

# **Employment Intensive Infrastructure Programme in Lebanon (EIIP)**

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## **BID DOCUMENT**

**ITB 64/2019**

### **Annex E-2**

#### **General Technical Specifications**

#### **Construction of agricultural roads and retaining walls in**

**Marjeyoun Municipality,**

**Nabatieh Governorate**

**Lebanon, September 2019**

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## SECTION 312000 – EARTH MOVING(EARTH WORK)

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. This Section includes the following:
  - 1. Structural Excavating and backfilling.
  - 2. Excavating and backfilling trenches for buried mechanical and electrical utilities and pits for buried utility structures.

#### 1.3 DEFINITIONS

- A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
  - 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

#### 1.4 SUBMITTALS

- A. Coordinate with the Engineer to establish the final level of platform for each area.
- B. Product data for backfilling materials
- C. Method statement: Prior to commencing any work, the Contractor shall submit a 'Method Statement' detailing how each item of work will be performed, including:
  - 1. Leveling Plan
  - 2. Excavation Plan
  - 3. Filling Plan
  - 4. List of tools, equipment and transport trucks to be used
  - 5. Supervision and control system.
- D. Samples and tests: Submit 50 kg representative samples of filling materials to an approved laboratory for tests as follows and submit results for approval.
  - 1. For soils with less than 50% fines: sieve analysis and compaction.
  - 2. For soils with more than 50% fines: sieve analysis, Atterberg Limits Compaction.
  - 3. For all soils: test in accordance with ASTM D1557 (Method D) to determine the optimum amount of water to be used with fill material to obtain maximum dry density.
  - 4. Tests shall be conducted for every source of filling materials and for every type of filling material encountered.

- E. Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:
  - 1. Classification according to ASTM D 2487 of each on-site and borrow soil material proposed for fill.
  - 2. Laboratory compaction curve according to ASTM D 698 and ASTM D 1557 for each on-site and borrow soil material proposed for fill.
- F. Relative compaction test results as well as all other laboratory test results submitted to the Engineer on a monthly basis, and kept in hand in the Contractor's on-site office so that they may be inspected at any time by the Engineer.
- G. Quality control program.
- H. Weekly and monthly quality control reports.
- I. Analysis of the results of testing as required by compaction and testing of earthworks.
- J. Survey measurements for tolerance control and payment purpose. Program of execution, calculation volume of excavations, periodicity of trucks, and fleet of trucks needed for the completion of the works within the program limits.
- K. Dumping area, relative permits and/or sub-agreements.

#### 1.5 QUALITY ASSURANCE

- A. Geotechnical Testing Agency Qualifications: An independent testing agency qualified according to ASTM E 329 to conduct soil materials and rock-definition testing, as documented according to ASTM D 3740 and ASTM E 548.
- B. Surveyor Qualifications: An independent licensed surveyor, acceptable to the Engineer and experienced in ground surveys.
- C. Quality Assurance, both Inspection and Acceptance, shall be conducted in accordance with the requirements of the engineer.
- D. Tolerances according to BS 5606.

#### 1.6 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Architect and then only after arranging to provide temporary utility services according to requirements indicated.

### PART 2 - PRODUCTS

#### 2.1 WATER

- A. Clean water shall be used in all Earthwork operations.
- B. Portable water shall be used for compaction of backfill material within the area paid for as structural excavation or within an area of one meter from all surfaces of the structure, whichever is the greater.

- C. The Contractor shall supply all water for construction including dust control, moisture-conditioning of fill material during compaction and such other needs as the Engineer may require.

## 2.2 MATERIALS ARISING FROM EXCAVATION

- A. Materials and conditions: Assess the nature of the work and the materials to be excavated. Take sole responsibility for the assessment of materials and conditions.
- B. Topsoil for preservation: Before beginning general excavation or filling, excavate topsoil from required areas and keep separate from excavated subsoil.

## 2.3 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: ASTM D 2487 Soil Classification Groups GW, GP, GM, SW, SP, and SM, or a combination of these groups; free of rock or gravel larger than (75 mm) in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
- C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, 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.
- D. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a (37.5-mm) sieve and not more than 12 percent passing a No. 200 (0.075-mm) sieve.
- E. Fill material shall be from one or more of the sources listed below:
  - 1. Suitable materials from the required excavations within the site of the work. This shall be the primary source of fill material.
  - 2. Borrow areas designated by the Engineer.
  - 3. From approved on-land borrow areas provided by the Contractor
  - 4. From approved commercial sources.
- F. Designation or approval of a borrow area does not mean that all material within that area is suitable fill material. Only material from such areas that meets the specification requirements shall be placed in the works. The Contractor shall be responsible for ensuring that materials obtained from borrow areas comply with the requirements of the Specification.
- G. Sand: ASTM C 33; fine aggregate, natural, or manufactured sand.
- H. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.
- I. Backfill and Fill: Satisfactory soil materials.
- J. Topsoil: to BS 3882, medium texture, neutral to slightly alkaline reaction, free of stones, pests, weed seeds and foreign matter.

- K. Drainage Course: Narrowly graded mixture of crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch (37.5mm) sieve and 0 to 5 percent passing a No. 8 (2.36-mm) sieve.
- L. Stone Mulch: Water-borne and durable gravel, washed free of loam, sand, clay and other foreign substances, evenly graded from 5 mm minimum to 25 maximum size and of natural gravel colour to be approved.
- M. Compacted cement granular fill: Materials to be used for composed cementitious fill shall be granular coarse grained soils from on-site excavation or borrow mixed with sulphate resistant cement at a ratio of 200 kg cement per cubic meter of fill. The constitution of the granular fill shall be similar to the above mentioned composition of compacted fill material. Laying of the cement granular fill shall be damped and compacted in order to have stabilized layer of base coarse. Curing shall be done for the following 48 hours. Cement granular fill shall be compacted at optimum moisture content. No subsequent layer shall be placed until the specified compaction is obtained for the previous layer.

### PART 3 - EXECUTION

#### 3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, 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."
- C. Protect and maintain erosion and sedimentation controls, during earthwork operations as specified by the engineer.
- D. Waterways: Temporarily divert, as necessary, ditches, field drains and other waterways encountered during excavations, and reinstate on completion. If reinstatement is not possible obtain instructions.

#### 3.2 SURVEY WORKS

- A. The Contractor shall coordinate with the Engineer to establish the reference bench marks and the site zero level, to determine the reference points related to the performance of his works.
- B. The Contractor shall assure the survey works needed for the execution of the earthworks and have a full time topographer to supervise team on site so to facilitate the day by day works.
- C. At the request of the Engineer, the Contractor shall take the responsibility to put aside, within the area assigned by the Engineer, the excavation material to be re-used for filling and compaction.
- D. The Contractor shall position the final levels and the boundary limits of the platforms whenever reached to the approval of the Engineer.

#### 3.3 EXCAVATION

- A. Methods: Submit details of proposed methods of working to avoid any nuisance, damage or danger to people and/or property.

- B. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
- C. No excavation material shall be wasted without written permission from the Engineer, and when such material is to be wasted, it shall be so placed that it will present a neat appearance and not be an injury to abutting property. Excavated materials wasted by the Contractor without written permission of the Engineer shall be replaced by the Contractor at his own expense
- D. The Contractor shall provide all labors; equipment and material required for the construction of items of grading works as specified and shown on the final construction drawings.
- E. Adjacent Excavations: Where an excavation encroaches below a line drawn at an angle from the horizontal of 45 degrees for dry stable soil or 30 degrees for wet clays or soils below water table from the nearest formation level of another higher excavation, then all work within the lower excavation and back-filling there must be completed before the higher excavation is made.
- F. Foundations Generally : Inform the Engineer as have his guidance as approval whenever:
  - 1. Natural bearing formation of undisturbed subsoil is not obtained at depth shown on the Drawings,
  - 2. Formation contains soft or hard spots or highly variable material.

### 3.4 EXCAVATIONS FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 25 mm. 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 the bottom 200mm to final grade just before placing concrete blinding. Trim bottoms to required lines and grades to leave solid base to receive other work.
- C. Final excavation to grade shall not be performed until just before the placement of reinforcing steel or concrete. When the bottom of the excavation is soil, the grade shall not be disturbed prior to the placement of concrete. When the bottom of the excavation is rock or other hard foundation material, it shall be cut to a firm surface as directed and all loose material removed. Any open seams shall be cleaned and filled with concrete, mortar or grout to the satisfaction of the engineer. Footing excavations shall be dewatered and made as dry as possible prior to the placement of backfill. Backfill material as specified shall be placed in lifts as directed and compacted as directed to the satisfaction of the engineer.
- D. Anti-Termite Treatment: Destroy ant-nests and vermin encountered during excavations. Apply approved proprietary pesticide solution of Dieldrin or Aldrin or equivalent in clean water with a spray maintaining a pressure of 150 psi to surfaces of excavations at the rate recommended by the manufacturer.
- E. Where footings are to be constructed using formwork, the excavations shall generally not extend more than 500 mm beyond the maximum dimension on each side of the proposed footing unless additional working space is clearly required and approved, by the Engineer.

- F. Sides of Excavations: Responsibility for upholding sides of excavations rests upon the Contractor.
- G. TEMPORARY SUPPORT SYSTEM
1. When a temporary support system is required to protect adjacent property or to protect the public during construction, the Contractor's design for such support system shall be submitted for approval prior to commencing its construction.
  2. All temporary support systems shall be designed with adequate factors of safety to serve with minimal maintenance, for the duration of its intended use, and shall include adequate safety provisions to protect the public from construction activities.
  3. Notwithstanding any approval of temporary support systems, the Contractor shall be solely responsible for the adequacy of their design and construction and for maintenance and all necessary safety precautions associated therewith.
  4. Steel Sheet Piling: Use as necessary to support sides of excavations and remove upon completion unless otherwise instructed.
  5. Special Support: Use as necessary to uphold excavations against sides of adjoining buildings, public footpaths, roads and the like, and remove on completion unless otherwise instructed.
- H. Unstable Ground: Inform the Engineer without delay if any newly excavated face will not remain unsupported sufficiently long to allow necessary earthwork support to be inserted. If instability is likely to affect adjacent structures or roadways, take appropriate emergency action. Responsibility for preventing instability rests upon the Contractor.
- I. Existing Foundations: Where old foundations, beds, drains etc. are encountered, obtain instructions before proceeding. Break out old foundations, beds, drains etc., seal off drain ends, remove contaminated earth, and disinfect as instructed.

### 3.5 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
- B. Excavate trenches to uniform widths to provide clearance of 300mm 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 in rock or other unyielding bearing material to allow for bedding course.



