

DIVISION 3
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SECTION 03100

FORMWORK

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Formwork for cast-in place concrete, with shoring, bracing and anchorage.
- B. Openings for other work.
- C. Form accessories.
- D. Form stripping.
- E. Formed concrete surface finishes.
- F. Remedial work to defective surfaces.

1.02 RELATED SECTIONS

- A. Section 01330 Submittal Procedures.
- B. Section 03200 Concrete Reinforcement.
- C. Section 03250 Concrete Accessories.
- D. Section 03300 Cast In Place Concrete.
- E. Section 03355 Exposed Aggregate Concrete Finish.

1.03 REFERENCES

- A. ACI 117 Standard Specifications for Tolerances for Concrete Construction and Materials.
- B. ACI 301 Structural Concrete for Buildings.
- C. ACI 318 Building Code Requirements for Reinforced Concrete.
- D. ACI 347 Recommended Practice for Concrete Formwork.
- E. ASTM A 184 Fabricated Deformed Steel Bar Mats for Concrete Reinforcement.

1.04 DEFINITIONS

- A. Formwork means the surface against which concrete is placed to form a face, together with all the immediate supports to retain it in position while concrete is placed.
- B. Falsework means the structural elements supporting both the formwork and the concrete until the concrete becomes self supporting.

- C. A formed face is one which has been cast against formwork.
- D. An exposed face is one which will remain visible when construction has been completed.

1.05 DESIGN REQUIREMENTS

- A. Design, engineer and construct formwork, shoring and bracing to conform to code requirements; resultant concrete to conform to required shape, line and dimensions.
- B. Design and construct formwork and falsework such that they support the loads imposed on them by fresh concrete, together with additional stresses from vibrating equipment and construction traffic, so that after the concrete has hardened the formed faces are in the position and have the shape and profile as shown on the drawings within the limits of the dimensional tolerances.
- C. The design of formwork is the responsibility of the Contractor.

1.06 SUBMITTALS FOR REVIEW

- A. Comply with Section 01330.
- B. Submit shop drawings and design calculations showing details of the proposed formwork and falsework for approval of the Engineer.
- C. Shop drawings: Indicate pertinent dimensions, materials, bracing and arrangement of joints and ties.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Construct temporary formwork of timbers, (soft wood plywood, plywood or lumber), metal sheet or other approved material such that concrete produced is of the required finish.
- B. Construct permanent formwork of slabs or blocks of precast concrete, natural stone, brickwork, preformed metal sheets or other approved material. Tighten them by such means as to prevent the leakage of grout from the concrete. Do not use breeze blocks or other porous materials as permanent formwork.
- C. The type and treatment of any lining to the forms be appropriate to the concrete finish required.

2.02 PREFABRICATED FORMS

- A. Provide one or more of the following form types as per manufacturer's standard product and as required by the project, matched, tight fitting, stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished concrete surfaces.
 - 1. Preformed steel forms of minimum 16 gauge or 1.5 mm thick.
 - 2. Thermoplastic polystyrene preformed plastic forms.

3. Glass fiber fabric reinforced plastic forms.
4. Pan type: Steel or glass fiber of size and profile required.

2.03 FORMWORK ACCESSORIES

- A. Form Ties: Removable type, galvanized metal or plastic, adjustable length, cone type, with waterproofing washer, free of defects.
- B. Form Release Agent: Colorless mineral oil which do not stain concrete, or absorb moisture, or impair natural bonding or color characteristics of coating intended for use on concrete and be one of the following types:
 1. Cream emulsion.
 2. Neat oil with surfactant added.
 3. Chemical release agent.
- C. Corners: Chamfered rigid plastic or wood strip 25 x 25 mm size of maximum possible lengths.
- D. Dovetail Anchor Slot: Galvanized steel, 0.8 mm thick, non-filled, release tape sealed slots, anchors for securing to concrete formwork.
- E. Flashing Reglets: Galvanized steel or rigid PVC, 0.8 mm thick, longest possible lengths, with alignment splines for joints, non-filled, release tape sealed slots, anchors to be secured to concrete formwork.
- F. Nails, Spikes, Lag Bolts, Through Bolts, Anchorages: Sizes as required, of sufficient strength and character to be secured to concrete formwork.
- G. Waterstops: Preformed mineral colloid strips, 9 mm thick, moisture expanding.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify lines, levels and centers before proceeding with formwork. Ensure that dimensions agree with drawings.

3.02 EARTH FORMS

- A. Earth forms are not permitted.

3.03 ERECTION

- A. Erect formwork, shoring and bracing to achieve design requirements, in accordance with requirements of ACI 301 and ACI 347.
- B. Provide bracing to ensure stability of formwork. Shore or strengthen formwork subject to overstressing by construction loads. Props shall be carried to construction which is

sufficiently strong to afford the necessary support without injury to any portion of the structure. This may mean in some cases that they be carried down to the foundations or other suitable bases.

- C. Arrange and assemble formwork to permit dismantling and stripping without shock and disturbance. Do not damage concrete during stripping. Permit removal of remaining principal shores. The responsibility for the safe removal of the props rests with the Contractor.
- D. Align joints and make watertight to prevent leakage of grout from concrete. Keep form joints to a minimum.
- E. All construction joints in formwork shall be tightly secured against previous or hardened concrete to prevent the formation of stepping or ridges in the concrete.
- F. Formwork shall be constructed to provide straight and true angles, arises or edges. Provide chamfer strips on external corners of beams columns and walls.
- G. Formwork panels shall have true angles to permit accurate alignment at the sides and provide a clean line at construction joints in the concrete.
- H. Coordinate this section with other sections of work which require attachment of components to formwork.
- I. When formwork is placed after reinforcement resulting in insufficient concrete cover over reinforcement before proceeding, request instructions from Engineer.
- J. Fix formwork panels with their joints either vertical or horizontal unless otherwise specified.
- K. Provide formwork to the top surface of concrete where the slope or nature of the Work requires it. Horizontal or inclined formwork to the upper surface of concrete is to be adequately secured against uplift due to the pressure of fresh concrete.

3.04 APPLICATION – FORM RELEASE AGENT

- A. Store and use release agents strictly in accordance with the manufacturer's instructions.
- B. Where the concrete surface is to be permanently exposed use only one agent throughout the entire area.
- C. Where the surface is to receive an applied finish, take care to ensure the compatibility of the release agent with the finish.
- D. Release agents not to come in contact with the reinforcement.

3.05 INSERTS, EMBEDDED PARTS AND OPENINGS

- A. Unless otherwise shown on the drawings or specifically approved, form all openings and holes and cast all inserts and fixings at the time of pouring.
- B. Locate and set in place items which will be cast directly in to concrete. Obtain approval for size, type and position of any hole, insert or fixing required before work proceeds.

- C. Coordinate with work of other sections in forming and placing openings, slots, reglets, recesses, sleeves, bolts, anchors, other inserts, and components of other work.
- D. Position recessed reglets for masonry anchors to the spacing and intervals required.
- E. Install accessories in accordance with manufacturer's instructions, straight, level, and plumb. Ensure items are not disturbed during concrete placement.
- F. Install waterstops in accordance with manufacturer's instructions continuous without displacing reinforcement. Heat seal joints watertight.
- G. Provide temporary ports or openings in formwork where required to facilitate cleaning and inspection. Locate openings at bottom of forms to allow flushing water to drain.
- H. Close temporary openings with tight fitting panels, flush with inside face of forms, and neatly fitted so joints will not be apparent in exposed concrete surfaces.
- I. Do not drill or cut away any part of the concrete works without the specific approval of the Engineer.
- J. If such drilling or cutting is carried out without approval the affected parts is classed as defective work.

3.06 FORMWORK TIES

- A. Obtain Engineer's approval for the materials and position of any ties passing through the concrete.
- B. Remove a tie so that no part of it is remaining in the concrete.
- C. Place the tie nearer to the finished surface of the concrete more than the specified thickness of cover to reinforcement.
- D. Fill any holes left after the removal of ties with concrete or mortar of approved composition unless otherwise specified.
- E. In waterproof concrete use tie through the concrete of a type with a baffle.

3.07 DEFECTIVE FORMWORK

- A. Where in the opinion of the Engineer any piece of formwork is damaged, deformed, worn or otherwise incapable of producing an acceptable finished concrete surface, he may declare such formwork defective. Repair such formwork to the satisfaction of the Engineer or remove from the site.

3.08 FORM CLEANING

- A. Clean forms as erection proceeds, to remove foreign matter within forms.
- B. Clean formed cavities of debris prior to placing concrete.
- C. Flush with water or use compressed air to remove remaining foreign matter. Ensure that water and debris drain out through clean-out ports.

3.09 FINAL PREPARATIONS

- A. Before concrete placing commences, secure all wedges and other adjusting devices against movement during concrete placing and maintain a watch on the formwork during placing to ensure no movement occurs.

3.10 STRIKING OF FORMWORK

- A. Inform and take approval of the Engineer to strike any formwork.
- B. Do not remove forms or bracing until concrete has gained sufficient strength.
- C. Unless otherwise directed, do not apply treatment of any kind, other than that required for curing after removal of the forms until it has been inspected.

3.11 SUBSEQUENT POUR

- A. Do not pour concrete against an existing concrete face until 24 hours of its casting.

