CONSTRUCTION MATERIALS

CONSTRUCTION MATERIALS

1. AGGREGATES

GENERAL

Aggregates shall be hard, strong, durable, dense and free from injurious amount of adherent coatings, clay, lumps, dust, soft or flaky particles, shell, mica, alkali, organic matter and other deleterioussubstances. The various sizes of particles of which an aggregate is composed of shall be uniformlydistributed throughout the mass.

Testing of aggregates shall be in accordance with BS 812 or ASTM C-136.

Approval of a source of aggregate by the Engineer shall not be construed as constituting the approval ofall materials to be taken from that source and the Contractor shall be responsible for the specifiedquantity and quality of all such materials used in the Work. Aggregates shall not be obtained fromsources, which have not been approved by the Engineer. The Contractor shall provide means of storing aggregates at each point where concrete is made suchthat

i. Aggregates shall be stored on a hard and dry patch of ground covered with a 50mm thick layer of lean concrete.

ii. Each nominal size of coarse aggregate and the fine aggregate shall be kept separated at all times.

iii. Contamination of the aggregates by the ground or other foreign materials shall be effectively prevented at all times.

iv. Each heap of aggregate shall be capable of draining freely.
v. The aggregates shall be handled so as to avoid segregation.

The Contractor shall make available to the Engineer such samples of the aggregate as he may require.Such samples shall be collected at the point of discharge of aggregate to the batching plant/mixermachine. If any such sample does not conform with the Specifications, the aggregate shall promptly beremoved from the Site and the Contractor shall carry out such modifications to the supply and storagearrangements as may be necessary to secure compliance with the Specifications.

Coarse aggregate

General

Coarse aggregate shall be obtained from breaking hard durable rock or gravel or Picked Jhama Bricks, which conform to the requirements of AASHTO Standard Specifications M-80. Coarse aggregate shall beclean, free from dust and other deleterious materials. The grading of the coarse aggregate shall be suchthat when combined with the approved fine aggregate and cement, it shall produce a workable concreteof maximum density.

Aggregate pieces shall be angular in shape and have granular or crystalline or smooth, but not glossynon-powdery surfaces.

Maximum allowable limits of deleterious substances that shall not be exceeded for coarse aggregate areshown in the following table:

Material	Mass Percent
Soft fragments	2.00
Clay Lumps	0.25
Material passing the 0.075mm sieve	0.50 for clay 1.50 for fracture dust
Thin or elongated pieces: Flakiness Index (BS 882-1992) less than	50 for uncrushed 40 for crushed

The Aggregate Crushing Value shall be less than 25% or the Ten percent Fine Value shall be greater than 150 kN according to BS 882-1992.Grading for nominal size coarse aggregate shall comply with the following ASTM C-33 standardgradations:

20mm nominal size Coarse Aggregate

Sieve Size (mm)	% Passing by Weight
25	100
19	90-100
12.50	20-55
9.50	0-15
4.75	0-5

40mm nominal size Coarse Aggregate

Sieve Size (mm)	% Passing by Weight
50	100
37.5	95-100
19	35-70
9.50	10-30
4.75	0-5

Coarse aggregate subject to five cycles of the Soundness Test, specified in ASTM C88, shall not show aloss exceeding 10% when magnesium sulphate solution is used except where otherwise approved.

The flakiness and elongation indices of the predominant size fractions in each single sized coarseaggregate, determined in accordance with BS 812, shall not exceed 20% and 35% by weightrespectively.

Aggregate for use in concrete which is subject to abrasion and impact shall comply with the Testrequirements of BS 812 and the Specification of BS 63 Part 1 and BS 63 Part 2 and BS 882 respectively.

Coarse aggregate shall be tested for drying shrinkage characteristics in accordance with BRS Digest No. 35.

Coarse aggregate shall be stored at Site in such a manner that it is not contaminated by fine aggregate, earth or other foreign matter. Adequate precautions shall be taken to prevent segregation of the coarseaggregate while it is being transported and stacked.

STONE AGGREGATE

The boulders to be used as coarse aggregate in concrete shall be composed of limestone, sandstone, granite, trap rock or rock of similar nature and shall have the following properties:

Minimum compressive strength	490 kg/cm^2
Specific gravity	2.4-2.7
Unit-weight	2245-2566 kg/m^3
Porosity	2 – 6%
Water absorption	1.5 – 5% by weight

The boulder shall be of uniform light colour as approved and shall be free from thin lamination, adherentcoatings and deleterious substances. The wear loss of coarse aggregate of all types shall not exceed 35% by weight when tested by the Los Angeles Abrasion Test.

The boulders shall be supplied in sizes that can be handled manually by one person. Stock piling shallbe such as to permit ready identification of the materials and shall be approved by the Engineer. Site forstockpiles shall be clean prior to storing materials. The stockpiles shall be built up in layers not to exceed1.22m in height and each layer shall be inspected before the next layer is started. The crushed boulderchips shall be stacked in accordance with the specified sizes in different stacks as directed by theEngineer. Height of each stack should not exceed 33% of the minimum base dimension of the stack.

BRICK AGGREGATE

Brick aggregate shall be as far practically as possible of uniform specific gravity. Blown bricks orunevenly burnt bricks shall not be crushed for the purpose of providing aggregates. Best possible firstclass picked jhama bricks of selected quality only shall be allowed for crushing.

Brick aggregate shall consist of first class Picked Jhama Brick chips graded as stated above under theSub-section ‘General’. All brick aggregates shall be screened and washed at Contractor’s own costs andshall consist of clean, well shaped cubical particles, free from splintered or flaky particles, soil, organicmatter or any deleterious materials.

STORAGE OF COURSE AGGREGATE

Aggregate of different sizes or grades and from different sources of supply shall not be mixed. Allaggregate shall be stored separately free from contact with earth and other deleterious matter. Thecoarse aggregate should be stockpiled in different stacks, according to the sieve sizes.

All precautions shall be taken during transport and stockpiling of coarse aggregate to preventsegregation. Segregated aggregate shall not be used until they have been thoroughly re-mixed and theresulting stack is of uniform and acceptable gradation.

Aggregate shall be stock-piled at least 7 (seven) days prior to their anticipated use to permit the Engineerto sample each stock-pile to determine the acceptability of the material for the intended use.

FINE AGGREGATE

GENERAL

Fine aggregates for use in the concrete and masonry work shall be non-saline clean natural sand andhave a Specific Gravity not less than 2.6 and conform to the requirements of ASTM C 144. It shall beangular (gritty to touch), hard and durable, free from clay, mica and soft flaky pieces. All sands must bewell washed and clean before use.

A well graded sand should be used for cement work as it adds to the density of the mortars andconcretes. Sand required for brick work needs to be finer than that for stone work.

Sand which contains 90% of particles of size greater than 0.06mm and less than 0.2mm is fine sand. Onthe other hand, sand which contains 90% of particles of size greater than 0.6mm and less than 2mm iscoarse sand.

Supply methods and stock piling of sand shall be such, as to permit ready identification of the materialdelivered and shall be approved by the Engineer.

IMPURITIES

Sand shall be clean and free from injurious amount of organic impurities. Deleterious substances shallnot exceed the following percentage by weight.

Material Passing No. 200 sieve	2.0
Shale, coat, soft or flaky fragments	1.0
Sulphur Compounds	0.3
Clay Lumps (wet, on No. 4 sieve)	0.00

Fine aggregate subject to five cycles of the soundness test, specified in ASTM C88 shall not show a lossexceeding 10 mass percent when magnesium sulphate solution is used except where otherwiseapproved.

GRADING

Sand shall be well graded from coarse to fine within the limits given below or shall conform to thespecified Fineness Modulus.

Fine Aggregate for concrete

Sieve No.	% Passing by Weight
9.5mm	100

4	95-100
16	45-80
50	10-30
100	2-10

Fine Aggregate for masonry

Sieve No.	% Passing by Weight
4	100
8	95-100
16	70-100
30	40-75
50	10-35
100	2-15

SAND FILL

Sand for sand fill shall consist of hard, dense, durable materials free from injurious amounts of claylumps, light weight materials or other deleterious substances.Unless otherwise specified on the Drawings, sand fill with gunny bags shall have Fineness Modulus notless than 0.8.Sand fill for the Geo-textile bags shall, unless otherwise approved by the Engineer, comply with thefollowing grading:

	mm
d_{90}	0.60 to 0.30
d_{86}	0.50 to 0.25
d_{60}	0.40 to 0.20
d_{50}	0.35 to 0.20
d_{10}	0.20 to 0.05

2. CEMENT

Cement used in the works shall be obtained from manufacturers, approved in writing by the Engineer and shall be Ordinary Portland Cement complying with the requirements of ASTM C150 Type 1 or BS 12 or equivalent standard. Special cements shall conform to the requirements provided in writing by the Engineer.

A certificate showing the place of manufacture and the results of standard tests carried out on the bulk supply from which the cement was extracted must accompany each consignment of cement delivered to the Site.

The Engineer may make any tests, which he considers advisable or necessary to ascertain, if the cement has deteriorated in any manner during transit or storage. Any cement which, in the opinion of the Engineer, is of doubtful quality shall not be used in the Work until it has been re-tested and test result sheets, showing that it complies in all respects with the relevant standard, have been delivered to and accepted by the Engineer.

Cement that becomes lumpy or otherwise deteriorated in transit or storage shall not be used for brick masonry or concrete works. All cement, found unsuitable for use, shall be removed from the Site immediately.

The Engineer shall ask to carry out sampling, inspection and testing of all cement as may consider be necessary. Samples shall be taken as instructed from the Site store or from elsewhere on the Work or from any places where cement is used for incorporation in the Work. The compressive strength and tensile strength of standard cubes and briquettes respectively shall be not less than as follows:

Days	Compressive Strength (N/mm^2)	Tensile Strength (N/mm^2)
3	12.4	1.0
7	19.3	1.9
28	27.6	2.4

Initial setting time shall be not less than 45 minutes and the final setting time shall be not more than 8hours. Cement, when tested for fineness, shall have a specific surface of not less than $160m^2/kg$.Cement when tested for soundness shall not have an expansion of more than 10 mm. The unit weight ofcement shall be a minimum of $14.16\ KN/m^3$.

WHITE CEMENT

White Cement shall be made from pure calcite lime stone and have the same physical properties asthose of Portland Cement Type 1, ASTM C-150.Atypical composition of White Cement is as follows:

CaO	65%
SiO2	25.5%
Al2O3	5.9%
Fe2O3	0.6%
MgO	1.1%
SO3	0.1%

REJECTION OF CEMENT

The Engineer may reject any cement as the result of any tests thereof notwithstanding themanufacturer's certificate. The Engineer may also reject cement, which has deteriorated owing toinadequate protection or from other causes where the cement is not to his satisfaction. The Contractorshall remove at his cost all rejected cement from the Site without delay.

STORAGE OF CEMENT

Cement shall be delivered at the Site in sound and properly sealed jute/paper bags, each plainly markedwith manufactures name or registered mark. Cement shall be well protected from weather by tarpaulinsor other approved cover during transit. Weight of individual bag containing cement shall be 50 kg andweight of all bags shall be uniform. Weight of cement shall be legibly marked on each bag. Bags inbroken or damaged condition shall be rejected.

The Contractor shall provide waterproof and well-ventilated godowns at the specified or approvedlocation at the Site having a floor of wood or concrete raised platform at minimum 450mm above theground so as to protect the cement against moisture from air or from any other source. Sheds shall belarge enough to allow a minimum 300mm gap between the stacked cement and the godown walls tostore cement in sufficient quantity to ensure continuity of work and to permit each consignment to bestacked separately therein to permit easy access for inspection. All storage facilities shall be subject toapproval by the Engineer.

Immediately upon arrival at the Site, cement shall be stored in the godowns with adequate provisions toprevent absorption of moisture. The Contractor shall use the consignments in the order in which they arereceived. Cement delivered to the Site in drums or bags provided by the supplier or manufacturer, shallbe stored in the drums or bags until used in the Work. Any cement in drums or bags, which has beenopened, shall be used immediately on opening. Cement shall not be stored in a godown for more than 3(three) months if bagged or 6 (six) months, if in bulk or a lesser period as directed by the Engineer. Afterthis period is over, any unused cement shall be removed from the Site.

3. ADMIXTURE

Admixture shall be used to provide excellent acceleration of gaining strength at early age and majorincrease in strength at all ages by significantly reducing water demand in a concrete mix, especiallysuitable for pre-cast concrete and other high early strength requirements. Admixture shall conform to BS5075 Part 3 and ASTM C 494.

4. REINFORCEMENT

MILD STEEL BAR

This is a type of bar plain and round or deformed in shape of a structural or intermediate gradeconforming to ASTM Specification A 510 or A 615 with a yield strength of not less than 280 MPa (N/mm^2)i.e. 40 grade.

HIGH STRENGTH DEFORMED ROD

Reinforcing steel under this type comprises Grade-60 Deformed re-bars. The steel shall conform toASTM Specification A 617M or A 615M of yield strength not less than 420 MPa (N/mm^2). The structuralgrade shall be made from billets. The ends of the bar shall be machine sheared perpendicular to the axisof the bar. The bars shall be free from injurious defects and shall have a workman like finish.

CLEANING AND STORAGE

Steel reinforcement bars and structural steel shall be stored in a way to prevent distortion, corrosion,scaling and rusting. Reinforcement bars and structural steel sections shall be coated with cement washbefore stacking, especially in humid areas. In the case of long time storage or storage in coastal areas,reinforcement bars and steel sections shall be stacked at least 200mm above the ground level.

Steel sections shall be stacked upon platforms, skids or any other suitable supports. Bars of differentsizes and lengths and structural sections shall be stored separately to facilitate issues in required sizesand lengths without cutting from standard lengths. Ends of bars and sections of each type shall bepainted with separate designated colours.

Tag line shall be used to control the load in handling reinforcing bars or structural steel when a crane isused. Heavy steel sections and bundles of reinforcing bars shall be lifted and carried with the help ofslings and tackles.

All bars, prior to its use, shall be cleaned with wire brush to make them free from nail scale, loose rust,dirt, paint, oil, grease or other foreign substances.

Bars of reduced sectional area to excessive rust shall be rejected.

All reinforcing steel shall be stored properly under shed not to be contaminated by oil, grease, dirt ormud.

All stacking and storing of bars shall be the Contractor's responsibility and contingent upon his Tender.

PRE-STRESSING STEEL AND ANCHORAGE

Pre-stressing reinforcement shall comprise high strength seven wire strand, high strength steel wire orhigh strength alloy bars conforming grade and type as shown on the Drawings.

Un-coated seven-wire strand shall conform to the specifications of AASHTO M 203.

Un-coated stress-relieved steel wire shall conform to the specifications of AASHTO M 204.

Un-coated high-strength bars shall conform to the specifications of AASHTO M 275.

1.6 RUSTLESS TYING WIRE

Rustless tying wire of 18 SWG shall be obtained from approved manufacturers and shall, as regardsstrength, comply with the requirements specified. The Contractor shall, at his own costs, provide bindingwires of required specifications.

1.7 LIME

Lime shall be stone lime of good quality high calcium lime containing calcium oxide from 95% upwards.The impurities, insoluble in acids, should not exceed 3% for the quick lime and 1% for the hydrated lime.Limes shall conform to the requirements of ASTM C 5 for quick lime and ASTM C 207 for hydrated lime.

STORAGE AND HANDLING OF LIME

Quicklime shall be slaked as soon as possible. If not possible, it may be stored in compact heaps havingonly the minimum of exposed area. The heaps shall be stored on a suitable platform under a roofprotected from rain and wind. A minimum space of 300mm shall be provided all round the heaps to avoidbulging of walls.

