DIVISION 3

CONCRETE

BUILDING WORK

DIVISION 3

CONCRETE

INDEX

SECTION 03100

CONCRETE FORMWORK

PART 1: GENERAL

1.01 DEFINITIONS

A. Formwork means the container or mould in which concrete is placed and hardens to form a structural element with the desired dimensions and surfaces, together with all the immediate supports to retain it in position while concrete is placed.

B. False work 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.

PART 2: PRODUCTS

2.01 MATERIALS

A. Temporary formwork shall be constructed of timbers, metal sheet or other approved material such that the concrete mass with the required dimensions and standard of surface finish will be produced.

B. Proprietary moulds shall be used for the forming of ribbed and waffle slabs.

C. Permanent formwork shall be constructed of slabs or blocks of precast concrete, natural stone, brickwork or other approved material, with joints so filled as to prevent the leakage of cement paste or slurry from the concrete. Breeze blocks or other porous materials shall not be used as permanent formwork.

D. The type and treatment of any lining to the forms shall be appropriate to the concrete finish required.

PART 3: EXECUTION

3.01 DESIGN

A. Before construction begins, the Contractor shall submit to the Engineer drawings showing details of the proposed formwork and false work. The design of formwork shall be the responsibility of the Contractor.

B. Formwork and false work shall be so constructed that they will 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 shall be in the position and have the shape and profile as shown on the drawings within the limits of the dimensional tolerances.

3.02 DEFLECTION AND CAMBER

A. The Contractor shall make allowances for any settlement or deflection of formwork that is likely to arise during construction so that the hardened concrete conforms accurately to the specified line and level. Unless otherwise shown on the drawings the formwork of all beams and slabs shall be constructed with the following upward cambers:

Spanning between supports	: 0.2% of the span at its center
Cantilevers	: 0.4% of the span at its free end

3.03 SUPPORT

A. The formwork shall be so arranged as to be readily dismantled and removed from the cast concrete without shock, disturbance or damage. The responsibility for the safe removal of the props shall rest with the Contractor.

B. Props shall be of sufficient strength and number and placed in such a manner that they adequately and without excessive deflection support the loads likely to be imposed on them. Props should be adequately cross braced.

C. Props shall be carried down 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 are carried down to the foundations or other suitable bases.

3.04 JOINTS AND EDGES

A. All joints in formwork shall be close fitting to prevent leakage of current paste or slurry from the concrete.

B. At construction joints in concrete, the formwork shall be tightly secured against previous or hardened concrete to prevent the formation of steps or ridges in the concrete.

C. Formwork shall be constructed to provide straight and true angles, arises or edges. Where chamfers are required, the fillets shall be accurately cut to size to provide a smooth and continuous chamfer.

D. Formwork panels shall have true angles to permit accurate alignment at the sides and provide a clean line at construction joints in the concrete.

E. Formwork panels shall be fixed with their joints either vertical or horizontal unless otherwise specified.

F. Formwork shall be provided 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 shall be adequately secured against uplift due to the pressure of fresh concrete.

3.05 FORMWORK TIES

A. The materials and position of any ties passing through the concrete shall be to the Engineer's approval. It shall be possible to remove a tie so that no part of it remaining in the concrete shall be nearer to the finished surface of the concrete than the specified thickness of cover to reinforcement. Any holes left after the removal of ties shall be filled with concrete or mortar of approved composition to provide matching of color, texture and finish with the adjacent concrete surface, unless otherwise specified.

B. In waterproof concrete any tie in the concrete shall be of a type with a baffle.

3.06 HOLES, INSERTS AND FIXINGS

A. Unless otherwise shown on the drawings or specifically approved, all holes shall be formed and all inserts and fixings cast in at the time of pouring.

B. Approval for size, type and position of any hole, insert or fixing required by the Contractor or any sub-contractor shall be obtained before the start of form work.

C. No part of the concrete works shall be drilled or cut away without the specific approval of the Engineer.

D. If such drilling or cutting is carried out without approval the affected parts shall be classed as defective work. It shall be the Contractor's responsibility to ensure that each of his sub-contractors, nominated or otherwise, is provided with a copy of this clause and abides by it.

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. Such formwork shall be repaired to the satisfaction of the Engineer or removed from the site.

3.08 RELEASE AGENTS

A. Release agents shall be materials marketed as such and shall be one of the following types: -

a) cream emulsion
b) neat oil with surfactant added
c) chemical release agent

B. Release agents shall be stored and used strictly in accordance with the manufacturer's instructions.

C. Where the concrete surface is to be permanently exposed only one agent shall be used throughout the entire area.

D. Where the surface is to receive an applied finish, care shall be taken to ensure the compatibility of the release agent with the finish.

E. Release agents shall not come in contact with the reinforcement.

3.09 FINAL PREPARATIONS

A. Immediately before the concrete is placed in any section of the formwork the interior of that section shall be completely cleared of all extraneous materials including water.

B. Before concrete placing commences, all wedges and other adjusting devices shall be secured against movement during concrete placing and the Contractor shall maintain a watch on the formwork during placing to ensure no movement occurs.

3.10 STRIKING OF FORMWORK

A. The Engineer shall be informed in advance when the Contractor intends to strike any formwork.

B. The time at which the formwork is struck shall be the Contractor's responsibility, but the minimum periods between concreting and the removal of forms shall be as follows: -

TABLE 1 - Minimum Period Before Striking

Location	Surface Temperature of Concrete Containing OPC in Degrees Centigrade: Not less than 16°C	Not less than 7°C
Beam sides, walls and columns	9 hours	12 hours
Slab soffits (fromwork props undisturbed)	4 days	7 days
Formwork props to slabs	11 days	14 days
Beam soffits (formwork props undisturbed)	8 days	14 days
Formwork props to beams	15 days	21 days

C. If the Contractor wishes to strip formwork from the soffits before the expiry of the period for props set out above, it shall be designed so that it can be removed without disturbing the props. The Contractor shall not remove props temporarily for the purpose of stripping formwork and subsequently replace them.

D. Unless otherwise directed, no treatment of any kind, other than that required for curing the concrete, shall be applied to the concrete after removal of the forms until it has been inspected.

3.11 SUBSEQUENT POUR

A. Concrete may not be poured against an existing concrete face until 24 hours after that concrete was cast.

3.12 FINISHED CONCRETE SURFACES

A. General:

Unless otherwise specified all concrete faces to be exposed in the finished works shall be fair face finish.

B. Treatment of Concrete Face:

Unless otherwise directed by the Engineer, no treatment of any kind except that required for curing the concrete and the removal of fins shall be applied to concrete surfaces until the Engineer has inspected them.

3.13 FORMED CONCRETE FINISHES

A. Where a particular type of finish is to be applied to formed surfaces it will be indicated on the drawings.

B. Type A Finish:

This finish is obtained by the use of properly designed formwork or moulds of closely jointed sawn boards. The surfaces will be imprinted with the grain of the sawn boards and their joints. In addition, small blemishes caused by entrapped air or water may be expected, but the surface should be free from voids, honeycombing or other large blemishes.

C. Type B Finish:

This finish is obtained by the use of properly designed forms of closely jointed wrought boards. The surfaces will be imprinted with the slight grain of wrought boards and their joints. Alternatively, steel or other suitable material may be used for the forms. Small blemishes caused by entrapped air or water may be expected, but the surface should be free from voids, honeycombing or other large blemishes.

Plywood sheeting may be used in lieu of sawn or wrought boards.

D. Type C Finish (Fair Faced):

This is to be a smooth even finish for exposed concrete work on the external face of the building, obtained by using an impervious sheet material. Parts of formwork panels are not to be replaced where this may cause a change of color in the concrete.
Abrupt irregularities are not to be greater than 2mm and gradual irregularities, expressed as maximum permissible deviation from 1m straight edge, are not to be greater than 3mm.

The surface shall be free from discoloration due to contamination or grout leakage.

Blowholes less than 5mm in diameter will be permitted but otherwise the surface shall be free from voids, honeycombing, segregation and other defects.

Projecting fins shall be removed and rubbed down with carborundum stone. Making good will not normally be permitted and areas, which have been rubbed down will not necessarily, be accepted.

Arises shall be chamfered at 45° and the chamfered face is to measure 25mm across unless otherwise indicated.

Form tie holes shall be make to appear as a regular pattern, and as shown on the drawings. Concrete should be poured evenly and continuously - measures being taken to prevent rise of concrete in form at a rate, which exceeds that on which their design is based.

Formwork should be waterproof, seals being used at connection to prevent escape of grout.

Any damaged formwork shall not be used.

Great care shall be taken to ensure that all foreign matter is removed before concrete is poured.

Release agents shall not be used without prior approval.

3.14 TRIAL PANELS

A. In order to ensure that the specified formed or worked finishes can be obtained by the method of construction proposed and to provide a standard by which the finishes in the Works can be assessed, trial panels shall be cast on site. These panels shall be approved before similar construction is begun in the Works.

B. The trial panels shall employ the materials, plant and concrete mix proposed for the Works. They shall be at least story height and 1m wide. They shall be of similar thickness and similarly reinforced to the elements they represent and shall incorporate all features, which may contribute to the final appearance of the work, e.g. such as:

- horizontal and vertical construction joints.

- horizontal and vertical panel joints

- arises and chamfers

3.15 UNFORMED CONCRETE SURFACES

A. Unless other noted or specified, all unformed surfaces shall be leveled and screeded to produce a uniform plain or ridged surface, surplus concrete being struck off by a straight edge immediately after compaction.

B. Surface of basement slabs not shown to receive screed shall have a power float finish. The surface shall be floated when the surface water has disappeared or when concrete has stiffened sufficiently to permit operation of power-driven floats. The surface shall be consolidated using power-driven floats, or by hand-floating if the area is small or inaccessible to power units.

C. Concrete to receive waterproofing membrane - steel toweled smooth finish.

D. Concrete to receive tiles, Pavers and horizontal cementitious finish - Consolidate screed and wood float finish to required grades.

3.16 DIMENSIONAL CONSTRUCTION TOLERANCES

A. Formwork shall be erected such that dimensions of concrete construction are within the tolerances quoted in BS 5606: 1978, British Standard Code of Practice for Accuracy in Building, except where the tolerances given in the Specification are more onerous.

B. The difference between dimensions shown on the drawing and the corresponding as-built dimension shall not be greater than the following:

Structure Parts	In plan dimension		In level
	Less than 2m		More than 2m
Foundations	15mm	25mm	15mm
Elsewhere 5mm	10mm	5mm	

Unless specified otherwise in this document.