3.12 FORMED CONCRETE SURFACE FINISHES

- A. Classes of Finish: Achieve the surface finish on formed concrete surfaces as shown on the Drawings and detailed hereunder.
 - 1. Class F1 Finish
 - a. Provide this finish for surfaces against which backfill or further concrete will be placed.
 - b. Use sawn boards, sheet metal or any other suitable material which will prevent the loss of fine material from the concrete being placed.
 - 2. Class F2 Finish
 - a. Provide this finish for surfaces which are permanently exposed to view but where the highest standard of finish is not required.
 - b. Use form faced with wrought thickened tongue and grooved boards with square edges arranged in a uniform pattern and close jointed or with suitable sheet material. The thickness of boards or sheets be such that there is no visible deflection under the pressure exerted by the concrete placed against them.
 - c. Provide joints between boards or panels vertical and horizontal unless otherwise directed.
 - d. This finish do not require general filling of surface pitting. Fins, surface discolouration and other minor defects are remedied by methods agreed by the Engineer.
 - 3. Class F3 Finish
 - a. Provide this finish for surfaces permanently exposed to view where good appearance is of special importance.

- b. To achieve this finish, which shall be free of board marks, face the formwork with plywood complying with ACI 301 or equivalent material in large sheets.
- c. Arrange the sheets in an approved uniform pattern. Wherever possible, arrange joints between sheets to coincide with architectural features or changes in direction of the surface. Keep joints between panels vertical and horizontal unless otherwise directed. Provide suitable joints between sheets to maintain accurate alignment in the plane of the sheets.
- d. Unfaced wrought boarding or standard steel panels will not be permitted for Class F3 finish.
- e. Ensure that the surface is protected from rust marks, spillages and stains of all kinds.

4. Class F4 Finish

- a. Provide this finish similar to that required for F3 but use it in places where a first class alignment and a dense surface free from air holes and other defects is required.
- b. Provide a high quality finish for exposed surfaces and be suitable for the application of decorative finishes and in other similar circumstances.
- c. Use this finish for concrete surface to have exposed aggregate finish complying with Section 03355.
- d. Provide this finish with careful selection of materials and the highest quality of workmanship and supervision at all stages.

B. Curved Surfaces

- 1. For curved surfaces where F2, F3 or F4 finishes are called for, build the formwork face with splines cut to make a tight surface and dressed to produce the required finish.
- 2. Alternatively face the single curvature surfaces with plastic or plywood linings attached to the backing with adhesive or with escutcheon pins driven flush.
- 3. Ensure that linings shall not bulge, wrinkle or otherwise deform when subjected to temperature and moisture changes.

3.13 DIMENSIONAL TOLERANCES

- A. Erect formwork such that dimensions of concrete construction are within the tolerances quoted in ACI SP-16, ACI 301, ACI 318, ACI 347 and ASTM A184 for accuracy in Building, except where the tolerances given in the Specification are more onerous.
- B. The permissible tolerances on formed concrete surfaces shall not exceed the values given in Table 1.

TABLE 1

Class of Finish	Tolerance in mm – see notes		
	A	B	C
F1	10	10	± 25 to ± 10
F2	5	10	± 15
F3	2	5	± 10
F4	Nil *	2	± 5

Notes:- The tolerances A, B and C given in Table 1 are defined as follows:

- A - is an abrupt irregularity in the surface due to misalignment or defects in the face of the formwork.
- B - is a gradual deviation from a plane surface as indicated by a straight-edge 3 m long. In case of curved surfaces replace the straight-edge by correctly shaped template.
- C - is the amount by which the whole or part of a concrete face is displaced from the correct position shown on the drawings.
- * Abrupt irregularities are not permitted in F4 finish. Remove by grinding any irregularities which remain after removal of formwork to achieve a transition of 1 in 50 between the surfaces adjacent to the irregularity.

3.14 REMEDIAL WORK TO DEFECTIVE SURFACES

- A. When on stripping any formwork the concrete surface is found to be defective in any way, do not attempt to remedy such defects prior to the Engineer's inspection.
- B. Do not make defective surfaces good by plastering at any stage.
- C. Honeycombed Areas
1. Repair areas of honeycombing which the Engineer agrees by cutting back to sound concrete or to 75 mm whichever is the greater.
 2. In the case of reinforced concrete cut back to at least 25 mm clear distance behind the reinforcement or to 75 mm, whichever is the greater.
 3. Make sides of the cavity at right-angles to the face of the concrete.
 4. After cleaning out with water and compressed air, apply a thin layer of cement grout

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 2. In the case of reinforced concrete cut back to at least 25 mm clear distance behind the reinforcement or to 75 mm, whichever is the greater.
 3. Make sides of the cavity at right-angles to the face of the concrete.
 4. After cleaning out with water and compressed air, apply a thin layer of cement grout

on to the concrete surfaces in the cavity and then fill immediately with concrete of the same class as the main body but with aggregate larger than 20 mm nominal size removed.

5. Use form against the cavity along with a lip to enable concrete to be placed. Fill it to a point above the top edge of the cavity.
 6. After seven days remove the lip of concrete and grind the surface.
- D. Grind the surface irregularities which are outside the limits of tolerance set out in Table 1 in the manner and to the extent instructed by the Engineer.

END OF SECTION 03100

SECTION 03200

CONCRETE REINFORCEMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Steel reinforcement for concrete in any part of the Works but excluding prestressing tendons or any other embedded steel.

1.02 RELATED SECTIONS

- A. Section 01330 Submittal Procedures.
- B. Section 01400 Quality Requirements.
- D. Section 03100 Concrete Formwork.
- E. Section 03250 Concrete Accessories.
- F. Section 03300 Cast In Place Concrete.
- G. Section 03400 Precast Concrete.
- H. Section 03410 Structural Precast Concrete.

1.03 REFERENCES

- A. CRSI Concrete Reinforcing Steel Institute - Manual of Practice.
 - B. CRSI 63 Recommended Practice for Placing Reinforcing Bars.
 - C. CRSI 65 Recommended Practice for Placing Bar Supports, Specification and Nomenclature.
 - D. ACI 301 Structural Concrete for Buildings.
 - E. ACI 318 Building Code Requirements for Reinforced Concrete.
 - F. ACI SP 66 American Concrete Institute - Detailing Manual.
 - G. ASTM A 184 Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement.
 - H. ASTM A 185 Specification for Welded Steel Wire Fabric for Concrete Reinforcement.
 - I. ASTM A 496 Specification for Steel Wire, Deformed, for Concrete Reinforcement.
 - J. ASTM A 497 Specification for Welded Deformed Steel Wire Fabric for Concrete Reinforcement.
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- K. ASTM A 615 Specification for Deformed and Plain Billet Steel Bars for Concrete Reinforcement.
- L. ASTM A 641 Specification for Zinc-Coated (Galvanized) Carbon Steel Wire.
- M. ASTM A 767 Specification for Zinc-Coated (Galvanized) Bars for Concrete Reinforcement.
- N. ASTM A 775 Specification for Epoxy-Coated Reinforcing Steel Bars.
- O. ASTM A 884 Specification for Epoxy-Coated Steel Wire and Welded Wire Fabric for Reinforcement.
- P. ASTM A 934 Specification for Epoxy-Coated Pre-Fabricated Reinforcing Bars.
- Q. AWS D 1.4 Structural Welding Code for Reinforcing Steel.
- R. AWS D 12.1 Welding Reinforcement Steel, Metal Inserts and Connections in Reinforced Concrete Construction.

1.04 SUBMITTALS FOR REVIEW

- A. Comply with Section 01330.
- B. Submit for Engineer's review all items described in this specification section.
- C. Submit manufacturer's certificate, certifying that the products meet or exceed specified requirements.

1.05 HANDLING AND STORAGE OF MATERIALS

- A. Comply with Section 01600.
- B. Handle epoxy coated bars with the systems having padded contact area.
- C. Use padded bundling bands or use suitable banding (use nylon rope instead of wire rope), to prevent damage to the coating.
- D. Lift all the bundles of coated bars with a strong back, spreader bar, multiple supports or via platform bridge to prevent bar-to-bar abrasion from sags in the bundles of coated bars.
- E. Do not drop or drag bars or bundles.
- F. Store reinforcement of all types on site in padded racks above ground in an approved manner so as to avoid damage to coatings.
- G. Provide reinforcement free from loose scale, rust, oil, grease or any other material that may impair the bond between the concrete and the reinforcement. Remove from site any reinforcement which has damaged the coating or pitted to an extent which, in the opinion of the Engineer, will affect its properties.
- H. Store mild steel reinforcement separately from high yield reinforcement.

1.06 QUALITY ASSURANCE AND TESTS

- A. Comply with Section 01400.
- B. Perform work in accordance with CRSI 63, 65 of ACI 301, ACI SP-66, ACI 318, ASTM A 184 and ASTM A 775.
- C. Provide Engineer with access to fabrication plant to facilitate inspection of reinforcement. Provide notification of commencement and duration of shop fabrication in sufficient time to allow inspection.
- D. The manufacturer's test certificate for ultimate strength, elongation and cold bending together with the chemical analysis of the steel may be called for by the Engineer for any consignment of reinforcing steel direct from the manufacturer. Where steel is obtained from an indirect supplier, the Engineer may require tests in an approved laboratory to prove compliance with the appropriate American Standards.
- E. The frequency of testing shall be as set out in the American Standards. Carry out additional tests as instructed by the Engineer.
- F. Any reinforcement which does not comply with the Specification remove immediately from site.