Un-slaked lime shall be stored in a watertight place and shall be separated from combustible materials.

Hydrated lime shall be supplied either in containers or sacks, such as jute bags lined with polyethylene orhigh density polyethylene woven bags lined with polyethylene or craft paper bags. It shall be stored in adry room to protect the lime from dampness and to minimize warehouse deterioration.

When dry slaked lime is to be used within a few days, it shall be stored on a covered platform andprotected from rain and wind. It shall be kept in a dry airtight godown when immediate use is notrequired. However, it shall never be stored for more than two months.
Workmen, handling bulk lime, shall wear protective clothing, respirators and goggles. They shall beinstructed for cleanliness as a preventive measure against dermatitis and shall be provided with handcream, petroleum jelly or similar protectors.

5. WATER

Water shall be clean, fresh and free from organic or inorganic matter in solution or suspension in suchamount that may impair the strength or durability of the concrete. Water shall be obtained from a supply, where possible. However, it may be taken from any other sources, only if approved. No water fromexcavation shall be used. Only water of approved quality shall be used for washing shuttering, curing ofconcrete and similar other purposes.

Water to be used in construction shall be stored in tanks, bottom and the sides of which shall beconstructed with brick or concrete. Contact with any organic impurities shall be prevented.

The tank shall be so located as to facilitate easy storage and filling in, and supply for construction worksand other purposes.

6. FILL

Materials for filling shall be uniform in character throughout and free from substances that by decay orotherwise may cause the formation of hollows or cavities or otherwise affect the stability of the filling.

Earth filling shall be of selected materials obtained from the excavation or carted fine sand as approvedby the Engineer. No soft chalk or clay or earth with a predominating clay content shall be used. Hardcore shall be selected hard clean gravel, broken brick, broken concrete, broken or crushed stone, quarrywaste or similar approved materials. Concrete for filling shall be to the proportions specified.

MATERIAL TESTING

MATERIAL TESTING

2.1 GENERAL

Notwithstanding the requirements stated in the detailed specifications for individual items, the followingminimum tests shall be performed in the laboratories (NED University Laboratory or Karachi Shipyard & Engineering Works Laboratory) or asdirected by the Engineer.

Contractor's Materials Engineer will be responsible for liaison and coordination with the Site laboratory,the Engineer, field sampling/testing staff and off-Site laboratories to ensure that all sampling, specifiedtests and inspections are carried out in a timely manner.

No inspection or approval by the Engineer shall relieve the Contractor of any of his duties and obligationsunder the Contract.

All test types and quantities described in the following Sub-sections are considered "Normal Testing" andanything beyond that in type and quantity is considered as "Special Testing". The Engineer may increasethe frequency of testing as per requirement.

2.2 TESTS

COURSE AGGREGATE

The tests mentioned below shall be carried out for each day's casting or per 15 cubic meter of concretewhichever provides the greater number of tests.

i. Gradation
ii. Unit weight
iii. Water absorption
iv. Specific gravity
v. Abrasion loss/Crushing loss

FINE AGGREGATE

The tests mentioned below shall be carried out for each day's casting or per 15 cubic meter of concretewhichever provides the greater number of tests.

i. Gradation
ii. Fineness Modulus (F.M.).
iii. Specific Gravity
iv. Water absorption
v. Surface moisture

CEMENT

For each consignment of a particular brand not exceeding 25 tons, at least 3 (three) samples collectedrandom shall be tested prior to the cement be incorporated in to the works to ascertain:

i. Consistency
ii. Setting time
iii. Compressive strength
iv. Fineness

REINFORCEMENT

For each consignment not exceeding 10 (ten) tons or as directed, 3 (three) representative samples ofeach size of M.S. bar shall be tested for:

i. Cross sectional area
ii. Unit weight
iii. Measurement of deformation
iv. Yield strength
v. Tensile strength
vi. Elongation
vii. Bending

Only Test Certificates issued by NED University Laboratoryor Karachi Shipyard & Engineering Works Laboratory shall be accepted by the Engineer.

TEST FOR WATER

Water will be tested to ensure that it remains free of oil, salt, acid, alkali, sugar, vegetable or otherinjurious substances.

WORKABILITY TEST FOR CONCRETE

The Slump Test shall be carried out as frequently as required by the Engineer and not less than one perhour during placing of concrete.

STRENGTH TEST FOR CONCRETE

The compressive strength of the concrete shall be determined by Cylinder Test. The Cylinder mouldsshall be 150mm in diameter and 300mm long. Each class of concrete shall be represented by at least sixCylinders. Not less than one group of six test Cylinders shall be made for each 30 cubic meter ofstructural concrete, but there shall be at least one group of six test Cylinders for each day's concretework. For columns and girders, one set of test Cylinders would be made from each batch of concrete notexceeding one cubic meter. Samples from which compression test specimen are moulded, shall beobtained in accordance with the Method of Sampling Fresh Concrete (ASTM C 172). The concretesamples would be collected from a point just before final placement or as directed by the Engineer.Cylinders may be collected from any batch (load) including the first. Specimens made to check theadequacy of the proportions for strength of concrete or as a basis for acceptance of concrete shall bemade and cured in accordance with methods and curing, concrete compression and flexure testspecimens in the field (ASTM C 31 or equal). Strength tests shall be made in accordance with themethod of test for compressive strength of moulded concrete cylinders (ASTM C 39 or equal).

Six Cylinders would form a set of sample for strength determination. Three Cylinders shall be tested atseven days and three cylinders shall be tested at twenty-eight days. Every twenty eight

daysCylinders shall attain the minimum specified compressive strength. The Contractor shall perform trial mixof his own to determine the characteristic strength or mean strength that has to be attained.

The twenty-eight days strength tests shall be used as a basis for acceptance of the concrete. Sevendays tests are made to obtain advance information on the adequacy of strength development. Age-strength relationships shall be pre-established for the materials and proportion used.

2.3 EXPENSES FOR TESTS

All expenses for the tests as stated in the above Sub-sections would be borne by the Contractor unlessotherwise provisions are made in the Tender Documents.

Any tests instructed by the Engineer both in type and quantity beyond those specified above shall bepaid to the Contractor, if not specific instructions are there under the concerned items of the TenderDocuments.

EXCAVATION AND BACK-FILL FOR STRUCTURES

EXCAVATION AND BACK-FILL FOR STRUCTURES

3.1 DESCRIPTION

This item of work shall consist of excavation in any type of soil/material for the foundation of structures,disposal of excavated materials, construction and removal of cofferdams, sheeting and other temporaryworks in protecting the stability and safety of the excavated foundations, pumping, de-watering/bailingwater from foundations, back-filling of completed structures with suitable back-fill.

No separate payment shall be made for the excavation and back-fill for structures when the works willinvolve use of cofferdams. The costs of this temporary work shall be deemed included as part of theTender sum.

The Work shall be carried out at the locations and according to the lines, levels, grades and dimensionsshown on the Drawings, stated in the BOQ and/or as directed by the Engineer.

3.2 MATERIALS

EXCAVATED MATERIAL

The Engineer shall classify all excavated materials either as suitable for fill or as waste.

Approved suitable excavated materials free from large lumps, wood or other objectionable materials shallbe placed as back-fill above the level of pile except where other materials are shown on the Drawings,stated in the BOQ and/or required by the Engineer.

ORDINARY FILL

Ordinary fill consists of earth having Liquid Limit not exceeding 50 and Plasticity Index notexceeding 20, as determined by AASHTO T89 & T90, and shall be used as back-fill material above the level of pile caps and areasexcept where other materials are shown on the Drawings, stated in the BOQ and/or required by theEngineer.

SAND

Unless otherwise stated on the Drawings or in the BOQ or ordered by the Engineer, back-fill materialbelow the top level of pile caps shall consist of sand free from chemical contamination with not more than10% of the material passing the No. 200 sieve (U.S. size). All other specifications should conform to whathave been illustrated under the relevant Sub-section of this Specification. The sand to be used shall beapproved by the Engineer prior to placing.

BLINDING CONCRETE

Blinding concrete shall be placed as backfill as shown on the Drawings, stated in the BOQ and/ororordered by the Engineer. The material shall conform to the specifications stated below:

Cement

Cement shall conform to the requirements of ASTM specification C 150 Type 1 or similarapproved standard for normal Portland cement.

Cement shall be free from any hardened lumps and foreign matter. It shall have a minimum of 90% of particles by weight passing the 75 micron sieve, an initial setting time in excess of 45minutes and a final setting time of not more than 375 minutes.

All other specifications should conform to what have been illustrated under the relevant Sub-sections of this Specification.

Coarse aggregate

Except otherwise stated, coarse aggregate shall consist of hard, durable angular fragments ofcrushed stone and/or crushed natural gravel conforming all other specifications illustratedunder the relevant Sub-section of this Specification.

Fine aggregate

All specifications should conform to what have been illustrated under the relevant Sub-sectionof this Specification.

Water

Water shall be subject to the approval of the Engineer and shall be reasonably clear, free fromoil, alkali, salts, acid and organic substances and other deleterious materials or objectionablequantities of suspended materials. All other specifications shall be in accordance with therequirements illustrated under the relevant Sub-section of this Specification.

3.3 CONSTRUCTION METHODS

EXCAVATION

The Contractor shall notify the Engineer before commencing excavation of the foundation trenches sothat the cross-section, elevations and measurements of the undisturbed ground may be taken. Thenatural ground adjacent to the structure shall not be disturbed without taking any permission from theEngineer.

Trenches and foundation pits for structures shall be excavated to the lines, grades and elevations asshown on the Drawings or as directed by the Engineer. The elevations of the bottom of the foundationsshown on the Drawings are approximate only and the Engineer may order such changes as deemednecessary to provide a secured foundation.

Where unstable soil is encountered at the bed level, it should be brought to the notice of the Engineerand all such unstable soil shall be removed as directed and replaced with suitable materials to provideadequate support for the structure.

On acceptance of the materials forming the bottom of any excavation by the Engineer subsequentlybecoming unacceptable to him due to exposure to weather condition or due to flooding or have becomepuddled, soft or loose during the work process, the Contractor shall remove such damaged, soft, or loosematerials and make additional excavation as per requirement. Such additional excavation shall be heldas excess excavation and the cost of the excess excavation and subsequent replacement with a suitableback-fill shall be at the expenses of the Contractor.

Any erroneous excavation or excess excavation for the conveniences of the Contractor, or overexcavation performed by the Contractor for any purpose or reasons shall be at the expenses of

theContractor. If the excavation for foundations exceeds the depths specified, the Contractor shall brought itback to the specified levels with sand, mass concrete or other approved materials conforming StandardSpecifications at the Contractor's own expenses.

Excavation shall be sufficiently large to provide necessary working space, shuttering and any otherTemporary Works required during construction.

Boulders, roots and any other objectionable materials encountered in excavation, shall be removed. Theexcavated foundation shall be cleared of all loose materials and cut to a firm surface.

When the footing is to rest on the ground and not on piles, special cares shall be taken not to disturb thebottom of the excavation and excavation to final grade shall be deferred until immediately before thefooting is placed. If foundation fill material is required, it shall be placed and compacted in layers notmore than 150mm thick or as directed by the Engineer. The dry density on compaction within 300mmbelow the top level shall not be less than 100% maximum dry density as determined in accordance withAASHTO T99 or ASTM D698.

In excavating foundation trenches, the last 150mm layer shall not be excavated until immediately beforecommencing the construction work except that the Engineer shall instruct otherwise. Any damages tothe work due to the Contractor's operation shall be repaired at the expenses of the Contractor.

The Contractor shall be solely responsible for the safety and stability of the excavation and shall provideall protective supports, bracing, sheet piles, shoring etc. as required. Shoring should be adequate toprovide enough safety to all the adjacent structures and land.

Excavated materials, classified as suitable for fill, shall be stockpiled. Waste materials and suitable fillmaterials in excess of requirement, shall be disposed of by the Contractor outside the limits of the Site.

The foundation material shall be cleared of all loose and displaced materials and cut to a firm surface,either leveled, stepped or serrated, as specified or shown on the Drawing or directed by the Engineerleaving a smooth solid bed to receive foundation.

No footing, bedding material or structure shall be placed on any foundation until the Engineer hasinspected and approved the depth of excavation and the foundation materials.

POOR FOUNDATION MATERIAL

When, in the opinion of the Engineer, the bottom of any excavated foundation is of soft or otherwiseunsuitable material, the Contractor shall remove the unsuitable material and fill with sand or blindingconcrete at the direction of the Engineer. The sand or concrete shall be placed following the proceduresspecified for back-filling. Sand shall be clear, all passing a No.4 sieve (U.S. size).

When the ground between the piles is too soft to support the green concrete, the Contractor shall submithis proposal for a bottom form to the Engineer for his approval. Extra excavation and foundation-fill orconcrete-fill in such case will not be paid separately.

If the bottom form is carried out by strengthening the ground in the aforementioned way, the Contractorshall, if requested, submit calculations showing that the pile cap will not be harmed during hardening dueto differential settlement between the piles and the strengthened ground.

DISPOSAL OF EXCAVATED MATERIAL

All excavated materials, so far accepted by the Engineer as suitable, shall be utilized as back-fill orembankment-fill. The surplus materials shall be termed as waste.

Excavated materials, suitable for use as back-fill, shall be deposited by the Contractor in spoil heaps atpoints convenient for re-handling of the materials during the back-filling operations.

Excavated materials shall be deposited in such places and in such a manner as not to cause damage toroads, services or properties either within or outside the project area and so as to cause no impedimentto the drainage of the Site or surrounding areas. The location of spoil heaps shall be subject to theapproval of the Engineer.

Waste materials shall be disposed of in accordance with the instruction of the Engineer.

PUMPING AND BAILING

The foundation shall be kept free from water at all times during the construction period. The ground waterlevel shall be maintained at a minimum of 0.9m below the lowest designed excavation level.

Pumping and bailing from any foundation shall be done so as to preclude the possibility of the movementof water through or alongside any concrete being placed. No pumping or bailing will be permitted duringthe placing of concrete and for at least 24 hours thereafter, unless it is done from a suitable sumpseparated from the concrete work by a watertight wall or from well points.

The Contractor shall be solely responsible and include in his rates all costs in designing the de-wateringsystem, providing all equipment and accessories required for de-watering. The rates shall also includecost for transportation, furnishing, installation, safe operation and maintaining of the system includingoperators, mechanics, the supply of power, fuel, lubricants, spares, repairing, etc. throughout and theremoval of the equipment at the end of the construction period under this Contract.

Excavations shall be as dry as possible prior to and during placing concrete. Placing of concrete underwater will only be permitted if indicated on the Drawings or approved by the Engineer.

BACK-FILLING

All excavated spaces shall be back-filled around the permanent structure to original ground level. Prior toplacing back-fill, all trash, metal, debris, lumber, bricks, soft materials and similar objectionable foreignmaterials shall be removed from the area to be back-filled. No back-fill shall be placed against anystructure without the prior permission of the Engineer.

Any protective support, bracing or shoring shall be removed, as the back-filling progresses in such amanner as to prevent caving-in.

Back-fill shall be of approved materials that will produce a dense and well-compacted filling. The materialshall be free from large lumps, organic or extraneous materials.

Ordinary fill placed as back-fill shall be laid and compacted. The moisture content of the fill materials,before compaction, shall be within + 5% of the Optimum Moisture Content. Each layer of materials shallbe compacted uniformly using approved compaction equipment and procedures. The materials shall becompacted to achieve not less than 90% Maximum Dry Density (STD) beneath the

bottom level. The drydensity, after compaction within 300mm below the top level, shall not be less than 95% Maximum DryDensity as determined in accordance with AASHTO T99 or ASTM D698 and soaked CBR (4 days) should be greater than 4% at95% Maximum Dry Density. The compacted layer shall be approved by the Engineer before theContractor can commence a new layer.