C. As-built dimensions to grid lines shall be measured from setting out lines.

D. The tolerance for the following shall be 5mm:

1. Plumb (in each 3m lift)

2. Bow and camber

3. Twist (distance of any corner from the plane containing the other three corners).

4. Squareness of corners (the longer of the two adjacent sides shall be taken as the base line and the deviation measured to the end of the shorter side).

The Contractor shall advise the Engineer when these tolerances are exceeded.

Any part of the works in which variations in any respect exceed the tolerances stated above may, at the discretion of the Engineer, be classed as defective work.

End of Section

SECTION 03200

CONCRETE REINFORCEMENT

PART 1: GENERAL

1.01 SCOPE OF SECTION

A. The work covered by this section includes the provision of labor, materials and plant necessary for the incorporation of steel reinforcement into the concrete in any part of the works but does not include prestressing tendons or any other embedded steel.

1.02 QUALITY STANDARDS

A. The following standards are referred to or implied by this technical specification.

BS 4449 Specification for carbon steel bars for the reinforcement of concrete.

BS 4466 Specification for bending dimensions and scheduling of reinforcement for concrete.

BS 4483 Specification for steel fabric for the reinforcement of concrete.

BS 5135 Specification for arc welding of carbon and carbon manganese steels.

1.03 SUBMITTALS FOR REVIEW

A. Section 01300 - Submittals: Procedures for submittals.

B. Submit for Engineers review all items described in this specification section.

PART 2: PRODUCTS

2.01 REINFORCEMENT

A. Bars for reinforcement shall be new, be of Saudi manufacture and shall conform to the following material specification: -

1.	Bars, Except Wldable	ASTM A615/A615M, Grade 60, deformed.
2.	Bars, Weldable	ASTM A706 or A615, Grade 60, deformed, with maximum carbon equivalent of 0.55 percent.
3.	Columns Spirals	ASTM A82, cold drawn wire.
4.	Welded wire fabric	ASTM A185 or A497 - Grade 75

B. Deformed bars shall be a bar with transverse ribs (or continuous helical ribs where present), at a substantially uniform spacing not greater than 0.8 Dai having a mean area of ribs above the core of the bar projected on a plane normal to the axis of the bar, not less than $0.15D^2$ area, where D is the nominal bar size.

2.02 TYING DEVICES

A. Tying devices shall be:

1. Black annealed mild steel wire of 1.6mm diameter.

2. Approved rustproof binding wire, or

3. Approved proprietary ties.

2.03 SPACER BLOCKS

A. Spacer blocks shall be used for ensuring that the correct cover is maintained to the reinforcement.

B. Blocks shall be of such materials and design as will be durable and not lead to corrosion of the reinforcement.

C. Spacer blocks made from cement, sand and small aggregate shall not exceed 50mm square in section and shall be securely wired to the reinforcement to ensure that they are not displaced when the concrete is poured. They shall be made of similar mix proportions and strength as the adjacent concrete. Plastic spaces shall be of approved design, and may not be permitted where heavy loads are to be carried.

PART 3: EXECUTION

3.01 REINFORCEMENT TESTS

A. 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 British Standard or equal.

B. The frequency of testing shall be as set out in the British Standards, which include:

1. Tensile tests for each diameter and grade of steel to be used in the works.

2. Bend tests for all bars with a diameter greater than 20mm.

3. Rebend tests for all bars with a diameter greater than 20mm.

The Contractor shall carry out additional tests as instructed by the Engineer.

C. Any reinforcement which does not comply with the Specification shall be immediately removed from site.

3.02 STORAGE OF MATERIALS

A. Reinforcement of all types shall be stored on site in racks above ground in an approved manner so as to avoid damage.

B. All reinforcement shall be free from loose scale, rust, oil, grease or any other material that may impair the bond between the concrete and the reinforcement. Any reinforcement which has become corroded or pitted to an extent which, in the opinion of the Engineer, will affect its properties shall be removed from site.

C. Mild steel reinforcement shall be stored separately from high yield reinforcement.

3.03 CUTTING AND BENDING

A. Reinforcement shall be bent to the dimensions given in the bar schedules in accordance with BS 4466 unless otherwise stated. The Contractor should check that schedules have been provided for each part of the structure.

B. No reinforcement shall be heated before bending.

C. Cold worked bars and hot rolled high yield bars shall not be straightened or bent again 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, bars shall be securely tied together in bundles or groups and legibly labeled as set out in BS 4466.

3.04 SPLICING AND WELDING

A. Reinforcement shall not be welded except where required by the Contract or agreed by the Engineer. If welding is employed the procedures shall be as set out in BS 5135. Details of all welding techniques to be used shall be submitted for approval and such trials made as are required to demonstrate the effect of the welding. No welding or splicing shall be made to the reinforcement except where described on the drawings, or where approved by the Engineer.

B. Except as otherwise indicated on the drawings, lap splices shall be detailed as tension lap splices in accordance with ACI 318.

3.05 CLEANING OF REINFORCEMENT

A. Reinforcement shall be free of all loose mill scale or rust, oil, grease, concrete or other harmful matter at the time of concreting.

3.06 FIXING OF REINFORCEMENT

A. All reinforcement shall be accurately placed with the correct cover and securely fixed in the positions shown on the drawings and to the satisfaction of the Engineer, who shall be given reasonable notice before pouring concrete that the reinforcement fixing is complete.

B. At intersections the reinforcement bars shall be bound together with tying wire and the loose ends of the wire shall be turned towards the inside of the member.

C. The Contractor shall 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 from being bent or sagging.

D. The actual concrete cover shall be not less than the required nominal cover minus 5mm. 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. The Contractor shall provide adequate mortar or plastic spacers to ensure that 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.

3.07 PROJECTING REINFORCEMENT

A. The Contractor shall protect projecting reinforcement without affecting its bond properties and shall ensure that it does not cause rust staining to any part of the works.

End of Section

SECTION 03250

CONCRETE JOINT ACCESSORIES

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, and appurtenances required and install concrete joint accessories for cast-in-place concrete as indicated on the drawings and specified herein.

1.02 RELATED WORK

A Other sections directly related to work covered in this section include the following:

1. Section 03200 - Concrete Reinforcement.
2. Section 03300 - Concrete.
3. Section 03350 - Concrete Finishes.
4. Section 07900 - Caulking.

1.03 SUBMITTALS

A Submittals shall be in accordance with the submittals Section.

B The following layout drawings shall be submitted for review prior to the start of concrete work.

1. Layout drawings showing the location of all concrete joints as indicated on the drawings and those additional concrete joints proposed by the Contractor to facilitate the construction.
2. Layout drawings showing the location and extent of all joint waterstops. The type and size of all waterstops to be used shall be indicated for each joint.

C The following technical information shall be submitted for review prior to their installation.

1. Catalog cuts for all products.
2. Additional product information and/or samples requested by the Engineer to determine conformance with the specifications.
3. Country of origin of all products.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING

A Plastic products shall be stored in a cool dry place out of direct sunlight.

PART 2: PRODUCTS

2.01 MATERIALS

A. PVC Water Stops Extruded PVC, heavy duty, ribbed or serrated, with "O" bulb closed center sections unless otherwise indicated on the drawings, 230 mm wide, complete with Junction Pieces:

Man: Expandite Ltd.
Chase Road
London NW10 6PS
England
Tel: (01) 965 8877
Tlx: (254220

Man: Greenstreak Plastic Products
3400 Treecourt Industrial Park
Box 7139, St. Louis, Mo. 63177
U.S.A.
Tel : 314 225 9400

Man : Servicised Ltd
Ajax Avenue
Slough
Berkshire SL1 4BH
England
Tel : 0753 692929
Tlx : 846966 Servcd G.

Ref : SERVITIECJ 230

or other equal and approved.

B Expansion joint materials

1. Filler : Expanded polystyrene , density 20 Kg / m3
2. Sealant : As specified in the caulking section.
3. Filler Adhesive : As recommended by manufacturer..

C Dowel Bars Mild steel, to BS4449, Grade 250, with sawn (not sheared) ends.

D Compressible Caps For dowel bars are to be approved type in corporating not less than 20mm of compressible material

2.02 PERFORMANCE AND DESIGN CRITERIA

A Construction joints shall be made at locations indicated on the drawings or specified. Construction joints shall not be made at other location without the concurrence of the Engineer.

Construction joints shall be located as follows:

1. In columns and Walls: At the underside of beams, girders, and at floor levels. Column bases will not be required to be monolithic with the floor beneath. Walls shall be divided into sections not greater than 18 m in length, except at corners which shall be as indicated on the drawings.

2. In Beams and Girders: At the quarter point of the span unless a beam intersects a girder at that point, in which case the joint in the girder shall be offset a distance equal to twice the width of the beam. The transfer of shear and other forces through the construction joint shall be provided for in a manner acceptable to the Engineer.

3. In Suspended Slabs: At or near the quarter point of the span in flat slab or T-beam construction. No joint will be permitted between a slab and a concrete beam or girder unless specifically required on the drawings. Suspended floor systems shall be divided by construction joints into approximately square sections not greater than 18 m in their longest dimension.

4. In Bottom Slab: Each bottom slab shall be divided into approximately square sections not greater than 18 m in their longest dimension.

   Construction joints in beams, girders, and slabs shall be perpendicular to the planes of their surfaces.

B Construction joints in the following locations shall be watertight and shall be provided with a continuous waterstop.

1. Walls and bottom slabs of dry pits or rooms where below finished grade and in contact with backfill or subgrade material on the opposite side.

2. Walls in contact with liquid where the opposite face is above finish grade or exposed in a dry pit or room.

3. Slabs in contact with liquid where the opposite face are exposed in a dry pit or room.

4. Other locations where specifically indicated on drawings.

C Contracting joints shall be provided at the locations indicated on the drawings, Accessible edges of each contraction joint shall be sealed as specified in the Caulking Section.

Elastic waterstops in contraction joints shall be continuous and shall be of the rubber "dumbbell" type or plastic (PVC) ribbed or serrated type. Waterstop embedment shall be equal on each site of the joint.

PART 3: EXECUTION

3.01 INSTALLATION

A Elastic waterstops shall be spliced and/or joined in conformity with the manufacturer's recommendations to form a continuous seal along the joints and at intersections. The finished splices and connections shall have a tensile strength of not less than 80 percent of the unspliced section. The splices and connections shall not be subjected to any force for ten minutes after making the splice or connection.