- D. Trench Bottoms, when bedding course is required under pipe: Excavate trenches 100 mm deeper than bottom of pipe elevation to allow for bedding course. Hand excavate for bell of pipe
  - 1. Excavate trenches 150 mm deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

### 3.6 SUBGRADE INSPECTION

- A. Proof-roll subgrade below the slab on grade, with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

### 3.7 UNAUTHORIZED EXCAVATION

- A. Any unauthorized over width of excavation beyond the lateral limits shown on the drawings or approved by the Engineer shall be backfilled with selected fill and compacted. Suitable fill material shall consist of uniformly graded granular material, capable of being compacted to 95% AASHTO T 180 maximum density, and having adequate permeability to permit free drainage through it and shall be cohesion less material, free of lenses, layers or other types of inclusions of material not meeting the requirements. This work shall be performed at the Contractor's expense.
- B. Any unauthorized over-depth excavation below the approved elevation shall be backfilled with plain concrete of 15MPa compressive strength approved by the Engineer. This work shall be performed at the Contractor's expense.

### 3.8 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
  - 1. Stockpile soil materials away from edge of excavations.

### 3.9 GRADING

- A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
- B. Grading inside Building Lines: Finish subgrade to a tolerance of 13 mm when tested with a 3-m straightedge.

### 3.10 BACKFILL

- A. Preparation: Remove vegetation, topsoil, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface before placing fills.
- B. No backfilling shall be performed before casting the slabs that support earth or retaining walls.
- C. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- D. Place and compact fill material in layers to required elevations as follows:
  - 1. Under structural slabs, use engineered fill.

2. Under footings and foundations, use engineered fill.
- E. Place and compact backfill in excavations promptly, but not before completing the following:
    1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
    2. Surveying locations of underground utilities for Record Documents.
    3. Testing and inspecting underground utilities.
    4. Removing concrete formwork.
    5. Removing trash and debris.
    6. Removing temporary shoring and bracing, and sheeting.
    7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
  - F. Surplus: Remove surplus imported filling materials from site
  - G. The Contractor shall notify the Engineer in writing, of his intent to start filling and compaction operations for each segment of the work.
  - H. Place Filling using approved methods to required dimensions, levels, lines and profiles and to permit water to drain freely.
  - I. Place backfill on subgrades free of mud.
- 3.11 UTILITY TRENCH BACKFILL (FOR EXISTING UTILITY IF ANY)
- A. Place 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. Concrete is specified in Division 03 Section "Cast-in-Place Concrete."
  - 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

### 3.12 MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill layer before compaction to within 2 percent of optimum moisture content.
  - 1. Do not place fill 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.

### 3.13 COMPACTION OF FILLS

- A. Surfaces to receive filling shall be cleared and all vegetation removed off site before filling is placed. Surfaces of ground shall be scarified and recompacted to at least 95% of maximum dry density as determined by ASTM D1557 (Method D). Compaction shall be to a depth of at least 200 mm below ground surface.
- B. Place fill 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.
- C. Place fill materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
- D. Filling operations shall be carried out as soon as practicable after testing and shall be executed in a continuous operation. The filling shall be placed in uniform layers and each layer of material being compacted shall have the test practical uniform moisture content to ensure satisfactory compaction and all subject to the approval of the Engineer. Method of compaction and the equipment used shall be appropriate for the material to be compacted and shall not transmit damaging shocks to the pipes or other services.
- E. Moisture content: Each layer of filling shall be moistened or dried to reach correct moisture content for required dry density. Spread and compact each layer to at least 95% of maximum dry density, unless otherwise specified, all as determined by ASTM D1557 (Method D). Each compacted layer shall be tested and approved prior to placing subsequent layers.
- F. Earth Filling Generally: Shall be selected fill spread, and leveled in 200 mm maximum layers each well consolidated with a suitable mechanical hammer.
- G. Deposit Earth Filling in a manner not to endanger the partly finished structure or sub-structure either by direct pressure or indirectly by overloading banks contiguous to the operation or in any other manner.
- H. Compact soil to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:
  - 1. Under structures and building slabs, scarify and recompact top 300 mm of existing subgrade and each layer of fill material at 95 percent.

### 3.14 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent geotechnical engineering testing agency to perform field quality-control testing.

- B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.
- C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.
- D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Perform tests at the following locations and frequencies:
  - 1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 186 sq. m or less of paved area or building slab, but in no case fewer than three tests.
  - 2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for each (30 m) or less of wall length, but no fewer than two tests.
  - 3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for each (46 m) or less of trench length, but no fewer than two tests.
- 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; recompact and retest until specified compaction is obtained.
- F. Compliance Survey: Conduct a survey of completed Earthwork to show grading compliance.

### 3.15 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, 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.
- 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.

### 3.16 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Topsoil for Preservation: Stockpile excavated topsoil required to carry out subsequent topsoiling operations in temporary spoil heaps on site as instructed.
- B. Surplus Subsoil: Remove from site to a tip, surplus excavated materials not required for filling, spreading and levelling or stockpiling
- C. Tips: Use only authorised tips for disposal of surplus excavated material removed from site. Pay all tipping fees

- D. Water: Keep excavations free from water and keep water from excavations clear of other work.
- E. Pumping: Do not disturb material in and around excavations by pumping operations.
- F. Sumps: Obtain approval of location of any sump, and fill with approved material when no longer required.
- G. Permanent Drainage System shall not be used for disposal of water from excavations without approval.

### 3.17 FOUND OBJECTS

- A. Particularly, refer to government's regulations concerning remains of historic monuments, ruins or objects concerning prehistory, history, art, archaeology, humanistic, etc...  
When discovering war vestiges such as arms, ammunition explosive weapons or alike:
  - 1. Clear danger zone from people;
  - 2. Advise immediately concerned authorities;
  - 3. Advise the Engineer;
  - 4. Provide a safety zone with ground-lights at full perimeter of danger sector;
  - 5. Appoint, on danger zone limits, a site guard to forbid access, until public authorities take over.

## SECTION 312100 - AGGREGATE SUBBASE COURSE

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. This Section includes aggregate for subbase course 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.
- B. Related Sections include the following:
  - 1. Division 31 Section 312000 "Earth Moving" for subgrade preparation, grading, and subbase course
  - 2. Division 31 Section 312200 "Aggregate Base Course" for aggregate base course.

#### 1.3 DEFINITIONS

- A. Aggregate Subbase Course: Subbase course composed of mineral aggregate uniformly blended and mixed with water.
- B. Subgrade: Compacted soil layer immediately below the subbase course.
- C. Subgrade Layer: 300 mm depth of soil material immediately below subgrade.
- D. Lot of Compacted Material: 500 m<sup>2</sup> of compacted subbase course.
- E. Utilities include on-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

#### 1.4 SUBMITTALS

- A. Product Data: For each type of manufactured material and product indicated.
- B. Samples: For the following:
  - 1. 100-kg samples, sealed in airtight containers, of each proposed aggregate material.
- C. Design Mixes: Based on heavy truck loading as per AASHTO criteria, for subbase course mix. Include alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.
  - 1. Provide compressive strength test results and moisture-density curves.
- D. 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 Supervision Consultant.

- E. Material Test Reports: Form a qualified independent testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of aggregate materials:
  - 1. Classification according to AASHTO M 145.
  - 2. Laboratory compaction curve according to AASHTO T180 (Method D).
  - 3. Analysis of the results of testing as required by compaction and testing of earthworks.
- F. Material Certificates: Certificates signed by manufacturers certifying that each material complies with requirements.
- G. Field Records for the Following:
  - 1. Test Section
  - 2. Verification of compliance of subgrade, in accordance with specified requirements, prior to placement of subbase course.
  - 3. Laboratory reports; laboratory density test results for each lot.
  - 4. Field reports; in - place density test results for each lot.
- H. Photographs or videotape, sufficiently detailed, of existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by earthwork operations.
- I. Minutes of preinstallation conference.
- J. Daily Progress Reports: Include location of all construction joints.
- K. Method statement : Prior to commencing any work, the Contractor shall submit a 'Method Statement' detailing how each item of work will be performed, including:
  - 1. Leveling Plan.
  - 2. Excavation Plan.
  - 3. Filling Plan.
  - 4. Methods of compaction and carrying out site grading.
  - 5. Control of water and dewatering plan.
  - 6. List of tools, equipment and transport trucks to be used.
  - 7. Supervision and control system.
- L. Quality control program.
- M. Weekly and monthly quality control reports.
- N. Survey measurements for tolerance control and payment purpose.
- O. Program of execution, calculation volume of excavations, periodicity of trucks, and fleet of trucks needed for the completion of the works within the program limits.
- P. Dumping area, relative permits and/or sub-agreements.

## 1.5 QUALITY ASSURANCE

- A. Codes and Standards: Comply with the Provisions of AASHTO or ASTM circulars and standards, except where different requirements are specified or shown on the drawings.
- B. 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.
- C. Manufacturer Qualifications: Engage a firm experienced in manufacturing similar to that indicated for this Project and with a record of successful in-service performance.
- D. Surveyor Qualifications: An independent licensed surveyor, acceptable to the Supervision Consultant and experienced in ground surveys.
- E. Testing Agency Qualifications: Demonstrate to Supervision Consultant'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.
- F. Regulatory Requirements: Conform to applicable standards of authorities having jurisdiction for asphalt paving work.
- G. Pre-installation Conference: Conduct conference at Project site to comply with General Requirements.

## 1.6 PROJECT CONDITIONS

- A. Provide a minimum 48 hour notice to the Supervision Consultant, and receive written notice to proceed, before interrupting any service, facility or utility operated or occupied by the Employer or others.
- B. Protect subbase coarse from rain, wind and sun, indentation and physical damage.
- C. 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.
- D. 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.
  - 1. Whenever needed, additional test borings and other exploratory operations shall be conducted at the Contractor's own cost and expense.
- E. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earthwork operations.
  - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from employers and authorities having jurisdiction.
  - 2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
- F. Notify utilities companies and authorities having jurisdiction for area where Project is located before commencing earthwork operations.



- G. Existing Utilities: Do not interrupt utilities serving facilities on or adjacent to Project site unless permitted in writing by Supervision Consultant and then only after arranging to provide temporary utility services according to requirements.
1. Include interruptions of utilities in the Contractor's Construction Schedule (CPM schedule) as milestones. Comply with requirements of Section 013200 (Construction Progress Documentation).
  2. Coordinate interruptions of utilities with owner and authorities having jurisdiction in accordance with CPM schedule.
  3. Do not proceed with utility interruptions without Supervision Consultant's written permission.
- H. 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

- A. Materials arising from excavations are to be used in sub-base course aggregate if it complies with AASHTO soil classification A-2-6 (Silty or clayey gravel with sand) or the specified requirements unless instructed by the Supervision Consultant to be removed from the site.
- B. Aggregate: Shall be sand, natural gravel, crushed stone or crushed gravel. The fine aggregate shall consist of screenings obtained from crushed stone, gravel, or sand.
- C. Aggregate may be washed, if directed, to remove excessive quantities of clay, silty clay or salts.
- D. Crushed Stone: Shall consist of hard, durable particles or fragments of stone, free from dirt or other objectionable matter, and shall contain not more than 8% of flat, elongated, soft, or disintegrated pieces.
- E. 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.
- F. 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.
- G. 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 course aggregate.