Sand back-fill shall be placed and thoroughly compacted in layers of not more than 150mm. Sand shouldbe clear, all passing a No. 4 U.S. Standard Sieve and conforming generally to ASTM C 144 for fineaggregate with F.M. not less than 1.2 or as required by the Engineer.

Layers of filling shall be tested as directed by the Engineer. Each compacted layer shall not be covereduntil the Engineer is satisfied that the specified degree of compaction has been achieved.

In placing back-fill, the materials shall be placed in, as far as possible, to approximately the same heighton each side of the structure. If conditions require appreciable higher back-filling on one side, theadditional materials shall not be placed until permission is given by the Engineer on being satisfied byhimself that the structure has enough strength to withstand any created pressure.

In general, no structure shall be subject to the pressure of back-filling until 3 (three) days on expiry of theperiod designated for removal of forms. This period shall be extended if abnormal curing conditions exist.

Adequate provisions shall be made for drainage during placing back-fill.

COFFERDAM

The term “cofferdam” denotes any temporary or removable structure, constructed to hold the surroundingearth, water or both, out of the excavation whether such structure is constructed of earth, timber, steel,concrete or any combination of these. The term includes earth dikes, timber cribs, sheet piling,removable steel shells and all bracings and it shall be understood to include excavation enclosed bypumping wells and well points.

Cofferdams shall be constructed so as to control water to preclude sliding and caving-in of the walls ofthe excavation.

The interior dimensions of cofferdams shall be such as to give sufficient clearance for the constructionand removal of any required forms and the inspection of the interior and to permit pumping.

If possible, cofferdams shall be so designed that no cross bracing shall be left in place. If this is notpossible, bracing left in place shall be of structural steel. The end of such structural members that wouldbe exposed when the structure is completed shall be boxed back at least 50mm behind the face. Theresulting holes shall be completely filled with concrete.

In general, sheet-piling cofferdams shall extend well below the bottom of the footings and shall be wellbraced and made maximum watertight.

When conditions are encountered which, in the opinion of the Engineer, render it impossible to de-waterthe foundation before placing of brickwork or concrete, the Engineer may require the construction of aconcrete foundation or seal. This shall be placed as directed by the Engineer. The foundation shall thenbe de-watered and the footing placed.

When foundation piles are to be driven inside a cofferdam and it is judged impossible to de-water thecofferdam before placing concrete, the excavation may be extended below the design level to a

depthsufficient to allow for swell of the materials during pile driving operations. Any materials that rise abovethe design level shall be removed.

Where it is possible to de-water the cofferdam, the foundation materials shall be removed to exact gradeafter the foundation piles are driven.

The natural streambed adjacent to the cofferdam shall not be disturbed without the permission of theEngineer. Any excavation adjacent to the cofferdam shall be back-filled to the original ground level to thesatisfaction of the Engineer.

Unless otherwise provided, cofferdams shall be removed on completion of the structure withoutdisturbing or marring the finished work. The Engineer may order the Contractor to leave any part or thewhole of the cofferdam in place and this shall not entitle the Contractor to claim for any additionalpayments.

The Contractor shall submit Drawings showing his proposed methods of cofferdam construction.However, the Contractor shall remain fully responsible for the adequacy of the design for strength andstability and for the safety of the people working therein.

3.4 MEASUREMENT

The volume of excavation and back-fill shall be measured in cubic meter.

The quantity of excavation for structures to be measured for payment shall include excavation for allstructures.

Back-filling with previously excavated materials shall not be measured or paid for separately but shall bedeemed included within the rate for excavation.

Volumes to be excavated for blinding concrete shall not be measured and the price for the excavationthereof shall be included in the above measured item for excavation and back-fill.

Back-fill with concrete or sand, where directed by the Engineer, including concrete seals shall bemeasured separately as the volume within the plan outline and top and bottom surfaces. Concrete orsand, placed to back-fill excavation beyond the excavation required, will not be measured for payment.

If sand fill is ordered over top level of pile cap, the fill shall be the specified filling volume measured onthe Drawings up to the profiles agreed upon in writing by the Engineer.

Removal of cofferdams, slides, silting or filling, if required, shall neither be measured nor paid for.

3.5 PAYMENT

The work measured shall be paid for at the Contract unit prices per cubic meter as shown in the Bill ofQuantities. The payment shall be the full compensation for all excavations and back-filling for structuresincluding supply of all materials, labour, equipment, tools and incidentals necessary to the successfulcompletion of the work.

The payment shall also be the full compensation for excavation and subsequentback-filling of working space around the foundation structure for shoring and other protective supports,for construction and removal of cofferdams, for de-watering and for disposal of surplus excavatedmaterials by hauling to any distance at approved locations.

Should it be necessary, in the opinion of the Engineer, to lower the footings to an elevation below thelevel shown on the Drawings, payment for the excavation and backfill for structures required below planlevel down to and including an elevation 1.5m below plan level for any individual footing will be made at aunit price equal to 115% of the Contract unit price and payment for the excavation from an elevationgreater than 1.5m below plan level down to and including an elevation 3m below plan level will be madeat a unit price equal to 125% of the Contract unit price for "Excavation and Back-filling for Structures".

Noadditional extra compensation will be allowed for any required cofferdam adjustments arising from suchlowering of footings.

In case where the extra depth required for any footing or footings exceeds 3m, a supplementaryagreement shall be made covering the quantities recovered from depths in excess of 3m below the plangrade.

Payment for Back-filling shall be included in the pay item for "Excavation and Back fill for Structures"except for sand fill and concrete fill. These fill types shall be measured as provided above and paid for atthe concerned Contract unit prices. However, no compensation shall be made for less Back-filling withexcavated materials or more surplus to waste in the pay item of "Excavation and Back-filling forStructures".

All payments for the Back-filling and compaction of those areas, which were removed as structuralexcavation shall be included in the appropriate unit rates as shown below:

Item of Payment	**Unit**
Excavation and back-fill for structures	Cubic meter / Cubic feet
Concrete back-fill for structures	Cubic meter / Cubic feet
Sand back-fill for structures	Cubic meter/ Cubic feet

DE-WATERING SYSTEM

DE-WATERING SYSTEM

4.1 DESCRIPTION

This item of work shall consist of draining out of surface water and/or controlling water accumulated fromany source that may require the use of pumps, other mechanical devices or the use of well point or tube-well system. All works to be carried out as per the stipulation of the BOQ and/or as instructed by theEngineer.

4.2 TYPES OF DE-WATERING SYSTEM

One or both of the following de-watering systems shall be adopted considering the actual field conditionsand requirements for proper execution of work.

i. De-watering by Sub-surface Water Control System
ii. De-watering by Surface Water Control System

4.3 CONTRACTOR'S RESPONSIBILITIES

The Contractor shall be solely responsible and include in his rates for the following tasks:

i. The design of the de-watering system including the collection of the requisite data, preparation of Plans and Drawings of the necessary de-watering system.

ii. Providing all equipment and accessories required for de-watering by the Surface Water Control System and Sub-surface Water Control System for satisfactory execution of the work.

iii. Transportation, furnishing, installation, safe operation and maintaining of the system including operators, mechanics, supply of power, fuel, lubricants, spares, repairing, etc. throughout and the removal of the equipment at the end of the construction period under this Contract.

The Contractor shall provide continuous supervision of the system by the persons competent to recognizeadverse conditions as they develop and take immediate corrective measures. The supervisor whosename and hours of duty duly furnished to the Engineer by the Contractor, shall have thorough knowledgeof the system including the ability to make minor emergency repairs.

The control of water throughout the time of this Contract shall be the full responsibilities of the Contractor.The ground water table shall be maintained at minimum of 0.9m below the lowest designed excavationlevel. Control methods shall be subject to the approval of the Engineer including the Contractor'sequipment, plans, methods, installation and operation procedures, etc.

The control methods adopted by the Contractor shall be subject to the approval of the Engineer includingequipment, plans, methods, installation, operation, monitoring, maintenance procedures and precautionsagainst the failure of any part of the system. The precautions shall include sufficient standby pumpingplant and essential spare parts. The standby pumping plant shall comprise at least one pump and thestandby pumping capacity shall be at least 10% of the total working capacity.

4.4 SITE INFORMATION

Any sub-soil investigation conducted by the Consultant will be made available for the Contractor's review. TheConsultant assumes no responsibility regarding the correctness of these data. It is the responsibility of theContractor to verify all sub-surface conditions prior to submitting his tender.

4.5 DE-WATERING BY SUB-SURFACE WATER CONTROL SYSTEM

GENERAL

De-watering by Sub-surface Water Control System is defined as controlling water accumulated from anysource requiring the use of well point or tube-well system.

Works to be performed under this Section include furnishing, installing, maintaining, operating andremoving the sub-surface water control system including observation wells, so that the requiredexcavation can be safely and properly performed and the structure built and back-filled to the elevation asshown on the Drawings.

PRECAUTIONARY MEASURES

Excavation shall not be made below a level 1m above the ground water level shown to exist by the waterlevel in the observation wells. If the distance to the ground water table becomes less than 1m or theEngineer has any reason to believe that rising ground water is likely to endanger either the openexcavation or the structure, back-filling may be ordered by the Engineer as a precaution against failure.

If for any reason, ground water control is lost and ground water appears in any portion of the excavation,the Contractor shall take immediate action to control and confine the flow. Any portion of the final gradewhich, in the opinion of the Engineer, has been damaged by the action of the ground water, shall beexcavated as directed by the Engineer and back-filled in accordance with the Specifications at no extracost to the Contract.

If it becomes necessary for any reason to stop the sub-surface de-watering operations before theconstruction of sub-structure is complete, the Engineer may order the Site to be flooded up to thesurrounding ground water level as de-watering is discontinued. Under no circumstance shall the Site beflooded by allowing the ground water to rise through the soil. If it becomes necessary to flood the Site asdescribed above, all equipment that can be damaged shall be removed to safety/a safe place.

The cost of all such back-filling, flooding and subsequent draining and re-excavation shall be included inthe lump sum price for de-watering and no extra payment beyond the Contract price will be allowed.

OPERATION

The sub-surface De-watering System shall be operated 24 hours of a day on all days of a week during theperiod that de-watering is required. The Contractor shall take prior precautions against failure of any partof the system.

MONITORING WELLS

Observation wells of 40mm diameter G.I. pipes with 1.25m long wire mesh strainer and full filters shall beinstalled by the Contractor to suitably monitor the ground water levels maintained by the

Contractor's de-watering system. The depth of wells shall be a minimum of 3m below the lowest level of the foundationexcavation. The Contractor shall provide a means for locking the access to the observation wells and shallmaintain a log book with daily readings of sub-soil water levels recorded every three hours, which shall bemade available at all times for inspection. The logbook shall be periodically checked and authenticated bythe Engineer's Representative.

REMOVAL OF SYSTEM

The de-watering system shall be removed when the construction has progressed to a stage that Site de-watering is no longer required; but only after receiving the written permission from the Engineer. Certainportions of the Contractor's de-watering system may be left in the ground when construction proceduresswill so require and when written permission of the Engineer is obtained. Any such portion of the de-watering system shall be plugged, capped and/or otherwise rendered harmless to the Work and thepublic.

4.6 DE-WATERING BY SURFACE WATER CONTROL SYSTEM

GENERAL

Evacuation of surface water is defined as draining out surface water by use of pumps, sump pump, graveldrain or other mechanical devices, but without requiring the use of a well point or tube-well system. Suchwater may accumulate from percolation, rain or pumping floodwater in to the area or any other source orcombination of sources.

Work to be performed under this Sub-section include furnishing, installing, maintaining, operating andremoval of the surface water draining system for de-watering the accumulated water from the area so thatthe desired construction can safely and properly be performed. The discharge line or the drainage systemfor the disposal of the evacuated water shall be constructed by the Contractor at his own costs inaccordance with the approved Drawing and by arranging private lands, if needed any.

OPERATION OF DE-WATERING SYSTEM

The Contractor shall make all arrangements for pumps, fuel, lubricants, maintenance and operation of theequipment and the whole Surface De-watering System and shall take precautions in advance againstfailure of any part of the system.

REMOVAL OF SYSTEM

The Surface De-watering System shall be removed upon obtaining written permission from the Engineerwhen the construction has progressed at a stage that Site de-watering is no longer required.

4.7 MEASUREMENT

The work shall be measured for payment as an item on a lump sum basis as specified in the BOQ.

4.8 PAYMENT

Payment shall only be admissible on implementation of the item of the BOQ and on the basis of theEngineer certifying that the work was necessary and implemented for the proper execution of constructionwork satisfying all Specifications described above. Payment shall be made at Lump Sum

rate as quoted inthe Contract. The rate shall cover the full compensation for all measures including the cost of labour,equipment, materials, tools required for this purpose and other incidentals necessary to complete this itemof work strictly in accordance with the Specifications stated above and/or as accepted by the Engineer.

Item of Payment	**Unit**
Pumping and bailing out water/de-watering of work site	Lump sum

EARTH FILLING AND SAND FILLING

EARTH FILLING AND SAND FILLING

5.1 EARTH FILLING

5.1.1 DESCRIPTION

This work shall consist of filling any place by furnishing, placing, compacting and shaping suitable earthmaterial of acceptable quality obtained from approved sources to make up levels to the lines, levels,grades, dimensions and cross sections in accordance with these specifications and as shown on theDrawings and/or as instructed by the Engineer.

5.1.2 MATERIALS

All fill materials shall be free from roots, sods or other deleterious materials.All fill materials shall be stockpiled outside the working areas. Materials shall be tested and approved bythe Engineer.The selected fill so stockpiled, shall satisfy the following criteria:

i. Liquid limit of fraction passing 425 micron sieve shall not exceed50% as determined by AASHTO T89.

ii. Plasticity index of fraction passing 425 micron sieve shall not exceed20%as determined by AASHTO T90.

iii. The dry density after compaction in layers more than 300mm below top level shall not be less than90% of the maximum dry density as determined in accordance with AASHTO T99 or ASTM D698.

iv. The dry density after compaction within 300mm below the top level (or such greater depth if shownon the plans and drawings) shall not be less than 95% maximum dry density as determined inaccordance with AASHTO T99 or ASTM D698.

v. Soaked (4 day) CBR greater than 4% at 95% MDD. The moisture content at the time of compaction shall be the optimum moisture content ± 5%.Sampling to be carried out as per ASTM D 75 and D 3665.

5.1.3 CONSTRUCTION METHODS

GENERAL

Prior to placing any fill upon any area, all clearing and grubbing operations shall be completed followingthe procedures stated below.

The original ground surface should be prepared by scarifying, watering, aerating and compacting. Thedry density after compaction shall not be less than 90% of MDD (STD).

Filling in swamps or water shall be carried out as indicated on the Drawings and as described in theseSpecifications. The Contractor shall, when ordered by the Engineer, excavate or displace

swampyground and backfill with suitable materials. Such backfill shall be river or beach sand unless otherwisedirected by the Engineer.

The materials that are borrowed from canals or other waterlogged areas for use as fill material, beingsaturated, shall initially be stockpiled to drain the excess water before placing it in the designated areas.

CLEARING

Clearing shall consist of the removal and disposal of everything above foundation level except those theEngineer directs are to be left undisturbed. The materials to be cleared shall include but not necessarilybe limited to trees, stumps, logs, bush, undergrowth, grass, crops, loose vegetable matter and structuresunless provided elsewhere.

All tree stumps shall completely be removed within the limits of earthwork.

Clearing shall also include the removal of existing fences, remnants of buildings, etc.