B Joint fillers shall be bonded to the previously poured concrete with a bonding agent compatible with the joint sealant and joint filler. The new concrete shall be poured directly against the joint filler. All installations shall be in accordance with the manufacturer's recommendations. Premolded filler shall be precut to butt tightly against the waterstop if present and to leave the recess detailed on the Drawings for sealant. All butt splices shall be taped to prevent intrusion of the second concrete placement into the filler joint.

C Dowel Bars:

Coat half of each bar with approved proprietary debonding compound or fit with approved plastics sleeve. Fix bars securely at required level, perfectly level, at right angles to and centered on the joint. Fit compressible caps to debonded ends of bars.

3.02 SEALING OF MOVEMENT JOINTS :

A Preparation and application is to be strictly as manufacturer's recommendations. Joints are to be thoroughly clean and dry, free from oil and loose material. Vigorously wire brush or grit blast the joint faces and clean out with compressed air. Prime faces of joint and allow to dry. Where exposed to view mask edges of joint with tape before priming and remove immediately after sealing. Apply sealant ensuring maximum adhesion to sides of joint and a neat, smooth and clean finish.

End of Section

SECTION 03300

CAST IN PLACE CONCRETE

PART 1: GENERAL

1.01 SCOPE OF SECTION

A. This technical specification establishes the quality of materials and workmanship and defines how quality is measured for concrete work.

1.02 QUALITY STANDARDS

A. The following standards are referred to or implied by this technical specification

BS 12 - Specification for ordinary and rapid hardening Portland Cement

BS 812 - Testing Aggregate

BS 882 - Specification for aggregates from natural sources for concrete

BS 1014 - Specification for pigments for Portland cement and Portland cement products

BS 1305 - Specification for batch type mixers

BS 1377 - Methods of test for soils for civil engineering purposes

BS 1881 - Testing concrete

BS 3148 - Methods of test for water for making concrete

BS 3892 - Specification for Pulverized Fuel Ash

BS 4027 - Specification for sulphate resisting Portland cement

BS 4550 - Methods of Testing Cement

BS 5075 - Concrete Admixtures

BS 5328 - Methods of Specifying Concrete

BS 8007 - Code of practice for design of concrete structures for retaining aqueous liquids

BS 8110 - Structural use of concrete

CP 102 - Code of practice for protection of buildings against water from the ground.

1.03 DEFINITIONS

A. Structural concrete is any class of concrete which is used in reinforced, prestressed or unreinforced concrete construction which is subject to stress and which is required to comply with Clause 3.02, 3.03 and 3.04 of this section of the Specification.

B. Non-structural concrete is composed of materials complying with this Specification 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 screed is non-structural concrete made with light aggregate, but otherwise complying with this specification. Density shall not be greater than 1000 kg/m^3.

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.

1.04 DESIGN

A. The design of the structural concrete has been carried out in accordance with ACI 318-89. Any concrete design carried out by the Contractor shall conform to those standards unless otherwise instructed by the Engineer. The provisions of these standards, unless otherwise stated, shall be held to be incorporated in this Specification.

1.05 VARIATIONS

A. No variations to the Specification or drawing may be made without approval. The Contractor shall submit details of any reasons for any proposed variations from this Specification, the drawings, and/or the Engineer's written or drawn instructions for approval.

1.06 MARKING

A. The Contractor shall mark, document and identify materials so as to ensure that they are used as specified.

1.07 DRAWINGS

A. All reinforced concrete work shall be carried out strictly in accordance with the reinforcement drawings and the reinforcement standard details.

PART 2: PRODUCTS

2.01 MATERIALS

A. The Contractor shall submit to the Engineer full details of all materials which he proposes to use for making concrete. No concrete shall be placed in the permanent works until the Engineer has approved the materials of which it is composed. Approved materials shall not thereafter be altered or replaced by other materials without the consent of the Engineer.

2.02 CEMENT

A. Cement shall generally be Ordinary Portland Cement (OPC), complying with ASTM C150, Type1 or BS 12, for all works above ground level. White or coloured cement shall comply with BS 12.

B. For work below ground level cement shall be Sulphate Resisting Cement (SRC) complying with ASTM C150, Type V or BS 4027, unless microsilica is specified, when OPC shall be used.

C. The cement shall be obtained directly from an approved manufacturer or an approved supplier and shall be delivered either in bulk by purpose built vehicles or in sealed bags. All cement shall be free flowing and free of lumps.

D. The total alkali content of the cement expressed as the sodium oxide equivalent shall not exceed 0.6% by weight.

E. The tricalcium aluminate (C_3Al) content of any cement shall not exceed 8.0%.

F. The sulphuric anhydride (SO_3) content shall not exceed 2.5%.

G. The specific surface (fineness), when determined by the method specified in BS 12 Appendix A, shall be at least 2500 sq.cm. per gm.

H. The heat of hydration, when measured as set out in BS 4550, shall not exceed 250 kJ/kg when tested at 7 days, nor exceed 290 kJ/kg when tested at 28 days.

J. The initial setting time shall be not less than 45 minutes and the final setting time shall be not more than 10 hours when tested as described in BS 4550.

K. Certificates of cement tests by the manufacturer will be called for by the Engineer. If such certificate is not made available, or if the Engineer considers that the manufacturers tests are inadequate, samples for testing shall be taken from different consignments as the Engineer may direct. Such samples shall weigh not less than 7 kg and shall be selected and tested in accordance with BS 4550.

2.03 STORAGE OF CEMENT

A. Storage of bulk cement shall be in weatherproof silos which shall bear a clear indication of the types of cement contained in them. Different types of cement shall not be mixed in the same silo. Storage silos shall be drawn down frequently to prevent cement caking.

B. Cement in bags shall be stored in a suitable weatherproof structure of which the interior shall be dry and well ventilated at all times. The floor shall be raised above the surrounding ground level and shall be so constructed that no moisture rises through it. Each delivery of cement in bags shall be closely stacked but shall not be stacked against an outside wall. Different types of cement in bags shall be clearly distinguished by visible markings and shall be stored in separate stocks. Cement in bags shall be used in the order in which they are delivered. Cement from broken bags shall not be used in the permanent works.

C. The Contractor shall provide sufficient storage capacity on site to ensure that his anticipated programme of work is not interrupted due to lack of cement.

2.04 AGGREGATES

A. Aggregates for concrete shall conform to the requirements for fine and coarse aggregates in BS 882 or ASTM C33.

B. Aggregates shall consist of crushed or naturally occurring materials having hard, durable, strong particles. All aggregates are to be washed with clean water to ensure compliance with the requirements of the specification. The use of marine aggregates will not be approved.

C. At least 30 days before concreting operations are due to commence, the Contractor shall submit for approval the names of the pits, quarries or manufacturing plants from which he proposes to obtain aggregates, together with evidence showing that the material complies with the requirements of the appropriate British Standards.

D. Fine aggregate shall either consist of natural sand or be obtained by crushing clean hard rock or be a mixture of these. Fine aggregate shall conform to BS 882 Table 5, Zone C or M. In order to achieve an acceptable grading it may be necessary to blend materials from more than one source.

E. Fine aggregate shall contain no excessive quantities of dust, soft or flaky particles, shells, congealed lumps, shale or other contaminations likely to adversely affect the strength or durability of the concrete or to attack the reinforcement.

F. Coarse aggregates shall consist of naturally occurring gravel or crushed granite and shall not contain harmful materials in sufficient quantity to affect adversely the strength or durability of the concrete or to attack the reinforcement.

G. Coarse aggregates shall be supplied in the nominal sizes specified and shall be graded in accordance with BS 882 or (ASTM C33) for single sized aggregates.

H. Aggregates shall comply with the mechanical properties in BS 882 and in addition the flakiness index, when determined by the sieve method described in BS 812, shall not exceed 40 for 40 mm aggregates, nor shall it exceed 35 for 20 mm aggregates. In construction specified on the drawings as watertight the coarse aggregates shall not have combined indices for flakiness and elongation exceeding 35, nor shall the flakiness index exceed 15.

J. The sulphate content (as SO_3) of both the fine and coarse aggregates shall not exceed 0.4% by weight. The total sulphate content of all the ingredients in a mix including cement, water and admixtures shall not exceed 4.0% of the weight of cement within the mix.

K. 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 shall not exceed the following limits expressed as a percentage of the weight of the cement in the mix :-

For prestressed concrete, steam cured concrete or concrete containing sulphate resisting cement : 0.05%

For any other reinforced concrete : 0.25% in 95% of all test results providing no result is more than 0.4%

L. The coarse aggregate should not have a water absorption of more than 3.0% when tested as defined in BS 812. If the proposed aggregate has an absorption of more than 3.0%, the Contractor shall 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.

M. The "10% Fines" values, when determined in accordance with BS 812, shall not be less than 50kN for the coarse aggregates. Where aggregates are to be used for concrete wearing surfaces, the "10% Fines' value shall not be less than 100kN.

N. After the magnesium sulphate soundness test, the weight loss shall not be more than 15% for the fine aggregate and 18% for the coarse aggregate.

O. No part of the aggregates shall 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.

P. The grading of an all-in aggregate, when analyzed as described in BS 812, shall be in accordance with Table 6 of BS 882 for the nominal size of aggregate specified.

Q. The Contractor shall carry out routine testing of aggregates for compliance with the specification during the period in which concrete is being produced for the Permanent Works. The routine tests include but are not limited to grading, silt and clay content, moisture content, check on organic impurities and chloride content. These tests shall be performed 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 tons of coarse aggregate and provided also that the aggregates are of uniform quality.

2.05 DELIVERY AND STORAGE OF AGGREGATES

A. Aggregates shall be delivered to site in clean and suitable vehicles. Different types or sizes of aggregates shall not be delivered in one vehicle.

B. Aggregates shall not be stored in contact with the ground and shall be protected against the intrusion of the ground and other foreign matter. There shall be a physical partition between the stores 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, the store heaps shall be covered to prevent contamination by wind blown material.

C. Aggregates, which in the opinion of the Engineer are not clean or which have become mixed due to defective storage, shall be removed from site immediately.

2.06 ADMIXTURES

A. Suitable admixtures may be used only with the prior written approval of the Engineer. Both the proposed dosage and method of use shall be submitted to the Engineer together with the following data:

1. The typical dosage and detrimental effects of under dosage and over dosage

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, an admixture shall comply with one of the following standards:

BS 1014 Pigments for cement, magnesium oxychloride and concrete.

BS 3892 Pulverized-fuel ash for use in concrete.

BS 5057 Concrete admixtures.