The Crushed Aggregate: Shall meet the requirements of one of the gradation shown in Table 1

TABLE 1: REQUIREMENTS FOR GRADATION OF AGGREGATE

Sieve Designation (Square openings)	Class A	Class B
	Percent by weight passing	
50 mm (2 in)	100	100
25 mm (1 in)	-	75 - 95
9.5 mm (3/8 in)	30- 65	40 - 75

4.75 mm (No.4)	25-55	30-60
2.00 mm (No. 10)	15-40	20-45
0.425 mm (No.40)	8-20	15-30
0.075 mm (No.200)	2-8	5-20

- H. The amount of the fraction of material passing the No. 200 mesh sieve shall not exceed one half the fractions passing the No. 40 mesh sieve.
- I. The material shall contain a minimum sand equivalent value of 25% (Dry condition) when tested in accordance with AASHTO T 176.
- J. The percentage of wear shall not exceed 40% after 500 revolutions, when tested in accordance with AASHTO T 96 (Los Angeles Abrasion Test).
- K. The absorption should be not more than 10%.
- L. The crushed aggregate subbase course material shall have a 4-day soaked CBR of not less than 40 when compacted at 100% of modified proctor AASHTO (T180) and tested in accordance with AASHTO T 193.
- M. When tested for soundness in accordance with AASHTO T 104, the material shall not show signs of disintegration and the loss by weight after 5 cycles shall not exceed 12 % in the case of the sodium sulphate test and 18% in the case of the magnesium sulphate test.
- N. 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.
- O. 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.
- P. 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

- A. 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

- A. 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 Supervision Consultant before

construction is permitted to start.

### 3.3 SURFACE PREPARATION

- A. Aggregate Subbase Course: Shall be placed directly on completed subgrade, preparation and the subgrade surface shall be as specified in section 312000.

### 3.4 TRIAL SECTIONS

- A. Before commencement of Site sub-base construction, the Contractor may be required to lay and compact trial sections of varying thickness of sub-base. Each trial section shall be 2 lanes wide by 50 m long, at approved locations on or close to the Site. Each trial section shall be laid using the same materials, mix proportions, mixing, spreading and compaction equipment, and construction procedures, proposed for use in the Works.
- B. The objectives of these trials shall be to determine the adequacy of the Contractor's equipment, the loose depth measurements that will result in the specified compacted layer depths, the field moisture content, and the relationship between the number of compaction passes and the resulting density of the sub-base material.
- C. The Contractor shall not proceed with sub-base construction until the methods and procedures established in the trials have been approved.
- D. The compaction trials shall involve all procedures specified for the permanent works including testing of any equipment, processes or procedures as proposed by the Contractor which are not included as a part of these specifications. Construction of the permanent works shall not commence until a rolling / compaction procedure has been approved in writing by the Supervision Consultant. Such approval shall in no way relieve the Contractor of his responsibilities and obligations stipulated in the Contract.
- E. The compaction trials shall not be measured or paid for separately but shall be considered an incidental obligation of the Contractor under this Section of the Specifications.

### 3.5 MIXING AND SPREADING

- A. The sub-grade shall be inspected and approved immediately prior to commencement of sub-base construction.
- B. 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.
- C. The Supervision Consultant may allow other methods of mixing provided such methods(s) do not reduce the standard of work. Demonstrate, in the presence of Supervision Consultant, ability to attain the requirement given in this Specification.
- D. 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.
- E. The Contractor shall correct, at his own expense, any deviation from specified elevation and compaction in the surface to receive aggregate subbase.
- F. 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.

- G. The 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.
- H. All 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.
- I. Neither hauling nor placement of material will not be permitted when, in the judgement of Supervision Consultant, 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.

### 3.6 COMPACTION

- A. The Contractor shall 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 is 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 the Contractor's expense.
- B. The 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.
- C. Rolling shall continue until the entire thickness of each subbase layer is thoroughly and uniformly compacted to 100% AASHTO T 180 maximum density. The subbase shall be watered or dried as may be necessary to obtain moisture content suitable for compaction.
  - 1. Density shall be measured in the field in accordance with AASHTO T 191 and determined in the laboratory in accordance with modified AASHTO T 180.
  - 2. Final rolling of the completed course shall be by means of an approved self-propelled roller.
  - 3. Rolling shall be accompanied by sufficient blading, to ensure a smooth surface, free from ruts or ridges and having the proper shape.
  - 4. When additional water is required, it shall be applied in an approved manner.
  - 5. The C.B.R. value of the subbase course after completion shall be not less than 40%.
- D. Areas inaccessible to normal compaction shall be compacted by use of portable mechanical tampers until the required standard of compaction is achieved.
- E. Each layer shall be completely compacted and approved prior to delivery of materials for the subsequent layer.
- F. Prior to placing a subsequent layer, the surface shall be made sufficiently moist as directed, to ensure proper bond between the layers.
- G. Edges and Edge Slopes of the Subbase Course shall be 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.

- H. Material which has dried out prior to final compaction, or which has dried and decompacted subsequent to final compaction, shall be watered and recompactd 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.

### 3.7 TOLERANCES AND MAINTENANCE OF COMPLETED SUBBASE

- A. The fully compacted and completed subbase course shall Conform to the lines, grades and cross sections as shown on the Drawings.
- B. Elevations of the finished subbase course shall be checked in the presence of Supervision Consultant at intervals of 20m on straight lines and of 10m on curves, and at intermediate points as directed.
- C. Tolerances (for final layer only) on elevations of finished surface shall not exceed + 10mm or - 15mm. Minus tolerance shall be compensated by the proceeding layer.
- D. When the finished surface is 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.
- E. All areas which exceed the specified tolerances shall be corrected by removing the defective sections of subbase course and reconstructing them or, if approved, by scarifying and adding new material and recompactd and finishing to the specified standard.
- F. Following completion and acceptance of the subbase course, it shall be maintained by the Contractor at his own expense as follows:
- G. The surface shall be broomed, rolled and otherwise maintained, keeping it free from ravelling and other defects until such time as the following course is placed.
- H. Water shall be applied at such times and in such quantities as directed.

### 3.8 TESTING

- A. Subbase course material shall be 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.
- B. Compaction: Tested in accordance with AASHTO T 191 (Sand Cone Method), AASHTO T 205 (Rubber Balloon Method) or AASHTO T 238 (Nuclear Method). If there is a significant delay between the construction of any layer and the following layer, the Supervision Consultant 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.

TABLE 2: Required Tests and Minimum Repetition for Subbase Course Material:

(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	When materials change	1. Proctor	Every 500 linear meter

	and/or as requested by Supervision Consultant		and/or as requested by Supervision Consultant
2. Plasticity Index and liquid limit	Every 500 linear m and/or when mater changed	2. Gradation	When materials changed and/or as requested by Supervision Consultant
3. Abrasion		3. Plasticity Index and liquid limit	Every 500 linear meter and/or when materials changed
4. CBR		4. CBR	
5. Sand Equivalent		5. Sand Equivalent	
6. Percentage of fractured Particles		6. Abrasion	
7. Chloride content		7. Clay lumps & friable particles	
8. Sulphate content		8. Field Density	Every 500 m <sup>2</sup>
		9. Thickness	As requested by Supervision Consultant

### 3.9 PROTECTION

- A. Do not perform work when the Supervision Consultant determines that weather or other conditions are such that construction operations will damage the finished work.
- B. Do not haul over aggregate subbase without approval. Repair damages resulting from occasional routing of equipment over the work.
- C. 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.



## SECTION 312200 - AGGREGATE BASE COURSE

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. This Section includes aggregate for base course constructed on the prepared underlying subbase course in accordance with the Specification and shall conform to the lines, grades, dimensions and typical cross section shown on the Drawings.
- B. Related Sections include the following:
  - 1. Division 31 Section 312100 "Aggregate Subbase" for aggregate subbase course
  - 2. Division 32 Section 321216 "Bituminous Pavement".

#### 1.3 DEFINITIONS

- A. Subbase: Compacted soil layer immediately below the base course.
- B. Subbase Layer: 200 mm depth of soil material immediately below base course.

#### 1.4 SUBMITTALS

- A. Product Data: For each type of manufactured material and product indicated.
- B. Samples: For the following:
  - 1. 100-kg samples, sealed in airtight containers, of each proposed aggregate material.
- C. Design Mixes: Based on heavy truck loading as per AASHTO criteria, for base course mix. Include alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.
  - 1. Provide compressive strength test results and moisture-density curves.
- D. 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 Supervision Consultant.
- E. Material Test Reports: Form a qualified independent testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of aggregate materials:
  - 1. Classification according to AASHTO M 145.
  - 2. Laboratory compaction curve according to AASHTO T180 (Method D).



3. Analysis of the results of testing as required by compaction and testing of earthworks.
- F. Material Certificates: Certificates signed by manufacturers certifying that each material complies with requirements.
- G. Field Records for the following:
1. Test Section
  2. Verification of compliance of subgrade or subbase, in accordance with specified requirements, prior to placement of base course.
  3. Laboratory reports; laboratory density test results for each lot.
  4. Field reports; in - place density test results for each lot.
- H. Photographs or videotape, sufficiently detailed, of existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by earthwork operations.
- I. Minutes of preinstallation conference.
- J. Daily progress reports, to include location of all construction joints.
- K. Method statement : Prior to commencing any work, the Contractor shall submit a 'Method Statement' detailing how each item of work will be performed, including:
1. Leveling Plan.
  2. Excavation Plan.
  3. Filling Plan.
  4. Methods of compaction and carrying out site grading.
  5. Control of water and dewatering plan.
  6. List of tools, equipment and transport trucks to be used.
  7. Supervision and control system.
- L. Quality control program.
- M. Weekly and monthly quality control reports.
- N. Survey measurements for tolerance control and payment purpose.
- O. Program of execution, calculation volume of excavations, periodicity of trucks, and fleet of trucks needed for the completion of the works within the program limits.
- P. Dumping area, relative permits and/or sub-agreements.
- 1.5 QUALITY ASSURANCE
- A. Codes and Standards: Comply with the Provisions of AASTO and ASTM circulars and standards, except where different requirements are specified or shown on the drawings.
- B. 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.

- C. Manufacturer Qualifications: Engage a firm experienced in manufacturing similar to that indicated for this Project and with a record of successful in-service performance.
- D. Surveyor Qualifications: An independent licensed surveyor, acceptable to the Supervision Consultant and experienced in ground surveys.
- E. Testing Agency Qualifications: Demonstrate to Supervision Consultant's satisfaction, based on Supervision Consultant'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.
- F. Regulatory Requirements: Conform to applicable standards of authorities having jurisdiction for asphalt paving work.
- G. Pre-installation Conference: Conduct conference at Project site to comply with General Requirements.