GRUBBING

Grubbing shall be confined to major roots beneath the excavations.In agricultural areas where the ground has been formed into ridges of dikes, the ground shall be roughlyleveled or graded to form a surface suitable for filling and to the satisfaction of the Engineer.

OWNERSHIP OF CLEARED MATERIALS

All cleared materials shall, unless otherwise provided for in the Contract, be the property of theDepartment.

SPREADING AND COMPACTION OF EARTH FILL

Earth carried from outside shall be placed on the land to be developed in horizontal layers and eachlayer shall not exceed a loose thickness that is required to obtain a compacted thickness of 150mm. Theearth of each basket is to be placed near to the earth placed before it and spread systematically. TheContractor shall not be allowed to throw earth in heaps.

The materials to be compacted shall be deposited in horizontal layers on the land to be developed with aloose thickness as stated above. The clods of earth shall be broken down to a maximum size of 25mmby striking the clods with the back of a spade or by using wooden drag or ladder or by any other suitablemeans before the next basket of earth is thrown close to it. Distribution of materials shall be made in sucha way that the compacted materials will become homogeneous and free from lenses, pockets, streaks orother imperfections. Excavating and placing operations shall be such that the materials, whencompacted, will be blended sufficiently to secure the best practicable degree of compaction, impermeability and stability and for this purpose the preceding compacted layer shall be scarified beforeplacing a new layer.

All fill materials shall generally be compacted mechanically. However, under some special circumstanceand when specifically allowed under the BOQ, the fill may be allowed to be compacted manually.

If the density measurement checks fall below the specified density level, re-compacting shall be requiredirrespective of the field compaction trial results. The Contractor shall be carried out such works

Earth fill materials, which does not contain sufficient moisture requirement for compaction in accordancewith the requirements of this Sub-section shall be reworked and watered as per direction of the Engineer. The Contractor shall carry out this work at his own expenses.

Earth fill materials containing excess moisture shall be reworked and dried prior to or during compaction.Drying of wet materials shall be performed by methods proposed by the Contractor and approved by theEngineer at the expenses of the Contractor.

Compaction of every layer shall have to be approved by the Engineer. In the event the Contractor fails toobtain the approval of the Engineer of a fill layer, the materials above the unsatisfactory layer shall beremoved and the unsatisfactory layer shall be re-compacted to satisfy the specifications at the expensesof the Contractor.

MANUALLY COMPACTED FILL

Fill shall be placed and compacted in layers for 150mm maximum compacted thickness, uniformlyspread and compacted over the fill area of each layer. If for any reason, progress in compaction of the fillis interrupted for any unreasonable time, the surface area of the fill shall be scarified or ploughed beforecompaction continues. Each layer shall be compacted, using controlled manual compaction methods toachieve at least 85% of the Standard Proctor maximum dry density.

Compaction of every layer shall have to be approved by the Engineer. In the event the Contractor fails toobtain the approval of the Engineer of a fill layer, the materials above the unsatisfactory layer shall beremoved and the unsatisfactory layer shall be re-compacted to satisfy the specifications at the expensesof the Contractor.

Under special circumstances and if directed by the Engineer, the Contractor shall excavate 5 to 10 trialpits each of size 2m long, 1m wide and 2m depth or to a depth of the improved land (whichever is less)at random spacing to test the degree of compaction. The size of voids encountered shall not exceed 5cm in diameter and the number of voids shall be less than 10 per square meter.

PROCEDURES FOR MANUAL COMPACTION

The earth shall be compacted manually using concrete drop hammers each weighing 6 kg to 7 kg, fittedwith a shaft of about 1.5m long. Ramming shall reduce the voids and shall continue until no furthershrinkage of earth is possible by ramming.

Before commencing ramming, the moisture content of the soil shall be increased or decreased as perrequirement by sprinkling the soil with water or by allowing natural drying of the soil as applicable so asto ensure that the materials shall have a moisture content of not less than 5% or greater than 5% dry of the optimum moisture required for the purpose of compaction. Both wetting and drying may be aided byfurrowing the fill and then re-spreading when the moisture content is suitable.

If the moisture content exceeds the aforementioned tolerance, the compaction operations shall notproceed until the material is wetted or allowed to dry out, as the case may be to obtain optimum moisturecontent within the permitted tolerances. However, there may be an exception with a specific approval ofthe Engineer. No adjustment in price shall be made on account of any operations of the Contractorrelated to wetting or drying the materials or on account of any delays occasioned thereby.

The preceding operations shall continue layer after layer until the top of the filling is reached.

MECHANICAL COMPACTION

In the case of mechanical compaction, area of development, designated on the Drawings or by theEngineer, shall be compacted to the lines and grades shown on the Drawings or established by theEngineer. The Contractor's operations in importing materials, designated for use, shall be such as willresult in an acceptable gradation of material when placed as determined by the Engineer.

Just prior to and during placement operations, the materials shall have a moisture content of not greaterthan 5% wet or less than 5% dry of the optimum moisture required for the purpose of compaction, asdetermined by Test No. 12 of BS 1337 and approved by the Engineer. The materials shall be so workedas to have uniform moisture content throughout the entire layer.

If the moisture content exceeds the aforementioned tolerance, the compaction operations shall notproceed until the materials are wetted or allowed to dry out, as the case may be to obtain the optimummoisture content within the permissible tolerances. However, there may be an exception with a specificapproval of the Engineer. No adjustment in price shall be made on account of any operations of the Contractor related to wetting or drying the materials or on account of any delays occasioned thereby.

When the material has been conditioned and placed as specified or directed, it shall be compacted withappropriate motorized vibratory compaction equipment or tampers of adequate weight and size asapproved by the Engineer. Each layer shall be compacted to obtain at least 98% compaction of themaximum dry density. If the test results show that the density has not met the requirement, theContractor shall have to carry out further compaction until the required density is achieved.

The in-situ dry density of the compacted fill shall be determined by the Sand Replacement Methoddescribed in Test No. 15 of BS 1377 or by other similar approved tests at locations as ordered by theEngineer.

5.1.4 MEASUREMENT

Measurements for earth filling works shall be taken for payment in cubic meters on cross sectionscompacted and accepted in place. The volume to be measured will be the net volume of required andaccepted filling, actually constructed and completed in accordance with the Specifications, to the lines, levels and cross sections required as per the Drawings or such other dimensions as directed by theEngineer. This stipulation of volume determination will be regardless of the method of excavation, filling, re-sectioning and backfilling at structures or type of materials.

The cross sections to be used shall be measured by pre-work (after clearing and stripping) and post-work field surveyed sections. Pre-work sections of the portion of the work allotted to the Contractor, computed through survey works, shall be signed by the Contractor before executing the works forretention by the Engineer.

5.1.5 PAYMENT

The unit rate paid per cubic meter for earth filling shall be in accordance with the Contract unit price,which payment shall constitute the full compensation for furnishing all materials and providing all labour,tools and equipment and works as specified. The rate shall also include costs of all other items relatedtherewith and all incidentals, which may need to be completed to execute the work strictly in accordancewith the Specifications and/or as per the directions of the Engineer.

Costs of all works and the cost of lead, lift or carriage shall be included in the unit rates for the relevantitem of earth filling works of the BOQ of the Contract. Unless otherwise specified, no royalties will be paidfor the purchase of earth from a private land regardless of its distance from the Site. No additionalpayment shall be made for purchasing a land and excavating the fill outside the rate agreed in theContract for the item of earth filling works.

No direct or separate payment shall be made for works required under the other sub-items of this item.Costs for such works shall be deemed to have included in the related items of the BOQ.

Payment shall only be made when all works have been completed in accordance with the designedsections satisfying all specifications and accepted by the Engineer.

Item of Payment	**Unit**
Earth filling	Cubic meter/ Cubic feet

5.2 SAND FILLING

5.2.1 DESCRIPTION

This work shall consist of filling in foundation trenches, inside plinth or at any other places by furnishing,placing, compacting and shaping suitable sand of acceptable quality and F.M. to make up levels to thelines, levels, grades, dimensions and cross sections in accordance with these specifications and asshown on the Drawings or BOQ and/or as instructed by the Engineer.

5.2.2
MATERIALS

Materials shall be of natural sand free from vegetable matters, from soft particles and from clay. F.M. ofsand shall be in accordance with the stipulations of the BOQ or as per the direction of the Engineer.

All fill materials shall be stockpiled outside the working areas. Materials shall be tested and approved bythe Engineer.The selected sand fill so stockpiled, shall satisfy the following criteria:

i. The fraction passing the 425 micron sieve shall have a Plasticity Index not greater than 10 (AASHTO, Soil Classification A-2-4).

The material shall have a soaked CBR value not less than 8% when compacted to 98% ofmaximum dry density as to be determined by AASHTO T-99.

5.2.3 CONSTRUCTION METHODS

GENERAL

Prior to placing any sand fill upon any area, all clearing and grubbing operations shall be completed.Within the limits of sand filling, tree stumps shall completely be removed.

The original ground surface should be prepared by scarifying, watering, aerating and compacting.

SPREADING AND COMPACTION OF SAND FILL

Sand fill shall be placed on the desired place in horizontal layers and each layer shall not exceed a loosethickness that will be required to obtain a compacted thickness of 150mm. Sand in each basket

is to beplaced near to the sand placed before it and spread systematically. The Contractor shall not be allowedto throw sand in heaps.

The compacted materials should become homogeneous and free from lenses, pockets, streaks or otherimperfections. Placing operations shall be such that the materials, when compacted, will be blendedsufficiently to secure the best practicable degree of compaction, impermeability and stability and for thispurpose the preceding compacted layer shall be scarified before placing a new layer.

All fill materials shall generally be compacted mechanically. However, under some special circumstanceand when specifically allowed under the BOQ, the fill may be allowed to be compacted manually.

If the density measurement checks fall below the specified density level, re-compacting shall be requiredirrespective of the field compaction trial results The Contractor shall carry out such works at his ownexpenses.

Sand fill materials not containing sufficient moisture requirement for compaction in accordance with therequirements of this Sub-section, shall be reworked and watered as per the direction of the Engineer.The Contractor shall carry out this work at his own expenses.

Sand fill materials containing excess moisture shall be reworked and dried prior to or during compaction.Drying of wet materials shall be performed by methods proposed by the Contractor and approved by theEngineer at the expenses of the Contractor.

Compaction of every layer shall have to be approved by the Engineer. In the event the Contractor fails toobtain the approval of the Engineer of a fill layer, the materials above the unsatisfactory layer shall beremoved and the unsatisfactory layer shall be re-compacted to satisfy the specifications at the expensesof the Contractor.

PROCEDURE FOR MANUAL COMPACTION

Sand shall be compacted manually by using concrete drop hammers each weighing 6 kg to 7 kg, fittedwith a shaft of about 1.5m long. Ramming shall reduce the voids and shall continue until no furthershrinkage of sand is possible by ramming.

Before commencing ramming, the moisture content of sand shall be increased or decreased as perrequirement by sprinkling water or by allowing natural drying of sand as applicable so as to ensure thatthe materials shall have a moisture content of not less than 3% or greater than 3% dry of the optimummoisture required for the purpose of compaction respectively.

The compaction operations shall not proceed until the material is wetted or allowed to dry out, as may berequired, to obtain optimum moisture content within the tolerances as permitted above. However, theremay be an exception with a specific approval of the Engineer. No adjustment in price shall be made onaccount of any operations of the Contractor in wetting or drying the materials or on account of any delaysoccasioned thereby.

The preceding operations shall continue layer after layer until the top of the filling is reached.

MECHANICAL COMPACTION

In the case of mechanical compaction, area of filling, designated on the Drawings or by the Engineer, shall be compacted to the lines and grades shown on the Drawings or established by the Engineer. TheContractor's operations in importing materials, designated for use, shall be such as will result the desiredF.M.

Just prior to and during compacting operations, the materials shall have a moisture content of not greaterthan 3% wet or less than 3% dry of the optimum moisture required for the purpose of compaction, asdetermined by Test No. 12 of BS 1337 and approved by the Engineer. The materials shall be so workedas to have uniform moisture content throughout the entire layer.

If the moisture content is less than optimum by more than 3% or is greater than optimum by more than3%, the compaction operations shall not proceed until the material is wetted or allowed to dry out, asmay be required, to bring the optimum moisture content within the tolerances. However, there may be anexception with a specific approval of the Engineer. No adjustment in price shall be made on account ofany operations of the Contractor in wetting or drying the materials or on account of any delaysoccasioned thereby.

When the material has been conditioned and placed as specified or directed, it shall be compacted withappropriate motorized vibratory compaction equipment or tampers of adequate weight and size asapproved by the Engineer. Each layer shall be compacted to obtain at least 98% compaction of themaximum dry density (STD). If the test results show that the density has not met the requirement, theContractor shall have to carry out further compaction until the required density is achieved.

5.2.4 MEASUREMENT

Measurement shall be taken for payment on the compacted volume of completed and accepted works incubic meter. The cross sections to be used will be the areas bound by the original ground (existing) shaped or leveled, the sides and the bottom of the foundation or the floor.

5.2.5 PAYMENT

Payment for sand filling shall be made at the Contract unit price per cubic meter measured as providedabove which price shall constitute the full compensation for furnishing all materials with their storage,placing, leveling and shaping, wetting or drying, compacting the fill materials and providing all equipment,tools and all incidentals necessary to complete the work true to the Specifications and/or as per thedirections of the Engineer.

Payment shall only be made when all works have been completed in accordance with the designedsections satisfying all Specifications and accepted by the Engineer.

Item of Payment	**Unit**
Sand filling	Cubic meter / Cubic feet

CEMENT CONCRETE BLOCK MASONRY

6.11 SCAFFOLDING

ERROR! BOOKMARK NOT DEFINED.

6.12 TOLERANCES

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6.13 MEASUREMENT & PAYMENT

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CONCRETE WORK

CONCRETE WORK

7.1
Concrete for structures

7.1.1
Description

This work shall consist of construction of all Portland Cement Concrete in structures, with or withoutreinforcement, which shall involve furnishing, placing, finishing and curing of concrete. All items ofconcrete work shall include elements of structures constructed by cast-in-place and pre-cast methodsusing either plain or reinforced concrete or any combination thereof and shall conform to thespecifications and requirements of the different Sub-sections of this item of work. All structures shall bebuilt in a workman like manner to the lines, grades and dimensions shown on the Drawings or asdirected by the Engineer.

All concrete works shall be carried out in accordance with BS 8110 or ASTM C-685 and as specified bythe Engineer.

All sampling and testing of constituent materials shall be carried out in accordance with the provisions ofthe appropriate British or American Standard and all sampling and testing of fresh and hardenedconcrete shall be carried out in accordance with the provisions of BS 1881 “Method of Testing Concrete”or similar under ASTM C 39.

7.1.2
Materials

General

Concrete shall be manufactured with the essential ingredients of Portland cement, fine aggregate, coarseaggregate and water as specified and shall be well mixed and brought to the proper consistency. Typeand source of ingredients used in concrete shall conform to the approved samples and shall not bevaried. The requirement for concrete, its constituent materials, methods and procedures shall conform toany of the Standard Specifications of ASTM, or BS or any other equivalent standard unlessotherwise specified herein or directed by the Engineer.

Materials shall conform to the requirements specified below and in the relevant Section titled‘Construction Materials' of this Specification.

Cement

Cement used in the works shall be Ordinary Portland Cement complying with the requirements of ASTMC 150 Type 1 or BS 12 or equivalent standard. Special cements shall conform to therequirements provided by the Engineer.

Use of cement

Cement of different manufacturers and with different brands or types shall be kept separately and shallnot be used in the same mix.

Consignment of cement shall be used in the order of delivery.

Only one brand, grade or kind of cement shall be used in a given structure, except upon the writtenpermission of the Engineer.

