.

Edges and Edge Slopes of the Subbase Course: Bladed or otherwise dressed to conform to the lines and dimensions shown on the Drawings and to present straight, neat lines and slopes as free of loose material as practicable.

Material which has dried out prior to final compaction, or which has dried and recompacted subsequent to final compaction, shall be watered and recompacted using approved equipment and procedures. If unable to return the material to its original or specified condition with respect to compaction, thickness, and surface tolerances, for the final layer only scarify the material and reconstruct the subbase course on a re-approved sub-grade surface or to the satisfaction of Engineer.

3.6 **TOLERANCES AND MAINTENANCE OF COMPLETED SUBBASE**

Compacted and Completed Subbase Course: Conform to the lines, grades and cross sections as shown on the Drawings.

Elevations of the Finished Subbase Course: Checked in the presence of Engineer at intervals of 20m on straight lines and of 10m on curves, and at intermediate points as directed.

Tolerances (for final only): Elevations of finished surface shall not exceed + 10mm or - 15mm.

Finished Surface: When tested with a 4.0 m long straightedge, placed parallel to, or at right angles to the centreline, the maximum deviation of the surface from the testing edge between any 2 contact points shall not exceed 12 mm.

Specified Tolerances: Areas which exceed shall be corrected by removing the defective sections of subbase course and reconstructing them or, by scarifying and adding new material and recompacting and finishing to the specified standard.

Completion and Acceptance of the Subbase Course: Maintained at own expense as follows:

The surface shall be broomed, rolled and otherwise maintained, keeping it free from raveling and other defects until such time as the following course is placed.
Water shall be applied at such times and in such quantities as directed.

3.7 TESTING

Subbase Course Material: Tested in accordance with Table 2 after mixing with water at the mixing plant or in-situ compaction and if satisfactory shall be approved for use. This approval shall not be deemed to constitute acceptance of the subbase course for full payment purposes.

Compaction: Tested in accordance with ASTM D1556 (Sand Cone Method) or ASTM D2167 (Rubber Balloon Method) or ASTM D2922 (Nuclear Method). If there is a significant delay between the construction of any layer and the following layer, the Engineer may require the compaction of the lower layer to be reverified to ensure that it has not loosened due to traffic, passage of construction equipment, adverse weather conditions or otherwise.

Required Tests and Minimum Repetition for Subbase Course Material

TABLE 2:

(A) Source of Materials		(B) Control on Site (The Road)	
Required Tests (A)	Repetition Required for all Test in (A)	Required Tests (B)	Repetition Required for all Tests in (B)
1. Gradation of Material	As requested by Engineer	1. Proctor	As requested by Engineer
2. Plasticity Index and liquid limit	1 sample in every 1000 m^3	2. Gradation	As requested by Engineer
3. Abrasion	1 sample in every 1000 m^3	3. Plasticity Index and liquid limit	1 sample in every 1000 m^3
4. CBR	1 sample in every 1000 m^3	4. CBR	1 sample in every 1000 m^3
5. Percentage of fractured Particles	As requested by Engineer	5. Abrasion	1 sample in every 1000 m^3
6. Chloride content	1 sample in every 1000 m^3	6. Clay lumps &friable particles	1 sample in every 1000 m^3
7. Sulphate content	1 sample in every 1000 m^3	7. Field Density	1 sample in every 500 m^3
		8. Thickness	As requested by Engineer

3.8 PROTECTION

- Do not perform work when the Engineer determines that weather or other conditions are such that construction operations will damage the finished work.

- Do not haul over aggregate subbase without approval. Repair damages resulting from occasional routing of equipment over the work.

Following the completion of the aggregate subbase course, all maintenance work necessary to keep the subbase course in a condition satisfactory for further work shall be performed.

END OF SECTION 321116.16

SECTION 321123 - AGGREGATE BASE COURSE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

Drawings and general provisions of the Contract, including General and Particular Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

This Section includes aggregate for base course composed of crushed aggregates constructed on the prepared underlying course in accordance with the Specification and shall conform to the lines, grades, dimensions and typical cross section shown on the Drawings.

Related Sections include the following:

Section “Earth Moving” for subgrade preparation, grading, and subbase course
Section "Aggregate Subbase” for aggregate subbase course.
Section “Asphalt Paving”.

1.3 **DEFINITIONS**

Aggregate Base Course: Base course composed of mineral aggregate uniformly blended and mixed with water.

Subgrade: Compacted soil layer immediately below the subbase or base course.

Subgrade Layer: 200 mm depth of soil material immediately below subgrade.

Test Section: 2000 m² of compacted aggregate base course, constructed for the purpose of verification of Contractor’s means, methods and equipment, and subject to approval by the Engineer, prior to commencement of the Work.

Lot of Compacted Material: 500 m² of compacted base course.

Utilities include on-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.**4** **SUBMITTALS**

Product Data: For each type of manufactured material and product indicated.

Samples: For the following:

100-kg samples, sealed in airtight containers, of each proposed aggregate material.

Design Mixes: For base course mix. Include alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

Provide compressive strength test results and moisture-density curves.

Qualifications Data: For forms and persons specified in “Quality Assurance” Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects/engineers and owners, and any other information required by Engineer.

Material Test Reports: Form a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of aggregate materials:

Classification according to ASTM 2487.
Laboratory compaction curve according to AASHTO T180 (Method D).

Material Certificates: Certificates signed by manufacturers certifying that each material complies with requirements.

Field Records for the following:

Test Section
Verification of compliance of subgrade or subbase, in accordance with specified requirements, prior to placement of base course.
Laboratory reports; laboratory density test results for each lot.
Field reports; in - place density test results for each lot.

Photographs or videotape, sufficiently detailed, of existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by earthwork operations.

Minutes of preinstallation conference.

Daily progress reports, to include location of all construction joints.

1.5 QUALITY ASSURANCE

Codes and Standards: Comply with the Provisions of the Egyptian code for Urban and Rural roads, except where different requirements are specified or shown on the drawings.