#### 1.6 PROJECT CONDITIONS

- A. Provide a minimum 48 hour notice to the Supervision Consultant, and receive written notice to proceed, before interrupting any service, facility or utility operated or occupied by the Employer or others.
- B. Protect base course from rain, wind and sun, indentation and physical damage.
- C. 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.
- D. 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.
  - 1. Whenever needed, additional test borings and other exploratory operations shall be conducted at the Contractor's own cost and expense.
- E. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earthwork operations.
  - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from employers and authorities having jurisdiction.
  - 2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
- F. Notify utilities companies and authorities having jurisdiction for area where Project is located before commencing earthwork operations.
- G. Existing Utilities: Do not interrupt utilities serving facilities on or adjacent to Project site unless permitted in writing by Supervision Consultant and then only after arranging to provide temporary utility services according to requirements indicated:
  - 1. Include interruptions of utilities in the Contractor's Construction Schedule (CPM schedule) as milestones. Comply with requirements of Section 013200 (Construction Progress Documentation).
  - 2. Coordinate interruptions of utilities with owner and authorities having jurisdiction in accordance with CPM schedule.

3. Do not proceed with utility interruptions without Supervision Consultant's written permission.
- H. 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

- A. Materials arising from excavations are to be used in base course aggregate if it complies with the AASHTO soil classification (A-1-a and A-1-b) or specified requirements unless instructed by the Supervision Consultant to be removed from the site.
- B. 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.
- C. Crushed Stone: Shall consist of hard, durable particles or fragments of stone, free from dirt or other objectionable matter, and shall contain not more than 8% of flat, elongated, soft, or disintegrated pieces.
- D. 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.
- E. 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.
- F. 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.
- G. Crushed Aggregate: Shall meet the requirements of one of the gradation shown in Table 1

TABLE 1: REQUIREMENTS FOR GRADATION OF AGGREGATE

Sieve Designation (Square openings)	Class A	Class B
	Percent by weight passing	
50 mm (2 in.)	100	-
25 mm (1 in)	75-95	100
9.5 mm (3/8 in.)	40-75	50-85
4.75 mm (No. 4)	30-60	35-65
2.00 mm (No. 10)	20-45	25-50
0.425 mm (No. 40)	15-30	15-30
0.075 mm (No.200)	5-20	5-15

- H. The material shall contain a minimum sand equivalent value of 45% (Dry condition) when tested in accordance with AASHTO T 176.

- I. 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.
- J. The percentage of wear shall not exceed 40% after 500 revolutions, when tested in accordance with AASHTO T 96 (Los Angeles Abrasion Test).
- K. The absorption should be not more than 10%.
- L. 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.
- M. When tested for soundness in accordance with AASHTO T 104, 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.
- N. 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. The friable particles 0.25% maximum.
- O. 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.
- P. 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

- A. 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

- A. 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 Supervision Consultant before construction is permitted to start.

#### 3.3 SURFACE PREPARATION

- A. Aggregate Base Course: Shall be placed directly on completed subbase. Preparation of the subbase surface shall be as specified in section 312100.

### 3.4 TRIAL SECTIONS

- A. If the Supervision Consultant deems it necessary the Contractor shall lay and compact trial sections of varying thickness of base. Each trial section shall be 2 lanes wide by 50 m long, at approved locations on or close to the Site. Each trial section shall be laid using the same materials, mix proportions, mixing, spreading and compaction equipment, and construction procedures, proposed for use in the Works.
- B. The objectives of these trials shall be to determine the adequacy of the Contractor's equipment, the loose depth measurements that will result in the specified compacted layer depths, the field moisture content for compaction, and the relationship between the number of compaction passes and the resulting density of the base course material.
- C. The Contractor shall not proceed with base course construction until the methods and procedures established in the trials have been approved.
- D. The compaction trials shall involve all procedures specified for the permanent works including testing of any equipment, processes or procedures as proposed by the Contractor which are not included as a part of these specifications. Construction of the permanent works shall not commence until a rolling / compaction procedure has been approved in writing by the Supervision Consultant. Such approval shall in no way relieve the Contractor of his responsibilities and obligations stipulated in the Contract.
- E. The compaction trials shall not be measured or paid for separately but shall be considered an incidental obligation of the Contractor under this Section of the Specifications.

### 3.5 MIXING AND SPREADING

- A. Before placing the mixed materials the surface of the sub-base shall be prepared.
- B. 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.
- C. The Supervision Consultant may allow other methods of mixing provided such methods(s) do not reduce the standard of work. Demonstrate, in the presence of the Supervision Consultant, ability to attain the requirement given in this Specification.
- D. Premixed material shall be placed on the sub-base in a uniform layer not less than 75 mm nor more than 200 mm of compacted thickness.
- E. Base 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.
- F. The amount of water added, as approved by the Supervision Consultant, shall be such that the material will be uniform and within the specified moisture content optimum range at the time of compaction.
- G. 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.

- H. All 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.
- I. Hauling or placement of material will not be permitted when, in the judgment of the Supervision Consultant, 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.

### 3.6 COMPACTION

- A. The water content of material shall be maintained during the placing period. Such adjustment in placing procedures or equipment shall be made as may be directed to obtain true grades, to minimize segregation of water, and to ensure a satisfactory base course
- B. Contractor shall 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 is 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 the Contractor's expense.
- C. Base 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.
- D. Rolling shall continue until the entire thickness of each base layer is thoroughly and uniformly compacted to 100% AASHTO T 180 maximum density.
  - 1. Density shall be measured in the field in accordance with AASHTO T 191 and determined in the laboratory in accordance with modified AASHTO T 180.
  - 2. Final rolling of the completed course shall be by means of an approved self-propelled roller.
  - 3. Rolling shall be accompanied by sufficient blading, to ensure a smooth surface, free from ruts or ridges and having the proper shape.
  - 4. When additional water is required, it shall be applied in an approved manner.
  - 5. The C.B.R. value of the base course after completion shall be more than 80%.
- E. Areas inaccessible to normal compaction equipment shall be compacted by use of portable mechanical tampers until the required standard of compaction is achieved, or to the satisfaction of Supervision Consultant.
- F. Each layer shall be completely compacted and approved prior to delivery of materials for the following layer.
- G. Prior to placing a following layer, the surface shall be made sufficiently moist as directed, to ensure proper bond between the layers.
- H. Edges and edge slopes of the base course shall be 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.
- I. Material which has dried out prior to final compaction, or which has dried and decompacted subsequent to final compaction, shall be watered and recompactd 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 Supervision Consultant.

### 3.7 TOLERANCES AND MAINTENANCE OF COMPLETED BASE

- A. The fully compacted and completed base course shall conform to the lines, grades and cross sections as shown on the Drawings.
- B. Elevations of the finished base course shall be checked in the presence of the Supervision Consultant at intervals of 20m on straight lines and of 10m on curves, and at intermediate points as directed.
- C. Tolerances (for final layer only) on elevations of finished surface shall not exceed + 10mm or - 15mm.
- D. When the finished surface is 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.
- E. All areas which exceed the specified tolerances 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.
- F. Following completion and acceptance of the base course, it shall be maintained by the Contractor at his own expense as follows:
  1. The surface shall be broomed, rolled and otherwise maintained, keeping it free from ravelling and other defects until such time as the following course is placed.
  2. Water shall be applied at such times and in such quantities as directed.
- G. 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 re-compaction may be done before applying prime coat. If full depth is dry, the whole base shall be removed and replaced.

### 3.8 TESTING

- A. Base course material shall be 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.
- B. Compaction: Tested in accordance with AASHTO T 191 (Sand Cone Method), AASHTO T 205 (Rubber Balloon Method) or AASHTO T 238 (Nuclear Method). If there is a significant delay between the construction of any layer and the following layer, Supervision Consultant 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.

TABLE 2: Required Tests and Minimum Repetition for Base Course Material

(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	When materials changed and/or as requested by Supervision Consultant	1. Proctor	Every 500 linear meter and/or as requested by Supervision Consultant
2. Plasticity Index and liquid limit	Every 500 linear meter and/or when materials changed	2. Gradation	When materials changed and/or as requested by Supervision Consultant
3. Abrasion		3. Plasticity Index and liquid limit	Every 500 linear meter and/or when materials changed
4. CBR		4. CBR	
5. Sand Equivalent		5. Sand Equivalent	
6. Percentage of fractured Particles		6. Abrasion	
7. Chloride content		7. Clay lumps & friable particles	
8. Sulphate content		8. Field Density	
			9. Thickness

### 3.9 PROTECTION

- A. Do not perform work when the Supervision Consultant determines that weather or other conditions are such that construction operations will damage the finished work.
- B. 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.





## SECTION 033000 - CAST-IN-PLACE CONCRETE

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. This Section specifies cast-in place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes.

#### 1.3 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag.

#### 1.4 PERFORMANCE REQUIREMENTS

- A. Structural Design: The Contractor shall carry out his own calculations and working drawings conforming to the information given below. The Contractor shall check and verify the following parameters for concrete design, and if there are any conflicts, he shall inform the Supervision Consultant as soon as possible and get approval before modifying anything.
- B. The structural design is based on the Lebanese code. If this code gives no guidance for case under consideration the following international codes of practice and standards, shall be used:
  - 1. Dynamic design
    - a. Seismic: UBC 1997 (Uniform Building Code)
    - b. Wind: The basic dynamic wind pressure shall be considered as given by an approved International Meteorology Service; (85 mile/hour).
  - 2. Reinforced concrete structures:
    - a. ACI 318M-11 (Building code requirements for reinforced concrete).
    - b. ACI 350R-01 (Code requirements for environment Engineering concrete structures).
    - c. AASHTO (American Association of State Highway and Transportation Officials).