PART 2 PRODUCTS

2.01 REINFORCEMENT

- A. Bars for reinforcement shall be:-
 - 1. Hot rolled mild steel bars to ASTM A 615.
 - 2. Hot rolled high yield deformed bars to ASTM A 615.
 - 3. Steel fabric to ASTM A 185 plain type, ASTM A 497 welded deformed type, ASTM A 497 deformed type.
 - 4. Reinforcing steel bars, welded wire fabric, and prefabricated reinforcing bars shall be epoxy-coated to ASTM A 775, ASTM A 884 and ASTM A 934.
- B. Deformed bars shall be as defined in ASTM A 615.

2.02 TYING DEVICES

- A. Tying devices shall be:
 - 1. Black annealed mild steel wire of 1.6 mm diameter.
 - 2. Approved rustproof binding wire, or
 - 3. Approved proprietary ties.

2.03 SPACER BLOCKS, CHAIRS, BOLSTERS, BAR SUPPORTS

- A. Use spacer blocks chairs, bolsters, bar supports for ensuring that the correct cover is maintained to the reinforcement.
- B. Provide blocks, chairs, bar supports and bolsters of such materials and design as will be durable and not lead to corrosion of the reinforcement such as plastic and plastic coated steel, or current blocks. These are sized and shaped for strength and support of reinforcement during concrete placement conditions.
- C. Use spacer blocks made from cement, sand and small aggregate not exceeding 50 mm square in section and secure with wire to the reinforcement to ensure that they are not displaced when the concrete is poured. Make these of similar mix proportions and strength as the adjacent concrete.

PART 3 EXECUTION

3.01 CUTTING AND BENDING

- A. Bend reinforcement to the dimensions given in the bar schedules in accordance with latest editions of ASTM A 184, ACI 318 CRSI 63 and CRSI 65 unless otherwise stated.
- B. Do not heat reinforcement before bending.
- C. Do not straighten or re-bend cold worked bars and hot rolled high yield bars once having been bent. Where it is necessary to bend mild steel reinforcement already cast in the concrete, the internal radius of bend shall not be less than twice the diameter of the bar.
- D. After bending, securely tie bars together in bundles or groups and legibly labelled as set out in CRSI 63 and CRSI 65.

3.02 SPLICING AND WELDING

- A. Locate reinforcing splices at point of minimum stress. Review and take instruction for location of splices with Engineer.
- B. Do not weld or splice reinforcement except where required by the Contract or agreed by the Engineer. When welding is employed follow the procedures shall be as set out in AWS D 1.4. Submit details of all welding techniques to be used and such trials made as are required to demonstrate the effect of the welding.

3.03 CLEANING OF REINFORCEMENT

- A. Clean reinforcement free of all loose mill scale, rust, oil, grease, concrete or other harmful matter at the time of concreting.

3.04 PLACEMENT AND FIXING OF REINFORCEMENT

- A. Accurately place all reinforcement with the correct cover and fix securely in the positions as shown on the drawings. Give reasonable notice of the intention to pour to the Engineer and that the reinforcement fixing is complete.

- B. At intersections bind together the reinforcement bars together with tying wire such that loose ends of the wire shall be turned towards the inside of the member.
- C. Supply and fix all chairs required to support the top mat of slab reinforcement or space the mats of all reinforcement adequately. In particular slab chairs must be close enough to prevent the reinforcement being bent or sagging.
- D. Provide the actual concrete cover not less than the required nominal cover minus 5 mm. No metal part of any device used for connecting bars or for maintaining reinforcement in the correct position shall remain within the specified minimum cover. Provide adequate mortar or plastic spacers to ensure the correct cover is achieved. The use of spacer blocks will not generally be permitted against a concrete face which is to be permanently exposed in the finished works.

3.05 PROJECTING REINFORCEMENT

- A. Protect projecting reinforcement without affecting its bond properties ensure that it does not cause rust staining to any part of the Works.

END OF SECTION 03200

SECTION 03250

CONCRETE ACCESSORIES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Accessories used in cast-in-place concrete construction, including but not limited to the following:
 - 1. Expansion, contraction and construction joints.
 - 2. Waterstops.
 - 3. Joint sealants.
 - 4. Coloured concrete.
 - 5. Floor hardeners.

1.02 RELATED SECTIONS

- A. Section 01330 Submittal Procedures.
- B. Section 02220 Structural Excavation and Backfilling.
- C. Section 02518 Concrete Pavers.
- D. Section 03100 Formwork.
- E. Section 03300 Cast in Place Concrete.
- F. Section 03370 Concrete Curing.

1.03 REFERENCES

- A. ASTM C 494 Specification for Chemical Admixtures for concrete.
- B. ASTM D 1190 Concrete Joint Sealer, Hot-Poured Elastic Type.
- C. ASTM D 1752 Preformed Sponge Rubber or Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.

1.04 DEFINITIONS

- A. Expansion and contraction joints are discontinuities in concrete designed to allow for thermal and other movements in the concrete.
- B. Expansions joints are formed with a gap between two concrete faces to permit subsequent expansion of the concrete. Expansion joints shall be formed in the positions and in accordance with the details shown on the drawings or elsewhere in the Specification.

C. Contraction joints are formed to permit initial contraction of the concrete and may include provision for subsequent filling. Contraction joints shall be either complete contraction joints or partial contraction joints and shall be formed in the positions and in accordance with the details shown on the drawings and elsewhere in the Specification.

D. A construction joint is the surface of contact whenever concrete is to be bonded to other concrete which has hardened.

1.05 SUBMITTALS

A. Comply with Section 01330.

B. Submit all the items described in this specification section with product data, manufacturer's installation instructions indicating procedures and interface required with adjacent work.

1.06 QUALITY ASSURANCE

A. Field Reference Samples:

1. Provide field constructed samples as identified and specified in this Section.
2. Engineer accepted samples will be quality control reference for remainder of Work and considered as minimum quality standards.
3. An Engineer accepted field reference sample may be integrated into the Work.
4. If not integrated into Work, retain accepted samples in-place on site until related Work is completed and accepted.

PART 2 PRODUCTS

2.01 COMPRESSIBLE JOINT FILLER

A. Non-absorbent, closed cell, non-extruding, non bituminous complying to ASTM D 1752.

B. Shall have:-

1. A minimum of 85% recovery after 50% compression.
2. Water absorption not exceeding 1.5% by weight after 72 hours immersion.
3. Density between 37 and 40 kg/m³.

C. Acceptable materials:-

1. Polyethylene foam expansion joint material.
2. Non-bituminous, wood fiber based joint material, Homex by Homasote or equal.
3. Standard or self-expanding cork material, ASTM D 1752.
4. Sponge rubber material, ASTM D 1752.

- D. Manufacturer: Fosroc Jubail 03-362-3875 or approved equal.

2.02 JOINT SEALANTS

- A. Gun grade, long life two part polysulphide sealing compound composed of selected fillers and pigments.
- B. Non-toxic, non-flammable, non-shrinkable and shall have a cyclic movement accommodation of + or - 17% of the mean joint width.
- C. Conforming to ASTM D 1190 non-slumping based on polysulphide rubber cured by the addition of lead dioxide hardener of a strength specified by the manufacturer to suit site conditions.
- D. Applied to a compatible polyethylene backing strip, all in accordance with the manufacturers instructions.
- E. Colour to be approved by the Engineer.
- F. Manufacturer: Forsoc, Jubail, 03-362-3875 - or approved equal.

2.03 BACKING STRIP OR ROD

- A. Closed cell foam, polyethylene compatible with furnished sealant rod, diameter minimum 3 mm larger than width of joint being sealed.

2.04 SLIP MEMBRANE

- A. Proprietary sliding bearing premoulded strip bearing of neoprene rubber with 7 mm minimum thickness reinforced with warpknitted polyester fabric.
- B. Design: Done by the manufacturer of the material.
- C. Installation: As per manufacturer's recommendations, provided at locations recommended by the manufacturer.
- D. Manufacturer: SK Bearings Ltd. Pampis Ford, Cambridge CB2-4HG or approved equal.

2.05 LAMINATED BEARINGS

- A. Elastomeric laminated bearings mechanically interlocked of natural rubber module, layered between metal plates.
- B. Number of layers shall be sufficient to cater for all applied vertical load and required displacement at bearing location (under beams).
- C. Bearings shall be mechanically anchored to the structure and be of precision manufacture with strict quality control and to be of plan size suitable to the connection under consideration.
- D. Manufacturer: CIPEC (France).

2.06 WATERSTOPS

- A. Made of materials which are resistant to chlorides, sulphates or other deleterious substances which may be present in the environment of the Permanent Works.
- B. Extruded from high quality unfilled polyvinylchloride (PVC) compounds and shall not contain any scrap or reclaimed PVC. Waterstops be of the type recommended by the manufacturer for intended use.
- C. Shall have an elongation breaking stress of at least 225% at 25°C, capable of accommodating a transverse movement of at least 10 mm.
- D. Supplied in maximum possible lengths consistent with ease of handling and construction requirements. Junctions between lengths of waterstops to be factory made.
- E. The sizes as per the drawings and of the same profile throughout the project.
- F. Manufacturer: Fosroc, Jubail or approved equal.