Installer Qualifications: Engage an experienced installer who has completed aggregate base course similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

Manufacturer Qualifications: Engage a firm experienced in manufacturing similar to that indicated for this Project and with a record of successful in-service performance.

Testing Agency Qualifications: Demonstrate to Engineer's satisfaction, based on Engineer's evaluation of criteria, that the independent testing agency has the experience and capability to satisfactorily conduct the testing indicated in access with standards without delaying the Work.

Regulatory Requirements: Conform to applicable standards of authorities having jurisdiction for asphalt paving work.

Pre-installation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section “Project Management and Coordination”.

1.6 PROJECT CONDITIONS

Provide a minimum 48 hour notice to the Engineer, and receive written notice to proceed, before interrupting any service, facility or utility operated or occupied by the Employer or others.

Protect base course from rain, wind and sun, indentation and physical damage.

Finished portions of the base course that are used by equipment in the construction of an adjoining section shall be protected to prevent marring or damaging the completed work.

Project Site Information: The Contractor is entirely responsible for his own assessment, interpretation, use and conclusions drawn from the information, data, tests, analyses and opinions contained in any Site Investigation report discussed or related to the project conditions.

-Whenever needed, additional test borings and other exploratory operations shall be - conducted at the Contractor's own cost and expense.

Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earthwork operations.

-Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from employers and authorities having jurisdiction.
-Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

Notify utilities companies and authorities having jurisdiction for area where Project is located before commencing earthwork operations.

Existing Utilities: Do not interrupt utilities serving facilities on or adjacent to Project site unless permitted in writing by Engineer and then only after arranging to provide temporary utility services according to requirements indicated:

-Notify Engineer not less than two days in advance of proposed utility interruptions.
-Do not proceed with utility interruptions without Engineer's written permission.

Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

PART 2 - PRODUCTS

2.1 AGGREGATE

Aggregate: Shall be either crushed stone or crushed gravel. The fine aggregate shall consist of screenings obtained from crushed stone, gravel, or sand. Aggregate may be washed, if directed, to remove excessive quantities of clay, silty clay or salts.

Crushed Stone: Shall consist of hard, durable particles or fragments of stone, free from dirt or other objectionable matter, and shall contain no more than 8% of flat, elongated, soft, or disintegrated pieces.

Crushed Gravel: Shall consist of hard durable stones, rocks, and boulders crushed to specified sizes and shall be free from excess flat, elongated, soft or disintegrated pieces, dirt, or other objectionable matter.

The method used in production of crushed gravel shall be such that the finished product shall be as uniform as practicable. The crushing of the gravel shall result in a product, which shall have at least 90% by weight of particles with at least one fractured face. All stones, rocks, and boulders of inferior quality occurring in the pit shall be wasted.

Any material passing 4.75 mm (No. 4) sieve and produced in the crushing process shall be incorporated in the base material up to the gradation limits required for the base course aggregate.

Crushed Aggregate: Shall meet the requirements of one of the gradation shown in Table 1 when tested in accordance with AASHTO T-11 and T-27

TABLE 1: REQUIREMENTS FOR GRADATION OF AGGREGATE

Sieve Designation (Square openings)	Percent by weight passing
50 mm (2 in)	100
37 mm (1 ½ in)	95 - 100
25 mm (1 in)	70-95
19 mm (¾ in)	55-85
9.5 mm (3/8 in)	40-70
4.75 mm (No.4)	30-60
0.60 mm (No.30)	12-30
0.075 mm (No.200)	5- 10

The amount of the fraction of material passing the No. 200 mesh sieve shall not exceed one half the fraction passing the No. 40 mesh sieve.

The percentage of wear shall not exceed 30% after 500 revolutions, when tested in accordance with AASHTO T 96 (Los Angeles Abrasion Test).

The crushed aggregate base course material shall have a 4-day soaked CBR of not less than 80 when compacted at 100% of modified proctor AASHTO (T180) and tested in accordance with AASHTO T 193.

When tested for soundness in accordance with AASHTO T 140, the material shall not show signs of disintegration and the loss by weight shall not exceed 12 % in the case of the sodium sulphate test and 18% in the case of the magnesium sulphate test.

The portion of aggregate, including any blended material, passing the 0.425 mm (No. 40) mesh sieve shall have a liquid limit (LL) of not more than 25 and plasticity index (PI) of not more than 4 when tested in accordance with AASHTO T 89 and T 90.

If additional fine material is required to correct the aggregate gradation, or for adjusting the LL or PI of the fraction passing the 0.425 mm (No. 40) sieve, it shall be uniformly blended and mixed with the aggregate material plant at the crushing plant or by an approved plant. Reworking of the material in situ to obtain the specified gradation will not be permitted. Additional fine material for these purposes shall be obtained from the crushing of stone, gravel, or natural material.

The crushed aggregate base course material shall have chloride content of less than 0.8 per cent and sulphate content of less than 0.50 per cent when tested in accordance with BS 812.

PART 3 - EXECUTION

3.1 OPERATION AT SOURCES OF SUPPLY

All work involved in clearing and grubbing of quarries and pits, including the handling of unsuitable material, shall be performed at own expense. The base material shall be obtained from approved

sources. The material shall be handled in a manner that shall secure a uniform and satisfactory product.

3.2 EQUIPMENT

All equipment used to handle, place, spread, moisten, compact and finish base course shall be on the site in very good working condition, and approved by Engineer before construction is permitted to start.

3.3 SURFACE PREPARATION

Aggregate Base Course: Shall be placed directly on completed subgrade or subbase. Preparation of the subgrade surface shall be as specified in section 312000.

3.4 **MIXING AND SPREADING**

Base Course Material: May be premixed with water, in a pugmill mixing plant. The amount of water added, as determined, shall be such that the material will be uniform and within the specified moisture content range at the time of compaction.

The Engineer may allow other methods of mixing provided such methods(s) do not reduce the standard of work. Demonstrate, in the presence of the Engineer, ability to attain the requirement given in this Specification.

Premixed Material: Placed on the subgrade in a uniform layer not less than 75 mm nor more than 200 mm of compacted thickness.