3. Design Loads:
  4. Refer To AASHTO
  5. Any structural design carried out by the Contractor shall conform to these standards unless otherwise instructed by the Supervision Consultant.
- C. Seismic Data:
1. Seismic Zone: 3.
  2. Seismic zone factor: 0.25 g in accordance with Lebanese regulations.
- D. Bearing capacity and soil
1. The Contractor shall take all measures and procedures to verify the below mentioned values including soil testing investigation, soil treatment, etc.
  2. For the structures refer to the Geotechnical Investigation Report.
  3. Soil unit weight as per geotechnical report.
  4. Angle of internal friction : 30°
  5. Any cavities and voids found within the ground must be fully grouted so that the allowable ground bearing capacity is achieved.
- E. Live load on roads (retaining wall design) = 2t/m<sup>2</sup>.
- F. Temperature variation: ± 20°C.
- 1.5 SUBMITTALS
- A. Product Data: For each type of manufactured material and product indicated.
  - B. The Contractor shall submit to the Supervision Consultant complete calculation notes of all structural elements and information for concrete works
  - C. The contractor shall submit to the Supervision Consultant a complete method statement and materials submittal with detailed specification compliance sheet, for his approval.
  - D. Soil Investigation Report: The Contractor shall take all measures and procedures to verify the allowable soil bearing capacity values listed in the General Notes and Typical Details drawing and shall submit soil investigation report and method of soil treatment if necessary. The Contractor shall notify the Supervision Consultant in the event the investigation indicates significant variation from the values of the bearing capacity, angle of internal friction, etc,... listed in the above mentioned drawing. In the case dimensions, sections, and reinforcement of the foundation shall be revised accordingly at the Contractor's expenses on the basis of revised calculations to the approval of the Supervision Consultant.
  - E. Design Mixes: For each concrete mix. Include alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

- F. Execution, Shop and Coordination Drawings: Submit in a format approved by the Supervision Consultant, with full details to the satisfaction of the Supervision Consultant to assist him in his approval.
- G. Steel Reinforcement Shop Drawings: Placing drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement. Bending dimensions for scheduling of bars for the reinforcement shall be in accordance with BS 8666 and BS EN ISO37666.
- H. Formwork Shop Drawings: Prepared by or under the supervision of a qualified professional engineer detailing fabrication, assembly, and support of formwork. Design and engineering of formwork are Contractor's responsibility.
1. Shoring and Reshoring: Indicate proposed schedule and sequence of stripping formwork, shoring removal, and installing and removing reshoring.
- I. Admixtures Certificate: The following information shall be submitted to the Supervision Consultant concerning any admixture proposed for use :
1. Brand name, manufacturer's name and address with manufacturer's recommendations for the admixture.
  2. Typical dosage and detrimental effects of under-dosage and over-dosage.
  3. Chemical names of the main active ingredients in the admixtures.
  4. Whether admixture contains chlorides or not. If present, the chloride content should be expressed as a percentage of equivalent anhydrous calcium chloride by weight of admixture. Submit to the Supervision Consultant the admixtures intended to be used in the Concrete mix for his approval.
  5. Whether or not admixture leads to air entertainment when used at the manufacturers recommended dosage.
- J. Samples: For the types of product indicated.
- K. Welding certificates: Copies of certificates for welding procedures and personnel.
- L. Qualification Data: For Installer, manufacturer, independent testing agency, 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 Supervision Consultant.
- M. Material Test Reports: For the following, from a qualified independent testing agency, indicating compliance with requirements for the following tests:
1. Aggregates: main tests needed are: Sieve Analysis (ASTM C136), Passing No. 200 sieve, Determination of Acid chloride and sulfate (BS EN 1744), Los Angeles Abrasion (ASTM C131), Determination of clay lumps (ASTM C142), Density & Specific gravity & Absorption (ASTM C128 & C127), Sand Equivalent (ASTM D2419), Bulk density & unit weight (ASTM C29), Organic impurities (ASTM C40),

- Soundness of aggregates (ASTM C88), shell content, Elongation, in addition to a combined grading test for aggregates (crushed sand + natural sand + medium aggregates + coarse aggregates) including grading curves, and others upon Supervision Consultant's request
2. Cement: detailed chemical analysis & physical tests (initial setting + final setting + surface area), upon Supervision Consultant's request
  3. Water: Main tests required are: Chemical Analysis of water mainly PH testing (ASTM D 1293), Sulfate testing (ASTM D 516), Chloride testing (ASTM D 512), Total dissolved Solids, and others upon Supervision Consultant's request.
  4. Steel reinforcement: Main tests required are: Tensile Strength (ASTM A 370), Bending strength (ASTM A 370), chemical analysis test, and others upon Supervision Consultant's request.
  5. Admixtures and water repellent: Chloride content, sulfate content, PH, Density, and others upon Supervision Consultant's request.
  6. Micro silica: Chloride content, Density, and others upon Supervision Consultant's request.
- N. Material Certificates: For each of the following, signed by manufacturers:
1. Cementitious materials and aggregates.
  2. Admixtures.
  3. Form materials and form-release agents.
  4. Steel reinforcement and accessories.
  5. Fiber reinforcement.
  6. Waterstops.
  7. Curing materials.
  8. Floor and slab treatments.
  9. Bonding agents.
  10. Adhesives.
  11. Vapor retarders.
  12. Semirigid joint filler.
  13. Joint-filler strips.
  14. Repair materials.
- O. Source for all materials should be identified and approved by the Supervision Consultant.
- P. Submit technical sheet of the couplers for approval.
- Q. Floor surface flatness and levelness measurements to confirm compliance with specified tolerances.

- R. Field quality-control test and inspection reports.
- S. Minutes of preinstallation conference.

#### 1.6 QUALITY ASSURANCE

- A. Professional Engineer Qualifications: A professional engineer who is legally registered and qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for formwork and shoring and reshoring installations that are similar to those indicated for this Project in material, design, and extent.
- B. Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
- C. Testing Agency Qualifications: An independent agency, acceptable to Supervision Consultant and qualified according to ASTM C 1077 and ASTM E 329 to conduct the testing indicated as documented according to ASTM E 548, and approved by the Supervision Consultant.
- D. Concrete finishes, unless otherwise specified:
  - 1. Smooth finish: apply to all concrete surfaces, unless otherwise specified.
- E. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from one source, and obtain admixtures through one source from a single manufacturer.
- F. Welding: Qualify procedures and personnel according to AWS D1.4, "Structural Welding Code--Reinforcing Steel."
- G. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:
  - 1. ACI 301, "Specification for Structural Concrete."
  - 2. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."
- H. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.
- I. Acceptance tests: All materials, goods and products which are going to be used or introduced into the works shall be tested before delivery to the site to prove that they comply with the quality requirements. The compliance of the acceptance tests has to be approved by the Supervision Consultant.
- J. Routine tests: After the approval, all materials, goods and products need continuous quality control by routine testing after different intervals, if not exempted by the Supervision Consultant.

- K. Additional tests: Additional tests which are not mentioned in this specification may be required by the Supervision Consultant, have to be carried out according to the standard test procedures if not mentioned by the Supervision Consultant.
- L. 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.
1. Build mockups in the location and of the size indicated or, if not indicated, as directed by Supervision Consultant.
  2. Notify Supervision Consultant seven days in advance of dates and times when mockups will be constructed.
  3. In presence of Supervision Consultant, damage parts of exposed surfaces as selected by Supervision Consultant, and demonstrate materials and techniques proposed for repairs to match adjacent undamaged surfaces
  4. Obtain Supervision Consultant's approval of mockups before starting cast-in-place concrete elements exposed to view.
  5. If Supervision Consultant determines that any mockup does not meet requirements, demolish and remove from the site and cast another until the mockup is approved.
  6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
  7. Demolish and remove mockups when directed.
  8. Build panel approximately (18 sq. m) for slab-on-grade and (9 sq. m) for formed surface in the location indicated or, if not indicated, as directed by the Supervision Consultant..
  9. Approved panels may become part of the completed Work if undisturbed at time of Substantial Completion.
- M. Tolerances: according to BS 5606 or ACI 117.
- N. Preinstallation Conference: Conduct conference at Project site to comply with General Requirements.
1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:
    - a. Contractor's superintendent.
    - b. Independent testing agency responsible for concrete design mixes.
    - c. Ready-mix concrete manufacturer.
    - d. Concrete subcontractor.
  2. Review special inspection and testing procedures for field quality control, concrete finishes and finishing, cold- and hot-weather concreting procedures, curing

procedures, construction contraction and isolation joints, and joint-filler strips, semirigid joint fillers, forms and form removal limitations, anchor rod and anchorage device installation tolerances, steel reinforcement installation, floor and slab flatness and levelness measurement, concrete repair procedures, and concrete protection.

## 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage. All reinforcement shall be stored on racks clear of the ground.
- B. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.
- C. Ready-Mixed Concrete: Transport and deliver concrete according to ASTM C 94/C 94M and BS 5328, and furnish batch ticket information.
- D. When air temperature is between 30 and 32 deg C, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 32 deg C, reduce mixing and delivery time to 60 minutes.
- E. Cements: obtain from an approved source. Cement shall be delivered in sealed and branded containers in batches not exceeding 100 tons or in purpose-made bulk delivery vehicle. Store all cement in suitable weatherproof and approve storage sheds which protect the cement from dampness. The consignment of cement as received shall be separately stored and used in order of delivery. Do not use cement manufactured more than twelve months prior to propose use on the site.

## PART 2 - PRODUCTS

### 2.1 FORM-FACING MATERIALS

- A. Fairface Finished Concrete, where required:
  - 1. This type of surface finish denotes a special finish required from aesthetic considerations. In additions to the requirements of smooth formed finished concrete (as mentioned below) the following additional requirements shall apply.
    - a. Produce fair-face finish with impervious sheet material (e.g. plastics faced plywood/steel sheet)
    - b. The formwork shall leave no stain on the concrete and shall be so joined and fixed to its backing so that it imparts no blemishes. It shall be of the same type and obtained from only one source for any one structure. Furnish in largest practicable sizes to minimize number of joints.
    - c. No gravel or rough sand pockets to be visible at the surface. Surfaces shall be free from voids, honey-combing, fins, projections and other defects



- d. Internal ties and embedded metal parts shall not be permitted unless otherwise approved by the Supervision Consultant.
  - e. Do not use concrete cover spacers without approval.
  - f. It is of major importance that the special finishes required on fairface surfaces are uniformly and consistently maintained with no variation in the color or consistency of the concrete within the same structure.
  - g. In order to achieve this, the Contractor shall make trial panels of the formed finishes specified. These panels shall be not less than 1.5 m high and 1 m wide and 250 mm thick and shall be cast in the manner and with materials as proposed for the actual Work. These panels are for the approval of the liners and are preliminary to the test samples carried out on site.
  - h. The Contractor shall provide at his own expense as many panels as required by the Supervision Consultant until a satisfactory trial panel has been accepted by the Supervision Consultant. In addition, the Supervision Consultant will require samples of exposed faces to be cast on site in the same manner as proposed for the prototypes. The Contractor shall submit to the Supervision Consultant and obtain his approval for all details before commencement of trials. These samples, when approved, will form the standard against which the corresponding finishes on the actual work will be judged.
  - i. If the required finish in the opinion of the Supervision Consultant, has not been obtained in the Works, the Contractor shall promptly carry out at his own expense all measures required by the Supervision Consultant to obtain the specified finish. Where remedial action is ordered by the Supervision Consultant, the entire exposed surface shall be so treated irrespective of whether or not the defective areas are localized or extensive.
  - j. Forms for circular, cylindrical and curved columns and walls, Pedestals, and Supports: Metal, glass-fiber-reinforced plastic, or fiber tubes that will produce fairfaced surfaces. Provide units with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.
- B. Smooth-Formed Finished Concrete:
1. Plywood, metal, or other approved panel materials.
  2. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and as follows:
    - a. High-density overlay, Class 1 or better.
    - b. Medium-density overlay, Class 1 or better; mill-release agent treated and edge sealed.
    - c. Structural 1, B-B or better; mill oiled and edge sealed.
    - d. B-B (Concrete Form), Class 1 or better; mill oiled and edge sealed.
  3. Form-facing panels that will provide continuous and smooth concrete surfaces of uniform appearance. Surfaces shall be free from voids, honey-combing, fins, projections and other defects.