2.07 COLORED CONCRETE

- A. Concrete shall comply with Section 03300.
- B. Integral concrete colorant: Admixture conforming to ASTM C 494. Final colors to be selected by the Engineer.
- C. Special Provisions for Colored Concrete:
 - 1. Air-entraining agent must be approved by manufacturer of concrete colorant. Use no other admixtures with colored concrete.
 - 2. Whenever Section 03300 concrete mix requirement conflicts with colorant manufacturer's requirement, colorant manufacturer's requirements govern.

2.08 FLOOR HARDENERS

- A. Abrasion resistant hardener
 - 1. Hardeners containing non-metallic, rust free, emery aggregate with hardness value not less than 9 on Mohs scale.
 - 2. Premixed dry powder, colour as chosen by Engineer.
 - 3. Follow manufacturer's instructions.
- B. Chemical Hardener
 - 1. Factory blended dry powder of Magnesium flourosilicate and zinc flourosilicate.
 - 2. Of non metallic, hard, dense surface resistant to oil and grease.
 - 3. Follow manufacturer's instruction and recommendation for different locations.

- C. Manufacturer: Fosroc, Jubail or approved equal.

PART 3 EXECUTION

3.01 EXPANSION JOINTS

- A. Form expansion joints in concrete structures by means of a closed cell filler board cast between the two adjoining edges of concrete. Provide expansion joints at spacings not exceeding 30 meters or where indicated and detailed on the drawings.
- B. Tape all joints in the filler board to prevent concrete seepage.
- C. Ensure that the expansion joint is not bridged at any point by concrete or any other solid matter that makes the joint ineffective.
- D. At exposed faces of expansion joints cut back the filler board on completion of the structure and seal the joint with an approved sealant and backing rod.

3.02 CONTRACTION JOINTS

- A. Form contraction joints for slabs and walls at locations indicated on the drawings or at suitable locations in the slabs as directed by the Engineer.
- B. Place timber or plastic crack inducer at the bottom of the slab joint and form or cut a surface groove at the top surface immediately above.

3.03 CONSTRUCTION JOINTS

- A. Form construction joints in solid slabs, beams and walls by inserting temporary vertical stopping-off boards against which concrete can be properly compacted. The position at which such joints may be made are to be approved by the Engineer.
- B. Cast the maximum length of concrete not exceeding 10 linear meters in one operation without contraction joints. However, the maximum area of concrete that may be cast in one operation shall not exceed 400 square meters.
- C. Expose aggregate on existing concrete surface with a light power tool over all contact areas, except within 25 mm of permanently exposed faces. Do not carry out this operation until the concrete is in position for more than 24 hours. Remove all loose materials by compressed air and water jet. When instructed by the Engineer thoroughly saturate the face with water and apply a layer of 1:1 slurry of cement and sand immediately prior to the deposition of the fresh concrete.

3.04 WATERSTOPS

- A. Provide waterstops where indicated and detailed on the drawings and at all horizontal and vertical construction, contraction and expansion joints in basement construction whether or not indicated on the drawings.
- B. Supply waterstops in maximum possible lengths consistent with ease of handling and construction requirements.

- C. Supply manufacturer's ready made joints, other than butt joints. Fabricate butt joints on site in accordance with manufacturer's instructions and with equipment supplied for the purpose by the manufacturer to form a continuous network providing a watertight seal along the line of all joints. Test all site made butt joints by an approved means.
- D. Store waterstop material carefully on site to avoid damage and contamination with oil, grease or other pollutants and in cool well ventilated spaces away from direct sunlight.
- E. Protect waterstops which are embedded in one side of a joint for a scheduled period of one month or more, from the sun by a method approved by the Engineer.
- F. Firmly fix waterstops in the formwork so that they cannot be displaced during concreting. Remove formwork around waterstops carefully to avoid damage. When waterstops suffer any damage which cannot be properly repaired insitu, the Engineer may require a section of concrete to be removed and the waterstops replaced.
- G. Place and compact concrete carefully around waterstops to avoid distortion or displacement.

3.05 INTEGRAL COLORED CONCRETE AND FLOOR HARDENERS

- A. Comply with recommendations and Application Instructions and other manufacturer's recommendations for acceptable techniques.
- B. For stamped concrete finish, lay concrete and apply patterns as required by the pattern supplier and applicator.
- C. For acceptance, completed floor areas must be uniform in color and be free from bumps or depressions.

END OF SECTION 03250

SECTION 03300

CAST IN PLACE CONCRETE

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Cast-in-place concrete for all structural and non-structural use.
- B. Establishes the quality of materials and workmanship and defines how quality is measured for concrete work.

1.02 RELATED SECTIONS

- A. Section 01330 Submittal Procedures.
- B. Section 01400 Quality Requirements.
- C. Section 03100 Concrete Formwork.
- D. Section 03200 Concrete Reinforcement.
- E. Section 03250 Concrete Accessories.
- F. Section 03370 Concrete Curing.
- G. Section 07105 Bituminous Membrane Waterproofing.

1.03 REFERENCES

- A. ACI 207.1 Mass Concrete.
- B. ACI 207.2 Effect of Restraint, Volume Change and Reinforcement on Cracking of Mass Concrete.
- C. ACI 207.4 Cooling and Insulating Systems for Mass Concrete.
- D. ACI 211.1 Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
- E. ACI 211.2 Selecting Proportions for Structural Lightweight Concrete.
- F. ACI 221 Guide for Use of Normal Weight and Heavyweight Aggregates in Concrete.
- G. ACI 224 Control of Cracking in Concrete Structures.
- H. ACI 224.3 Joints in Concrete Construction.
- I. ACI 301 Structural Concrete for Buildings.
- J. ACI 302 Guide for Concrete Floor and Slab Construction.
- K. ACI 304 Recommended Practice for Measuring, Mixing, Transporting and Placing

Concrete.

- L. ACI 305R Hot Weather Concreting.
- M. ACI 306R Cold Weather Concreting.
- N. ACI 318M Building Code Requirements For Reinforced Concrete.
- O. ASTM C 31 Standard Practice for Making and Curing Test Specimens in the Field.
- P. ASTM C 33 Standard Specifications for Concrete Aggregates.
- Q. ASTM C 40 Standard Specifications for Organic Impurities in Fine Aggregates for Concrete.
- R. ASTM C 42 Standard Specifications for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
- S. ASTM C 94 Standard Specifications for Ready-Mixed Concrete.
- T. ASTM C 127 Standard Specifications for Specific Gravity and Absorption of Coarse Aggregate.
- U. ASTM C 128 Standard Specifications for Specific Gravity and Absorption of Fine Aggregate.
- V. ASTM C 136 Standard Specifications for Sieve Analysis of Fine and Coarse Aggregates.
- W. ASTM C 143 Standard Specifications for Slump of Hydraulic Cement Concrete.
- X. ASTM C 150 Standard Specifications for Portland Cement.
- Y. ASTM C 260 Standard Specifications for Air-Entraining Admixture for Concrete.
- Z. ASTM C 470 Standard Specifications for Molds for Forming Concrete Test Cylinders Vertically.
- AA. ASTM C 494 Standard Specifications for Chemical Admixtures for Concrete.
- AB. ASTM C 618 Standard Specifications for Fly Ash and Raw or Calcinated Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.

1.04 DEFINITIONS

- A. Structural concrete is any class of concrete which is used in reinforced, prestressed or unreinforced concrete construction subject to stress.
- B. Non-structural concrete is composed of materials complying with this Section but for which no strength requirements are specified and which is used only for filling voids and similar purposes where it is not subjected to significant stresses.
- C. Lightweight concrete screed is non-structural concrete made with light aggregate, but otherwise complying with this specification. Dry density shall not be greater than 1040

kg/m³.

- D. A pour refers to the operation of placing concrete into any mould, bay or formwork etc, and also to the volume which has to be filled. Pours in vertical succession are also referred to as lifts.
- E. Water/Cement ratio is the ratio by weight of the free water in the mix divided by the weight of cement in the mix. Free water is the water in the mix excluding water absorbed by the aggregate.

1.05 SUBMITTALS

- A. Comply with Section 01330.
- B. Full details of all proposed materials to be used for making concrete. Do not place concrete until the Engineer has approved the materials of which it is composed. Do not alter or replace approved materials without the consent of the Engineer.
- C. The proposed name of the Independent Testing Authority complying to the requirements of Section 01410.
- D. Full details of the proposed batching plant, mode of transportation and placing equipment and make arrangements for inspection and certification, prior to the production of concrete complying with the procedure published by the Ready Mix Concrete Manufacturer's Associations.

1.06 QUALITY ASSURANCE

- A. Perform work in accordance with ACI 301.
- B. The design of the structural concrete members to be in accordance with ACI 318M. Any concrete design carried out to conform to the above standard unless otherwise instructed by the Engineer. The provisions of this standard, unless otherwise stated be held to be incorporated in this Specification.
- C. No variations to the Specification or drawings to be made without approval. Submit details of any reasons for the proposed variations from this Specification, the drawings, and the Engineer's written or drawn instructions for approval.
- D. Comply with the appropriate American Standards and manufacturer's specifications for all materials used. Acquire cement and aggregate from the same source for all work. Mark, document and identify materials so as to ensure that they are used as specified.
- E. Conform to ACI 305R when concreting during hot weather.
- F. Perform all sampling, laboratory and site tests by an Independent Testing Agency/Laboratory complying with section 01400.
- G. Carry out all tests and checks on site in the presence of or as directed by the Engineer and as required by the Specification.
- H. Maintain at the site the following apparatus in good operating condition:

1. Apparatus for assessing workability in accordance with ACI 304.
 2. Apparatus for making concrete cylinders in accordance with ASTM C 470.
 3. A maximum and minimum thermometer close to the works for measuring atmospheric shade temperature.
 4. A wet and dry bulb thermometer for measuring relative humidities.
- I. When the concrete arrived on site does not meet the specified slump or any other test requirements and reached the site beyond the time limit, Engineer has authority to reject the load of concrete. Cart away the rejected concrete out of project site immediately.