C. The use of calcium chloride as an admixture will not be approved.

2.07 WATER

A. The water to be used in mixing concrete shall be clean and free from all harmful matter in suspension or solution and shall satisfy the recommendations given in BS 3148. If directed by the Engineer, the Contractor shall carry out tests in accordance with BS 3148 to establish compliance with the Specification.

2.08 WATERSTOPS

A. Waterstops shall conform to the requirements of Section 03250: Concrete Accessories.

2.09 REJECTED MATERIALS

A. All materials which have been damaged or are contaminated or unidentifiable or do not in all respects comply with the Specification shall be rejected and removed immediately from the site at the Contractor's expense.

2.10 TESTING LABORATORY AND EQUIPMENT

A. The Contractor shall submit for approval the name of the Testing Authority he proposes to employ. He shall, in addition maintain at the site the following apparatus which shall be kept in good repair throughout the Contract:

1. Apparatus for assessing workability in accordance with BS 1881.

2. Apparatus for making concrete cubes in accordance with BS 1881.

3. A maximum and minimum thermometer to be kept on the Site close to the Works for measuring atmospheric shade temperature.

4. Two soil thermometers for measuring concrete and ground temperature.

5. A wet and dry bulb thermometer for measuring relative humidities.

2.11 TESTS

A. All tests and checks carried out on site shall be in the presence of or as directed by the Engineer. The Contractor shall be responsible for carrying out all tests required by the Specification or called for by the Engineer. Unless otherwise specified the costs of all tests required are to be met by the Contractor whether the test results show the material or workmanship to be satisfactory for the work or not.

B. If the Contractor proposes to adopt a designed concrete mix then he shall be responsible for carrying out the preliminary tests in accordance with Clause 3.03 of this section of the Specification and send the results to the Engineer before placing any structural grade concrete made from the materials to be tested. No structural concrete shall be placed in the works until the relevant mix has been approved by the Engineer. The preliminary tests shall be carried out at the start of the contract on samples of the materials the Contractor intends to use on structural concrete grades. The preliminary tests shall be repeated whenever the Contractor proposes to change his source of supply and whenever in the opinion of the Engineer there was sufficient variation from the previously approved sample that new tests are required.

2.12 RECORDS

A. Temperature: A daily record shall be kept of maximum and minimum outside shade temperatures.

B. Concreting and Test Cubes: The Contractor shall submit weekly to the Engineer a complete record of concreting, giving the date, location, concrete grade and mixer (if more than one).

C. These records shall be set out in such a way that the test cube results may be easily referred to the works concrete to which they relate.

PART 3: EXECUTION

3.01 CONSTITUENTS

A. Concrete shall be made from cement, aggregate and water, all as specified and approved. No other ingredients shall be added without the prior approval of the Engineer.

3.02 CONCRETE CLASSES

A. Classes of concrete to be used in various locations indicated on the drawings shall be as shown in Table 1. The class of concrete is denoted by the minimum 28 day characteristic cube strength and the type of cement. The strength and other parameters specified are those assumed for the design of the structure and must be achieved by the Contractor in the finished buildings.

TABLE 1

Class of Concrete	Minimum Cement Content kg/m3	Maximum Water Cement Ratios	Nominal Maximum Aggregate Size mm	Characteristic Strength at 28 days N/mm2
				Cube Strength to BS 1881
C15/S	240 (SRC)	0.55	20	15
C16/S	270(SRC)	0.55	20	16
C20	300 (OPC)	0.5	20	20
C20/S	300 (SRC)	0.5	20	20
C30	360 (OPC)	0.45	20	25
C30/S	360 (SRC)	0.40	20	25

B. The measured slump of different classes of concrete shall be in accordance with the requirements of BS 5328 or ASTM C143.

C. DESIGNED MIXES

a. Target Mean Strength:

The concrete mix shall be designed to have at least the required minimum cement content and/or maximum water/cement ratio and to have a mean strength greater than the specified characteristic strength by at least the current margin.

b. The current margin for each particular type of concrete mix shall be determined; it may be taken as having the smaller of the values given by 1. or 2.

i) 1.64 times the standard deviation of cube tests on at least 100 separate batches of concrete of nominally similar proportions of similar materials and produced over a period not exceeding 12 months by the same plant under similar supervision, but not less than 1/6 of the characteristic strength of concrete of grade 15, or 3.75 N/mm^2 for concrete of grade 30 or above.

ii) 1.64 times the standard deviation of cube tests of at least 40 separate batches of concrete of nominally similar proportions of similar materials and produced over a period exceeding 5 days but not exceeding 6 months by the same plant under similar supervision but not less than 1/3 of the characteristic strength for concrete of grade 15 or 7.5 N/mm^2 for concrete of grade 30 or above.

c. Where there is insufficient data to satisfy 1. or 2. above, the margin for the initial mix design should be taken as two-thirds of the characteristic strength for concrete of grade 15 or $15N/mm^2$ for concrete of grade 30 or above.

d. On the basis of satisfactory and consistent works cube results the Engineer may at his discretion reduce this figure but to not less than $7N/mm^2$ and the mix may be redesigned accordingly.

e. Change of Current Margin:

A recalculated margin should not be adopted unless it differs from the current margin by at least 18% when based on 40 separate batches, 11% when based on 100 batches, or 5% when based on 500 batches.

3.03 QUALITY CONTROL OF CONCRETE PRODUCTION

A. For each class of concrete in production at each plant for use in the Permanent Works, samples of concrete shall be taken 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 BS 1881. A slump test shall be carried out in accordance with the requirements of BS 1881 whenever the Engineer may require it.

B. Concrete cubes shall be 150 mm cubes. Samples shall be taken for every 20 cubic metres of concrete placed with a minimum of one sample taken every day on which the mix is used. From each sample cubes shall be made, one for testing seven days after casting and two for testing 28 days after casting. The average strength of the two cubes crushed at 28 days shall be referred to as one test result.

C. All cubes shall be clearly marked with the date of casting and accurate records shall be supplied to the Engineer, stating the dates of taking and testing of samples, together with the results of tests and the exact position from which the sample was taken.

D. If in the opinion of the Engineer, from the evidence of the cube test, the concrete is not likely to be capable of fulfilling its purpose, the Engineer shall require 3 cores to be taken from the area represented by the test cubes. The actual location shall be decided by the Engineer.

These cores shall be taken and tested in accordance with the requirements of BS 1881 and if the average of the three cores when reduced to the corrected equivalent test cube strength at 28 days falls below the specified strength, further cores are to be cut in order to determine the extent of the unsatisfactory concrete. The volume of concrete shown to be below the required strength shall be taken out and replaced at the Contractor's expense.

3.04 EVIDENCE OF SUITABILITY OF PROPOSED MIX PROPORTIONS

A. Evidence shall be submitted to the Engineer for each grade of concrete that the mix has been designed to give sufficient workability to be placed and compacted by the methods to be used on site.

B. If adequate data for "target mean strength" is not available, trial mixes shall be prepared.

C. Information to be Supplied:

The following information shall be provided before any design mix is supplied. Subsequently the Contractor shall declare any change in sources of materials and any change in cement content which results in a difference greater than 20 kg/m from the cement content last declared.

1. Nature and source of each material, and for aggregates, grading curves.

2. Appropriate existing data as evidence of satisfactory previous performance for target mean strength and current margin and if required workability and w/c ratio.

3. Proposed quantities of each ingredient per cubic metre of fully compacted concrete.

3.05 TRIAL MIXES

A. Where trial mixes are required three separate batches of concrete shall be made using materials likely to be typical of the proposed supply and preferably under full scale production conditions. Sampling and testing shall be in accordance with B.S. 1881 and 3148.

B. The workability of each of the trial batches shall be determined and three cubes made from each batch for test at 28 days. A further three cubes from each batch shall be made for test at 7 days if required. The trial mix proportions will be approved if the average strength of the nine cubes tested at 28 days exceeds the specified characteristic strength by the current margin minus 3.5N/mm^2 or if nine tests at 7 days indicate that it is likely to be exceeded by this amount.

C. If trial mixes are required to demonstrate that the maximum free water / cement ratio is not exceeded, two batches shall be made in a laboratory with cement and surface dry aggregates known from past records of the supplier of the material to be typical. The proposed mix proportions will not be accepted unless both batches have the correct cement content and a free water / cement ratio below the maximum specified value at the proposed degree or workability.

3.06 TESTING PLAN FOR CONCRETE CUBES

A. Concrete test cubes shall be 150mm cubes, made, cured, and tested in accordance with B.S. 1881 and 3148.

B. Cubes shall be taken at the point of discharge from the mixer or the ready mix delivery vehicle.

C. Cubes shall be made individually.

D. Compliance with the specified characteristic strength may be assumed if:

1. the average strength determined from any group of four consecutive test cubes exceeds the specified characteristic strength by not less than 0.5 times the current margin, and

2. each individual test result is greater than 85% of the specified characteristic strength.

E. The Contractor shall make all necessary arrangements for curing and delivery of samples and test pieces to the Testing Authority.

3.07 ACCEPTANCE OF WORKS CONCRETE

A. The Contractor shall take Four cubes from each sample, Two for test at 7 days, the other for test at 28 days. Sampling shall be at the rate of 4 per day for the first 10 days or for the first 40 samples, and at one per $20m^3$ thereafter.

B. If any cube fails to meet the strength required, then the Contractor shall carry out full investigation into the cause. If the Engineer is not satisfied with the results of the Contractor's investigation or any additional tests which shall be carried out at the Contractor's expense, then the works made from concrete mixed between the times of the sampling for the previous and subsequent satisfactory sets of cubes shall be classed as defective work.

3.08 MIXING CONCRETE

A. Unless otherwise agreed by the Engineer concrete shall be mixed in an approved type of mechanical weigh-batcher. No hand mixing will be allowed.

B. The weighing and water-dispensing mechanisms shall be maintained in good order. Their accuracy shall be maintained within the tolerance described in BS 1305 and checked against accurate weights and volumes when required by the Engineer.

C. The weights of cement and each size of aggregate as indicated by the mechanisms employed shall be within a tolerance of +/- 2 percent of the respective weights per batch agreed by the Engineer. The weight of the fine and coarse aggregates shall be adjusted to allow for the free water contained in the fine and coarse aggregates which shall be determined by the Contractor by a method approved by the Engineer immediately before mixing begins, and further as the Engineer requires.

D. The materials shall be mixed until they are uniformly distributed and the mass is of uniform consistency and colour, but in no case shall the mixing time be less that 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.

E. Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed. Mixing plant shall be thoroughly cleaned before changing from one type of cement to another.