4. Furnish in largest practicable sizes to minimize number of joints.
- C. Sides of footings shall be cast directly into the excavation walls, unless otherwise directed by the Supervision Consultant.
- D. Chamfer Strips: Wood, metal, PVC, or rubber strips, (20 by 20 mm), minimum wherever required.
- E. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.
  1. Formulate form-release agent with rust inhibitor for steel form-facing materials.
- F. Form Ties: Factory-fabricated, removable or snap-off metal or glass-fiber-reinforced plastic form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
  1. Furnish units that will leave no corrodible metal closer than 25 mm to the plane of exposed concrete surface.
  2. Furnish ties that, when removed, will leave holes no larger than 25 mm in diameter in concrete surface.
  3. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

## 2.2 STEEL REINFORCEMENT

- A. Reinforcing Bars: High tensile steel conforming to ASTM-A 615M, Grade 75, deformed,  $f_y = 5200 \text{ Kg/cm}^2$ .
  1. Maximum Carbon Content: 0.3%
- B. Low-Alloy-Steel Reinforcement Bars: ASTM A706, deformed when welding is required.
- C. Steel Bar Mats: ASTM A 184M, assembled with clips.
- D. Plain-Steel Welded Wire Reinforcement: ASTM A 185, plain, fabricated from as-drawn steel wire into flat sheets.
- E. Deformed-Steel Welded Wire Reinforcement: ASTM A 497, flat sheet.
- F. Reinforcement weight/m as published in the BS4449 shall be used for calculating reinforcement quantities.

## 2.3 REINFORCEMENT ACCESSORIES

- A. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place.

1. Spacers shall be of such materials and design as will be dense durable, not lead to corrosion of the reinforcement, and not cause spalling of the concrete cover. Spacer blocks made from cement, sand and small aggregates shall match the mix proportions and appearance of the surrounding concrete and shall have cylinder compressive strength, durability of not less than the surrounding concrete. They shall accordingly support the reinforcement, resist displacement, not cause indentation of the formwork.
  2. Spacers will not be permitted against a concrete face which will be exposed in the finished works.
  3. Concrete spacer blocks made on Site are not permitted.
  4. For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected or CRSI Class 2 stainless-steel bar supports.
- B. Joint Dowel Bars: Plain-steel bars, ASTM A 615M, Grade 420. Cut bars true to length with ends square and free of burrs.

C. COUPLERS

1. Couplers shall comply with BS 8110 when used with reinforcement bar.
2. Standard tapered thread coupler to join the reinforcing bars. It comprises an internally threaded sleeve with two right hand threads tapered toward the middle of the coupler.
3. Installation:
  - a. Supply coupler fixed to one of the corresponding reinforcing bar.
  - b. Position the continuation bar in the sleeve and rotate the bar into the coupler
  - c. Tighten the joint to the specified torque using a wrench on the continuation bar.

4. Coupler dimension shall be as per the following table:

Bar diameter	12	16	20	25	32	40	50
External diameter (d)	22	25	30	36	46	55	70
Coupler length (l)	58	70	74	90	112	138	170
Weight (kg)	0.04	0.17	0.26	0.43	0.86	1.42	2.22
Torque (Nm)	60	110	165	265	285	330	350

5. Manufacturer: Lenton by Erico, or approved equal.

2.4 CONCRETE MATERIALS

- A. Portland Cement: ASTM C 150, Ordinary Portland Cement Type II. (Moderate Sulfate Resistant Cement) Use one brand and source of cement throughout the project unless otherwise approved by the Supervision Consultant.
- B. Cementitious replacement material may be added to substructure concrete to ensure durability requirements as below.

1. Fly Ash: ASTM C 618, Class F.
  2. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
- C. High Alumina Cement: is prohibited.
- D. Normal-Weight Aggregates: ASTM C 33, for “Severe Weathering Region” hard durable carefully graded to the requirements of ASTM C 33. Provide aggregates from a single source.
1. Nominal Maximum Coarse-Aggregate Size: 20 mm.
  2. Combined Aggregate Gradation: Well graded from coarsest to finest with not more than 18 percent and not less than 8 percent retained on an individual sieve, except that less than 8 percent may be retained on coarsest sieve and on 0.3-mm sieve, and less than 8 percent may be retained on sieves finer than 0.3 mm.
  3. Material passing the 0.075-mm sieve must not, in any case, exceed 3 percent, by weight, of the combined aggregate.
  4. Maximum water absorption of 2%, for all types of aggregates, when tested according to ASTM C127.
  5. Free of material causing staining or reacting with cement and with less than 5% magnesium, sulfate soundness loss.
  6. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement obtained from natural sand.
  7. All sand shall be screened and washed. Beach sand is not allowed.
- E. Lightweight aggregates:
1. The lightweight aggregates shall be composed predominately of lightweight cellular and granular inorganic material.
  2. For insulating concrete: Unless otherwise specified, the lightweight aggregates for insulating concrete shall comply in all respects with ASTM C332
- F. Water: ASTM C 94/C 94M and potable.

## 2.5 ADMIXTURES

- A. Suitable admixtures may be used only if approved by the Supervision Consultant. Both proposed dosage and method of use shall be submitted to the Supervision Consultant.
- B. Standards: Tests for quality control on the main types of admixtures shall be carried out according to ASTM C494 and ASTM C260 respectively.
- C. Trial mix: Before approving any admixture, the Supervision Consultant shall require tests to be carried out. These shall be done by trial mixes and compared with concrete of the same class but containing no admixture (control mix) to determine the effects of the admixture especially regarding workability, setting time, and density.

- D. Admixtures should not impair the durability of the concrete nor combine with the ingredients to form harmful compounds nor increase the risk of corrosion of the reinforcement.
- E. No deviation from the approved sources of colouring agents shall be allowed by the Supervision Consultant or by the Owner.
- F. Pulverized fuel ash shall not be permitted and should not be used for sulphate resisting concrete.
- G. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
  - 1. Air-Entraining admixture: ASTM C 260.
  - 2. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
  - 3. Retarding Admixture: ASTM C 494/C 494M, Type B.
  - 4. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
  - 5. Water-Reducing and Accelerating Admixture: ASTM C 494, Type E.
  - 6. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
  - 7. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
  - 8. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.
- H. Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete and complying with ASTM C 494/C 494M, Type C.
- I. Non-Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, non-set-accelerating, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete.
- J. Color Pigment: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, free of carbon black, nonfading, and resistant to lime and other alkalis.
  - 1. Color: As selected and approved by the Supervision Consultant.

## 2.6 WATERSTOPS

- A. Flexible PVC Waterstops: CE CRD-C 572, with factory-installed metal eyelets, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.

1. Profile: Surface type ribbed with central bulb at expansion joint and ribbed without center bulb at construction joint.
2. Dimensions: 225 mm by 10 mm thick; nontapered, unless otherwise specified.

## 2.7 VAPOR RETARDERS

- A. Vapor Retarder: ASTM E 1745, Class C; or polyethylene sheet, ASTM D 4397, not less than 0.25 mm thick:

## 2.8 FLOOR AND SLAB TREATMENTS (WHERE SLABS ARE EXPOSED)

- A. Slip-Resistive Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of fused aluminum-oxide granules or crushed emery with emery aggregate containing not less than 50 percent aluminum oxide and not less than 25 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials.
- B. Unpigmented Mineral Dry-Shake Floor Hardener: Factory-packaged dry combination of portland cement, graded quartz aggregate, and plasticizing admixture.
- C. Pigmented Mineral Dry-Shake Floor Hardener: Factory-packaged dry combination of portland cement, graded quartz aggregate, coloring pigments, and plasticizing admixture. Use coloring pigments that are finely ground, nonfading mineral oxides interground with cement.
  1. Color: As selected by the Supervision Consultant from manufacturer's full range.
- D. Penetrating Liquid Floor Treatment: Clear, chemically reactive, waterborne solution of inorganic silicate or silicate materials and proprietary components; odorless; colorless; that penetrates, hardens, and densifies concrete surfaces.

## 2.9 CURING MATERIALS

- A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.
- B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 305 g/sq. m when dry.
- C. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- D. Water: Potable.
- E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

- F. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, nondissipating, certified by curing compound manufacturer to not interfere with bonding of floor covering.

## 2.10 RELATED MATERIALS

- A. Polythene sheet under slab on grade: should have a water vapor performance of 0.016 grain/hr.ft<sup>2</sup>.in.Hg in accordance with ASTM E 96 and should be approved by the Supervision Consultant.
- B. Expansion and Isolation Joint Fillers: Extruded-Polystyrene Board Insulation, ASTM C 578, of type IV. Joints shall agree with the structural requirements, having the following technical characteristics:
  - 1. Minimum density should be 32-35 kg/m<sup>3</sup>.
  - 2. Minimum compressive strength = 300 KPa
  - 3. Water Absorption: 1 % by Volume.
  - 4. Flammability: Class B1, as per DIN 4102.
  - 5. Thermal Conductivity: 0.032 W/mK
  - 6. Widths and thicknesses: as shown on drawings and details.
  - 7. Approved Manufacturer: Carlisle or approved equal.
- C. Fire Resistant Joint fillers, as per Supervision Consultant' request. Heavy duty Board glue: of type as required by the Supervision Consultant.
- D. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
- E. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements, and as follows:
  - 1. Types I and II, non-load bearing and IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.
- F. All bolts, washers, nuts and threads shall conform to BS 4190 Gr. 4.6 or ASTM A325 when diameter is less than 16mm and to BS 3692 Gr. 8.8 and 10.9 or ASTM A490 when diameter is greater than 16mm.
- G. 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.
- H. 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.

- I. All embedded steel components shall be hot dip galvanized steel in accordance with ASTM A123 or ASTM A153 as appropriate of grade 50 unless otherwise specified.

## 2.11 REPAIR MATERIALS

- A. 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.
  1. Cement Binder: ASTM C 150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
  2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
  3. Aggregate: Well-graded, washed gravel, 3.2 to 6 mm or coarse sand as recommended by underlayment manufacturer.
  4. Cylinder compressive Strength: Not less than 350 Kg/cm<sup>2</sup> at 28 days when tested according to ASTM C 109/C 109M.
- B. Repair Overlayment: 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.
  1. Cement Binder: ASTM C 150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
  2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
  3. Aggregate: Well-graded, washed gravel, 3 to 6 mm or coarse sand as recommended by topping manufacturer.
  4. Cylinder compressive Strength: Not less than 350 Kg/cm<sup>2</sup> at 28 days when tested according to ASTM C 109/C 109M.

## 2.12 POST INSTALLED REBAR CONNECTIONS USING INJECTION MORTAR

- A. Injection mortar shall be used whenever post installed rebar connections are required to connect new reinforcement to existing structure.
- B. Rebar applications are, but not limited to the following:
  1. Structural connections (e.g. walls, slabs, stairs, etc...).
  2. Starter bars.
  3. Variations to design.
- C. The contractor is requested to submit the following:
  1. Product description (material, suitability for cracked or uncracked concrete, suitability for seismic design, etc...).