COARSE AGGREGATE

Coarse aggregate for all types of Concrete with the exception of blinding concrete shall conform to therequirements of ASTM C 33.

Coarse aggregate shall be hard, durable, clean, free from dust and other deleterious materials. Thegrading of the coarse aggregate shall be such that when combined with the approved fine aggregate andcement, it shall produce workable concrete of maximum density.

NOMINAL SIZE OF COARSE AGGREGATE

Different sizes of coarse aggregates should be mixed in proportions, which would be determined duringtrial mixes. The course aggregate to be used in the concrete mix shall be dry mixed from different sizesin specified/selected proportion one day before casting.

Nominal size of the coarse aggregate shall not be larger than one-fifth of the narrowest dimensionbetween sides of forms or one-third the depth of slabs or three-fourth the minimum clear spacingbetween individual reinforcing bars or bundle of bars.

FINE AGGREGATE

Fine aggregates shall be non-saline clean natural sand and have a specific gravity not less than 2.6, aFineness Modulus not less than what will be specified for a particular type of concrete. It shall conform tothe requirements of ASTM C-33 or equivalent standard.

WATER

All sources of water for use in concrete shall be subject to the approval of the Engineer. Water shall bereasonably clean, free from injurious quantities of oil, alkali, salts and organic materials or othersubstances that may be deleterious to concrete or reinforcement and shall not contain any visibly solidmaterial. Water whose concentration of chloride ion is in excess of 3,000 ppm (parts per million) shall notbe used for the production of concrete. If requested by the Engineer, water shall be tested by comparingwith water of known satisfactory quality. Such comparison shall be made by means of standard cementtests for soundness, time of setting and mortar strength. Any indications of unsoundness, change in timeof setting of plus or minus 30 minutes or more, or reduction of more than 10 percent in mortar strengthshall be sufficient cause for rejection of the water under test.

ADMIXTURES

Suitable admixtures may be used in concrete mixes with the prior acceptance of the Engineer. The typeand source of admixture, and the amount added and method of use shall be to the acceptance of theEngineer, who shall be provided with the following data:

i. The manufacturer's recommended dosage and detrimental effects of under-dosage and over-dosage.
ii. The chemical name of the main active ingredients in the admixture.
iii. Whether or not the admixture contains chloride and, if so, the chloride content of the admixture expressed in percentage of equivalent anhydrous calcium chloride by weight of admixture.
iv. Whether or not the admixture leads to the entraining of air when used at the manufacturers recommended dosage.
v. Evidence of previous satisfactory performance of concrete containing the additive.

Admixtures containing chloride other than impurities from admixture ingredients shall not be used inconcrete containing embedded aluminium, or in concrete cast against permanent galvanized metalforms.

In admixtures for use in reinforced concrete, the chloride ion content shall not exceed one percent byweight of the admixture.If more than one admixture is used, the admixtures shall be compatible with each other and shall beincorporated into the concrete mix in correct sequence so that the desired effects of all admixtures areobtained.

Fly ash or other pozzolans used as admixtures shall conform to 'Specification for Fly Ash and Raw orCalcined Natural Pozzolan for use as a Mineral Admixture in Portland Cement Concrete (ASTM C 618)'.All air entraining admixtures shall conform to 'Specification for Air entraining Admixtures for Concrete(ASTM C 260)'.

Air entraining and chemical admixtures shall be incorporated into the concrete mix in a water solution.The water so included shall be considered to be a portion of the allowed mixing water. Admixtures shallbe incorporated through a dispensing system sufficiently accurate to deliver within + 5% of the approveddosage rate.

All admixtures shall be used strictly in accordance with the manufacturer's instructions. A 'Literature ofCompliance' of the admixture shall be furnished to the Engineer for each shipment of admixture used inthe work. The said literature shall be based upon laboratory test results from an approved testing facilityand shall authenticate that the admixture meets all requisite specifications.

7.1.3 TESTING OF MATERIALS

GENERAL

All tests shall be performed at Site and/or in the PEC Laboratories. Testing outside the scope of Site orPEC Laboratories shall be carried out at a recognized laboratory that will be designated by theEngineer. The test results shall be authenticated by the Head of the Laboratory.

CEMENT

Hydraulic cement shall be sampled and tested in accordance with the standard methods referred to inAASHTO M 85.

Cement may be sampled either at the factory or at the Site of the Work as provided in the Specifications.

The Contractor shall notify the Engineer of dates of delivery so that there will be sufficient time forsampling the cement, either at the factory or upon delivery. If this is not done or if additional tests arenecessary, the Contractor may be required to re-handle the cement in the store for the purpose ofobtaining the required samples.

Sampling shall normally be instructed by the Engineer for every stored 200 cubic meter of concreteproduction with the concerned cement type or if the source of cement has been changed.

AGGREGATE

Tests to assess the suitability of the aggregates proposed for use in concrete to be placed in thepermanent works shall be as follows:

i. Grading
ii. Magnesium sulphate soundness
iii. Specific gravity and water absorption
iv. Clay, silt and dust content
v. Organic impurities
vi. Sulphate and chloride content
vii. Elongation and flakiness
viii. Potential alkali reactivity
ix. Los Angeles Abrasion Test
x. Aggregate drying shrinkage.

These tests are to be carried out in accordance with the appropriate ASTM Standards and the resultsshall comply with the limits given therein or as otherwise stated in this Specification. Grading shall becarried out at least at a weekly interval when concrete is being produced on a regular basis or before thestart of production when irregular.

The Contractor shall supply samples of the aggregate materials proposed to be used for testing ofElongation and Flakiness Index, Los Angeles Abrasion Value (coarse aggregate) and Fineness Modulus(fine aggregate) and grading and other tests as required by the Engineer.

From the aggregate materials proposed by the Contractor, samples shall be selected according to ASTM D 75 and D 3665 in the presence of the Engineer. The samples shall be brought to the Site laboratory andtested for proving their conformance with the relevant Section of BS or ACI Codes.

The quality control of the aggregate shall be as directed by the Engineer. Grading shall normally bechecked daily.

Moisture content of the aggregate shall be determined daily and at any time when a change in themoisture content is expected.

If the Contractor proposes to change the source of supply of aggregates, samples from the new sourceshall similarly be supplied and tested.

Grading of mixed coarse aggregate shall be checked at Site.

WATER

The water used in mixing or curing concrete shall be tested by methods described in AASHTO TestMethod T 260.

In sampling water for testing, care shall be taken that the containers are clean and that samples arerepresentative.

When comparative tests are made with a water of known satisfactory quality, any indication ofunsoundness, marked change in time of setting, or a reduction of more than 10 percent in mortarstrength, shall be sufficient cause for rejection of the water under test.

Water shall be tested before commencement of work or any time required by the Engineer, or if thesource is changed.

ADMIXTURES

The Contractor shall submit to the Engineer specifications and samples of any admixtures or additivesthat he proposes to use at least 28 days before the commencement of construction or manufacture of theparticular structure on which he intends to use the admixture.

Any tests the Engineer may require on concrete mixes on account of the Contractor's proposal to useadditives shall be carried out at the expenses of the Contractor.

7.1.4 COMPOSITION OF CONCRETE
CONCRETE CLASSES

The class of concrete and properties applicable to the concrete in various parts of structures shall be asspecified in the following table.

Each mix shall be designed to ensure optimum workability, prevent segregation and produce a dense,durable concrete by adjusting the fine and coarse aggregate proportions following procedures as statedunder the Sub-section of 'Design of Concrete Mix' of this Specification.

Concrete Class	28 day Cylinder strength in lbs/in^2 (minimum)	Coarse Aggregate Type	Mix Ratio (by volume) (only indicative)
A-1	4000	Crushed Stone	1:1:2
A-2	3000	Crushed Stone	1:1.5:3
A-3	2500	Crushed Stone	1:2:4

The various classes of concrete shall be placed at locations as would be specified on the Drawings (if so)or elsewhere as directed by the Engineer.

Strength requirement is the only determining factor for acceptance of any above stated class of concrete.The mix ratio only shows the minimum cement requirement and it shall not put the Engineer under anyobligation to accept concrete unless the requisite strength is established. If required, the cement contenthas to be increased to attain the desired strength without any additional costs to be paid to theContractor.

Strength of each and every cylinder tested should conform the aforementioned specified value. Trialmixes for every class of concrete with representative material from the Site, shall be prepared by theContractor in the laboratory in accordance with the approved procedures. The nominal strength in thesetests shall exceed the specified minimum strength by 10%.

If required, suitable admixtures as approved by the Engineer would have to be added to the concrete mixto attain the desired strength without any additional costs to be paid to the Contractor. The effect of theadmixture shall be carefully observed by trial mix and tests before its use.

As the work progresses, the Engineer reserves the right to change the proportions from time to time, ifconditions warrant so in the interest of satisfactory output. Any such changes will be made at noadditional compensation to the Contractor.

7.1.5 REGULATION OF WATER CONTENT

The amount of water used in the concrete for volume batching shall be regulated to adjust for anyvariation of the moisture content or grading of the aggregates as they enter the mixer as follows:

The batched volume of damp fine aggregate shall be corrected to the equivalent volume of dryaggregate. The volume of moisture in the aggregates shall be deducted from the free water to be addedto the mix. To expedite correction to fine aggregate, a “bulking curve” showing the relation betweenmoisture content and increase over dry volume shall be prepared in advance by tests on the fineaggregate used. The Engineer may direct the use of a slump less than that specified whenever concreteof such lesser slump can be consolidated into place by means of vibration specified herein. Addition ofwater to overcome stiffening of the concrete before placing will not be permitted. Concrete shall haveuniform consistency from batch to batch. Aggregate shall not be batched for concrete when free water isdripping from the aggregate.

Concrete mix proportions shall be such that the concrete is of adequate workability and can properly becompacted. Suggested ranges of values of workability of concrete for some placing conditions are givenin the following Table.

Degree of Workability	Placing Conditions	Nominal maximum aggregate (mm)	Compac-ting factor	Slump mm
Very Low	Small sections (i.e. pre-cast or > 300mm thick)	20	0.78	0-10
	subjected to intensive vibration and large sections	40	0.78	0-25

	to normal vibration			
Low	Simple reinforced sections with vibration and large sections without vibration	20 40	0.85 0.85	10-25 25-50
Medium	Simple reinforced sections without vibration and heavily reinforced sections with vibration	20 40	0.92 0.92	25-50 50-100
High	Heavily reinforced sections without vibration	20 40	0.95 0.95	50-125 100-175

When the consistency of the concrete is found to exceed the nominal slump, the mixture of subsequentbatches shall be adjusted to reduce the slump to a value within the nominal range. Batches of concretewith a slump exceeding the maximum specified shall not be used in the work.

If concrete of adequate workability cannot be obtained by the use of the minimum cement content aswould be allowed, the cement and water content shall be increased without exceeding the specifiedwater/cement ratio, or an approved admixture shall be used.

7.1.6 DURABILITY OF CONCRETE

SPECIAL EXPOSURES

For concrete intended to have low permeability when exposed to water, the water cement ratio shall notexceed 0.50.

For corrosion protection of reinforced concrete exposed to brackish water, sea water or spray from thesesources, the water cement ratio shall not exceed 0.40.

If minimum requirement of concrete cover as given under the Section on ‘Reinforcing Steel’ is increasedby 12mm, water cement ratio may be increased to 0.45.

The requirement of water cement ratio on Normal Weight Aggregate Concrete, if exposed to Sulphatecontaining solutions, shall be calculated using the weight of cement meeting the requirements of ASTMC 150 or C 595 plus the weight of fly ash or pozzolan satisfying ASTM C 618 and/or slag satisfyingASTM C 989.

SULPHATE EXPOSURES

Concrete to be exposed to sulphate containing solutions or soils shall conform to the requirements of theTable given below or be made with a cement that provides sulphate resistance with the maximum watercement ratio provided in the Table.

Calcium chloride shall not be used as an admixture in concrete exposed to severe or very severesulphate containing solutions, as defined in Table given below.

Requirements for Normal Weight Aggregate Concrete Exposed to Sulphate Containing Solutions

Sulphate exposure	Water Soluble Sulphate (SO4) in soil (percent by weight)	Sulphate (SO4) in water (ppm)	Cement Type[1]	Maximum Water Cement Ratio, by weight
Negligible	0.00-0.10	0-150		
Moderate[2]	0.10-0.20	150-100	II, IP(MS), IS(MS), P(MS), I(PM) (MS) I(SM) (MS)	0.50
Severe	0.20-2.00	1500-10,000	V	0.45
Very Severe	Over 2.00	Over 10,000	V plus pozzolan[3]	0.45

Note:

1. For types of cement see ASTM C150 and C595.
2. Sea water
3. Pozzolan that has been determined by test or service record to improve Sulphate resistance when used in concrete containing Type V cement.

CORROSION OF REINFORCEMENT

For corrosion protection, maximum water soluble Chloride ion concentrations in hardened concrete atages from 28 to 42 days contributed from the ingredients including water, aggregates, cementitiousmaterials, and admixtures, shall not exceed the limits specified in the Table given below. When testing isperformed to determine water soluble Chloride ion content, test procedures shall conform to AASHTO T260, “Methods of Sampling and Testing for Total Chloride Ion in Concrete and Concrete Raw Materials”.

Type of Member	Maximum water soluble Chloride ion (C1) in Concrete, percent by weight of cement
Reinforced concrete exposed to chloride in service	0.15
Reinforced concrete that will be dry or protected from moisture in service	1.00
Other reinforced concrete construction	0.30

When reinforced concrete will be exposed to brackish water, sea water, or spray from these sources, the above requirements for water cement ratio, or concrete strength and minimum cover requirements (shown under the relevant Sub-section of the Section on 'Reinforcing Steel') shall be satisfied.

7.1.7 DESIGN OF CONCRETE MIX

When designing the concrete mix, the following conditions shall be considered:

Strength

The class of the concerned concrete is to be as shown on the Drawings (if shown). The class is the specified cylinder strength of 28 days and shall be determined as indicated above in the Table under the Sub-section on 'Concrete Classes' of this Section.

Water/Cement Ratio

The ratio of free water to cement when using saturated surface dry aggregate shall be as low as possible and not to exceed 0.50 by weight for all concrete.
For concrete in pile caps in contact with the ground, the water cement ratio shall not exceed 0.45.

Cement Type and Minimum Content

Type-1 Cement shall be used for all classes for "Concrete".

Minimum Filler Content

Filler is defined as fine concrete aggregates including cement with a grain diameter less than 0.25mm. It shall not be less than (except mass concrete) 435 Kg per cubic meter Concrete for maximum 20mm size Coarse Aggregate. The same for maximum 40mm size Coarse Aggregate shall not be less than 350 kg per cubic meter of Concrete.

Coarse Aggregate

The maximum size of the coarse aggregate shall be either 40mm or 20mm and the grading and quality shall be as indicated in the portion of 'Coarse Aggregate' under the Sub-section on 'Construction Materials' of this Specification or as specified on the Drawings or as directed by the Engineer.

Fine Aggregate

The grading and quality is to be as indicated in the portion of Sub-section on 'Fine Aggregate' under the Section on 'Construction Materials' of this Specification or as specified on the Drawings or as directed by the Engineer.

Workability

The concrete shall be of suitable workability to obtain full compaction. Slumps measured, as described in ASTM C-143 shall be in accordance with the values shown unless otherwise required or approved by the Engineer.
The designed concrete mix shall be approved by the Engineer to meet the requirements for each structural component.