Base Course Material: Placed to the required width using a self-propelled spreader or motor grader and shall be delivered such that it is ready for compaction without further shaping.

Material: Shall not be handled in such a way as to cause segregation. If the spreader causes segregation in the material or leaves ridges or other objectionable marks on the surface which cannot be readily eliminated or prevented by adjustment of the spreader operation, the use of such spreader shall forthwith be discontinued and it shall be replaced by a spreader capable of spreading the material in a proper manner.

Segregated Material: Removed and replaced with well graded material. "Skin" patching will not be permitted. Only minor surface manipulation and watering to achieve the required surface tolerances will be permitted during the compaction process.

Hauling or placement of material will not be permitted when, in the judgement of the Engineer, the weather or surface conditions are such that hauling operations will cause cutting or rutting of subgrade or cause contamination of the base course material.

3.5 COMPACTION

Compaction: Plan the sequence of operations so that the least amount of water will be lost by evaporation from uncompleted surfaces. If placing of succeeding layer of material in delayed to the extent that additional water is required to prevent raveling or excessive drying, the application of such water shall be carried out in an approved manner and at own expense.

Base Course: Material shall be compacted by means of approved compaction equipment, progressing gradually from the outside towards the center, with each succeeding pass uniformly overlapping the previous pass.

Rolling: Continue until the entire thickness of each base layer is thoroughly and uniformly compacted to 100% AASHTO T 180 maximum density.

Final rolling of the completed course shall be by means of an approved self-propelled roller. Rolling shall be accompanied by sufficient blading, to ensure a smooth surface, free from ruts or ridges and having the proper shape.
When additional water is required, it shall be applied in an approved manner.

Areas Inaccessible to Normal Compaction: Compacted by use of portable mechanical tampers until the required standard of compaction is achieved, or to the satisfaction of Engineer.

Each Layer: Completely compacted and approved prior to delivery of materials for the following layer.

Prior to placing a following layer, the surface shall be made sufficiently moist as directed, to ensure proper bond between the layers.

Edges and Edge Slopes of the Base Course: Bladed or otherwise dressed to conform to the lines and dimensions shown on the Drawings and to present straight, neat lines and slopes as free of loose material as practicable.

Material which has dried out prior to final compaction, or which has dried and decompacted subsequent to final compaction, shall be watered and recompacted using approved equipment and procedures. If unable to return the material to its original or specified condition with respect to compaction, thickness and surface tolerances, for the final layer only scarify the material and reconstruct the base course on a re-approved subbase surface or to the satisfaction of Engineer.

3.6 TOLERANCES AND MAINTENANCE OF COMPLETED BASE

Compacted and Completed Base Course: Conform to the lines, grades and cross sections as shown on the Drawings.

Elevations of the Finished Base Course: Checked in the presence of the Engineer at intervals of 20m on straight lines and of 10m on curves, and at intermediate points as directed.

Tolerances (for final only): Elevations of finished surface shall not exceed + 10mm or - 15mm.

Finished Surface: When tested with a 4.0 m long straightedge, placed parallel to, or at right angles to the centerline, the maximum deviation of the surface from the testing edge between any 2 contact points shall not exceed 12 mm.

Specified Tolerances: Areas which exceed shall be corrected by removing the defective sections of base course and reconstructing them or, by scarifying and adding new material and recompacting and finishing to the specified standard.

Completion and Acceptance of the Base Course: Maintained at own expense as follows:

-The surface shall be broomed, rolled and otherwise maintained, keeping it free from raveling and other defects until such time as the following course is placed.
Water shall be applied at such times and in such quantities as directed.

-The aggregate base needs to be mechanically swept and cleaned with compressed air before the application of prime coat.

The base shall be sealed with prime coat before it is dried out. If the surface has dried out then light watering and recompaction may be done before applying prime coat. If full depth is dry, the whole base shall be removed and replaced.

3.7 TESTING

Base Course Material: Tested in accordance with Table 2 after mixing with water at the mixing plant or in-situ compaction and if satisfactory shall be approved for use. This approval shall not be deemed to constitute acceptance of the base course for full payment purposes.

Compaction: Tested in accordance with ASTM D1556 (Sand Cone Method) or ASTM D2167 (Rubber Balloon Method) or ASTM D2922 (Nuclear Method). If there is a significant delay between the construction of any layer and the following layer, Engineer may require the compaction of the lower layer to be reverified to ensure that it has not loosened due to traffic, passage of construction equipment, adverse weather conditions or otherwise.

Required Tests and Minimum Repetition for Base Course Material

TABLE 2:

(A) Source of Materials		(B) Control on Site (The Road)	
Required Tests (A)	Repetition Required for all Test in (A)	Required Tests (B)	Repetition Required for all Tests in (B)
1. Gradation of Material	As requested by Engineer	1. Proctor	As requested by Engineer
2. Plasticity Index and liquid limit	1 sample in every 1000 m^3	2. Gradation	As requested by Engineer
3. Abrasion	1 sample in every 1000 m^3	3. Plasticity Index and liquid limit	1 sample in every 1000 m^3
4. CBR	1 sample in every 1000 m^3	4. C.B.R	1 sample in every 1000 m^3
5. Percentage of fractured Particles	As requested by Engineer	5. Abrasion	1 sample in every 1000 m^3
6. Chloride content (combined aggregate)	1 sample in every 1000 m^3	6. Clay lumps & friable particles	1 sample in every 1000 m^3
7. Sulphate content (combined aggregate)	1 sample in every 1000 m^3	7. Field Density	1 sample in every 500 m^3
		8. Thickness	As requested by Engineer

3.8 **PROTECTION**

Do not perform work when the Engineer determines that weather or other conditions are such that construction operations will damage the finished work.
Following the completion of the crushed aggregate base course, all maintenance work necessary to keep the base course in a condition satisfactory for further work shall be performed.

END OF SECTION 321123

SECTION 321216 - ASPHALT PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

Drawings and general provisions of the Contract, including Conditions of Contract and Division 1 Specification Sections, apply to this Section.