2. Injection mortar technical data sheet
  3. European Technical Approval (ETA).
  4. ISO certificate.
  5. Design loads, design concept and embedment depth.
  6. Field pull out test done by an independent agency, and in presence of the consultant.
  7. Sample.
  8. Detailed method of application including method of borehole cleaning.
  9. 5 years warranty for materials and workmanship from the date of Taking Over Certificate of the whole of the Works.
- D. Approved manufacturers: HILTI, SIKA, FISCHER, or approved equal.

### 2.13 CONCRETE MIXES, GENERAL

- A. Prepare design mixes for each type and strength of concrete determined by either laboratory trial mix or field test data bases, as follows:
1. Proportion normal-weight concrete according to ACI 211.1 and ACI 301.
  2. Proportion lightweight structural concrete according to ACI 211.2 and ACI 301.
- B. Use a qualified independent testing agency for preparing and reporting proposed mix designs based on laboratory trial mixes.
- C. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.
- D. Total sulphate content in concrete mix arising from constituents and other sources shall not exceed 0.4% by weight of aggregates or 4.0% by weight of cement in mix.
- E. Slump
1. as directed by the Supervision Consultant.
- F. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:
1. Fly Ash: 25 percent.
  2. Combined Fly Ash and Pozzolan: 25 percent.
  3. Ground Granulated Blast-Furnace Slag: 50 percent.
  4. Combined Fly Ash or Pozzolan and Ground Granulated Blast-Furnace Slag: 50 percent portland cement minimum, with fly ash or pozzolan not exceeding 25 percent.
- G. Air Content max : 2 percent for 20-mm- nominal maximum aggregate size.

- H. Do not air entrain concrete to trowel-finished interior floors and suspended slabs. Do not allow entrapped air content to exceed 3 percent.
- I. Admixtures: Use admixtures according to manufacturer's written instructions and as specified.
  - 1. Use water-reducing admixture or high-range water-reducing admixture (superplasticizer) in concrete, as required, for placement and workability.
  - 2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions
  - 3. 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 0.50.
  - 4. Use corrosion-inhibiting admixture in concrete mixes where indicated.
- J. Evidence of suitability : For each mix submit, in writing, details of:
  - 1. Proposed quantities of each ingredient per cubic meter of compacted concrete,
  - 2. Evidence showing that proposed constituent materials and method of manufacturing will produce concrete of required quality.
- K. Approval: Do not use mixes before submitted information and evidences have been approved. This approval is not however sufficient by itself and will not interfere or influence other requirements pertaining to mixes' compliance with due specifications.
- L. Color control: Obtain approval before altering proportions or grading of concrete exposed in finished work.

## 2.14 CONCRETE MIXES FOR CONCRETE ELEMENTS

- A. Proportion normal-weight concrete mixture.
- B. The Contractor shall submit for approval concrete mix designs for each class of concrete to be used in the works.
- C. The concrete compressive strength is defined in terms of the 28 day characteristic strength for 15x30 standard cylinder. The compressive strengths listed below are the design compressive strengths. The average of all cylinder crushing strengths obtained on site for each of the sections of the Project shall exceed the required design characteristics strength  $f^c$  as recommended by concrete conformity procedures in British Standards.
- D. Classes of Concrete
  - 1. Slab on grade etc...  
 $f^c = 30$  MPa
  - 2. Blinding  
 $f^c = 20$  MPa.

3. Cyclopean Concrete  
 $f'c = 15 \text{ MPa}$

Where  $f'c$  is the compressive strength on cylinder 15x30cm after 28 days.

E. Water Cement Ratio and Minimum Cement Content

1. For structural concrete with  $f'c = 30 \text{ MPa}$ , water cement ratio shall be 0.35, the minimum cement content shall be  $400 \text{ Kg/m}^3$ .
2. For blinding concrete  $f'c = 20 \text{ MPa}$ , maximum water-cement ratio shall be 0.5, the minimum cement content shall be  $250 \text{ Kg/m}^3$ .
3. For cyclopean concrete  $f'c = 15 \text{ MPa}$ , the minimum cement content shall be  $150 \text{ Kg/m}^3$ .
4. For screed the minimum cement content shall be  $200 \text{ Kg/m}^3$ .

F. Chloride Permeability

1. Chloride permeability of underground concrete structure shall not exceed 2000 coulomb tested in accordance with ASTM C1202.

G. Basis of Design

1. The Contract design has been produced on the basis of a design compressive strength on cylinder at 28 days.
2. The inter-relation between cube 15x15x15cm versus cylinder 15x30cm strength of concrete will be based upon the BS 8500-1, 2002, table A.20 and BS EN 206-1 if directed by the Supervision Consultant.

- H. All concrete are to be normal weight ( $2500 \text{ Kg/m}^3$ ), well compacted and in accordance with the specification.

## 2.15 FABRICATING REINFORCEMENT

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

## 2.16 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and ASTM C 1116, and furnish batch ticket information. Each load shall be accompanied by a delivery note stamped with the time of mixing and stating the concrete grade and quantities of each material including water additives.
1. When air temperature is between 30 and 32 deg C, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 32 deg C, reduce mixing and delivery time to 60 minutes.
- B. In situ Mixing on Site: Not allowed under any circumstances, unless specifically authorized by the Supervision Consultant.

2.17 TESTING AND APPROVAL OF CONSTITUENT MATERIALS

- A. Preliminary tests and samples: tests and samples shall be provided and approved before making and placing concrete unless otherwise specified.
- B. Samples of natural aggregates: submit preliminary samples to ASTM or BS standards of aggregates proposed for concrete work.
- C. Preliminary tests on natural aggregates: obtain preliminary tests to ASTM or BS standards for:
  - 1. Sieve analysis
  - 2. Clay, silt and fine dust
  - 3. Specific gravity
  - 4. Water absorption
  - 5. Bulk density, voids and bulking
  - 6. Moisture content
  - 7. Organic impurities
  - 8. Aggregate impact value
  - 9. Aggregate crushing value
  - 10. 10% fines value
  - 11. Crushing strength
  - 12. Aggregate abrasion value
  - 13. Chemical properties (soluble salt contents).Obtain tests on every consignment from a new source and additional tests required by the Supervision Consultant.
- D. Test certificates for cement: provide manufacturer's test certificates and obtain approval before starting trial mixes. Obtain manufacturer's test certificates every 28 days during the progress of the work and retain on the site.
- E. Tests on cement: representative samples from a minimum of ten bags from each batch shall be obtained and tested in accord with the requirements of BS 12, BS 4027 or ASTM C150 depending on the type of cement. Batches and consignments which do not fulfill the required cement quality tests shall not be used in the work and shall be removed immediately from the site.

## PART 3 - EXECUTION

## 3.1 FORMWORK

- A. 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 structure can support such loads.
- B. Construct formwork to concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.
- C. Limit concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:
  - 1. Class A, (3 mm) for smooth-formed finished surfaces with no finishes.
  - 2. Class B, (6 mm) for rough-formed finished surfaces intended to receive plaster or stucco.
- D. Construct forms tight enough to prevent loss of concrete mortar.
- E. 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.
  - 1. Install keyways, reglets, recesses, and the like, for easy removal.
  - 2. Do not use rust-stained steel form-facing material.
- F. 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.
- G. 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.
- H. Chamfer exterior corners and edges of concrete receiving applied waterproofing membranes.
- I. Do not chamfer corners or edges of concrete unless otherwise indicated..
- J. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.
- K. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

- L. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
- M. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.
- N. The Contractor should provide a workshop to repair the defective formwork on site. The re-use of formwork is depending on the resulting finish quality and according to the Supervision Consultant for approval.

### 3.2 EMBEDDED ITEMS

- A. 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. Embedded items shall be provided in due time for installation, without delaying the progress of the work.
  - 1. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC's "Code of Standard Practice for Steel Buildings and Bridges."
  - 2. Install reglets to receive 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.
  - 3. Install dovetail anchor slots in concrete structures as indicated.
- B. The Contractor shall refer to mechanical and electrical drawings for verification of openings, pipes and sleeves (location, size, levels,...) in the reinforced concrete structural members. No openings, pipes or sleeves other than indicated on structural drawings shall be placed without the approval of the Supervision Consultant.

### 3.3 REMOVING AND REUSING FORMS

- A. 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 for 24 hours after placing concrete, if concrete is hard enough to not be damaged by form-removal operations and curing and protection operations are maintained.
- B. Leave formwork for beam soffits, joists, slabs, and other structural elements that supports weight of concrete in place as specified.
  - 1. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.
- C. In determining the time for the removal of forms, consideration shall be given to the location and character of the structure, weather and other conditions influencing the setting of the concrete.

- D. Formwork shall be removed in a manner not to damage the concrete, and at times to suit the requirements for its curing and to prevent restraint that may arise from elastic shortening, shrinkage or creep.
- E. Minimum Period Before Striking for Ordinary Structural Concrete:

Type of Formwork	Minimum Period Before Striking Surface Temperature of Concrete		
	16°C	7°C	t°C
Vertical formwork to columns, walls and Large beams	24 hours	36 hours	<u>600 hrs</u> t + 10
Soffit formwork to slabs	6 days	9 days	<u>150 days</u> t + 10
Props to slabs	10 days	15 days	<u>250 days</u> t + 10
Soffit to formwork to beams	9 days	14 days	<u>230 days</u> t + 10
Props to beams	14 days	21 days	<u>360 days</u> t + 10

- F. 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.
- G. 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 Supervision Consultant.

### 3.4 SHORES AND RESHORES

- A. Comply with ACI 318 (ACI 318M) and ACI 301 for design, installation, and removal of shoring and reshoring.
  - 1. Do not remove shoring or reshoring until measurement of slab tolerances is complete.
- B. 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.
- C. 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.