F. Delivery notes with each batch delivered shall record the following :-

1. Date and time of arrival
2. Time and place of mixing
3. Registration of truck and depot
4. Time and place of adding water
5. Mix class
6. Details of any approved additives.

3.09 TRANSPORT AND PLACING OF CONCRETE

A. The method of transporting and placing concrete shall be to the approval of the Engineer. Concrete shall be so transported and placed that contamination, segregation or loss of constituent materials does not occur.

B. All formwork and reinforcement contained in it shall be clean and free from standing water immediately before the placing of the concrete.

C. Concrete shall not be placed in any part of the structure until the Engineer's approval has been given.

D. If concreting is not started within 24 hours of approval being given, approval shall again be obtained from the Engineer. Concreting shall then proceed continuously over the area between construction joints. Fresh concrete shall not be placed against in site concrete which has been in position for more than 30 minutes unless a construction joint is formed in accordance with this specification. When in site concrete has been in place for 4-hours no further concrete shall be placed against it for a further 20-hours.

E. Concrete when deposited shall have a temperature of not less than $5^{o}C$ and not more than 32^{o} C except with the approval of the Engineer.

F. Except in the case of columns or where otherwise agreed by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth not exceeding 300 mm and each layer shall be well consolidated before the subsequent layer is placed.

G. Except in the case of columns or unless otherwise agreed by the Engineer, concrete shall not be dropped into place from a height exceeding 2 metres. When trunking or chutes are used they shall be kept clean and used in such a way as to avoid segregation.

H. Concrete shall not be pumped or discharge through aluminum or alloy conduits. Concreting shall be carried out continuously and no concrete shall be placed on concrete which has sufficiently set as to cause the formation of seams or planes of weakness with the section. Where concrete cannot be placed continuously, construction joints as specified shall be formed, only where shown on the drawings or approved by the Engineer.

J. The time elapsing between mixing and placing a batch of concrete shall be as short as practicable. The time should be no longer than will permit completion of placing and compaction before the onset of initial set and in any case no longer than one hour from the time the water is added to the mix.

3.10 INTERRUPTIONS TO PLACING

A. If concrete placing is interrupted for any reason and the duration of the interruption cannot be forecast or is likely to be prolonged, the Contractor shall immediately take the necessary action to form a construction joint so as to eliminate as far as possible feather edges and sloping top surfaces and shall thoroughly compact the concrete already placed. All work on the concrete shall be completed while it is still plastic and it shall not thereafter be disturbed until it is hard enough to resist damage. Plant and materials to comply with this requirement shall be readily available at all times during concrete placing.

B. Before concreting is resumed after such an interruption the Contractor shall cut out and remove all damaged or uncompacted concrete, feather edges or any other undesirable features and shall leave a clean sound surface against which the fresh concrete may be placed.

C. If it becomes possible to resume concrete placing without contravening the Specification and the Engineer consents to a resumption, the new concrete shall be thoroughly worked in and compacted against the existing concrete so as to eliminate any cold joints.

3.11 PUMPED CONCRETE

A. If it is the Contractor's intention to transport concrete by pumping he is to obtain the Engineer's written approval at the commencement of the contract. When submitting his proposals to the Engineer the Contractor must furnish the Engineer with full details of the mix design, the area and volume of concrete that he intends to place in an operation and the distance over which the concrete is to be pumped. The foregoing Clause on mix design will apply equally to a concrete that is designed to be "pumped".

3.12 COMPACTION OF CONCRETE

A. All concrete shall be compacted to produce a dense homogeneous mass. Unless otherwise agreed by the Engineer, it shall be compacted with the assistance of mechanical vibrators, and sufficient mechanical vibrators in serviceable condition shall be 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. No vibrator shall be operated by a workman who has had insufficient training in its use.

D. With immersion vibrators the tubular part of the tool shall be inserted vertically into the full depth of the concrete to be vibrated at points 600 mm apart and at least 100 mm away from any formwork. The vibrators shall be kept constantly moving whilst in action to prevent segregation. 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. Vibration shall be stopped after the decrease in volume is no longer apparent or before localised areas of grout or laitance are formed. Should the supply of concrete from the mixer be interrupted the vibrators should be lifted clear from the work.

E. Care shall be taken to ensure that concrete is fully compacted around waterstops without distorting, displacing or damaging the waterstops.

F. If the surface of a floor slab exhibits cracking while the concrete is still plastic it shall be reworked to close the cracks.

3.13 PROTECTION OF FRESH CONCRETE

A. Freshly placed concrete shall be protected from rainfall and from water running over the surface until it is sufficiently hard to resist damage from this cause.

B. No traffic shall be allowed on any concrete surface until such time as it is hard enough to resist damage by such traffic.

C. Concrete placed in the Permanent Works shall not be subjected to any structural loading until it has attained at least it's minimum average strength as defined previously.

3.14 CONCRETING IN HOT WEATHER

A. 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 retamped to close the cracks.

B. No concrete shall be mixed and placed whilst the shade temperature is above $42^{O}C$ on a rising thermometer or above $43^{O}C$ on a falling thermometer. The Contractor shall supply an accurate maximum and minimum thermometer and hang it in an approved place in the works.

C. The Contractor shall 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 should not exceed $32^{O}C$ and the Contractor should take all necessary precautions to ensure that the limit is not exceeded. Concrete with a temperature less than $32^{O}C$ 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 approval 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 $77^{O}C$.
7. use of white or light reflective paints on mixer drums and water storage tanks.
8. shading of the mixing area.

3.15 PROTECTION TO SUBSTRUCTURE

A. A layer of polythene sheeting shall be laid over the prepared formation or compacted subbase under slabs on grade and at other locations designated by the Engineer prior to concreting and carried up the sides of such members to ground level or other level defined by the Engineer.

B. Bituminous waterproofing membrane shall be provided to the underside of slabs and vertical faces of concrete walls in basements and underground storage tanks where indicated on the drawings. Bituminous waterproofing membrane shall be installed in accordance with the requirements of Section 07005.

C. Waterstops shall be installed in accordance with Section 03250: CONCRETE ACCESSORIES.

3.16 LIQUID CONTAINING CONSTRUCTION

A. All liquid containing construction shall be tested to ensure no leakage or damp penetration. The testing shall be carried out before waterproof backing or other finishes are applied to the construction and before back-filling any excavation.

B. The Contractor shall 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. Measures shall be taken by the Contractor to ensure that the level of water is not affected by rainfall or undue evaporation.

C. Should it be apparent from the test results, external inspection or any other source that leakage or damp penetration has occurred then remedial work to make the construction completely watertight shall be carried out at the Contractors expense and to the Engineers approval. The construction shall be retested until the results are satisfactory.

3.17 DEFECTIVE WORK

A. Any remedial treatment to surfaces shall be agreed with the Engineer following inspection immediately after removing the formwork and shall be carried out without delay.

B. Any concrete, the surface of which has been treated before being inspected by the Engineer, shall be 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, then this work will be deemed unacceptable and rejected.

D. Where rejected work has to be cut out or re-built, the operation shall be carried out by the Contractor at his own expense and without delay.

E. The extent of the work to be removed and the methods to be used in the removal and replacement of this work shall be proposed by the Contractor for the Engineer's approval.

F. The Engineer's approval must be obtained before any cutting of concrete is carried out. If such cutting of concrete is carried out without the Engineers approval the affected areas shall be classified as defective. The Contractor is responsible for ensuring that a copy of this clause is given to each of his subcontractors, nominated or otherwise, and that they abide by it.

End of Section

SECTION 03370

CONCRETE CURING

PART 1: GENERAL

1.01 DESCRIPTION

A. The work covered in this section includes the methods to be employed for the correct curing of cast-in-place and precast concrete.

PART 2: PRODUCT

2.01 CURING COMPOUNDS

A. Suitable curing compounds may be used only with the written approval of the Engineer. Both the proposed dosage and method of use shall be submitted to the Engineer.

B. The use of the curing compound on surfaces which are to receive a bonded finish shall only be approved if it is proven 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. Curing compounds used on surfaces exposed to the sky shall, if instructed by the Engineer, contain sufficiently finely divided flake aluminum 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 shall become stable and impervious to the evaporation of water from the concrete surface within sixty minutes of application. The material shall not react chemically with the concrete and shall not crack, peel or disintegrate within three weeks after application.

2.02 WATER

A. Water used for curing shall be of the same quality as that used for mixing concrete as described in Clause 2.07 of Division 03300 of this Specification.

PART 3: EXECUTION

3.01 GENERAL

A. Immediately after compaction and for 7 days thereafter, concrete shall be protected against harmful effects of weather, including rain, rapid temperature changes, and from drying out. The methods of protection used shall be subject to the approval of the Engineer.

B. The method of curing used shall prevent loss of moisture from the concrete. On concrete surfaces which are to be waterproofed, curing compounds shall not be used. Details of all curing methods to be used shall be subject to the approval of the Engineer.

3.02 METHODS OF CURING

A. For formed surfaces all formwork must remain in place for at least 48 hours, unless otherwise agreed by the Engineer. If removal occurs within 7 days from casting, the exposed surface must be cured. Formwork which remains in place should be insulated steel or timber formwork.

B. In cases where formwork is removed within 7 days of casting, the exposed concrete surfaces shall be closely covered with impermeable sheeting, properly secured to prevent its removal by wind and the development of air spaces beneath it. Alternatively the Contractor shall 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 a pigmented reflective curing compound shall be applied immediately to the surface.

C. For other surfaces the above methods are acceptable subject to the additional requirement that if the area considered is exposed to the effects of sun or wind, ponding to a depth of at least 50 mm shall be provided. Ponding shall take place 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, sheltering of the concrete, during casting and for a period of at least 24 hours after casting, shall be provided. Such sheltering shall be in addition to the curing procedures described previously. Formwork left in place shall be regarded as sheltering.

E. The Contractor shall 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

SECTION 03400

PRECAST CONCRETE

PART 1: GENERAL

1.01 SCOPE OF SECTION

A. This section covers all precast units for use in the Permanent Works, whether instructed under the Contract or proposed by the Contractor, together with all necessary fixings, anchors etc., for the units.

B. For precast concrete construction this section of the Specification takes precedence over all other relevant sections.

1.02 DESIGN

A. All precast reinforced members shall comply with BS 8110, except when otherwise defined in the Specification or on the Drawings. Design shall be carried out by the Contractor.

1.03 DEFINITIONS

A. The term "Contractor" used within this section of the Specification shall be deemed to include the approved specialist precast contractor for the supply and erection of precast units. The name of the proposed precast concrete Contractor together with relevant technical information shall be submitted for the approval of the Engineer.