1.2 **SUMMARY**

This Section includes the following:

Hot-mix asphalt paving.
Bituminous concrete wearing course.
Bituminous concrete base course.
Hot-mix asphalt patching.
Hot-mix asphalt overlay.
Bituminous prime and tack coats.
Wheel stops.

Related Sections include the following:

Section "Earth Moving" for Subgrade.
Section “Aggregate Subbase Course” for subbase courses.
Section “Aggregate Base Course” for base courses.

1.3 SYSTEM DESCRIPTION

Provide bituminous concrete pavement according to the materials, workmanship, and other applicable requirements of the Standard Specifications.

1.Standard Specification: As indicated.

1.4 SUBMITTALS

Product Data: For each product specified. Include technical data and tested physical and performance properties.

Job-Mix Designs: For each job mix proposed for the Work.

Shop Drawings: Indicate pavement markings, lane separations, and defined parking spaces. Indicate dedicated handicapped spaces with international graphics symbol.

Qualification Data: For firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects/engineers and owners, and other information specified or required by Engineer.

Material Test Reports: Indicate and interpret test results for compliance of materials with requirements indicated.

Material Certificates: Certificates signed by manufacturers certifying that each material complies with requirements.

1.5 QUALITY ASSURANCE

Installer Qualifications: Engage an experienced installer who has completed hot-mix asphalt paving similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

Manufacturer Qualifications: Engage a firm experienced in manufacturing hot-mix asphalt similar to that indicated for this Project and with a record of successful in-service performance.

Testing Agency Qualifications: Demonstrate to Engineer's satisfaction, based on Engineer's evaluation of criteria, that the independent testing agency has the experience and capability to satisfactorily conduct the testing indicated in accordance with Standards, without delaying the Work.

Regulatory Requirements: Conform to applicable standards of authorities having jurisdiction for asphalt paving work.

Asphalt Paving Publications: Comply with AI's "The Asphalt Handbook", except where other requirements are stipulated.

Preinstallation Conference: Conduct conference at Project site to comply with requirements of Division 1 Section "Project Management and Coordination" Review methods and procedures related to asphalt paving including, but not limited to, the following:

Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
Review condition of substrate and preparatory work performed by other trades.
Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.
Review and finalize construction schedule for paving and related work. Verify availability of materials, paving Installer's personnel, and equipment required to execute the Work without delays.
Review inspection and testing requirements, governing regulations, and proposed installation procedures.
Review forecasted weather conditions and procedures for coping with unfavorable conditions.

1.6 DELIVERY, STORAGE, AND HANDLING

Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.

Store pavement-marking materials in a clean, dry, protected location and within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.7 PROJECT CONDITIONS

Environmental Limitations: Do not apply asphalt materials if substrate is wet or excessively damp or during wet weather the following conditions are not met:

Prime and Tack Coats: Minimum surface temperature of 15 deg C.
Bituminous Base Course: Minimum surface temperature of 15 deg C and rising at time of placement.

Bituminous Wearing Course: Minimum surface temperature of 15 deg C at time of placement and when the air temperature is at or above 5 deg C.

PART 2 - PRODUCTS

2.1 AGGREGATE

General: Use materials and gradations that have performed satisfactorily in previous installations.

General: Crushed stone, screenings and mineral filler, with or without sand meeting the specified gradation.

Aggregates shall consist of not more than 8 percent of flat elongated pieces according to U.S. Army, Corps of Engineers CRD C119. 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.

Passing a stripping test according to AASHTO T283 “Resistance of Asphalt Concrete Mixtures to Moisture-Induced Damage”.

Aggregates shall comply with the following:

1.	Liquid Limit (ASTM D4318)	25 maximum
2.	Plasticity Index (ASTM D4318)	5 maximum
3.	Loss by Abrasion Test (ASTM C131)	30 per cent maximum
	Soundness Test, Loss of Weight using Sodium Sulfate (5 cycle) (ASTM C 88)	12 per cent maximum
	Soundness Test, Loss of Weight using Magnesium Sulfate (5 cycle) (ASTM C 88)	10 per cent maximum
6.	Aggregate Water Absorption (ASTM C128)	2.0 per cent maximum
7.	Chloride Content (BS 812)	0.8 per cent maximum
8.	Sulphate content (BS 812)	0.3 per cent maximum

Aggregate particles shall be clean, hard, durable and sound. Crushing shall result in a product such that, for particles retained as 4.75mm (No. 4) sieve, at least 100% by weight shall have 1 (one) or more fractured faces and minimum 85% by weight shall be fully crushed.

Mineral Filler: Rock or slag dust, hydraulic cement, or other inert material complying with ASTM D 242.

Combined aggregates meeting the following requirements when tested according to ASTM C 136:

Sieve Size	Percent Passing by Weight	
	Bituminous Base Course	Bituminous Wearing Course
32.0 mm	100	----

25.0 mm	80-100	100
19.0 mm	62-92	86-100
12.5 mm	----	69-87
9.5 mm	45-75	58-78
4.75 mm	30-55	40-60
2.36 mm	20-40	25-45
0.850 mm	15-30	15-30
0.425 mm	10-22	10-22
0.180 mm	6-15	6-15
0.075 mm	2-8	2-8

Coarse Aggregate: Sound; angular crushed stone or crushed gravel; complying with ASTM D 692.

Fine Aggregate: Sharp-edged natural sand or sand prepared from stone or gravel, or combinations thereof; complying with ASTM D 1073.

For hot-mix asphalt, limit natural sand to a maximum of 10 percent by weight of the total aggregate mass.

2.2 ASPHALT MATERIALS

Asphalt Cement: ASTM D 946 for penetration-graded material; Grade 60-70 (mixing temperature 145 deg C - 165 deg C).

Asphalt Cement: ASTM D 3381 for viscosity-graded material.

Prime Coat: ASTM D 2027; medium-curing cutback asphalt; MC-70.

Prime Coat: ASTM D 977, emulsified asphalt or ASTM D 2397, cationic emulsified asphalt, slow setting, factory diluted in water, of suitable grade and consistency for application.