PART 2 PRODUCTS

2.01 CONCRETE MATERIALS

A. Cement

1. Cement: Ordinary Portland Cement (OPC), complying with ASTM C 150, for all works above ground level. White or coloured cement shall comply with ASTM C 150.
2. Low-heat Portland cement, complying with ASTM C 150, in large concrete sections above ground, where necessary, to reduce temperature development.
3. For work below ground level, use Sulphate Resisting Portland Cement (TYPE V) complying with ASTM C 150.
4. Obtain the cement directly from an approved manufacturer or an approved supplier and deliver either in bulk by purpose built vehicles or in sealed bags. All cement to be free flowing and free of lumps.
5. The total alkali content of the cement expressed as the sodium oxide equivalent not to exceed 0.6% by weight.
6. The tricalcium aluminate (C_3A) content of any cement not to exceed 8% and for sulphate resisting cement 5%.
7. The sulphuric anhydride (SO_3) content to be more than not 2.3%.
8. The heat of hydration not to exceed values listed in ASTM C 150.
9. The initial setting time to be not less than 45 minutes and the final setting time not more than 10 hours.
10. Certificates of cement tests done by the manufacturer will be called for by the Engineer. If such certificate is not made available, or when the Engineer considers that the manufacturer's tests are inadequate, take samples for testing from different consignments as directed by the Engineer. Such samples to be of weight not less than 7 kg and be selected and tested by the Independent Testing Authority complying to the requirements of Section 01410.

11. Storage of Cement

- a. Store bulk cement in weatherproof silos bearing a clear indication of the types of cement contained in them. Do not mix different types of cement in the same silo. Draw down silos frequently to prevent cement caking.
- b. Store cement in bags in a suitable weatherproof structure of which the interior has to be dry and well ventilated at all times. Raise the floor above the surrounding ground level and construct such that no moisture rises through it. Stack closely each delivery of cement in bags but do not stack against an outside wall. Distinguish clearly different types of cement in bags by visible markings and store in separate stacks. Use cement in bags in the order of delivery. Do not use cement from broken bags.
- c. Provide sufficient storage capacity on site to ensure that anticipated programme of work is not interrupted due to lack of cement.

B. Aggregates

1. Conform to the requirements for fine and coarse aggregates in ASTM C 33.
2. Consist of crushed or naturally occurring materials having hard, durable, strong particles. Wash all aggregates with clean water. The use of marine aggregates will not be approved.
3. At least 45 days before concreting operations are due to commence, submit for approval the proposed names of the pits, quarries or manufacturing plants to obtain aggregates, together with evidence showing that the material complies with the requirements of ACI 221.
4. Use fine aggregate of natural sand or of crushed clean hard rock or a mixture of these. Conform to ASTM C 33. In order to achieve an acceptable grading it may be necessary to blend materials from more than one source refer Table 2 for grading requirements.
5. Fine aggregate not to contain excessive quantities of dust, soft or flaky particles, shells, concealed lumps, shale or other contaminations likely to adversely affect the strength or durability of the concrete or to attack the reinforcement.
6. Provide coarse aggregates of naturally occurring crushed rock and not containing harmful materials in sufficient quantity affecting adversely the strength or durability of the concrete or to attack the reinforcement.
7. Supply coarse aggregates in the nominal sizes specified and graded in accordance with ASTM C 33 for single sized aggregates, refer Table 2.
8. Comply aggregates with the mechanical properties in ASTM C 33 and in addition the flakiness index when determined by the sieve method described in ASTM C 136 not exceed 40 for 40 mm aggregates, nor shall it exceed 35 for 20 mm aggregates. In watertight constructions, the coarse aggregates shall not have combined indices for flakiness and elongation exceeding 35, nor the flakiness index exceed 15.
9. The sulphate content (as SO_3) of both the fine and coarse aggregates not to exceed 0.4% by weight. The total sulphate content of all the ingredients in a mix including cement, water and admixtures not to exceed 4.0% of the weight of cement within the mix.
10. The chloride content (as Na Cl) shall not exceed 0.05% by weight. The total chloride

content arising from all ingredients in a mix including cement, water and admixtures not to exceed the following limits expressed as a percentage of the weight of the cement in the mix :-

- a. For prestressed concrete, steam cured concrete or concrete containing sulphate resisting cement : 0.05%.
 - b. For any other reinforced concrete : 0.25% in 95% of all test results providing no result is more than 0.4%.
11. The coarse aggregate when tested shall have a water absorption as defined in ASTM C 33. When the proposed aggregate has an absorption of more than the specified value, demonstrate by trial mixes and tests that the strength and durability of the concrete are not adversely affected and that adequate workability can be maintained during the placing and compacting processes.
 12. Determine the "10% Fines" values, in accordance with ASTM C 33. Where aggregates are to be used for concrete wearing surfaces, the "10% Fines" value to be as specified in ASTM C 33.
 13. The weight loss after the magnesium sulphate soundness test, not to be more than 15% for the fine aggregate and 18% for the coarse aggregate.
 14. Aggregates not to contain any mineral known to have a potential to cause alkali silica, alkali silicate, alkali carbonate or any other damaging chemical reactions between alkalis and aggregates.
 15. The grading of all aggregate, when analysed, to be as per ASTM C 33 for the nominal size of aggregate specified and as given in Tables 1 and 2.
 16. Carry out routine testing of aggregates for compliance with the specification during the period concrete is being produced. The routine tests include but are not limited to grading, silt and clay content, moisture content, check on organic impurities and chloride content. Perform these tests on aggregates from each separate source on the basis of one set of tests for each day on which aggregates are delivered to site provided that no set of tests shall represent more than 250 tonnes of coarse aggregate and provided also that the aggregates are of uniform quality.
 17. Delivery and Storage of Aggregates
 - a. Deliver aggregates to site in clean and suitable vehicles. Do not deliver different types or sizes of aggregates in one vehicle.
 - b. Do not store aggregates in contact with the ground and protect against the intrusion of the ground and other foreign matter. Provide a physical partition between the store heaps of fine and coarse aggregates and between separate heaped sizes of coarse aggregate which may have been segregated for mix control. When concreting is not being carried out, cover the store heaps to prevent contamination by wind blown material.
 - c. Remove aggregate from site immediately, which in the opinion of the Engineer are not clean or have become mixed due to defective storage.

C. Water

1. Use clean water free from all harmful matter in suspension or solution and satisfying the recommendations given in ASTM C 94. When directed by the Engineer, carry out tests in accordance with ASTM C 94 to establish compliance with the Specification.

Table 1

Sieve	Percent Passing
9.5 mm	100
4.75 mm	95 to 100
2.36 mm	80 to 100
1.18 mm	50 to 85
600 ìm	25 to 60
300 ìm	10 to 30
150 ìm	2 to 10

Table 2
Grading Requirements for Course Aggregate

Size No.	Nominal Size mm	100 mm	90 mm	75 mm	63 mm	50 mm	37.5 mm	25 mm	19 mm	12.5 mm	9.5 mm	4.75 mm	2. 36 mm	1.18 mm
1	90-37.5	100	90 to 100	-	25 to 60	-	0 to 15	-	0 to 5	-	-	-	-	-
2	63-37.5	-	-	100	90 to 100	35 to 70	0 to 15	-	0 to 5	-	-	-	-	-
3	50-25.0	-	-	-	100	90 to 100	35 to 70	0 to 15	-	0 to 5	-	-	-	-
357	50-4.75	-	-	-	100	90 to 100	-	35 to 70	-	10 to 30	-	0 to 5	-	-
4	37.5-19.0	-	-	-		100	90 to 100	20 to 55	0 to 15	-	0 to 5	-	-	-
467	37.5-4.75	-	-	-		100	90 to 100	-	35 to 70	-	10 to 30	0 to 5	-	-
5	25-12.5	-	-	-			100	90 to 100	20 to 55	0 to 10	0 to 5	-	-	-
56	25.0-9.5	-	-	-			100	90 to 100	40 to 85	10 to 40	0 to 15	0 to 5	-	-
57	25.0-4.75	-	-	-			100	90 to 100	-	25 to 60	-	0 to 10	0 to 5	-
6	19.0-9.5	-	-	-				100	90 to 100	20 to 55	0 to 15	0 to 5	-	-
67	19.0-4.75	-	-	-				100	90 to 100	-	20 to 55	0 to 10	0 to 5	-
7	12.5-4.75	-	-	-				-	100	90 to 100	40 to 70	0 to 15	0 to 5	-
8	9.5-2.36	-	-	-				-		100	85 to 100	10 to 30	0 to 10	0 to 5

2.02 ADMIXTURES

- A. Use suitable admixtures only with the prior written approval of the Engineer. Submit both the proposed dosage and method of use to the Engineer together with the following data:
 - 1. The typical dosage and detrimental effects of underdosage and overdosage.
 - 2. The chemical name(s) of the main active ingredient(s) in the admixture.
 - 3. Whether or not the admixtures contain chlorides and, if so, the chloride content of the admixture expressed as a percentage of equivalent anhydrous calcium chloride by weight of admixture.
 - 4. Whether or not the admixture leads to the entrainment of air when used at the manufacturer's recommended dosage.
- B. Unless otherwise agreed on, comply admixture with one of the following standards:
 - 1. ASTM C 618 Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.
 - 2. ASTM C 260 Air-Entraining Admixtures for Concrete.
 - 3. ASTM C 494 Chemical Admixtures for Concrete.
- C. The use of calcium chloride as an admixture will not be approved.
- D. Pozzolan shall not be used in concrete mixes for construction of elevated slabs.