Prior to the commencement of concrete operations, the Contractor shall design a mix for the concreteand prepare and test concrete samples of this mix under laboratory conditions. Preliminary mixes shallbe repeated and adjusted as necessary to produce a concrete mix meeting the requirements statedunder the Sub-section on “Composition of Concrete” of this Specification. The details of the mix and testresults shall be submitted to the Engineer for his approval.

Following the Engineer’s approval of the mix design, the Contractor shall prepare a trial mix in thepresence of the Engineer. The trial mix shall be batched, mixed and handled using the same methodsand plant, the Contractor proposes to use. The mix shall comprise not less than half a cubic meter ofconcrete. The proportions of cement, aggregates and water shall be carefully determined by weight inaccordance with the Contractor’s approved mix design and sieve analysis shall be made for the fine andcoarse aggregates.

Twelve concrete cylinder samples shall be made from the trial mix in the presence of the Engineer. Theconcrete cylinders shall be made, cured, stored and tested in accordance with BS 1881 or ASTM C-39. Six cylinders shall be tested at 7 days and six cylinders shall be tested at 28 days.If the strength of any of the cylinders tested at 28 days is recorded below the characteristic strength, theContractor shall redesign the mix, make further preliminary mixes for the Engineer’s approval. He shallthen undertake additional trial mixes and test the resultant samples until a satisfactory mix is obtainedand approved by the Engineer.

From the same mix as that from which the test specimens are made, the workability of the concrete shallbe determined by the slump test in accordance with ASTM C-143. The remainder of the mix shall be castin a mould and compacted. After 24 hours, the sides of the mould shall be struck off and thesurface examined in order to satisfy the Engineer that an acceptable surface can be obtained with themix.

When a proposed mix has been approved, no variation shall be made in the mix proportions, or in thetype, size, grading zone or source of any of the constituents without the consent of the Engineer. He mayrequire further trial mixes to be made before any such variation is approved.

Until the Engineer approves the results of trial mixes for a particular class of concrete, no concrete of therelevant class shall be placed in the works.

During production, the Engineer may require additional trial mixes before a substantial change is made inthe materials or in the proportions of the materials to be used. However, it will not need to be carried outwhen adjustments are made to the mix proportions during production in order to minimize the variabilityof strength and to approach more closely the target mean strength.

Trial mixes for mass concrete are not requested provided the Contractor is able to submit test resultsfrom mixes carried out before which prove that the demanded quality of the mass concrete is accordingto the Specifications.

When the Contractor intends to purchase factory-made pre-cast concrete units, trial mixes may bedispensed with provided that evidence is given to satisfy the Engineer that the factory regularly producesconcrete, which complies with the Specifications. The evidence shall include details of mix proportions,water-cement ratios, slump tests and strengths obtained at 28 days.

Selection of the trial mix is the ultimate responsibility of the Contractor regardless of its approvalaccorded by the Engineer.

7.1.8 PROPORTIONING OF MIX

Proportions of materials for concrete shall be such that:

i. Workability and consistency are achieved for proper placement into forms and around reinforcement, without segregation or excessive bleeding.
ii. Resistance to special exposures to meet the durability requirements are provided, and
iii. Conformance with strength test requirements is ensured.

The approved mix shall be proportioned by weight or, except cement by volume, if volume batching isapproved by the Engineer. Allowance shall be made for the moisture content of the aggregates.

Fine and coarse aggregates and water may only be measured by volume in boxes or containersapproved by the Engineer. Cement shall be added to Concrete Mixer by whole number of bags only.

7.1.9 CONCRETE IN BLINDING LAYERS

The blinding concrete/lean concrete (Mix 1:3:6) shall be mixed in proportion by volume whereverspecified on the Drawings. Ordinary Portland Cement and well-graded aggregate of maximum nominalsize, not exceeding 40mm, shall be used unless otherwise specified.

7.1.10 BATCHING

GENERAL

The Contractor shall provide and maintain suitable measuring equipment and devices of good orderrequired to determine and control accurately the relative amount of various materials entering the mix.

All measurements shall be by weight/volume and shall be accurate within a tolerance of 1% for eachbatch. Besides, the deviation from the average amount of filler from ten samples of different batches offresh concrete should not be more than 6%.

Satisfactory methods of handling materials shall be employed.

A batching plant shall be used for measuring materials but alternative methods proposed by theContractor may be considered subject to the approval of the Engineer. The batching plant shall includebins, weighing hoppers and scales for the fine aggregate and for each separated size of coarseaggregate. If cement is used in bulk, a bin, hopper and scales for the cement shall be included. Thecontainer shall be watertight.

Provisions satisfactory to the Engineer shall be made for batching other components of the mix at thebatching plant or at the mixer, as may be necessary. The batching plant may be either of stationary or ofmobile type. It shall always be properly leveled within the accuracy required for the proper operation ofthe weighing mechanisms.

BINS AND HOPPERS

Bins with adequate separate compartments for fine aggregate and for each required size of coarseaggregate shall be provided in the batching plant. Each compartment shall discharge

efficiently andfreely in to the weighing hopper. Means of control shall be provided so that as the quantity desired in theweighing hopper is being approached, the material may be added slowly and shut off with precision. Aport or other opening for removing an overload of the several materials from the hopper shall beprovided.

Weighing hoppers shall be constructed so as to discharge fully.

SCALES

The scales for weighing aggregates and cement shall be of either the beam type or the dial type withoutspring. They shall be accurate within one-half of 1% under operating conditions throughout the range ofuse. Ten 25 kilogram weights shall be available for checking the accuracy. All exposed fulcrums, clevisesand similar working parts of scales shall be kept clean. When beam-type scales are used, provision shallbe made for indicating to the operator that the required load in the weighing hopper is being approached.The device shall indicate at least the last 100 kilograms of load and upto 25 kilograms over-load. Allweighing and indicating devices shall be in full view of the operator while charging the hopper and heshall have convenient access to all controls.

Cement may be measured by weight, or in standard bags weighing 50 kilograms net each. Whenmeasured by weight, a separate satisfactory scale and hopper shall be provided together with a boot orother approved device to transfer the cement from the weighing hopper.

The amount of water shall be measured by weight separately on an individual scale or may be measuredby volume.

Any solid admixture, to be added, shall be measured by weight. However, liquid or pest admixtures maybe measured by volume or weight.

7.1.11 QUALITY CONTROL OF CONCRETE

GENERAL

The Contractor shall assume the full responsibility that the quality of the concrete conforms to theSpecifications and this responsibility shall not be waived by the tests carried out and the test resultsapproved by the Engineer.

The Contractor shall thus at his own discretion establish additional testingprocedures as necessary.The Contractor shall be responsible for providing samples of concrete and its constituent materials eitherfor testing by himself or for testing at the Engineer's laboratory or laboratory designated by the Engineer.For this purpose, concrete test cylinders, which shall be made in accordance with BS 1881/ASTM C 31shall be deemed to be 'Samples'. All sampling of constituent materials shall be carried out in accordancewith the provisions of the appropriate British/American Standard and all sampling of fresh and ofhardened concrete shall be carried out in accordance with the provisions of BS 1881/ASTM C 31 unlesssuch provision is at variance with the Specification.

The tests, which the Contractor is required to undertake on behalf of the Engineer, are those to becarried out on fresh concrete at the place of final deposit, or elsewhere at Site as directed by theEngineer.

ADJUSTMENT OF WATER/CEMENT RATIO

The Contractor shall test aggregates for moisture content and so determine the water- cement ratio ofthe fresh concrete. Determination of water-cement ratio shall be carried out as required by the Engineerand the results and calculations shall be submitted to him.

SLUMP TESTS

Slump testing of concrete shall be carried out as required by the Engineer. The minimum is one test atthe commencement of each casting, one per hour of casting and one each time a strength test specimenis taken.

The Engineer shall make available a slump cone at Site and the testing shall be carried out inaccordance with ASTM C-143.

The slump of concrete to be used in the works shall not exceed the slump of the trial mix by more than 10% and shall in any case be not more than the maximum specified.

COMPRESSIVE STRENGTH

The Contractor shall, in the presence of the Engineer, sample concrete for testing from the batching andmixing plant at the time of pouring of concrete into the forms or elsewhere. Samples shall be obtained atuniform intervals throughout the production or delivery of concrete for a given placement.

The Contractor shall carry out cylinder testing of concrete strength as required by the Engineer. Aminimum of three test cylinders shall be taken for each day's casting or for every 15 cubic meters ofconcrete cast in larger pours.

After stripping, each cylinder shall be indelibly marked with the date of taking cylinder, location in thestructure and prescribed number.

The Engineer shall make available 2 sets of three test moulds (cylinder) at Site. Samples for testing shallbe taken in the presence of the Engineer and shall be dated.

Tests cylinder shall be tested for 7 days and 28 days compressive strength in accordance with ASTM C-39.

A strength test result shall be the average of the strengths of two cylinders made from the same sampleof concrete and tested at 28 days. Strength level of an individual class of concrete shall be consideredsatisfactory if both of the following requirements are met:

i. Average of three consecutive strength tests equals of exceeds the specified strength.
ii. No individual strength test (average of two cylinders) falls below the specified strength by morethan 3.5 N/mm^2.

However, the following may be an alternative –

The average strength of the three consecutive cylinders, tested at 28 days, shall exceed the specifiedstrength. One out of the three cylinders tested may have a value less than the specified strengthprovided that it is not less than 85% of the specified strength, except that not more than one test resultper element may be below the specified strength.

FAILURE TO PASS TESTS

If cylinders taken at Site during the progress of the works fail to reach the specified strength, no furtherpouring of concrete shall take place until the cause of the failure has been established and correctivemeasures have been taken to the satisfaction of the Engineer.

The Engineer may require that core samples are taken and tested in accordance with ASTM C 42 or similar standard or other tests be performed on sections of the works made from the suspect concrete. Ifsuch tests fail to demonstrate the integrity of the sections of the works, all sections made with thesuspect concrete shall be removed from the Site. Costs of all such tests and removal of concreteincluding the cost of the concrete shall be borne by the Contractor.

TESTING HARDENED CONCRETE

Entire operation shall be carried out as per the approval of the Engineer with due precaution so that thestructural integrity is no way affected. The Contractor shall remain responsible for any negligence. Ifapproved by the Engineer, on each specific occasion, hardened concrete liable to rejection shall betested for compressive strength in accordance with ASTM C 42 at the Contractor's expenses. Unlessotherwise directed, cores shall be 150mm in diameter. At least three specimens shall be cored andtested from the locations as directed by the Engineer.

If the average compressive strength of the core specimens, so obtained, is equal to or greater than 85%of the specified 28-days cylinder, compressive strength for that section of the work (the concreterepresented by the core specimen) shall be considered to be structurally satisfactory.

If the concrete is considered to be structurally satisfactory, the holes left by the removal of the test coresshall be appropriately repaired or as directed by the Engineer. Unless otherwise directed, concrete thatwill fail to meet the requirements of the Specifications shall be removed and replaced in an approvedmanner without any extra costs to the Employer.

7.1.12 CONCRETE CONSTRUCTION

7.1.12.1GENERAL

The Contractor shall, in due time and as soon as possible, submit his proposed construction methodsand work programme along with Shop Drawings to the Engineer and shall obtain his approval beforecommencement of any works.

The Contractor shall maintain an adequate number of trained and experienced supervisors and foremenat the Site to supervise and control the Work.

7.1.12.2 MIXING CONCRETE

GENERAL

All concrete shall be mixed in batch mixers. It may be mixed at the Site of construction, at a central plant,or in transit. Each mixer shall have attached to it, in a prominent place, a manufacturer's plate showingthe capacity of the drum in terms of mixed concrete and the speed of rotation of the mixing drum.

MIXERS AT THE SITE OF CONSTRUCTION

Mixers at local Sites shall be approved drum-type capable of combining the aggregate, cement, andwater into a thoroughly mixed and uniform mass within the specified mixing period and of discharging themixture without segregation.

The mixer shall be equipped with a suitable charging hopper, water storageand a water-measuring device, accurate within 1%. Controls shall be so arranged that the water can beapplied only while the mixer is being charged. Suitable equipment for discharging the concrete shall beprovided. The mixer shall be cleaned at suitable intervals. The pickup and throw over blades in the drumshall be replaced when they have lost 10% of their depth.The mixer shall be operated at a drum speed of not less than 15 nor more than 20 revolutions per minuteat the recommended speed of the manufacturer. The batched materials shall be so charged into thedrum that a portion of the water shall enter in advance of the cement and aggregates and the water shallcontinue to flow into the drum for a minimum time of 5 seconds after all the cement and aggregates arein the drum. Mixing time shall be measured from the time all materials, except water, are in the drum andshall, in the case of mixers having a capacity of 1 cubic meter or less, not be less than 50 seconds normore than 70 seconds. Mixing shall be continued for at least 90 seconds after all materials are in thedrum, unless a shorter time is shown to be satisfactory by the mixing uniformity tests of 'Specification forReady Mixed Concrete' (ASTM C 94). In the case of dual drum mixers, the mixing time shall not includetransfer time. The contents of an individual mixer drum shall be removed before a succeeding batch isemptied therein. Any concrete mixed less than the specified minimum time shall be discarded anddisposed of by the Contractor at his own expenses.

The volume of concrete, mixed per batch, shall not exceed the mixer's nominal capacity in cubic metersas shown on the manufacturer's guaranteed capacity standard rating plate on the mixer. However, anoverload upto 20% of the mixers nominal capacity may be permitted provided concrete test data forstrength, segregation and uniform consistency are satisfactory, and provided no spillage of concretetakes place.

Re-tempering concrete by adding water or by other means shall not be permitted. Concrete, which is notof the required consistency at the time of placement, shall not be used.

CENTRAL PLANT MIXERS

These mixers shall be of approved drum type capable of combining the aggregate, cement and waterinto a thoroughly mixed and uniform mass within the specified mixing period and of discharging themixture without segregation. Central plant mixers shall be equipped with an acceptable timing device thatwill not permit the batch to be discharged until the specified mixing time has elapsed. The water systemfor a central mixer shall be either a calibrated measuring tank or a meter and shall not necessarily be anintegral part of the mixer.

The mixer shall be cleaned at suitable intervals. It shall be examined daily for changes in interiorcondition. The pick-up and throw-over blades in the drum shall be replaced when they have lost 10% oftheir depth.

Central plant mixers, which have a capacity of 2-5 cubic meters and greater than 5 cubic meters, maypermit a minimum mixing time of 90 seconds and 120 seconds respectively provided a mixing analysisand tests of the job materials indicate such produced concrete is equivalent to strength and uniformity tothat attained as stated in the preceding paragraphs.

HAND MIXING

The Engineer shall normally not allow any hand mixing in the preparation of concrete. However, undersome special circumstances, exigencies and for small works, it may be compelling to allow hand mixingwhile preparing the concrete. In the case hand mixing is allowed, the procedures stated below shall befollowed in a chronological order:

i. Water-tight platform should be constructed with cement concrete or bricks. The size of the platformshall be such that it will be possible to accommodate the requisite quantity of mixture in a singlebatch. The materials of a single batch should be calculated out carefully.

ii. The requisite quantity of sand, being determined at a certain proportion, should be measured in awooden box of specified size and to be spread on the platform with uniform thickness and the top isto be leveled. The requisite quantity of cement should also be measured and spread with uniformthickness over the stack of sand.

iii. Sand and cement as stacked above shall have to be mixed up by reversing with spade starting fromone end and progressing towards the other. This procedure to be carried on carefully, thoroughlyand repeatedly in such a manner that the mixture ultimately turns into a uniform colour and density.The mixture should then be stacked in a heap on a portion of the platform.

iv. The requisite quantity of coarse aggregate should then be stacked on the left out spaces of theplatform and the top surface be leveled. The previously mixed sand and cement mixture shall thanbe spread with uniform thickness over the coarse aggregate. The height of these two layers incombination should better not to exceed 250mm. They are then to be thoroughly mixed with spadefor several times. In each time, the mixing should proceed from one end. The mixing shall becontinued until the mixture takes a uniform colour and density. The mixture will than be stacked withuniform height and leveled (the height of the stack may normally be maintained at 250mm).

v. The top surface of the stack will than be shaped concave and the requisite amount of water to bepoured in. It is then be thoroughly mixed with spade with caution and as quickly as possible. Themixing shall be continued till the mixture takes a uniform colour and density. The mixture shallinvariably be conveyed, placed, compacted and to be given the final shape within 45 minutes onmixing.