Tack Coat: ASTM D 977, emulsified asphalt or ASTM D 2397, cationic emulsified asphalt, slow setting, factory diluted in water, of suitable grade and consistency for application.

Tack Coat: ASTM D 2028; rapid curing cutback asphalt; RC-70.

Water: Potable.

2.3 AUXILIARY MATERIALS

Herbicide: Commercial chemical for weed control, registered by Environmental Protection Agency (EPA). Provide granular, liquid, or wettable powder form.

Sand: ASTM D 1073, Grade Nos. 2 or 3.

Wheel Stops: Precast, air-entrained concrete, 17.2-MPa minimum compressive strength, approximately 150 mm high, 225 mm wide, and 2150 mm long. Provide chamfered corners and drainage slots on underside, and provide holes for anchoring to substrate.

1.Dowels: Galvanized steel, diameter 20 mm, minimum length 250 mm.

2.4 MIXES

Hot-Mix Asphalt: Provide dense, hot-laid, hot-mix asphalt plant mixes approved by authorities having jurisdiction and designed according to procedures in AI's "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types, or in accordance with the Marshall method for Asphalt Institute Manual MS-2.

Provide mixes with a history of satisfactory performance in geographical area where Project is located.

Provide mixes complying with the composition, grading, and tolerance requirements of ASTM D 3515 for the following nominal, maximum aggregate sizes:

Base Course: 25 mm.
Wearing Course: 19 mm.

Combine the mineral aggregates and asphalt to conform to the following composition limits by weight:

Total Mineral Aggregates:	
Bituminous Base Course	95.5 to 96.6 percent
Bituminous Wearing Course	95.5 to 96.6 percent

Asphaltic Binder:

Bituminous Base Course	3.4 to 4.5 percent
Bituminous Wearing Course	3.4 to 4.5 percent

C. When tested according to ASTM D5581 (75 blow each face) the asphaltic mixture shall conform to the following requirements:

		Base Course	Wearing Course
1.	Marshall Stability	1000 Kg.F minimum	1200 Kg.F minimum
2.	Flow (mm)	2.0 to 4.0	2.0 to 4.0
3.	Stiffness (Kg.F/mm)	500	500
4.	Voids in total mix, %VIM	4.0 to 7.0 percent	4.0 to 7.0 percent
	Voids in mineral aggregate based on maximum aggregate size, VMA	min. 12 percent	min. 15 percent
6.	Voids Filled with Bitumen, VFB	50 to 70 percent	50 to 70 percent
7.	Loss of Marshall stability by submerging specimens in water at 60°C for 24 hours, compared to stability measured after submersion in water at 60°C for 30 minutes	Max. 25%	Max 25%
8.	% Air Voids at Refusal*	2 min.	2 min.

*prior to final approval, the proposed job mix, but with a bituminous content at the upper percentage limits shall be compacted to Refusal (400 to 600 blows) and the resulting voids in the mix shall not be less than 2%.

Variation from the approved job-mix, based on results of 4 tests, shall not exceed the following:

Aggregates passing No. 4 (4.75 mm) and larger	4 percent
Aggregates passing No. 8 (2.36 mm), No. 16 (1.18 mm), No. 30 (0.6 mm), and No. 50 (0.3 mm)	3 percent
Aggregates passing No. 100 (0.15 mm) and No. 200 (0.075 mm)	1 percent
Asphalt content	0.2 percent
Temperature	14 deg C
Air voids in total mix	1 percent

PART 3 - EXECUTION

3.1 EXAMINATION

Verify that subgrade is dry and in suitable condition to support paving and imposed loads.

Proof-roll the aggregate base course using heavy, pneumatic-tired rollers to locate areas that are unstable or that require further compaction.

Inspect surfaces on which asphalt materials are to be placed for conformance to the required compaction, grades, and sections.

Notify Engineer in writing of any unsatisfactory conditions. Do not begin paving installation until these conditions have been satisfactorily corrected.

3.2 COLD MILLING

Clean existing paving surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement, including hot-mix asphalt and, as necessary, unbound-aggregate base course, by cold milling to grades and cross sections indicated.

3.3 PATCHING AND REPAIRS

All saw-cutting and breaking of existing pavements of any type, cleaning, patching, sealing or carrying out pavement repair works shall be coordinated with the Engineer through the submission of detailed method statement for every area that needs repair. The method statement should show the extent of patching or repair works, the steps that shall be followed and the materials that shall be used for each type of repair, with due consideration to the applicability of the proposed method and materials to each specific repair case. The execution shall not start before receiving the written approval of the Engineer. The requirements set in Clauses B, C, D and E below, are for guidance only and shall be coordinated with the approved method statement and with the Engineer's
Representative on Site.

Patching: Saw cut perimeter of patch and excavate existing pavement section to sound base. Recompact new subgrade. Excavate rectangular or trapezoidal patches, extending 300 mm into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically.

Tack coat faces of excavation and allow to cure before paving.
Fill excavation with dense-graded, hot-mix asphalt base mix and, while still hot, compact flush with adjacent surface.
Partially fill excavation with dense-graded, hot-mix asphalt base mix and compact while still hot. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.

Leveling Course: Install and compact leveling course consisting of dense-graded, hot-mix asphalt surface course to level sags and fill depressions deeper than 25 mm in existing pavements.

- Install leveling wedges in compacted lifts not exceeding 75 mm thick.

- Crack and Joint Filling: Remove existing filler material from cracks or joints to a depth of 6 mm. Refill with asphalt joint-filling material to restore watertight condition. Remove excess filler that has accumulated near cracks or joints.

1.Tack Coat: Apply according to Article 3.6.

3.4 SURFACE PREPARATION

General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

Sweep loose granular particles from surface of unbound-aggregate base course. Do not dislodge or disturb aggregate embedded in compacted surface of base course.

Remove loose materials from existing asphalt pavement and clean surface using approved mechanical sweepers, blowers, and hand brooms. Remove loose broken, or shattered asphaltic material along the edges of existing surfaces. Shape, blade, and broom the exposed subgrade and a sufficient width of shoulder to provide a uniform firm subgrade for the new surface course.

Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written
application Control of Traffic: Do not permit unnecessary traffic on the surface after it has been approved to receive asphaltic material instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.

Mix herbicide with prime coat when formulated by manufacturer for that purpose.

Prime Coat: Apply according to Article 3.6.

Control of Traffic: Do not permit unnecessary traffic on the surface after it has been approved to receive asphaltic material.

3.5 TRIAL SECTIONS

At the start of plant operation, the Contractor shall place a trial section for each Job Mix Formula used. The contractor shall construct a trial section 250 m long and two lane-widths wide (operating simultaneously), with a longitudinal cold joint. The trial section shall be of the same depth as the course which it represents. The underlying grade or pavement structure upon which the trial section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment used in construction of the trial section shall be the same equipment to be used on the remainder of the course represented by the trial section. The trial section shall be placed at locations approved by the Engineer’s Representative on Site.

One random sample shall be taken at the plant, triplicate specimens compacted, and tested for stability, flow, and laboratory air voids. A portion of the same sample shall be tested for theoretical maximum density, aggregate gradation, and asphalt content. Four randomly selected cores shall be taken from the finished pavement mat, and four from the longitudinal joint, and tested for density. Random sampling shall be in accordance with procedures contained in ASTM D 3665. The test results shall conform to all specified requirements for work to continue. If all test results meet the specified requirements, the trial section shall remain as part of the project pavement. If test results exceed the specified tolerances, the test section shall be removed and replaced at no cost to the project and another test section shall be constructed.

If the initial trial section should prove to be unacceptable, the necessary adjustments to the Job Mix Formula, plant operation, placing procedures, and/or rolling procedures shall be made. A second trial section shall then be placed. Additional trial sections, as required, shall be constructed and evaluated for conformance to the specifications. Full production shall not begin until an acceptable section has been constructed and accepted.

3.6 PRIME AND TACK COATS

General: When required, prepare a test section of an approved length for determining the rate of application for each type of material. Subsequent test sections may be required and previously established rate or rates of application may be altered when necessary.

Prime Coat: Apply uniformly over surface of compacted-aggregate base to a line 200 mm outside edge of pavement line, at a rate of 0.75 to 1.50 L/sq. m. Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure for 48 hours minimum.

Apply liquid asphalt at temperatures within the range of 50 to 70 deg C. Reject materials heated to temperatures above 108 deg C until the material can be resampled and retested.
If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use just enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
Protect primed substrate from damage until ready to receive paving.

Tack Coat: Apply uniformly to existing surfaces of previously constructed asphalt or Portland cement concrete paving and to surfaces abutting or projecting into new, hot-mix asphalt pavement. Apply at a uniform rate of 0.30 to 0.60 L/sq. m of surface.

Apply liquid asphalt at temperatures within the range of 50 to 70 deg C. Reject materials heated to temperatures above 108 deg C until the material can be resampled and retested.
Allow tack coat to cure undisturbed before paving.
Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

Application:

Apply by approved pressure distributors. Spray nozzles and spray bar shall be adjusted and frequently checked to ensure uniform distribution. Stop spraying upon clogging or interference of any nozzles, and take corrective measures before resuming.
Hand sprays will be approved only for priming small patches or areas that cannot be primed by normal operation of the distributor.
Application at the junction of spreads shall not be in excess of the specified amount. Squeegee excess from the surface and correct skipped and deficient areas by means of approved hand sprayers.

Blotting: When approved, after the material has been applied for 48 hours and has not dried sufficiently, apply a light application of sand as blotter material. Apply blotting material sparingly and only on areas that have not dried.

3.7 ASPHALTIC CONCRETE BATCHING AND MIXING

Preparation of Asphalt Cement: Heat asphalt cement within a temperature range of 135 deg C to deg C at the time of mixing. All material heated to more than 204 deg C in storage tanks shall be rejected.

Preparation of Mineral Aggregate:

Heat and dry aggregates to a temperature after screening of not more than 163 deg C. Reject and remove aggregates from the bins, if they contain sufficient moisture to cause foaming in the mixture, or if their temperature is in excess of 163 deg C.

Immediately after heating, screen aggregates into at least 3 sizes and convey into separate bins ready for batching and mixing. When separating into three bins is impractical, the number of separations may be reduced to two with approval. Screen and produce gradations of heated and dried aggregates which are reasonably uniform and result in the production of a mixture as specified.

Preparation of Asphaltic Mixture:

Introduce aggregates and asphalt cement into the mixture in proportionate amount according to the job-mix formula. The temperature of the asphalt, except for temporary fluctuations, shall be not lower then 32 deg C below the temperature of the aggregate at the time the materials enter the mixer or pug mill.
Use the shortest mixing time that will produce a satisfactory mixture based on the procedure for determining the percentage of coated particles described in ASTM D 2489. The mixing times shall be set to achieve 90 percent of coated particles for base mixtures and 95 percent of coated particles for surface mixtures.
Dry mixing time, if required for the batch plants, shall not exceed 10 seconds. Wet mixing time shall not exceed 50 seconds. Timing shall begin at the start of asphalt introduction into the pug mill at batch plants.
The length of mixing time for continuous plants shall be determined by the following formula or other approved methods:

$$\text{Mixing time in seconds} = \frac{\text{Pugmill dead capacity in kilos}}{\text{Pugmill output in kilos/second}}$$

Preparation of Hot-Mix Asphalt Placement:

-Apply a prime coat or tack coat to surface on which asphaltic concrete is to be placed, unless otherwise approved.
-Maintain line and grade control by means of taut reference string lines or other approved methods. If the existing surface is determined to be acceptable, it may be used for control, and the use of the string line waived. If directed, establish and maintain centerline points.

3.8 HOT-MIX ASPHALT PLACING

Spread and finish asphaltic concrete true-to-line and grade by means of an automatically controlled paver except that the use of the automatically controlled paver may be waived and a manually controlled paver or hand methods may be used on irregular or other sections when approved.