2.03 ACCESSORIES

- A. Plastic Sheeting
 - 1. Use the plastic or polythene sheeting material for placing, where shown, immediately below concrete slabs, foundations, etc., and for other uses as defined elsewhere in the specification of 300 microns nominal thickness and a minimum thickness of 250 microns meeting the requirements of ASTM C 171.
 - 2. The material to be chemically inert and unaffected by subsoil acids and alkalis.
 - 3. Store the sheeting away from the direct rays of sun.
 - 4. Make all joints in the plastic sheeting with jointing tape and minimum laps of 300 mm.
- B. Bituminous Membrane Waterproofing

Where indicated on the drawings, bituminous waterproofing membrane to horizontal and vertical concrete surfaces of basements and other underground structures to conform to Section 07105.
- C. Waterstops

Waterstops: Conforming to the requirements of Section 03250.

2.04 CONCRETE MIX

A. Formulate concrete mix from cement, aggregate and water, all as specified and approved. Do not add other ingredients without prior approval of the Engineer.

B. Design Mixes

1. Design the concrete mixes to the requirement of ACI 318 and ACI 211.1.
2. Design the concrete mix to have at least the required minimum cement content, maximum water/cement ratio, the required average strength, f'_{cr} in accordance with the requirements of ACI 318 outlined in Chapter 5 and as per 2.04C, Table 3.

C. Concrete Classes

Following types of concrete as shown in Table 3 is to be used in various locations indicated on the drawings. The type of concrete is denoted by the minimum 28 day cylinder strength and the type of cement. The specified compressive strength and other parameters specified are those assumed for the design of the structure and must be achieved in the finished structures.

TABLE 3

Type	Cube Strength after 28 days [MPa]	Minimum Quantity of cement kg per m3 of concrete	Maximum Permissible Water/cement Ratio
C15	15	250 kg cement type II	0.4
C28	28	400 kg cement type II	0.4
C35	35	450 kg cement type II	0.4

D. Use Microsilica for the concrete in the construction of all walls and slabs to all the liquid retaining structures. Provide microflow superplasterizer by Master Builder or approved equal, with the mix containing microsilica additive in accordance with the manufacturer recommendation.

E. Quality Control of Concrete Production (Ready Mix Plant)

1. When a ready mix concrete supplier is used, propose names of suppliers to the Engineer, one of which will be approved. Submit for each proposed supplier, plant and mix results of full scale trial mixes. The average strength obtained in 28 day tests from these trials to exceed the specified cylinder strength by at least the value given in 5.3.2.2 of ACI 318-95. Make sure that the average strength (f'_{cr}) of delivered concrete is equal or exceeds the average

strength (f'_{cr}) of the approved design mixes.

2. Submit standard deviations for each supplier and plant, derived from results tested by an independent agency on a recent construction project of similar size. Make available all the records to the Engineer upon request.
3. When designed mix is proposed, conduct preliminary tests in accordance with Specification and send the results to the Engineer before placing any structural grade concrete. Do not place any structural concrete in the works until the relevant mix is approved by the Engineer. Conduct the preliminary tests at the start of the works on samples of the intended materials to be used for structural concrete grades. Repeat the preliminary tests when there is a change in source of supply and when in the opinion of the Engineer there is sufficient variation from the previously approved sample that new tests are required.
4. Take samples of concrete for each class of concrete in production at each plant and at the point of discharge from the mixer or the ready mix delivery vehicle as instructed by the Engineer and in the presence of a representative of the Engineer, all in accordance with the sampling procedures described in ASTM C 31.
5. Measure the concrete slump of the different classes of concrete in accordance with ASTM C 143.
6. Concrete cylinders shall be 150 mm diameter. Take one set of samples for every 20 cubic meters of concrete placed with a minimum of one set of samples taken every day on which the mix is used. From each sample take three cylinders, one for testing after 7 days of casting and two for testing after 28 days of casting. The average strength of the two cylinders crushed at 28 days shall be referred to as one test result.
7. Provide field cured samples conforming to ASTM C 31 as directed by the Engineer.
8. Concrete shall be deemed to comply with the strength specified when both of the following requirements are met:
 - a. Every arithmetic average of any three consecutive strength tests equals or exceeds the average strength (f'_{cr}) at 28 days, and
 - b. No individual strength test (average of two cylinders) falls below the specified average strength (f'_{cr}) at 28 days by more than 3.5 N/mm^2 .
9. When any strength test of laboratory-cured cylinders falls below specified value (f'_{cr}) by more than 3.5 N/mm^2 or when tests of field-cured cylinders indicate deficiencies in protection and curing, take steps to assure that load-carrying capacity of the structure is not jeopardized.
 - a. When the likelihood of low-strength concrete is confirmed and calculations indicate that load-carrying capacity is significantly reduced, carry out tests on cores drilled from the area in question in accordance with ASTM C 42. In such cases, take three cores for each strength test.
 - b. When concrete in the structure will be dry under service conditions, air dry the cores (temperature 15° to 25° C , relative humidity less than 60%) for 7 days before test and

test them dry. When concrete in the structure will be more than superficially wet under service conditions, immerse cores in water for at least 40 hr and test them wet.

- c. Concrete in an area represented by core tests is considered structurally adequate when the average strength result of three cores is equal to at least 85% of f'_c and where no single core is less than 75% of f'_c . Additional testing of cores extracted from locations represented by erratic core strength results shall be permitted.
 - d. When the above criteria are not met and where the structural adequacy remains in doubt, follow the Engineer's decision for the appropriate action.
10. All cylinders shall be clearly marked with the date of casting and supply accurate records to the Engineer, stating the dates of casting and testing of samples, together with the results of tests and the exact position from where the sample was taken.

E. Mixing Concrete on Site

- 1. Unless otherwise agreed by the Engineer, mix concrete in an approved type of mechanical weigh-batcher. No hand mixing will be allowed.
- 2. Maintain the weighing and water-dispensing mechanisms in good order.
- 3. The weights of cement and each size of aggregate as indicated by the mechanisms employed to be within a tolerance of $\pm 2\%$ of the respective weights per batch agreed by the Engineer. Adjust the weight of the fine and coarse aggregates to allow for the free water contained in the fine and coarse aggregates which are to be determined by approved methods immediately before mixing begins, and further as the Engineer requires.
- 4. Mix the materials until they are uniformly distributed and the mass is of uniform consistency and colour, but in no case mixing time be less than two minutes after all the materials have been added to the drum. The drums on all mixers shall revolve at the speeds recommended by the manufacturer.
- 5. Thoroughly clean the mixers which have been out of use for more than 30 minutes before any fresh concrete is mixed or before changing from one type of cement to another.
- 6. Record the following on delivery notes with each batch delivered:-
 - a. Date and time of arrival.
 - b. Time and place of mixing.
 - c. Registration of truck and depot.
 - d. Time and place of adding water.
 - e. Mix class.
 - f. Cement content.
 - g. Type of cement.
 - h. Details of any approved additives.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Comply with Section 01039.
- B. Verify site conditions.
- C. Verify requirements for concrete cover over reinforcement.
- D. Verify that anchors, seats, plates, reinforcement and other items to be cast into concrete are accurately placed, positioned securely, and will not cause hardship in placing concrete.

3.02 PREPARATION

- A. Prepare previously placed concrete by cleaning with steel brush and applying bonding agent.
- B. Prepare construction joints by use of high pressure water jet or other methods approved by the Engineer to remove surface laitance and loose concrete.
- C. In locations where new concrete is dowelled to existing work, drill holes in existing concrete, insert steel dowels and pack solid with approved epoxy/non-shrink grout.
- D. Coordinate the placement of joint devices with erection of concrete formwork and placement of form accessories.

3.03 TRANSPORTING AND PLACING CONCRETE

- A. Take acceptance of the Engineer for the method of transporting and placing concrete. Transport and place concrete such that contamination, segregation or loss of constituent materials does not occur.
- B. Ensure all formwork and reinforcement placed in the proposed concreting area is clean and free from standing water immediately before placing the concrete.
- C. Place concrete in accordance with ACI 301, ACI 318 and ACI 304.
- D. Notify Engineer minimum 24 hours prior to commencement of operations.
- E. Ensure reinforcement, inserts, embedded parts, formed expansion and contraction joints are not disturbed during concrete placement.
- F. Install vapor barrier/retarder under interior slabs on grade. Lap joints minimum 150 mm and seal watertight by taping edges and ends.
- G. Repair vapor barrier/retarder damaged during placement of concrete reinforcement by lapping over damaged areas minimum 150 mm and sealing it watertight.
- H. Do not place concrete in any part of the works until the Engineer's approval is received. The Engineer shall have the right to reject any concrete which does not meet specified test requirements or time limitations.
 - 1. In case concreting does not start within 24 hours of approval being given, obtain approval

again from the Engineer.