7.1.12.3 CONVEYING CONCRETE

GENERAL

Concrete shall be conveyed from the mixer/batching plant to the place of final deposit as rapidly aspossible by methods that will prevent segregation or loss of materials. Conveying equipment shall becapable of providing a supply of concrete to the place of deposit without segregation of ingredients andwithout interruptions sufficient to permit loss of plasticity between successive increments. Re-mixing ofconcrete shall not be allowed. Concrete, which does not reach its final position in the forms within thestipulated time, shall not be used.

Mixed concrete shall be transported from the central mixing plant to the work Site in agitator trucks orupon written permission by the Engineer in non-agitator trucks. Delivery of concrete shall be so regulatedthat placing is at a continuous rate unless delayed by the placing operations. The intervals betweendelivery of batches shall not be so great as to allow the concrete in place to harden partially, and in nocase such an interval shall exceed 30 minutes.

AGITATOR TRUCKS

Unless otherwise permitted in writing by the Engineer, agitator trucks may be used for transportation ofcentral plant mixed concrete. Agitator trucks shall have watertight revolving drums suitably mounted andshall be capable of transporting and discharging the concrete without segregation. The agitating speed ofthe drum shall not be less than 2 or more than 6 revolutions per minute. The volume of the mixedconcrete permitted in the drum shall not exceed the manufacturer's rating nor exceed 80% the grossvolume of the drum.

Upon approval by the Engineer, open-top revolving-blade truck mixers may be used in lieu of agitatingtrucks for transportation of central plant mixed concrete.

The interval between introduction of water into the mixer drum and final discharge of the concrete fromthe agitator shall not exceed 45 minutes. During this interval the mix shall be agitated continuously.

NON-AGITATOR TRUCKS

Bodies of non-agitating equipment shall be smooth, watertight metal containers equipped with gates thatwill permit control of the discharge of the concrete. Covers shall be provided when needed for protectionagainst weather.

The non-agitating equipment shall permit delivery of the concrete to the work Site in a thoroughly mixedand uniform mass with a satisfactory degree of discharge.

Uniformity shall be satisfactory, if samples from the one-quarter and three-quarter points of the load donot differ by more than 30mm in slump. Discharge of concrete shall be completed within 30 minutes afterthe introduction of the mixing water to the cement and aggregate.

TRUCK OR TRANSIT MIXERS

These shall be equipped with electrically actuated counters by which the number of revolutions of thedrum or blades may readily be verified and the counters shall be actuated at the commencement ofmixing operations at designated mixing speeds. The mixer when loaded shall not be filled to more than60% of the drum gross volume. The mixer shall be capable of combining the ingredients of the concretein to a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree ofuniformity.

Except when intended for use exclusively as agitators, truck mixers shall be provided with a water-measuring device to measure accurately the quantity of water for each batch. The delivered amount ofwater shall be within plus or minus 1% of the indicated amount.

Truck mixers may be used for complete mixing at the batch plant and as truck agitators for delivery ofconcrete to job Site or they may be used for complete mixing of the concrete at the job Site. They shalleither be a closed watertight revolving drum or an open top revolving blade or paddle type.

The amount of mixing shall be designated in number of revolutions of the mixer drum. When a truckmixer is used for complete mixing, each batch of concrete shall be mixed for not less than 70 nor morethan 100 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of theequipment as the “mixing speed”. Such designation shall appear on a metal plate attached to the mixer.If the batch is at least 0.5 cubic meter less than guaranteed capacity, the number of revolutions at mixingspeed may be reduced to not less than 50. Mixing in excess of 100 revolutions shall be at the agitatingspeed. All materials, including the mixing water, shall be in the mixer drum before actuating therevolution counter, which will indicate the number of revolutions of the drum or blades.When wash water (flush water) is used as a portion of the mixing water for the succeeding batch, it shallbe accurately measured and taken into account in determining the amount of additional mixing waterrequired.

When wash water is carried on the truck mixer, it shall be carried in a compartment separatefrom the one used for carrying or measuring the mixing water. The Engineer will specify the amount ofwash or flush water and may specify a “dry” drum, if wash water is used without measurement or withoutsupervision.

When a truck is used for complete mixing at the batch plant, mixing operations shall begin within 30minutes after the cement has been added to the aggregate. After mixing, the truck mixer shall be used asan agitator, when transporting concrete, at the speed designated as agitating speed by the manufacturerof the equipment. Concrete discharge shall be completed within 45 minutes after the addition of cementto the aggregates. Each batch of concrete, delivered at the job Site, shall be accompanied by a time slipissued at the batching plant, bearing the time of departure therefrom. When the truck mixer is used forthe complete mixing of the concrete at the job Site, the mixing operation shall begin within 30 minutesafter cement has been added to the aggregates.

The rate of discharge of the plastic concrete from the mixer drum shall be controlled by the speed ofrotation of the drum in the discharge direction with the discharge gate fully opened.

7.1.12.4 HANDLING AND PLACING OF CONCRETE

Concrete placing shall not be commenced without the written approval of the Engineer or hisrepresentative. This approval shall be in the form of a standard checklist approved by the Engineer priorto the commencement of the Work. The checklist shall be filled in and approved by the Engineer or hisrepresentative during his inspection and acceptance of materials, plant and equipment, concrete pouringarrangements, the positioning, fixing and condition of reinforcement and any other items to be embeddedincluding the cleanliness, alignment and suitability of the containing surfaces or formwork.

The temperature of concrete at the time of placing shall not exceed 35°C.

In preparation for the placing of concrete all sawdust, chips and other construction debris and extraneousmatter shall be removed from the interior of forms. Struts, stays and braces, serving temporarily to holdthe forms in correct shape and alignment, pending the placing of concrete at their locations, shall beremoved when the concrete placing has reached an elevation rendering their

service unnecessary.These temporary members shall entirely be removed from the forms and not be buried in the concrete.The concrete shall be placed in the position and sequences indicated on the Drawings, and Specificationor as directed by the Engineer. The concrete shall be placed in clean, oiled formwork and compactedbefore initial set has occurred. In any event concrete shall not be placed later than 30 minutes from thetime of mixing.

Concrete shall be placed in horizontal layers and each layer shall not be more than 600mm thick exceptas hereinafter provided. When less than a complete layer is placed in one operation, it shall beterminated in a vertical bulkhead. Each layer shall be placed and compacted before the preceding batchhas taken initial set to prevent injury to the green concrete and avoid surfaces of separation between thebatches. Each layer shall be compacted so as to avoid the formation of a construction joint with apreceding layer that has not taken the initial set.

The concrete shall be deposited as far as possible in its final position without re-handling or segregationand in such a manner so as to avoid displacement of the reinforcement and other embedded items orformwork.

Open troughs and chutes shall be of metal or metal line. The use of long troughs, chutes and pipes forconveying concrete from the mixer to the forms shall be permitted only on written authorization of theEngineer. Where chutes are used to convey the concrete, their slopes shall not be such as to causesegregation. Where long steep slopes are required, the chutes shall be equipped with baffles or be inshort lengths that reverse the direction of movement. In case an inferior quality of concrete is producedby the use of such conveyors, the Engineer may order discontinuation of their use and the installation ofa satisfactory method of placing.

Pneumatic placing of concrete shall be permitted only if authorized by the Engineer. The equipment shallbe so arranged that a vibration does not damage freshly placed concrete.

Where concrete is conveyed and placed by pneumatic means, the equipment shall be suitable in kindand adequate in capacity for the work. The machine shall be located as close as practicable to the placeof deposit. The position of the discharge end of the line shall not be more than 3m from the point ofdeposit. The discharge lines shall be horizontal or inclined upwards from the machine. At the conclusionof placement, the entire equipment shall be thoroughly cleaned.

Placement of concrete by pumping shall be permitted only if authorized by the Engineer. The equipmentshall be so arranged that vibrations do not damage freshly placed concrete. Where concrete is conveyedand placed by mechanically applied pressure, the equipment shall be suitable in kind and adequate incapacity for the work. The operation of the pump shall be such that a continuous stream of concretewithout air pockets is produced. When pumping is completed, the concrete remaining in the pipeline, if itis to be used, shall be ejected in such a manner that there is no contamination of the concrete orseparation of the ingredients. After this operation, the entire equipment shall be thoroughly cleaned.

For simple spans, concrete shall preferably be deposited by beginning at the centre of the span andworking from the centre towards the ends. Concrete in girders shall be deposited uniformly for the fulllength of the girder and brought up evenly in horizontal layers. For continuous spans, the concreteplacing sequence shall be as shown on the plans or agreed by the Engineer.

Concrete in slab and girder haunches less than 1m in height shall be placed at the same time as that inthe girder stem.

Concrete in slab spans shall be placed in one continuous operation for each span unless otherwiseprovided.

Concrete in T-beam or deck girder may be placed in one continuous operation, if permitted by theEngineer.

Concrete in columns and pier shafts shall be placed in one continuous operation unless otherwisedirected.

Unless otherwise permitted by the Engineer, no concrete shall be placed in the superstructure until thecolumn forms have been stripped off sufficiently to determine the character of the concrete in thecolumns. The load of the superstructure shall not be applied to the supporting structures until they havebeen in place at least 14 days unless otherwise permitted by the Engineer.

When the placing of concrete is temporarily discontinued, the concrete, after becoming firm enough toretain its form, shall be cleaned of Latinate and other objectionable materials to a sufficient depth toexpose sound concrete. To avoid visible joints as far as possible upon exposed faces, the top surface ofthe concrete adjacent to the forms shall be smoothen with a trowel. Where a “feather edge” might beproduced at a construction joint, an inset form shall be used to produce a blocked out portion in thepreceding layer which shall produce an edge thickness of not less than 150mm in the succeeding layer.Work shall not be discontinued within 450mm of the top of any face unless provision has been made fora coping less than 450mm thick, in which case, if permitted by the Engineer, a construction joint may bemade at the under side of the coping.

Immediately following the discontinuance of placing concrete, all accumulations of mortar splashed uponthe reinforcement steel and the surfaces of forms shall be removed. Dried mortar chips and dust shall notbe puddled into the unset concrete. If the accumulations are not removed prior to the concrete becomingset, care shall be exercised not to injure or break the concrete-steel bond at and near the surface of theconcrete while cleaning the reinforcement steels.

Where concrete is required to be placed against undisturbed ground, the entire space between thefinished concrete surface and the ground, including any over-break, is to be completely filled withconcrete of the specified class. The concrete shall be well rammed and compacted to ensure that allcavities are filled and the concrete is everywhere in contact with the ground. Where permitted by theEngineer, any extensive patches of over-break may first be filled with concrete belonging to theappropriate Class as directed by the Engineer.

Where concrete is required to be placed against a metal surface to which it is required to adhere, careshall be taken to work the concrete well into the re-entrant angles and to ensure contact by hammeringthe metal part on its free side provided that this is done without damaging the metal or its protectivecoating, if any.

Concrete shall not be dropped through a height greater than 1200mm except with the approval of theEngineer who may order the use of bankers and the turning over of the deposited concrete by handbefore being placed.

When placing operations would involve dropping the concrete more than 1200mm, it shall be depositedthrough sheet metal or other approved pipes. As far as practicable, the pipes shall be kept full ofconcrete during placing and their lower ends shall be kept buried in the newly placed concrete. Afterinitial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends ofreinforcement bars, which are projected.

All chutes, troughs and pipes shall be kept clean and free from coatings of harden concrete bythoroughly flushing with water after each run. Water used for flushing shall be discharged clean.

The laying of concrete shall be carried out in such a way that the exposed faces of concrete shall beplain, smooth, sound and solid, free from honeycomb and excrescencies. After compaction the exposedconcrete surface shall be struck off smooth with hand held steel floats. No plastering of imperfectconcrete faces will be allowed. Any concrete that is defective in any way shall, if so ordered by theEngineer, be cut out and replaced to such depth or be made good in such manner as the Engineer maydirect.

Construction joints shall be formed in the work where indicated on the Drawings or as previouslyapproved by the Engineer. Where necessary, the Contractor shall allow for working beyond ordinaryworking hours to allow each section of concrete to be completed in a continuous pour with the placing ofconcrete carried upto each construction joint.

7.1.12.5 DEPOSITING CONCRETE UNDER WATER

Concrete shall not be deposited in water except with the approval of the Engineer and under hisimmediate supervision and in this case the method of placing shall be as defined in this portion.

Concrete deposited in water shall be with 10 percent excess cement. It shall be carefully placed in acompact mass in its final position by means of Tremie, a bottom opening bucket or other approvedmethods and shall not be disturbed after being deposited. Special cares must be exercised to maintainstill water at the point of deposit. Concrete shall not be placed in running water. The method of depositingconcrete shall be so regulated as to produce approximately horizontal surfaces. The forms under watershall be watertight.

The discharge end of the Tremie shall be closed at the start of work so as to prevent water entering thetube and shall be entirely sealed at all times. The Tremie tube shall be kept full to the bottom of thehopper. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raisingthe discharge end, always keeping it in the deposited concrete. The flow shall be continuous until thework is completed. Concrete slump shall be in between 100mm and 150mm.

Depositing of concrete by the opening bucket method shall conform to the following specifications. Thetop of the bucket shall be open. The bottom doors shall open freely downward and outward when tripped.The bucket shall be completely filled and slowly lowered to avoid backwash. It shall not be dumped untilit rests on the surface upon which the concrete is to be deposited. When discharged, it shall bewithdrawn slowly until it goes well above the concrete.

7.1.12.6 COMPACTION OF CONCRETE

Concrete, during and immediately after depositing, shall be thoroughly compacted. The compaction shallbe done by mechanical vibration subject to the following provisions:

i. The vibration shall be internal unless special authorizations of other methods are given by theEngineer or as provided herein.

ii. Mechanical vibrators of the capacity as approved by the Engineer shall be used in conjunction withor without hand rammers, pokers or any other means as directed by the Engineer.

iii. Vibrators shall be of a type and design as approved by the Engineer. They shall be capable oftransmitting vibration to the concrete at frequencies of not less than 4,500 impulses per minute.

iv. The intensity of vibration shall be such as to visibly affect a mass of concrete of 20mm slump over aradius of at least 450mm.

v. Vibrators must be operated by skilled workmen engaged/appointed by the Contractor mainly for thisjob.

vi. Surface vibrators of the type of Pan-vibrators, or vibrating screens shall be used for compactingcastings of shallow depth as directed by the Engineer.

vii. The Contractor shall provide a sufficient number of vibrators to properly compact each batchimmediately after it is placed in the forms. Spare vibrators shall be readily on hand in case ofbreakdown.

viii. Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement andembedded fixtures, and into the corners and angles of the forms.

ix. Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. Thevibrators shall be inserted and withdrawn from the concrete slowly. The vibration shall be ofsufficient duration and intensity to thoroughly compact the concrete, but shall not be continued so asto cause segregation. Vibration shall not be continued at any one point, to the extent that localizedareas of grout are formed.

x. While using immersion vibrators in walls, these should be lowered to the bottom of the wall beforedepositing of concrete is started and pulled up as it proceeds. When using vibrators, concrete canbe placed from bottom to top of wall in one process, provided it is laid in regular layers. Caresshould be taken to ensure that vibrators are not trapped under a great depth of concrete.

xi. Application of vibrators shall be at points uniformly spaced and not further apart than twice theradius over which the vibration is visibly effective.

xii. Vibration shall not be applied directly or through the reinforcement to sections or layers of concrete, which have hardened to the degree that the concrete ceases to be plastic under vibration. It shallnot be used to make concrete flow in the forms over distances so great as to cause segregation,and vibrators shall not be used to transport concrete in the forms.

xiii. Vibration shall be supplemented by such spading as is necessary to ensure smooth surface anddense concrete along form surfaces and in corners and locations impossible to reach with thevibrators.

xiv. In columns, deep beams and walls mild striking by mallets at the outer faces of the form worksshould also be done simultaneously during use of vibrator for compaction.