1.04 SUBMITTALS

A. Before precasting commences the Contractor shall submit to the Engineer, for his approval, full details of each type of unit showing the proposed method of hoisting and erecting, the location and detail of proposed lifting points and all reinforcement the Contractor considers necessary to cater for the stresses resulting from demoulding, lifting, transporting and erecting the units.

PART 2: PRODUCTS

2.01 MOULDS

A. Moulds for precast units shall comply with the general requirements of Section 03100 of the Specification.

B. Moulds shall be so constructed that they do not suffer distortion or dimensional changes during use and are tight against loss of cement or fines from the concrete. They shall be constructed so that units may be removed without sustaining any damage.

C. Moulds shall be set up on firm foundations so that no settlement occurs under the weight of the fresh concrete.

D. Release agents used for demoulding shall not stain the concrete or affect its properties in any way.

2.02 REINFORCEMENT

A. Reinforcement in precast units shall comply with the requirements of Section 03200 of the Specification.

B. When preformed cages are used the cages shall be made up on jigs to ensure dimensional accuracy & shall be carefully supported within the mould in such a way that they cannot move when concrete is placed.

C. Cover to main reinforcement shall be as shown on the drawings. Bars shall be spaced so that the minimum clear distance between them is the maximum nominal aggregate size plus five millimeters but in any case not less than the diameter of the bar.

2.03 CEMENT, AGGREGATES AND WATER

A. Cement, aggregates and water in precast concrete shall comply with the requirements of Section 03300 of the Specification.

2.04 SPACER BLOCKS

A. Spacer blocks shall comply with the requirements of Section 03300 of the Specification. In addition the use of concrete or plastic spacer blocks shall not be permitted against a concrete face which is exposed in the finished works.

2.05 METAL FIXINGS

A. All inserts or fixings permanently cast within the concrete shall be of stainless steel or phosphor bronze.

B. Stainless steel inserts or fixings shall be alloy type 316.S16 or 316.S12 complying with BS 970 and BS 1449.

C. Phosphor bronze inserts and fixings shall be alloy type PB102 complying with BS 2874.

2.06 PRESTRESSING STRANDS

A. Prestressing strands, where required, shall conform the requirements of Section 03200 of this specification.

PART 3: EXECUTION

3.01 GENERAL

A. In addition to the following requirements, the manufacture of all precast concrete units shall be in accordance with the requirements of Section 03300 of the Specification unless specifically stated otherwise.

3.02 CASTING OF UNITS

A. Concrete for precast units shall comply with Section 03300 of the Specification, using the class of concrete specified on the drawings.

B. The area in which units are cast shall be adequately protected from the weather so that the process is not affected by rain, freezing conditions, sun or drying winds.

C. All the concrete in each unit shall be placed in one operation unless otherwise approved.

D. The Contractor shall submit for approval details of inserts for lifting units into their final position in the works, and details for propping of the units. Where it is not possible to provide lifting inserts, suitable sling positions shall be indicated on the units.

E. The requirements for concreting in hot weather, contained in Section 03300, shall also apply to precast concrete production.

3.03 CURING PRECAST UNITS

A. Requirements for curing shall be generally as set out in Section 03370 of the Specification.

B. If the Contractor proposes curing at elevated temperatures, the method shall be subject to the agreement of the Engineer.

3.04 DIMENSIONAL TOLERANCES

A. Precast concrete elements shall be cast and erected such that dimensions of finished construction are within the tolerances quoted in BS 5606: 1978, British Standard Code of Practice for Accuracy in Building, except where the tolerances given in this Specification are more onerous.

B. The units delivered to site must comply with the following tolerances unless greater dimensional variations do not affect the correct assembly, performance and appearance of the building or cause unacceptable variations to finishes or other works.

C. Height, Width

up to 2 m	0 to -3 mm
2 to 6 m	0 to -5 mm
over 6 m	0 to -7 mm

D. Cross Section

up to 250 mm	+/- 3 mm
250 to 500 mm	+/- 5 mm
500 to 750 mm	+/- 6 mm

E. Straightness or Bow (Deviation from intended line)

up to 3 m	+/- 4 mm
3 to 6 m	+/- 6 mm
6 to 12 m	+/- 8 mm

F. Squareness (difference in sides)

up to 3 m	+/- 6 mm

G. The position of individual concreting bolts, bolt holes, projecting steel or other devices in any associated group (e.g. the joint of two precast units) shall be within 5 mm of their true position in the group in which they are cast. The longitudinal location of any such group shall be within 8 mm of its true position in the unit in which it is cast, provided that such tolerance does not adversely affect the proper assembly of the whole structure.

3.05 SURFACE FINISH

A. The formed faces of precast units shall be fairfaced and the unformed faces shall be as defined in Section 03100 of the Specification, unless another class of finish is specified on the Drawings.

B. In cases where a special finish is required a trial panel shall be constructed by the Contractor, which after approval by the Engineer shall be kept available for inspection at the place of casting and production units shall thereafter match the approved pattern.

C. Exterior cladding units shall be cast using white cement concrete.

3.06 HANDLING AND STORAGE OF UNITS

A. Precast units shall be handled in a manner which will not cause damage of any kind and shall be stored on a hard, impermeable base. Prestressed units and large precast normally reinforced units shall be handled and stored so that no stresses shall be induced in excess of those which they will incur in their final positions in the Permanent Works unless they have been designed to resist such stresses.

B. Units shall be marked indelibly with the reference number and date of casting and shall be stacked on suitable packers which will not damage the concrete or stain the surfaces. Not more than two packers shall be placed under each unit and these shall be located either at the positions of the permanent support points or in positions such that the induced stresses in the unit will be a minimum.

3.07 TESTING UNITS

A. Precast units shall be capable of safely sustaining the loads which they have been designed to carry. If instructed by the Engineer, the Contractor shall subject units selected by the Engineer to load tests simulating the working conditions. Details of such tests shall be agreed between the Engineer and the Contractor.

3.08 ERECTION AND TEMPORARY SUPPORT

A. Prior to the commencement of erection the Contractor shall submit for the approval of the Engineer details of his proposed arrangements for lifting and erecting the precast units. The Contractor shall ensure that the precast units are fully supported until all joints and fixings are completed. Temporary supports shall be adequate to resist all construction loads, including wind, which may be applied to the member and shall be designed to the approval of the Engineer. Temporary supports shall be arranged so as to permit the proper finishing and curing of insite jointing materials and shall not be removed or released until the required strength is attained in the jointing materials.

B. Any units which are damaged, cracked, discoloured or overloaded during handling or erection on site shall be replaced at the Contractors expense.

3.09 JOINTING

A. The bearing surfaces of precast units shall have grouted bed joints. All joint surfaces shall be thoroughly cleaned. Bed joints shall be formed by leveling the units on stainless steel shims, the shims being bedded in grout. The top surface of the shims shall, before placing the unit, be below the surface of the grout and finally the shims shall have a cover of 25 mm of grout.

B. The grout to be used shall be a non-shrink grout. Mixing, placing & curing of grout shall be strictly in accordance with the manufacturers recommendations.

C. All sockets, bolt holes, etc. shall be grouted up under pressure using the non-shrink grout as for bed joints.

3.10 GASKETS

A. Joints where shown on the drawings between precast unit shall be fitted with Neoprene Gaskets of a colour to match the precast concrete.

3.11 PROTECTION OF PRECAST PANELS

A. Protective membranes and edge battens are to be left in place as necessary during and after erection.

3.12 FIXING AND CONNECTION

A. Fixing of units and connections between units shall be in accordance with the instructions on the drawings, unless otherwise agreed with the Engineer.

3.13 PRECAST CONCRETE KERBS, CHANNELS AND EDGINGS

A. Refer to Section 02527; Precast Concrete Kerbs.

3.14 PRECAST CONCRETE PAVING

A. Refer to Section 02518; Paving Blocks.

End of Section

DIVISION 4

MASONRY

BUILDING WORK

DIVISION 4

MASONRY

INDEX

SECTION 04200

MASONRY

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required to construct all masonry work as shown and as specified herein.

B The work under this Section is limited to the Concrete Reinforcement Section and, with the exception of items embedded in concrete, is to be installed under this section.

C The work under this section includes, but is not necessarily limited to, the following:

1. Blockwork
2. Masonry joint reinforcement, ties, and anchors
3. Buildings-in required precast components

1.02 RELATED WORK NOT INCLUDED

A Other sections directly related to work covered in this section include the following:

1. Section 03300 - Concrete.
2. Section 03600 - Grout.
3. Section 05500 - Miscellaneous Metal
4. Section 07005 - Waterproofing and Dampproofing.
5. Section 07900 - Caulking.

1.03 SUBMITTALS

A Submit to the Engineer, as provided in the Submittals Section, sample of block, joint reinforcing, dovetail anchors, slots, blocks fixing ties, cavity trays, and proprietary cavity closures.

B Resubmit as required until acceptable.

C Before commencing with the laying of any architectural masonry, construct on the Site, where directed by the Engineer, one sample exterior wall panel, minimum dimension, 2 meters by 1.3 meters of block showing type and tooling of mortar and bond, block fixing ties, and movement joint for the Engineer's review.

Reconstruct until acceptable. Sample panels shall remain in place for the duration of the masonry work. Remove sample panel at the completion of the work as directed by the Engineer.

D Certificates: Before commencing work submit agreement from manufacturers of blocks that movement joints are located at positions recommended by them.

1.04 MATERIAL DELIVERY, HANDLING AND STORAGE

A General: deliver store and handle in accordance with manufacturer's recommendations.

B Transport: Transport materials in cool containers and do not allow to stand in sun: especially ensure that metal barrows and containers and boards for mortar and mortar materials are cool.

C Storage: keep blocks dry at all times; store on prepared areas free from clinker or ashes or sulphate bearing soils; cover block stacks and sand piles with tarpaulins; allow air circulation.

D Storage: Store cement and lime above ground in dry structures and use in order of delivery.

1.05 PROTECTION OF MATERIALS

A All masonry materials for the work of this Section shall be delivered stored and handled so as to preclude damage of any nature. Manufactured materials, such as cement and lime, shall be delivered and stored in their original containers, plainly marked with identification of material and maker. Materials in broken containers, or in packages showing water marks or other evidence of damage, shall not be used and shall be removed from the Site.