2. Proceed concreting continuously over the area between predetermined expansion, control and construction joints.
 3. Do not place fresh concrete against cast-in-place concrete which has been in position for more than 30 minutes unless construction joint is formed in accordance with this specification.
 4. When cast-in-place concrete has been in place for 4 hours or more no further concrete shall be placed against it for a further 20 hours.
- I. Concrete when deposited shall have a temperature of not less than 5°C and not more than 28°C except with the approval of the Engineer.
 - J. Except in the case of columns or where otherwise agreed by the Engineer, place the concrete in horizontal layers to a compacted depth not exceeding 300 mm and consolidate each before the subsequent layer is placed.
 - K. Except in the case of columns or unless otherwise agreed by the Engineer, do not drop concrete into place from a height exceeding 2 meters. When trunking or chutes are used, keep them clean and used in such a way as to avoid segregation.
 - L. Do not pump concrete through aluminium or alloy conduits. Carry out concreting continuously and do not place concrete on concrete which has sufficiently set to cause the formation of seams or planes of weakness with the section. Where concrete cannot be placed continuously, form construction joints as specified and shown on the drawings or approved by the Engineer.
 - M. Keep the time elapsing between mixing and placing a batch of concrete as short as practicable. The time to be no longer than will permit completion of placing and compaction before the onset of initial set and in any case not longer than one hour from the time the water is added to the mix.

3.04 PLACEMENT OF CONCRETE IN LARGE SECTIONS

- A. Submit proposals for the casting of large concrete sections, where the minimum dimension is greater than 500 mm, which shall include, but not limited to, proposed methods for controlling generated heat of hydration with supporting calculations, temperature monitoring and curing. Comply with the recommendations of ACI 207.1, ACI 207.2, ACI 207.4, ACI 211.1 and ACI 224.3. All proposals are subject to the Engineer's approval.
- B. Monitor the temperature of the concrete in large sections throughout pouring of the complete section by the use of thermocouples. Ensure that the temperature of the concrete does not exceed 70°C and that any temperature differential (center to surface) across the section does not exceed 30°C . Continue temperature monitoring until the temperature in the hottest part of the section is less than 20°C greater than the minimum daily ambient temperature.

3.05 INTERRUPTIONS TO PLACING

- A. 1. When concrete placing is interrupted for any reason and the duration of the interruption cannot be forecast or is likely to be prolonged, take the necessary action to form a construction joint so as to eliminate as far as possible feather edges and sloping top surfaces and compact

thoroughly the concrete already placed.

2. Complete all the work on the concrete while it is still plastic and do not thereafter disturb until it is hard enough to resist damage.
 3. Plant and materials to comply with this requirement shall be readily available at all times during concrete placing.
 4. The use of high pressure water blast equipment is also recommended immediately following the final set of concrete.
- B. Before concreting is resumed after such an interruption cut out and remove all damaged or uncompacted concrete, feather edges or any other undesirable features and leave a clean sound surface against which the fresh concrete can be placed.
- C. Where it becomes possible to resume concrete placing without contravening the Specification and the Engineer consents to a resumption, compact and thoroughly work the new concrete against the existing concrete so as to eliminate any cold joints.

3.06 PUMPED CONCRETE

- A. Take Engineer's written acceptance at the commencement of the Contract.
- B. Furnish the Engineer with full details of the mix design, the area and volume of concrete to be placed in an operation and the distance over which the concrete is to be pumped.
- C. The foregoing Clause on mix design shall apply equally to a concrete that is designed to be "pumped".

3.07 COMPACTION OF CONCRETE

- A. Compact concrete to produce a dense homogeneous mass with the assistance of mechanical vibrators, keep sufficient mechanical vibrators in serviceable condition on site so that spare equipment is always available in the event of breakdowns.
- B. Mechanical vibrators shall be of the immersion type capable of operating at between 7,000 and 10,000 cycles per minute.
- C. Do not allow vibrator to be operated by workmen who do not have sufficient training in its use.
 1. Insert vertically the tubular part of immersion vibrator into the full depth of the concrete to be vibrated at points 600 mm apart and at least 100 mm away from any formwork.
 2. Keep the vibrators constantly moving whilst in action to prevent segregation.
 3. Vibration shall not be applied directly or through the formwork or reinforcement to sections or layers of concrete which have taken their initial set or to concrete which has ceased to become plastic under vibration.
 4. Stop vibration after the decrease in volume is no longer apparent or before localised areas of grout or laitance are formed.
 5. When the supply of concrete from the mixer is interrupted, the vibrators shall be lifted out

clear from the work.

- D. Take care to ensure that concrete is fully compacted around waterstops and embedded items without distorting, displacing or damaging the waterstops or other items.

3.08 PROTECTION OF FRESH CONCRETE

- A. Protect freshly placed concrete from rainfall and from water running over the surface until it is sufficiently hard to resist damage from this cause.
- B. Do not allow any traffic on any concrete surface until such time as it is hard enough to resist damage by such traffic.
- C. Do not subject concrete placed in the Permanent Works to any structural loading until it has attained at least its minimum average strength as defined in 2.04 C.

3.09 CONCRETING IN HOT WEATHER

- A. On exposed concrete surfaces in high temperatures and strong drying wind conditions, use a curing method which shields the concrete. Apply the curing in position not later than half an hour after final tamping. When the surface exhibits cracking while the concrete is still plastic then retamp it to close the cracks.
- B. Do not mix or place the concrete whilst the shade temperature is above 43°C on a rising thermometer or above 45°C on a falling thermometer. Supply an accurate maximum/ minimum thermometer and hang it in an approved place in the Works site.
- C. Plan the day's concreting in such a manner as to ensure that each bay or panel is completed at a proper construction joint before the temperature rises above the permissible limit.
- D. The temperature of fresh mixed concrete at the point of placement not to exceed 28°C and take all necessary precautions to ensure that the limit is not exceeded. Concrete with a temperature less than 28°C can be produced by combinations of the following methods:
 - 1. Use of sliced, flaked or crushed ice to reduce temperature of mixing water. All ice shall be melted before adding to concrete.
 - 2. Night casting (subject to the prior acceptance of the Engineer).
 - 3. Shading of aggregates.
 - 4. Moistening of aggregates with potable water.
 - 5. Cooling of formwork and reinforcement.
 - 6. Using cement with a temperature of less than 77°C .
 - 7. Use of white or light reflective paints on mixer drums and water storage tanks.
 - 8. Shading of the mixing area.

3.10 FINISHES ON FREE SURFACES

A. Finish horizontal or nearly horizontal surface which are not cast against formwork to the class shown on the Drawings and detailed hereunder.

1. U1 Finish

- a. Provide U1 finish to all surfaces for which no higher class of finish is called for on the drawings, finishing schedule or instructed by the Engineer.
- b. Level and screed the concrete to produce a uniform plain or ridged surface, surplus concrete being struck off by a straightedge immediately after compaction.

2. U2 Finish

Treat surface as Class U1 finish and after the concrete has hardened sufficiently, floated it by hand or machine sufficient only to produce a uniform surface free from screed marks.

3. U3 Finish

Float surface as for a U2 finish but to the tolerance stated below. When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface. Steel-trowel it under firm pressure to produce a dense, smooth, uniform surface free from trowel marks.

4. U4 Finish

The requirement is similar to U3 finish, but the permissible tolerances are smaller.

5. U5 Finish – Brushed Finish

Prepare the concrete surface first as a U2 finish and then lightly brush with a stiff brush over the surface to produce a textured finish. Clean the surface when it is hard set.

B. Surface Tolerances

The permissible tolerances on free surfaces not to exceed the values given in Table 4.

Table 4
Surface Tolerances

Class Of	Tolerance in mm – see Notes		
	A	B	C
U1	Not applicable	10	+20 or –10
U2	Nil	10	+20 or –10
U3	Nil	5	+12.5 or –7.5
U4	Nil	2	+5 or –5
U5	Nil	5	+12.5 or –7.5

Notes:

1. Column A is the maximum allowable value of any sudden change of level in the surface.

2. Column B is the maximum allowable value of any gradual irregularity of the surface, as indicated by the gap between the surface and a three metre long straightedge or correctly shaped template placed on the surface.
3. Column C is the maximum allowable value of the difference in level or position between a straightedge or correctly shaped template placed on the surface and the specified level or position of that surface.
4. Where dimensional tolerances are given on the Drawings or elsewhere in the Specification they shall take precedence over those given in Table 4.

3.11 PROTECTION TO SUBSTRUCTURE

- A. Provide bituminous waterproofing membrane to the underside of slabs and vertical faces of concrete walls in basements and other underground structures where indicated on the drawings. Install Bituminous waterproofing membrane in accordance with the requirements of Section 07105.
- B. Waterstops: Install in accordance with Section 03250.
- C. Except where indicated otherwise on the drawings or agreed by the Engineer, protect all buried concrete surfaces, exposed after the removal of formwork, using two coats of bituminous paint-on material and wrapping all buried surfaces with polyethelene sheet complying with clause 2.03A.

3.12 LIQUID CONTAINING CONSTRUCTION

- A. Test all liquid containing construction to ensure that there is no leakage or damp penetration. Carry out the testing before waterproofing and other finishes are applied to the construction and before back-filling any excavation.
- B. Seal completely all drains and fill the construction with clean water to a predetermined level. Once filled the level is to be recorded at daily intervals for a period of fourteen days or as otherwise directed by the Engineer. Ensure that the level of water is not affected by rainfall or undue evaporation.
- C. When it is apparent from the test results, external inspection or any other source that leakage or damp penetration has occurred, then carry out remedial work to make the construction completely watertight to the Engineers acceptance. Retest the construction until the results are satisfactory.