Place the mixture in consecutive, adjacent strips with a minimum width of 3 m except where edge lanes require strips of lesser width. Unless otherwise directed, begin placing along the centerline of crowned sections or on the high side or areas with a one-way slope.

Operate the paver at a speed which will give the best results for the type of paver being used and which coordinates satisfactorily with the rate of delivery of the mixture to the paver so as to provide a uniform rate of placement without intermittent operation of the paver. Regulate the speed of the paver to eliminate pulling and tearing of the bituminous mat.

Deliver asphaltic concrete to the paver at a temperature between 135 and 163 deg C. Do not use mixtures delivered to the paver at temperatures outside this range.

Place asphaltic concrete so that after rolling the nominal thickness will not exceed 80 mm. Where practical, the top layer shall not exceed 50 mm in thickness.

The maximum thickness for layers may be increased when such increase is determined not to be detrimental to placement and rolling conditions.

Make surface test to check conformity with the specified crown and grade immediately after initial compression. Correct all variations by the removal or addition of materials and by continuous rolling. The finished surface shall not vary by more than the specified tolerances. After the completion of final rolling, retest the smoothness of the course. Immediately correct all humps and depressions exceeding the specified tolerances, as approved. Replace and recompact the pavement where holes are made for test purposes.

3.9 JOINTS

Make joints to ensure thorough and continuous bond. Construct transverse construction joints in previously laid material by cutting the material back vertically for its full depth to expose a fresh surface. Transverse joints in one layer shall be offset by at least 600 mm from transverse joints in the previous layer. Transverse joints in adjacent lanes shall be offset a minimum of 3 m.

Offset longitudinal joints in successive layers not less than 300 mm.

Before placing the fresh mixture against a cut joint or against old pavement, spray or paint the contact surface with a thin uniform coat of liquid asphalt. Where a finishing machine is used, make the longitudinal joint by overlapping the screed on the previously laid material for a minimum width of 25 mm and depositing a sufficient amount of material so that the joint formed will be smooth and tight.

3.10 COMPACTION

After spreading and strike-off, compact the asphaltic concrete to the density specified in Article 13. Complete rolling before appearance of cracks.

Begin initial or breakdown rolling as soon as the asphaltic concrete will bear the roller without undue displacement. Roll longitudinally, beginning at the low side of the work and proceeding toward the high side, or centerline.

Overlay successive strips by at least one half the drum width. Alternate trips of the roller shall be of different lengths.

Prevent adhesion of mixture by moisten the roller drums with water; an excess of water will not be permitted.

Follow initial or breakdown rolling by rolling with a pneumatic-tire roller. Perform finish rolling with tandem roller. Select number and size of roller required to obtain the specified density.

Operate rollers continuously so that all areas of the pavement will receive substantially equal compaction. Placing will be ordered to stop at any time that proper rolling is not being performed.

Repairs: Remove paved areas that are defective or contaminated with foreign materials. Remove paving course over area affected and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.11 CONTACT SURFACES

Paint contact surfaces of concrete structures with a thin uniform coating of approved asphaltic material. Place asphaltic concrete uniformly high near contact surfaces so that after compaction it shall be 6 mm above the edge of such structures.

3.12 FIELD QUALITY CONTROL

Sampling: The job shall be divided into lots of 2000 metric tons. Each lot will further be subdivided into four equal sublots. One random sample shall be taken from each sublot and tested. For aggregate gradation, asphalt content and in-place density tests, samples shall be taken from in-place asphaltic concrete paving. For Marshall test, samples shall be taken from trucks.

Testing: Tests shall be performed in accordance with the following:

Resistance to Plastic Flow of Bituminous Mixture: ASTM D5581**.**
Bulk Specific Gravity of Compacted Bituminous Mixture: ASTM D 2726.

Acceptance:

The gradation will be acceptable when variation from the approved job mix for the average of four samples is within the limits of tolerances specified.
The asphalt content will be acceptable when variation from the approved job mix for the average of four samples is within the limits of tolerances specified.
The compaction density for all bituminous courses shall be equal to or greater than 98% of the average Marshall bulk specific gravity for each day's production unless otherwise directed by the Engineer. (90% of the results shall be greater than the lower specification tolerance limit of 96.3%).
Surfaces: Variation of the surface when tested with a 5-m straightedge placed parallel with the centerline to not exceed 8 mm for Bituminous Base Course and 5 mm for Wearing Course.
Elevations: Variations from gradeline, elevations and cross sections are not to exceed 10 mm above or 6 mm below the elevations shown. Straightedge will be used for testing of transverse irregularities.

Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances (Point 4 of Clause 3.12.C above).

In-Place Density: Samples of uncompacted paving mixtures and compacted pavement will be secured by testing agency according to ASTM D 979.

Reference laboratory density will be determined by averaging results from 4 samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D5581**,** and compacted according to job-mix specifications.
Select above or below. Coordinate with "Compaction" Article.
Reference maximum theoretical density will be determined by averaging results from 4 samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
One core sample will be taken for every 800 sq. m or less of installed pavement, but in no case will fewer than 3 cores be taken. Cores shall be reinstated by placing “Repair Cold Asphalt” in the core holes and compacting it with tamping rod to the satisfaction of the Engineer.
Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.

- Determination of Thickness of Courses.