B All masonry shall be shipped stacked with hay or straw protection or other suitable protective device and shall be similarly stacked off the ground on the site. Masonry shall be unloaded with suitable equipment or manually in manner to prevent damage. Masonry units shall not be dumped from trucks. In addition, all masonry stored on the site shall be protected from the weather and staining with the use of tarpaulins or other covering acceptable to the Engineer.

1.06 PROJECT ENVIRONMENTAL CONDITIONS

A Work in Adverse Weather: Except where precautions are taken to maintain materials and ambient temperatures above 4°C do not mix mortar or lay blocks or dpc material when temperature on falling thermometer reaches 4°C or until temperature on ascending thermometer in shade reaches 4°C .

B Take all necessary measures to ensure that block laying continues without interruption during adverse weather.

C Hot Weather Work: take all necessary steps to keep mortar and blocks and dpc and other materials cool including:

1 Do not mix mortar or lay units while shade temperature is above 40°C in a rising thermometer or above 43°C on a falling thermometer.

2 Do not allow temperature of fresh mixed mortar to exceed 30°C. Take suitable measures to ensure this.

D Contractor is deemed to have allowed in his Tender for all steps necessary for compliance with above.

1.07 ADJUSTMENT AND CLEANING OF COMPLETED WORK

A Clean off mortar splashes and other stains from wall surfaces by scrubbing and washing down with clean water. Do not use acids.

1.08 PROTECTION DURING PROGRESS OF WORKS

A Protect work from damage by heat, rain and frost. When humidity is less than 50% and wind speed exceeds 4m/second provide shelter for wet mortar for at least 24 hours after mixing to avoid dehydration.

B In any period of interruption and in hot weather protect from damage; use approved coverings that extend down both sides of exposed walls to cover work done in previous 24 hours and permit free air flow and prevent heat build up.

C Prevent all blocks from becoming wet.

1.09 PROTECTION OF COMPLETED WORK

A Keep completed wall clean and protect from staining.

PART 2: PRODUCTS

2.01 MATERIALS - GENERAL

A Aggregates-General: Obtain from sources approved by the engineer.

2.02 MATERIALS - BLOCKS

A Concrete Blocks Except as otherwise described, provide blocks complying in all respects with BS 6073: Part 1 in accordance with Blockwork Schedule. Where a described size differs from that in BS all other provisions of BS apply, manufactured from ordinary Portland cement to ASTM C150, Type I and natural aggregates to ASTM C-33, and shall meet the following compressive strength classes:

1 - Hollow blocks: 30 kg/cm^2 of gross area

2 - Solid blocks: 35 kg/cm^2

B Do not use tongued and grooved blocks without the Engineer's permission.

C Surfaces of blocks that are to receive plaster or render to be suitably textured and capable of receiving plaster or tender without addition of bonding measures.

D Blocks must be dry and properly cured when delivered to site.

2.03 MATERIALS - TIES

A Cavity Walls: Use approved galvanized vertical twist type wall ties complying with the requirements of BS 1243, or others having at least equivalent strength and stiffness, all in accordance with the minimum spacing and embodiment requirements of BS 5628 Pt. 1.

B Double Leaf (Collar Jointed Walls) : Use approved galvanized flat metal wall ties in accordance with the requirements of BS 5628 Pt1 clause 29.5 and the requirements of BS 1243.

C Single Skin Walls: Use approval galvanized ties in accordance with the requirements of BS 1243 & BS 5628.

2.04 MATERIALS - MOVEMENT JOINTS

A Movement Joint Sealant: Movement joint sealant shall be suitable for the purpose intended & used in accordance with manufacturers instructions.

B Movement Joint Filler: For vertical joints, shall be expanded polystyrene.

C Suitable ties provisions to be made for transfer of lateral shear across all movement joints.

D Sleeved sliding ties to be used to laterally support tops of block work walls to ensure no vertical load is transferred from the structural elements on to the block work walls.

E For all movement joint spacing refer to architect drawings and the manufactures specification.

2.05 MORTAR MATERIALS

A Portland cement shall conform to ASTM C150, Type I for mortar above ground.

B Lime for Brick masonry mortar shall be hydrated, conforming to ASTM C207, Type S, non air-entrained.

C Sand shall be clean, durable particles, free from injurious amounts of organic matter. The sand shall conform to the limits of ASTM C144.

D Water shall be free from injurious amounts of oils, acids, alkalis or organic matter, and shall be clean and fresh.

E White Cement: to BS 12.

F Coloured Mortar: shall obtain its colour from pigments complying with BS 1014 and colour of mortar shall be approved by the Engineer as part of a sample panel.

G Admixtures: do not use admixtures, other than plasticiesers, without prior approval. Do not use calcium chloride or any admixtures containing calcium chloride.

H Plasticisers: to BS 4887 or ASTM C494 Type A.

2.06 MORTAR MIXES

A Mortar for block shall be one part Portland cement, two parts lime and 8parts sand, where block is reinforced lime should not be used.

B Mortar for brick shall conform to ASTM C270, Type S. Provide test data as required to substantiate strength requirements of 130 kg/cm^2 at 28 days. Ingredients shall be accurately measured by volume in boxes especially constructed for the purpose by the Contractor. Measurement by shovel will not be allowed. Measure materials in a damp, loose condition.

C Mortar for frames and elsewhere as required shall be one part portland cement, one part sand.

PART 3: EXECUTION

3.01 MORTAR

A Mortar shall be machine mixed in an approved type of mixer in which the quantity of water can be accurately and uniformly controlled. The mixing time shall not be less than 5 minutes, approximately 2 minutes of which shall be for mixing the dry materials and not less than 3 minutes for continuing the mixing after the water has been added. Where hydrated lime is used for mortar requiring a lime content, the Contractor will have the option of using the dry-mix method or first converting the hydrated lime into a putty.

Where the dry-mix method is employed, the materials for each batch shall be well turned over together until the even color of the mixed, dry materials indicates that the cementitious material has been thoroughly distributed throughout the mass, after which the water shall be gradually added until a thoroughly mixed mortar of the required plasticity is obtained.

B Mortar boxes shall cleaned out at the end of each day's work, and all tools shall be kept clean. Mortar that has begun to set shall not be used.

3.02 MASONRY - INSTALLATION

A All block shall be laid in full beds of mortar with shoved joints and with all joints shushed solidly in each course. Block shall be damp when laid. All block shall be laid up from an outside scaffold and shall be carried up simultaneously at an approximate level. Bricks receiving minor handling defects, if allowed to be used, shall be used in surfaces to be plastered.

B All masonry shall be laid a full bed of mortar, applied to shells only. Butter the vertical joint of unit already set in the wall and all contact faces of the unit to be set. Each unit shall be placed and shoved against the unit previously laid so as to produce a well-compacted vertical mortar joint for the full shell thickness. Units shall set with all cells in a vertical position. The moisture content of the units when laid shall not exceed 35 percent of the total absorption as determined by laboratory test.

C All masonry shall be laid in stretcher (running) bond. Fill all joints with mortar dense and neat. Joints shall be 10 mm wide with all joints uniform.

D Sizes shall be as specified and called for on the drawings, and the space between face and the backup material shall be shushed full of mortar.

E Coordinate with the work of installing pressed metal frames. Fill frames fully with mortar.

F All masonry slots, chases, or openings required for the proper installation of the work of other sections shall be constructed as indicated on the drawings or in accordance with information furnished before the work is started at the points affected. No chase shall cut into any wall constructed of hollow units after it is built, except as directed and acceptable to the Engineer.

G Build in all miscellaneous items to be set in masonry for which placement is not specifically provided under separate Divisions, including reglets, precast concrete and ties, electrical panel boxes, sleeves vents, grilles, anchors, grounds, and electric conduits and fixtures. Cooperate with other trades whose work is to be coordinated with the work under this section.

H All anchorage, attachment, and bonding devices shall be set so as to prevent slippage and shall be completely covered with mortar.

I All ties and reinforcing for masonry shall be furnished and installed under this section.

J Space ties as follows:

To columns (Abutting or not exceeding 450 mm centres vertically, passing walls) placing on each side of any movement joint.

To Edge Beams not exceeding 450 centres horizontally in one row along face of edge beam at each floor level.

To Openings and at Vertical provide additional ties within 150 mm of Movement joints edges at not exceeding 450 mm vertical centres.

K Install vertical masonry reinforcement where indicated on the drawings or specified herein.

L Aluminum: Any aluminum surface that will be in contact with block or mortar is to be painted with black bitumen coating solution to BS 3416 Type 1. Ensure that protective coating is adequate and if not arrange of a further coat of bitumen to be applied.

M Concrete Blocks: Protect and keep dry at all times.

N Concrete Blocks: Where items requiring strong solid fixings are to be fixed to block work e.g. radiators hanging cupboards provide solid (100%) blocks of fixing bricks to receive fixings

O Block Nibs Against Steel or Concrete: Where nibs less than 200mm in length occur against steel or concrete surfaces tie nibs to, steel or concrete using dovetail anchors at not exceeding 230 mm vertical centres placed in vertical metal slots cast in concrete, or shot fired into steel.

P Reinforcement: Where length of an internal partition wall exceeds 5m in unbroken length provide continuous horizontal reinforcement in each alternative course of block work bed on and surround with mortar and keep back 12 mm from faces. Provide for.

Q Non-Load Bearing Walls: Tie across control joints with strips of expanded metal mesh or 6 mm rod mesh placed across joint in alternate courses. Provide at least 25 mm of cover to all metal.

R Metal in Walls: All metal in external walls to be hot-dip galvanized. Part 1 including preliminary and site tests at 7 days and 28 day. Arrange for copies of test report to be sent directly on to the Engineer from laboratory within 7 days of completion of test.

3.03 CLEANING

A All holes in exposed masonry shall be pointed, and defective joints shall be cut out and repointed with mortar of same color as that of the original and adjoining work.

B Exposed masonry shall be protected against staining by wall coverings, and excess mortar shall be wiped off the surface as the work progresses.

C All exposed masonry shall be thoroughly cleaned. Before applying any cleaning agent to the entire wall, it shall be applied to a sample wall area of approximately 2 square meters in a location approved by the Engineer. Use only those cleaning agents recommended by the brick manufacturer. No further cleaning work may proceed until the sample area is acceptable to the Engineer, after which time the same cleaning materials and method shall be used on the remaining wall area.

3.04 FIELD QUALITY CONTROL

A Tests: take samples of fresh or hardened mortars when directed, and submit to approved testing laboratory for testing of compressive strength to BS 5628: Part 1 including preliminary and site tests at 7 days and 28 days. Arrange for copies of test report to be sent directly o to the Engineer from laboratory within 7 days of completion of test.