3.13 DEFECTIVE WORK

- A. Carry out remedial treatment to surfaces as agreed with the Engineer following inspection immediately after removing the formwork.
- B. Any concrete, the surface of which has been treated before being inspected by the Engineer, is liable for rejection.
- C. Any concrete which in the opinion of the Engineer is damaged or is in any way defective due to lack of compliance with any of the foregoing Clauses, or is not true to an acceptable line or level compatible with the requirements of second fixings and finishes, is deemed to be unacceptable and rejected.
- D. Where rejected work has to be cut out or re-built, the operation shall be carried out immediately without any delay.

- E. Propose the extent of the work to be removed and the methods to be used in the removal and replacement of the work for the Engineer's review.
- F. The Engineer's acceptance must be obtained before any cutting of concrete is carried out. If such cutting of concrete is carried out without the Engineer's approval the affected areas shall be classified as defective.

3.14 RECORDS

- A. Temperature: Keep daily record of maximum and minimum outside shade temperatures.
- B. Concreting and Cylinders: Submit weekly to the Engineer a complete record of concreting, giving the date, location, concrete grade cement content, No. of samples taken for testing, and source of supply (when more than one). These records to be set out in such a way that the test cylinder results can be easily referred to the concrete to which they relate.

END OF SECTION 03300

SECTION 03370
CONCRETE CURING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Curing of cast-in-place and precast concrete.

1.02 RELATED SECTIONS

- A. Section 01330 Submittal Procedures.
- B. Section 03300 Cast In Place Concrete.
- C. Section 03355 Exposed Aggregate Concrete Finish.

1.03 REFERENCES

- A. ACI 301 Structural Concrete for Buildings.
- B. ACI 302 Recommended Practice for Concrete Floor and Slab Construction.
- C. ACI 308 Standard Practice for Curing Concrete.
- D. ASTM C 171 Sheet Materials for Curing Concrete.
- E. ASTM C 309 Liquid Membrane-Forming Compounds for Curing Concrete.

1.04 SUBMITTALS

- A. Comply with Section 01330.
- B. Product Data: Provide data on all items specified under this Section.

1.05 QUALITY ASSURANCE

- A. Perform work in accordance with ACI 301 and ACI 302.

PART 2 PRODUCTS

2.01 CURING COMPOUNDS

- A. Use suitable curing compounds only with the written approval of the Engineer. Curing compounds to be in accordance with ASTM C 309. Submit both the proposed dosage and method of application to the Engineer.
- B. Approve the use of the curing compound on surfaces which are to receive a bonded finish only when it is proven beyond doubt that the use of the compound has no detrimental effect on the applied finish.

- C. Curing compounds shall contain a dye to enable the extent of the spread to be seen easily.
- D. Use curing compounds on surfaces exposed to the sky, containing sufficiently finely divided flake aluminium in suspension to produce a complete coverage of the surface with a metallic finish when applied at the rate recommended by the manufacturer.
- E. Curing compounds to become stable and impervious to the evaporation of water from the concrete surface within sixty minutes of application. The material not to react chemically with the concrete, crack, peel or disintegrate within three weeks after application.

2.02 SHEET MATERIALS FOR CURING CONCRETE

- A. Sheet materials for curing concrete shall be in accordance with ASTM C 171.
- B. Polyethylene film shall have a minimum thickness of 0.15 mm or as indicated on the drawings whichever is more.

2.03 WATER

- A. Water used for curing shall be of the same quality as that used for mixing concrete as described in Section 03300.

PART 3 EXECUTION

3.01 GENERAL

- A. Cure surfaces in accordance with the recommendations of ACI 308.
- B. Immediately after compaction and for 7 days thereafter, protect concrete against harmful effects of weather, including rain, rapid temperature changes, and from drying out. The methods of protection used to be subject to the acceptance of the Engineer.
- C. Use such method of curing that it prevents loss of moisture from the concrete. On concrete surfaces which are to be waterproofed, do not use curing compounds. Details of all curing methods to be used are subject to the approval of the Engineer.

3.02 METHODS OF CURING

- A. For formed surfaces: Unless otherwise agreed by the Engineer all formwork to remain in place for at least 48 hours; form when removed within 7 days of casting, cure the exposed concrete surface. Use insulated steel or timber for formwork which remains in place.
- B. In cases where formwork is removed within 7 days of casting, cover the exposed concrete surfaces closely with impermeable sheeting, properly secured to prevent its removal by wind and the development of air spaces beneath it. Alternatively keep the exposed surfaces continuously wet by means of a water spray or by covering with a water absorbent material which is kept wet. Subject to the approval of the Engineer, apply pigmented reflective curing compound immediately to the surface.
- C. For other surfaces the above methods are acceptable subject to the additional requirement that when the area considered is exposed to the effects of sun or wind, provide ponding to a depth of at least 50 mm. Start ponding as soon as possible at the end of concreting, but not

before the concrete can resist surface damage.

- D. When the humidity is less than 50% and the wind speed exceeds 4 m/second, provide shelter to the concrete, during casting and for a period of at least 24 hours after casting. This is in addition to the curing procedures described previously. Formwork left in place is regarded as sheltering.
- E. Limit the development of temperature differentials in concrete after placing by any means appropriate to the circumstances as accepted by the Engineer.

END OF SECTION 03370

SECTION 03720
CONCRETE REPAIR

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Methods and materials for the reports of defective concrete surfaces.

1.02 RELATED SECTIONS

- A. Section 01330 Submittal Procedures.
- B. Section 03250 Concrete Accessories.
- C. Section 03300 Cast-In-Place Concrete.
- D. Section 03400 Precast Concrete.

1.03 REFERENCES

- A. ASTM C 33 Specifications for Concrete Aggregates.
- B. ASTM C 150 Portland Cement.
- C. ASTM C 404 Aggregates for Masonry Grouts.
- D. ASTM C 882 Bond Strength of Epoxy Resin Systems Used with Concrete.
- E. ASTM D 638 Test Method for Tensile Properties of Plastics.
- F. ASTM D 695 Compressive Properties of Rigid Plastics.
- G. ASTM D 790 Flexural Properties of Plastics and Electrical Insulating Materials.

1.04 SUBMITTALS

- A. Comply with Section 01300.
- B. Product Data: Indicate product standards, physical and chemical characteristics, technical specifications, limitations, maintenance instructions, and general recommendations regarding each material.
- C. Manufacturer's Certificate: Certify that specified products shall meet or exceed requirements.

1.05 QUALITY ASSURANCE

- A. Materials Manufacturer: Company specialized in manufacturing the products specified in this Section with minimum three years experience.
- B. Applicator: Company specialized in concrete repair with minimum ten years documented

experience.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Comply with manufacturer's instructions for storage, shelf life limitations, and handling.

PART 2 PRODUCTS

2.01 PATCHING MATERIALS

- A. Epoxy Resin: Two-part epoxy adhesive containing 100% solids, meeting the following minimum characteristics:

Characteristic	Test Method	
1. Bond Strength	ASTM C 882	30 Mpa
2. Tensile Strength	ASTM D 638	45 Mpa
3. Elongation	ASTM D 638	2 % precast at 7 days at 21 °C
4. Flexural Strength	ASTM D 790	45 Mpa
5. Compressive Strength	ASTM D 695	55 MPa

- B. Bonding Agent: Polyvinyl acetate emulsion, dispersed in water while mixing, non-coagulant in mix, water resistant when cured.
- C. Portland Cement: ASTM C 150, Type I color as selected.
- D. Sand: ASTM C 33; C 404; uniformly graded, clean.
- E. Water: Clean and potable.
- F. Cleaning Agent: Commercial muriatic acid.

2.02 MIXING EPOXY MORTARS

- A. Mix epoxy mortars in accordance with manufacturer's instructions for purpose intended.
- B. Mix components in clean equipment or containers. Conform to pot life and workability limits.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that surfaces are ready to receive work.
- B. Beginning of installation means acceptance of substrate.

3.02 PREPARATION

- A. Clean concrete surfaces of dirt, laitance, corrosion, or other contamination; wire brush, rinse surface and allow to dry.
- B. For areas patched with epoxy mortar, remove broken and soft concrete 6 mm deep. Remove corrosion from steel. Clean surfaces mechanically; rinse with water.

3.03 REPAIR WORK

- A. Repair exposed structural, shrinkage, and settlement cracks of concrete by the epoxy injection method.
- B. Repair spalling, fill voids flush with surface, apply surface finish.

3.04 APPLICATION - EPOXY MORTAR

- A. Trowel apply mortar mix. Tamp into place filling voids at spalled areas.
- B. For patching honeycomb, trowel mortar onto the surface, work mortar into honeycomb to bring surface flush with surrounding area. Finish trowelled surface to match surrounding area.
- C. Cover exposed steel reinforcement with epoxy mortar, feather edges to flush surface.

3.05 APPLICATION - CEMENTITIOUS GROUT

- A. Apply coating of bonding agent to concrete surfaces. Provide full surface coverage.
- B. Apply cementitious grout by steel trowel. Tamp into place filling voids at spalled areas. Work mix into honeycomb.
- C. Damp cure cementitious grout for four days.

END OF SECTION 03720