### 3.5 VAPOR RETARDERS

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

### 3.6 STEEL REINFORCEMENT

- A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that would reduce bond to concrete.
- C. 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.
  - 1. Weld reinforcing bars according to AWS D1.4 only, where indicated and allowed by the Supervision Consultant.
- D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.
- E. Install welded wire reinforcement 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.
- F. Unless otherwise noted, splice lengths shall be as follows:
  - 1. 60 x Bar diameter for beams, slabs, walls, columns and footings. No splice shall be made at places not indicated on drawings without the approval of the Supervision Consultant.
- G. Reinforcement shall not be in contact with pipework.
- H. Bending dimensions for scheduling of bars for the reinforcement shall be in accordance with ASTM A615 or BS 8666.
- I. All reinforcement details shall be in accordance with ACI 318 for in-situ and cast reinforced concrete. In addition all reinforcement detail shall be in accordance with the recommendations of the ACI 315-29 details and detailing of the concrete reinforcement.
- J. Unless otherwise shown on drawings, the minimum concrete protective cover for reinforcement shall be as follows:
  - 1. For fair faced concrete elements exposed to weather: 5.0 cm
  - 2. For basement walls: Outside face: 5.0 cm Inside face: 5.0 cm
  - 3. For footings: 5.0 cm
  - 4. For all surfaces in contact with water or vapor: 5.0 cm
  - 5. For earth retaining walls: Exposed to earth: 5.0 cm Exposed to weather: 5.0 cm
  - 6. For slabs, beams and walls not exposed to earth or weather: 3.0 cm



### 3.7 JOINTS

- A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.
- B. Joints shall be located between areas having different loads.
- C. Expansion joints shall have class I movement capability.
- D. Joints shall agree with the structural requirements.
- E. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by the Supervision Consultant.
  - 1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.
  - 2. Form keyed joints as indicated. Embed keys at least (38 mm) into concrete.
  - 3. 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.
  - 4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
  - 5. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
  - 6. Approval from the design Engineer shall be obtained for the location of any construction joints not shown on the plans.
- F. 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 1cm, unless otherwise specified as follows:
  - 1. 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. The Contractor shall propose and submit a detailed layout for contraction joints to be approved by the Supervision Consultant prior to any execution works.
  - 2. 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.
- G. 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.
  - 1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface, unless otherwise indicated.

2. Terminate full-width joint-filler strips not less than 13 mm or more than 25 mm below finished concrete surface where joint sealants, specified in Division 7 Section 079200 "Joint Sealants," are indicated.
3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.

### 3.8 WATERSTOPS

- A. Flexible Waterstops: Install in construction joints and at other joints indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of the Work. Field fabricate joints in waterstops according to manufacturer's written instructions.

### 3.9 CONCRETE PLACEMENT

- A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.
- B. Do not add water to concrete during delivery, at Project site, or during placement unless approved by the Supervision Consultant.
- C. Deposit concrete continuously in one layer or in horizontal 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 indicated. Deposit concrete to avoid segregation.
  1. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.
  2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
  3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations 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 mixture constituents to segregate.
  4. Under condition of rain, the placing of concrete shall not commence or shall be stopped unless adequate protection is provided to prevent damages to the surface mortar, or damaging flow, or wash of the Concrete surface.
- D. 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.
  1. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
  2. Maintain reinforcement in position on chairs during concrete placement.

3. Screed slab surfaces with a straightedge and strike off to correct elevations.
  4. Slope surfaces uniformly to drains where required.
  5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.
- E. 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 frost, freezing actions, or low temperatures.
1. When average high and low temperature is expected to fall below (4.4 deg C) for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.
  2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
  3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.
  4. Under condition of rain, the placing of concrete shall not commence or shall be stopped unless adequate protection is provided to prevent damage to the surface mortar, or damaging flow, or wash of the concrete surface.
- F. Hot-Weather Placement: Comply with ACI 301 and/or BS 8110 clause 6.2.5, and as follows:
1. Maintain concrete temperature between 20 and 22 deg C at time of placement. Chilled mixing water 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 Contractor's option.
  2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.
  3. On exposed concrete surface in high sun temperatures and/or strong drying wind conditions, the Contractor shall use a curing method which also shields the concrete and this shall be placed in position no later than half an hour after final tamping. If the surface exhibits cracking while the concrete is still plastic then it shall be re-tamped to close the cracks.
  4. No Concrete shall be placed whilst the shade temperature is above the requirements of ACI 301. The Contractor shall supply an accurate maximum and minimum thermometer and hang it in an approved position in the works.
- G. Foundations shall be supported on original stiff strata. In case foundations must be supported on fill, cyclopean concrete or proper compaction shall be performed according to Supervision Consultant instruction and approval.

### 3.10 FINISHING FORMED SURFACES

- A. General: Comply with ACI 301 and ACI 347 requirements for finishing formed surfaces.

- B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defects. Remove fins and other projections that exceed herein specified limits on formed-surface irregularities.
  - 1. Apply to all concrete surfaces, unless otherwise specified.
- C. 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.

### 3.11 FINISHING FLOORS AND SLABS

- A. General: Comply with ACI 302.1R recommendations for screeding, restraighening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.
- B. Scratch Finish: While still plastic, texture concrete surface that has been screeded and bull-floated or darbied. Use stiff brushes, brooms, or rakes to produce a profile amplitude of 1/4 inch (6 mm) in 1 direction.
  - 1. Apply scratch finish to surfaces indicated to receive concrete floor toppings and to receive mortar setting beds for bonded cementitious floor finishes.
- C. Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power driven floats. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraighening until surface is left with a uniform, smooth, granular texture.
  - 1. Apply float finish to surfaces to receive trowel finish and to be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing.
- D. Trowel Finish: After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and restraighten until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
  - 1. Apply a trowel finish to surfaces exposed to view or to be covered with thin-film-finish coating system.
  - 2. Finish and measure surface so gap at any point between concrete surface and an unveled, freestanding, (3-m-) long straightedge resting on 2 high spots and placed anywhere on the surface does not exceed (3.2 mm)
- E. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, and ramps, and elsewhere as indicated.
  - 1. 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 Supervision Consultant before application.

- F. 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:
1. 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.
  2. After broadcasting and tamping, apply float finish.
  3. After curing, lightly work surface with a steel wire brush or an abrasive stone, and water to expose slip-resistive aggregate

### 3.12 MISCELLANEOUS CONCRETE ITEMS

- A. 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 the Work.
- B. 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 from manufacturer furnishing machines and equipment.

### 3.13 CONCRETE PROTECTING AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 301 for hot-weather protection during curing.
- B. 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.
- C. 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 for the remainder of the curing period.
- D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.
- E. Cure concrete according to ACI 308.1, by one or a combination of the following methods:
1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
    - a. Water.

- b. Continuous water-fog spray.
  - c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 300-mm lap over adjacent absorptive covers.
2. 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.
    - a. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.
    - b. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.
    - c. Cure concrete surfaces to receive floor coverings with either a moisture-retaining cover or a curing compound that the manufacturer certifies will not interfere with bonding of floor covering used on Project..
  3. Curing Compound: Apply uniformly in 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. Maintain continuity of coating and repair damage during curing period.
    - a. After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer unless manufacturer certifies curing compound will not interfere with bonding of floor covering used on Project.
  4. 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.

### 3.14 LIQUID FLOOR TREATMENTS

- A. Penetrating Liquid Floor Treatment: Prepare, apply, and finish penetrating liquid floor treatment according to manufacturer's written instructions.
  1. Remove curing compounds, sealers, oil, dirt, laitance, and other contaminants and complete surface repairs.
  2. Do not apply to concrete that is less than 28 days' old.
  3. 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.
- B. 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.

### 3.15 CONCRETE SURFACE REPAIRS

- A. Defective Concrete: Repair and patch defective areas when approved by the Supervision Consultant. Remove and replace concrete that cannot be repaired and patched to the Supervision Consultant's approval.
- B. Patching Mortar: Mix dry-pack patching mortar, consisting of one part Portland cement to two and one-half parts fine aggregate passing a No. 16 (1.18-mm) sieve, using only enough water for handling and placing.
- C. 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.
  - 1. 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.
  - 2. 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.
  - 3. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by the Supervision Consultant.
- D. 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.
  - 1. 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.
  - 2. After concrete has cured at least 14 days, correct high areas by grinding.
  - 3. 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.
  - 4. 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.
  - 5. 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.

6. 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 a (19-mm) clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mixture as original concrete except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
  7. 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.
- E. Perform structural repairs of concrete, subject to the Supervision Consultant's approval, using epoxy adhesive and patching mortar.
- F. Repair materials and installation not specified above may be used, subject to the Supervision Consultant's approval.

### 3.16 FIELD QUALITY CONTROL

- A. Samples: To ensure adequate quality control of mixes on the site, take samples per type of concrete such as (slab on grade, walls, beams, columns, etc...) of each concrete mix from every mixing point in accordance with the recommendations of BS 8110 and the requirements of BS 1881 or in accordance with ACI 318-89 Part 3, Chapter 4.
- B. Testing and Inspecting: Engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- C. Inspections:
1. Steel reinforcement placement.
  2. Steel reinforcement welding.
  3. Headed bolts and studs.
  4. Verification of use of required design mixture.
  5. Concrete placement, including conveying and depositing.
  6. Curing procedures and maintenance of curing temperature.
  7. Verification of concrete strength before removal of shores and forms from beams and slabs.
- D. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:



1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 4 cu. m, but less than 20 cu. m, plus one set for each additional 38 cu. m or fraction thereof.
2. When frequency of testing will provide fewer than five compressive strength tests for each concrete mix, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
3. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
4. Air Content: ASTM C 231, pressure method, for normal-weight concrete; AASTM C 1733, volumetric method, for structural light weight concrete, one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
5. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 4.4 deg C and below and when 27 deg C and above, and one test for each composite sample.
6. Unit Weight: ASTM C 567, fresh unit weight of structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
7. Compression Test Specimens: ASTM C 31/C 31M.
  - a. Cast and laboratory cure two sets of two standard cylinder specimens for each composite sample.
  - b. Cast and field cure two sets of two standard cylinder specimens for each composite sample.
8. Cylinder compressive-Strength Tests: ASTM C 39/C 39M; test one set of two laboratory-cured specimens at 7 days and one set of two specimens at 28 days.
  - a. Test one set of two field-cured specimens at 7 days and one set of two specimens at 28 days.
  - b. A cylinder compressive-strength test shall be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.
9. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
10. Strength of each concrete mixture will be satisfactory if every average of any three consecutive cylinder compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa).
11. Test results shall be reported in writing to the Supervision Consultant, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions

- and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
12. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by the Supervision Consultant but will not be used as sole basis for approval or rejection of concrete.
  13. Permeability Tests for all concrete in contact with soil and/or water:
    - a. Absorption Test: The absorption test of the hardened concrete shall be carried out as a measure of water permeability on prototype samples of different components of the structure before the mix design or manufacturing method are approved. The prototype samples shall be short sections of not less than 1.0m x 1.0m x full thickness. The samples shall be fully reinforced and cast in similar environment as the actual structure. Absorption tests shall be in accordance with BS 1881 Part 122.
      - 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 2 percent.
      - One test should be performed each one month for each used mix. If results show consistency, frequency of tests may be reduced as directed by the Supervision Consultant.
    - b. The chloride permeability of the concrete shall be determined using cores taken from the prototype samples, in accordance with ASTM C1202 or AASHTO T277 "Rapid Determination of the Chloride Permeability of Concrete". The limit of 2000 coulombs shall not be exceeded.
    - 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.
  14. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by the Supervision Consultant. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42/C 42M or by other methods as directed by the Supervision Consultant.
  15. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
  16. Correct deficiencies in the Work that test reports and inspections indicate does not comply with the Contract Documents.
- E. Measure floor and slab flatness and levelness according to ASTM E 1155 (ASTM E 1155M) within 48 hours of finishing.