The Contractor shall compensate for minor deficiencies in the thickness of any bituminous course in the pavement structure by increasing the thickness of the subsequent bituminous course. After completion of the final (wearing) course any deficiencies in the thickness of any course which have not been compensated for by increasing the thickness of a subsequent course, will be considered deficiencies in the final (wearing) course.
Cylinder core samples shall be taken as specified for in situ bulk specified gravity core samples.
Thickness of bituminous courses shall be determined by average caliper measurement of cores, rounded upwards to the nearest mm.
Paved sections to be measured separately shall consist of each 300 lin.m section in each paved strip. The last section in each paved strip shall be 300 m plus the fractional part of 300 m remaining. Other areas such as intersections, entrances, crossovers, ramps, etc. shall be measured as one section and the thickness of each shall be determined separately. Small irregular unit areas may be included as part of another section.
One core shall be taken from each section by the Contractor at approved locations and in the presence of the Engineer. When the measurement of the core from any paved section is not deficient by more than 5 mm from the specified thickness, the core will be deemed to be of the specified thickness as shown on the Drawings.
When the measurement of the core from any paved section is deficient by more than 5 mm but not more than 20 mm, 2 additional cores spaced at not less than 100 m shall be taken and used together with the first core to determine the average thickness of such section.
When the measurement of the core from any paved section is less than the specified thickness by more than 20 mm, the average thickness of such section shall be determined by taking additional cores at not less than 5 m intervals parallel to the centerline in each direction from the affected location until, in each direction, a core is taken which is not deficient by more than 20 mm. Exploratory cores for deficient thickness will not be used in average thickness determinations.
Any deficiencies in the total thickness of bituminous courses shall be subject to a proportional reduction in the volume of final (wearing) course measured for payment. Alternatively, the Contractor shall construct all at his own expense, a surface course overlay, if practicable in the judgement of the Engineer. Any such overlay shall be a minimum of 40 mm compacted thickness and to the specified standard of the course it is overlaying.
If the deficiency in total asphalt layers thickness is from 0 - 3mm, full payment will be made, on condition that deficiencies are not found in more than 10% of the total project.

Deficiencies between 3mm and 10mm, 80% of the full payment for the bituminous courses will be made.

3.13 TESTING FREQUENCY

(A) Source of Materials		(B) Control on Site (The Road)	
Required Tests (A)	Repetition Required for all Test in (A)	Required Tests (B)	Repetition Required for all Tests in (B)
Gradation of Material	As requested by Engineer	1. Coring	1 sample in every 800 m^2
		2. In-place density	1 sample in every 800 m^2
		3. Asphalt content	As requested in the Specification
		4. Bulk specific gravity	As requested in the Specification
		5. Volumetric tests	As requested in the Specification
		6. Pavement density tests	As requested in the Specification
		7. Smoothness	As requested in the Specification
		8. Plastic Flow	As requested in the Specification
		9. Thickness	As requested in the Specification

3.14 **INSTALLATION TOLERANCES**

Thickness: Compact each course to produce the thickness indicated within the following tolerances:

Base Course: Plus or minus 10 mm.
Wearing Course: Plus 6 mm, no minus.

Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 3-m straightedge applied transversely or longitudinally to paved areas:

Base Course: 6 mm.
Surface Course: 3 mm.
Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 6 mm.

3.15 Paint lines work of Asphalt.

The contractor must carry out the work of providing, supplying, and the material shall comply with the below requirement. Technical conditions and specifications for painting:

1. The contractor is obliged to carry out the paint work during the official working hours only unless he obtains written permission from the supervising engineer.
2. The contractor must calibrate the heating temperatures of the hot paint boilers and ensure that the temperature is regular inside the boiler and the contractor's full responsibility as the heating is required to be done using oil to ensure regular heating.
3. When implementing intermittent paint lines, the disparity in the lengths of the intermittent paint lines should not exceed 10%.
4. The contractor must hand over all the spatial work that he will perform before the paint is carried out, including pre-MARKING.
5. The minimum required for reflection in the dry state of the paint surface (Dry Road Marking) is as follows:
    1. RL yellow - 90MCD/M/L
    2. RL white - 120MCD/M/LX

The contractor must provide a device to examine the reflector of the paint on site and be calibrated by the Royal Scientific Society to be used during implementation and for the purposes of receiving the initial works.

6.the material shall be have abrasion resistant Epoxy resin adhesive pavement line striping and road marking paint shall be cold application, fast dry ,excellent performance meets the federal specification TTP-115 .and conforming AASHTO M 248 or M237

- Laboratory tests:

The contractor will bear the cost of laboratory tests that are carried out to control the quality of the materials executed on the site and in various stages during the implementation of the works as follows:

1. Two random yellow samples, two random white samples and random samples of glass granules for materials supplied to the site or when changing the source and as instructed by the engineer and employer.
2. A random sample of every 1000 linear meters of paints executed on site to conduct field tests in terms of thickness, reflector, and general appearance.

3.16 Precast Concrete Paving blocks.

A- The bricks of the floor (interlock) that are supplied and installed on the work site must (BS 6717: Part 1: 2001 Precast Concrete Paving Blocks) in addition to the attached specification.

B- Executive drawings must be submitted before the work is started and approved by the supervising engineer.

C- the installation of interlock before testing and the issuance of the laboratory result and the approval of the engineer prior to proceed work in site.

D- Direct installation of interlock is prohibited before the appearance and success of the results of the test of the base course.

E- Before directing installation, the final floor surfaces of the final floor should be specified for all the areas to be covered by interlock, if this is done in the right technical ways according to the rules and the approval of the engineer.

The installation of interlock before the construction of the broiler is prohibited by the flower basins and the ends of the pavements that are not specified by the walls.

G- A layer of sand should be placed at least ٦5cm clean and free of impurities over the palls course in the pavement must finish the surface of the sand well using the mug, the mage, and the appropriate tools so that the surface is finally obtained level.

H- The interlock is installed according to the technical rules followed so that the floor is fixed and called from the tiles according to the required levels, provided that the distance between the deposit and the deposit does not exceed 0.2 m and must be done tiling using thread, cod and balance so that the surface of the ground is completely level with a variation of no more than 0.5 thousand and according to the approval of the engineer.

I- It is not allowed to use interlock, angle breaker, edge-like or containing any defects such as color difference, wickedness, etc.

J- Consider the color compatibility of the single area and for this purpose each area must be tiled with tiles from one mission.
K- The work of concrete locks in the necessary places according to the design plans with all necessary as instructed by the supervising engineer.
L- The interlock tiles must be installed in a straight and compact manner and in a manner that is instructed by the supervising engineer.
M- The final layer of interlock is dissonant and done according to the instructions of the supervising engineer.
N- Sand should be sprayed as a final layer to fill the blanks.

END OF SECTION 321216