B Testing solid concrete blocks: ten blocks from each batch are to be selected by the engineer for testing for compressive strength. Results are to be as follows:

Individual block	not less than 30 kg/cm2
Average of 10 blocks	not less than 35 kg/cm2

C Testing hollow concrete blocks: ten blocks from each batch are to be selected by the Engineer for testing for compressive strength. Results are to be as follows:

Individual block	not less than 25 kg/cm2 of gross area
Average of 10 blocks	not less than 30 kg/cm2 of gross area

End of Section

SECTION 04400

NATURAL STONE SLAB CLADDING

PART 1: GENERAL

1.01 SCOPE OF WORKS

A Work to be done under this section includes, but is not limited to, the following items including all labor, materials, equipment and incidental to Extents of interior and exterior stonework as indicated on the drawings and as specified herein.

1. Exterior and Interior stone and granite includes the following:

   a. Wall and Column Facing.

   b. Soffits.

1.02 RELATED WORK

A Other sections directly related to work covered in this section include the following:

1. Section 03300.

1.03 QUALITY ASSURANCE

A Obtain stone from quarry with consistent colour range and texture throughout the works.

B Fabrication of stone shall be carried out by operatives or sub-contractor which has successfully fabricated stone similar to the quality specified for a period of not less than 5 years and is equipped to provide the quantity shown.

C Stone shall match appearance of agreed samples held by the Engineer.

D Job Mock-up: Prior to installation of stonework, provide sample panels of stonework indicated with proposed range of colour, texture and workmanship to be expected in completed work, and to size directed by the Engineer. Build mock-up at site, as directed, using stone, anchors, jointing, insulation and waterproofing as applicable as shown and specified in accordance with final shop drawing.

E Obtain the Engineer's acceptance of visual qualities of sample panels before start of stonework. Replace unsatisfactory mock-up work, as directed, until acceptable to the Engineer. Retain sample panels during construction as a standard for judging completed stonework. Do not alter, move or destroy mock-up until work is completed.

F Allowable Installed Tolerances:

1- Variations from Plumb: For surfaces of columns and walls as well as for arises, external corners, joints and other conspicuous lines do not exceed 6 mm in any story, or in 6.0m maximum, nor 12 mm in 12.0m or more.

2- Variation in level: For grades shown on lintels, stools, horizontal joints and other conspicuous lines do not exceed 6 mm in 6. mm in 6.0m maximum nor 12 mm in 12.0 m or more.

3- Variation in linear Building line: For positions shown in plan and related portion of columns, and wall facing, do not exceed 12 mm in any bay or 6.0 m maximum, nor 12 mm in 12.0 m or more.

4- Variations in Cross-Sectional dimensions: For columns and thickness of walls from dimension shown, do not exceed minus 3 mm, nor plus 3 mm.

5- Variations in stone dimensions, do not exceed + or – 3 mm.

1.04 SUBMITTALS

A Samples

1- Stonework: Submit sets of samples not less than 400mmx250mm in size of each different type, colour, grade and finish of stonework required. Include in each set full range of exposed colour and texture to be expected in completed work.

2- Mortar: Submit samples of mortar to match colour of each type of stonework required. Replace unsatisfactory samples as directed until acceptable to the Engineer.

B Shop drawings: Submit cutting and setting out drawings showing sizes, dimensions, sections and profiles of stonework units, arrangements and provisions for jointing (Including movement and construction joints) anchoring, and fastening, supports and other necessary details for lifting devices and reception of other work. Indicate block size from base to top of wall elevations, by showing extent of each typical block size in zones, as indicated on the Owner's drawings. Show, location of inserts (for stone anchors and supports) which are to be built into concrete anchors and supports) which are to be built into concrete or masonry. Show large size details of special features.

1.05 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Protect stone during storage and construction against moisture, soiling, staining and physical damage.

B. Handle stone to prevent chipping, breakage, soiling or other damage. Do not use pinch or wrecking bars without protecting edges of stone with wood or other rigid materials.

Lift with wide-belt type slings wherever possible; do not use wire rope or ropes containing tar or other substances which might cause staining. If required, use wood rollers and provide cushion at end of wood slides.

C. Store stone on wood skids or pallets, covered with non-staining, waterproof membrane. Place and stack skids and stones to distribute weight evenly and to prevent breakage or cracking of stones. Protect stored stone from weather with waterproof, non-staining covers or enclosures, but allow air to circulate around stones.

D. Protect mortar materials and stonework accessories from weather, moisture and contamination with earth and other foreign materials.

1.06 JOB CONDITIONS

A Installer must review installation procedures and coordination with other work, with contractor, and other contractors and subcontractors whose work will be affected by stonework.

B During all seasons, protect partially completed stonework when work is not in progress. Cover top of walls with strong waterproof, non-staining membrane extending at least 600 mm down both sides of walls and anchor securely in place.

C Installation Temperature limits: Do not set stone when air temperature on temperature of materials is below 7 degrees C.

PART 2: PRODUCTS

2.01 QUALITY OF STONE

A To be first quality, each type obtained from one strata, from one quarry and delivered in one shipment. Slabs are to be hard and free from cracks and other defects to surfaces and edges which may impair structural integrity, function r appearance and are to be cut square and true with clean edges and uniform in shape and thickness. Submit supplier's test results for each type of stone for the following tests, which must meet the following:

	Unit	Stone	
Weight per unit of volume	ton/m3	2.5	not less
Absorption coefficient	Wt %	3	not more
Modules of rupture	N/mm2	6.9	not less
Abrasion resistance	%	10%	not more

2.02 MATERIALS

A Ajlon lime stone:

To be obtained from quarries having sufficient quantities to complete the works as indicated on the drawings. The color variation shall be within the limits established on the mock-up and approved by the Engineer. Minor natural markings which are characteristic of the material which do not impair strength or appearance will be permitted.

All cladding stone shall be 40 mm thick after finishing. Corners, balustrade copings and special shapes shall be cut from the solid to the dimensions indicated on the drawings. The finish for exposed surfaces shall be fine mechanical bush hammered, as stated on the drawings. No visible saw marks shall be evident. All blocks shall be plane, square and true to sizes indicated on the drawings. Corners and special shapes shall be finished to sizes indicated on the drawings.

Generally all stone work shall be cut to size, finished and prepared for fixing in the shop.

B Fixings: 8 mm diameter steel bar 200 mm both sides net, to be fixed to backing wall by anchors, expanding bolts and sockets to avoid problems of misplaced pockets or channels.

C Mortar: to the requirements of Section 04200 of the Specification, comprising 4 parts ordinary Portland cement and 1 part sand.

Sealant for movement joints: one-part moisture cured silicone sealant to ASTM C920 or BS 5889 type A, or two-part polysulphide sealant to BS 4254.

PART 3: EXECUTION

3.01 GENERALLY

A Design: complete the design and detailing of the work and provide for approval structural design calculation and complete information based on information provided. Drawings are to show each stone unit and type and location of each fixing.

3.02 CUTTING OF STONE

A stones are to be cut so that the bedding is appropriate to its position in the building finished dimensions of stone units including minimum thickness are to be such that the cladding, when erected, complies with the requirements for accuracy of erection

B when details on drawings show stone corner as one piece, two pieces may be used cut at 45° and glued together with approved non stain epoxy adhesive complying with ANSI A136.1 and as recommended by the Stone supplier. Provide stainless steel dowels as necessary, and joints are to be tested to ensure complete rigidity.

C In order to accommodate permissible deviations within the building structure, selected stone units must be left oversize for cutting to precise dimensions taken on site; units are to be selected and clearly identified as such on the shop drawings.

D Use a suitable bench saw for cutting on site.

3.03 INSPECTION OF STONE UNITS

A Completed units must be carefully inspected and checked for match with approved samples and compliance with the Specification before dispatch to site. Inform the Engineer at appropriate stages in production of units so that he may inspect them before delivery to site.

3.04 FIXING AND JOINTING

A Before commencing erection, survey the building structure, including any fixing inserts, and report to the Engineer immediately any inaccuracy preventing proper positioning of units.

B Accuracy of erection:

1 - average width of any joint must not deviate from average of all nominally identical joints by more than +/-20%

2 - within the length of any joint (including in-line continuations across transverse joints) the greatest width must not exceed the least width by more than 40%, any variation being evenly distributed with no sudden changes

3 - offset in elevation between nominally in-line edges across a transverse joint must not be more than 20% of the width of the transverse joint

4 - offset in plan or section between flat faces of adjacent panels across any joint must not be more than 20% of the width of that joint

5 - widths of joints must be such as to ensure that joints perform as intended and are within recommendations of joint material manufacturer

6 - finished work must have a satisfactory appearance, being square, regular, true to line, level and plane with satisfactory fit at all junctions, all to approval.

C Fixings

1 - do not exceed torque figures or shim dimensions recommended by manufacturer,

2 - grout dowel bars with fairly dry mortar or suitable epoxy or polyester mix, well tamped in,

3 - give reasonable notice to the Engineer to allow inspection to take place before covering up load bearing fixings,

4 - give reasonable notice to the Engineer, as required, of the completion of stone courses to allow inspection of restraint fixings and cavity before proceeding with the next course,

5 - anchors or ties must not be subjected to any loading until complete curing or hardening has taken place,

6 - cramp holes and mortices shall be carefully drilled or cut to avoid fracture of the stone slab,

7 - patching will not be permitted and any damaged slab shall be removed and replaced.

3.05 JOINT AND SEALANTS

A Basic joints: all joints to be flush closed type. Wood or plastic joint spacers may be used but remove and make good to match as soon as mortar has set.

B Movement joints: in addition to basic joints, the following sealant filled joints is required:

1 - horizontal movement joints at floors, to coincide with support fixings

2 - vertical movement joints at intervals to accommodate relative movement between cladding and structure

3 - structural movement joints

4 - joints between cladding and windows or doors.

C Where the width of any type of joint is not shown on the Drawings, it is to be determined by the Contractor, and is to be as small as practicable having regard to shrinkage, thermal and other movements which may be expected in the building structure and cladding.

D Application of sealants backing strip, bond breaker and primer are to be types recommended by sealant manufacturer, preparation of joint, depth of sealant and application are to be strictly as sealant manufacturer's recommendations, joint must be thoroughly clean, dry and free from oil; finely abrade and/or prime as appropriate; mask edges of joint with tape before priming and remove immediately after sealing, insert backing strip and apply sealant ensuring maximum adhesion to sides of joint and a neat, smooth and clean finish.

End of Section