The provisions of this Sub-section shall also apply to pre-cast piling, concrete cribbing and other pre-castmembers except that the manufacturer's methods of vibration may be used, if approved by the Engineer.

7.1.13 PROTECTION OF CONCRETE FROM ADVERSE CONDITIONS

GENERAL

Concrete shall be protected from damage from the effects of sunshine, dry wind, rain, running water ormechanical damage for a continuous period, until the concrete has reached at least three quarters of its28-days strength, but for not less than 10-days. Temperature of the concrete mixture shall require to bemaintained between 10°C and 32°C unless otherwise provided herein. The Contractor shall submit hisproposals to achieve this protection for the Engineer's approval.

Damaged concrete shall be removed and replaced generally. However, it may be repaired to anacceptable condition if found appropriate by the Engineer.

PROTECTION FROM RAIN

During rainy weather, proper protection shall be given to ingredients, production methods, handling andplacing of concrete. If required in the opinion of the Engineer, the concrete depositing operation shall bepostponed and newly placed concrete shall be protected from rain after forming proper construction jointfor future continuation.

PROTECTION FROM HOT WEATHER

During hot weather, proper attention shall be given to ingredients, production methods, handling, placing,protection, and curing to prevent excessive concrete temperatures or water evaporation that could impairrequired strength or serviceability of the member or structure.

Under a temperature above 32oC surfaces of forms, reinforcing steel, steel beam flanges etc. that remainin contact with the mix shall be cooled down below this temperature by means of water spray or by anyother appropriate methods.

PROTECTION FROM COLD WEATHER

Under a cold weather condition, temperature of the concrete shall be maintained not below 7°C duringthe curing period for the first six days on placement of concrete unless pozzolan cement or fly

ashcement is used. Periods to be followed in the latter case have been shown in the table given below:

% of cement replaced by weight with pozzolans	Required period of controlled temperature
10%	8 days
11-15%	9 days
16-20%	10 days

However, this requirement may be waived in the case the compressive strength of 65% of the specified28-days design strength is achieved in 6-days.

If external heating is used in maintaining the requisite temperature, heat shall be applied and withdrawngradually and uniformly so that the concrete surface is not heated more than 32°C.

Temperature of concrete at the time of placement in sections less than 300mm in thickness shall not beless than 16°C when the air temperature is below 2°C.

SPECIAL REQUIREMENTS FOR ROOF SLABS

Prior to the application or curing, concrete being placed and finished for roof slabs shall be protectedfrom damage due to rapid evaporation when the weather is low humid, windy or having hightemperature. Such protection shall be adequate to prevent premature crusting of the surface or anincrease in dry cracking. In providing such protection the humidity of the surrounding air shall be raisedwith fog sprayers operated upwind of the deck.

CONCRETE EXPOSED TO SALT WATER

Unless otherwise specifically provided, concrete for structures exposed to salt water shall be mixed for aperiod of not less than 2 minutes and water content of the mixture shall be carefully controlled andregulated so as to produce concrete of maximum impermeability. The concrete shall be thoroughlyconsolidated as necessary to produce maximum density and a complete lack of rock pockets. Unlessotherwise shown on the Drawings, the clear distance from the face of the concrete to the reinforcing steelshall not be less than 100mm. No construction joints shall be formed between levels of extreme lowwater and extreme high water or the upper limit of wave action as determined by the Engineer. Betweenthese levels the forms shall not be removed, or other means provided to prevent salt water from comingin direct contact with the concrete for a period of not less than 30 days after placement. Except for therepair of any rock pockets and the plugging of form tie holes, the original surface, as the concrete comesfrom the forms, shall be left undisturbed. Special handling shall be provided for pre-cast members toavoid even slight deformation cracks.

7.1.14 PERFORATIONS AND EMBEDDING OF SPECIAL DEVICES

The Contractor is responsible for determining in advance of making any concrete pours, all requirementsfor perforation of concrete sections or embedding therein of special devices of other

trades, such asconduits, pipes, weep holes, drainage pipes, fastenings, etc. Any concrete, poured without prior provisionhaving been made, shall be subject to correction at the Contractor's own expenses.

Devices to be embedded in the concrete shall be shown on the Drawings or directed by the Engineer.

Conduits, pipes and sleeves of any material not harmful to concrete and within the limitations specifiedherein shall be permitted to be embedded in concrete with the approval of the Engineer, provided theyare not considered to replace structurally the displaced concrete.

Conduits and pipes of aluminium shall not be embedded in structural concrete unless effectively coatedor covered to prevent aluminium concrete reaction or electrolytic action between aluminium and steel.

Conduits, pipes, and sleeves passing through a slab, wall, or beam shall not impair significantly thestrength of the construction.Conduits and pipes, with their fittings, embedded within a column, shall not displace more than 4% of thearea of cross-section on which strength is calculated or which is required for fire protection.

Except when the Engineer approves Drawings for conduits and pipes, embedded conduits and pipeswithin a slab, wall or beam (other than those merely passing through) shall satisfy the following:

i. They shall not be larger in outside dimension than 1/3rd the overall thickness of slab, wall, or beamin which they are embedded.

ii. They shall not be spaced closer than 3 diameters or widths on centers.

iii. They shall not impair significantly the strength of the construction.

Conduits, pipes and sleeves shall be permitted provided that they are not exposed to rusting or otherdeterioration, have nominal inside diameter not over 50mm and are spaced not less than 3 diameters oncenters.Pipes and fittings shall be designed to resist effects of the material, pressure, and temperature to whichthey will be subjected.

No liquid, gas, or vapor excepting water, not exceeding 30°C nor 0.3 N/mm^2 pressure, shall be placed inthe pipes until the concrete has attained its design strength.

Piping in solid slabs, unless it is for radiant heating, shall be placed between the top and bottomreinforcements.

Concrete cover for pipes, conduits, and fittings shall be not less than 40mm for concrete exposed toearth or weather nor 20mm for concrete not exposed to weather or in contact with the ground.

Reinforcement with an area not less than 0.002 times the area of concrete section shall be providednormal to piping.

Piping and conduit shall be so fabricated and installed that cutting, bending, or displacement ofreinforcement will not be required.

7.1.15 CURING OF CONCRETE

GENERAL

In order to prevent loss of water, all newly placed concrete shall be cured by use of one or more of themethods specified herein. The Engineer shall select the method that should be followed for curing aconcrete of particular type of work or member. Curing shall commence immediately after the free waterhas left the surface and finishing operations are complete. In the case the concrete surface begins to drybefore the selected cure method is applied, the surface of the concrete shall be kept moist by a fog sprayapplication so as to prevent any damages to the surfaces.

Curing by other than steam or radiant heat methods shall continue uninterrupted for at least 7 daysexcept that when pozzolans in excess of 10 percent, by weight, of the Portland cement are used in themix. When such pozzolans are used, the curing period shall be at least 10 days. For other than top slabsof structures, the above curing periods may be reduced and curing may be terminated when testcylinders, cured under the same conditions as the structure, indicate that concrete strength of at least 70percent of that specified has been reached.

High early strength concrete shall be maintained above 10°C and in a moist condition for at least the firstthree days, except when cured in accordance with Accelerated Curing Method.

During periods of hot weather, water shall be applied to the concrete surfaces being cured by the liquidmembrane method or by the forms-in-place method, if considered necessary by the Engineer, Theprocess shall continue for a period that the Engineer determines a cooling effect is no longer required.

MATERIALS

WATER

Water used in curing of concrete shall be subject to approval and shall be reasonably clean and free ofoil, salt, acid, alkali, sugar, vegetable, or other injurious substances. Water shall be tested in accordancewith and shall meet the suggested requirements of AASHTO T 26. Where the source of water isrelatively shallow, the intake shall be so enclosed as to exclude silt, mud, grass, or other foreignmaterials.

LIQUID MEMBRANES

Liquid membrane forming compounds for curing concrete shall conform to the requirements of ASTM C309.

WATERPROOF SHEET MATERIALS

Waterproof paper, polyethylene film, and white burlap polyethylene sheet shall conform to therequirements of ASTM C 171.

METHODS

Forms-in-place method

Formed surfaces of concrete may be cured by retaining the forms in place for the required time.

Water method

Concrete surface shall be kept continuously wet by ponding, spraying or covering with materials that arekept continuously and thoroughly wet. Such materials may consist of cotton mats, multiple layers ofburlap or other approved materials, which do not discolour or otherwise damage the concrete.

Liquid membrane curing compound method

The liquid membrane method shall not be used on surfaces where a rubbed finish is required or onsurfaces of construction joints unless it is removed by sand blasting prior to placement of concreteagainst the joint. Type 2 white pigmented liquid membranes may be used only on the surfaces that willnot be exposed to view in the completed works or on surfaces where their use has been approved by theEngineer.

When membrane curing is used, the exposed concrete shall be thoroughly sealed immediately after thefree water has left the surface. Formed surfaces shall be sealed immediately after the forms are removedand necessary finishing has been done. The solution shall be applied by power-operated atomizing sprayequipment in one or two separate applications. Hand-operated sprayers may be used for coating smallareas. Membrane solutions containing pigments shall be thoroughly mixed prior to use and agitatedduring application. If the solution is applied in two increments, the second application shall follow the firstapplication within 30 minutes. Satisfactory equipment shall be provided, together with means to properlycontrol and assure the direct application of the curing solution on the concrete surface so as to result in auniform coverage at the rate of 4.5 liters for each 14 square meter of area.

If the film is damaged by inclement weather condition or in any other manner during the curing periodand before the film has dried sufficiently, a new coat of the solution shall be applied to the affectedportions equal in curing value to that specified above.

Waterproof cover method

This method shall consist of covering the surface with a waterproof sheet material so as to preventmoisture loss from the concrete. This method may be used only when the covering can be securedadequately to prevent moisture loss.

The concrete shall be wet at the time the cover is installed. The sheets shall be of the widest practicablewidth and adjacent sheets shall overlap a minimum of 150mm and shall be tightly sealed with pressuresensitive tape, mastic, glue, or other approved methods to form a complete waterproof cover of the entireconcrete surface. The paper shall be secured so that wind will not displace it. Should any portion of thesheets be broken or damaged before expiration of the curing period, the broken or damaged portionsshall be immediately repaired. Sections that have lost their waterproofing qualities shall not be used.

Accelerated curing

Curing by high-pressure steam, steam at atmospheric pressure, heat and moisture or other acceptedprocesses, shall be permitted to accelerate strength gaining and reduce time of curing.

Accelerated curing shall provide a compressive strength of the concrete at the load stage considered, atleast equal to the required design strength at that load stage.

Curing process shall be such, as to produce concrete with a durability at least equivalent to that obtainedfor concrete cured by the above methods.

The use of accelerated curing method for concrete containing other types of cement or any admixtureshall be subject to the Engineer's acceptance.

Field cured specimens

The Engineer may require strength tests of cylinders cured under field conditions to check adequacy ofcuring and protection of concrete in the structure.

Field cured cylinders shall be cured under field conditions in accordance with "Practice for Making andCuring Concrete Test Specimens in the Field" (ASTM C 31).

Field cured test cylinders shall be moulded at the same time and from the same samples as laboratorycured test cylinders.

Procedures for protecting and curing concrete shall be improved when the strength of field curedcylinders at the test age designated for determination of f'c is less than 85% of that of companionlaboratory curedcylinders. The 85% limitation shall not apply, if field cured strength exceeds f'c by morethan 3.5 N/mm^2.

7.1.16 FINISH AND FINISHING

GENERAL

Surface irregularities shall be classified as "abrupt" or "gradual". Offsets caused by displaced ormisplaced form sheathing or lining of form sections, or loose knots in forms or otherwise defectiveformwork, will be considered as "abrupt" irregularities. All other irregularities will be considered asgradual irregularities.

Where a surface is partly below and partly above the final ground level, the finish for the exposed surfaceshall extend for 0.15m below the ground level.

The formed surfaces, which will be permanently buried under earth, will require no treatment for abruptor gradual irregularities. However, repair of defective concrete and filling of holes left by the removal offasteners from the ends of tie rods shall be undertaken.

All abrupt and gradual irregularities on all exposed surfaces shall be removed by sack rubbing or sandblasting or grinding or by all these methods or any other methods approved by the Engineer, which is notharmful to the concrete. The permissible surface irregularities shall not exceed 6mm for abruptirregularities and 13mm for gradual irregularities. The permissible irregularities may be reduced at placesof the surface where, in the opinion of the Engineer, the formed finish does not provide the desired effectand no extra payment shall be permissible for such work.

Holes, honeycombs, or other defects left by forms shall be promptly repaired in accordance with therelevant Sub-section of this Specification.

All surfaces such as blinding concrete, opening for second stage concrete etc. on which concrete is to beplaced subsequently, shall not be finished for abrupt or gradual irregularities.

Generally, concrete surface shall remain as cast and no plastering work will be performed on it. Theformwork shall be lined with a material approved by the Engineer to provide a smooth finish of uniformtexture and appearance. This material shall leave no stain on the concrete and shall be so joined andfixed to its backing that it imparts no blemishes. It shall be of the same type and obtained from only onesource throughout any one structure. The Contractor shall repair any imperfections in the resulting finishas required by the Engineer for which no extra payment shall be made to him. Internal ties andembedded metal parts will be allowed only with the Engineer's specific approval.

CONCRETE SURFACE FINISHING

Skilled workmen shall perform finishing of concrete surfaces to the satisfaction of the Engineer. Exposedflat concrete surfaces shall be screed to produce an even and uniform surface and then they shall begiven a trowel finish unless otherwise specified on the Drawings. All exposed and unprotected edgesshall be given 20mm x 20mm chamfers.

The Concrete surface finish on upward facing, horizontal or sloping faces shall be, except for blindingconcrete or otherwise stated on the Drawings, a "fair" surface. A 'fair' surface shall be obtained byscreeding and trowelling with a wood float.

Screeding shall be carried out following compaction of the concrete by the slicing and tamping action of ascreed board running on the top edges of the formwork or screeding guides to give a dense concreteskin true to line and level.

Wood float trowelling shall be carried out after the concrete has stiffened and the film moisture hasdisappeared. Working should be kept to the minimum compatible with a good finish and the surface shallbe true to the required profile to fine tolerance. Whenever necessary, the Contractor shall provide anderect overhead covers to prevent the finished surfaces from being marred by rain drops or drippingwater.

The surface of blinding concrete shall be obtained by screeding as described above.Where a "fine" surface is indicated on the Drawings, this shall be obtained in a similar manner to "fair"surface except that a steel float shall be used in lieu of the wood float.

Formed surface for painting exposed to view shall be smooth and free from projections and shall berubbed smooth immediately after the forms are removed. Formed surfaces shall be classified as follows:

i. Unexposed concrete surfaces upon or against which backfill or concrete is to be placed, require notreatment except the removal and repair of defective concrete.

ii. Exposed surfaces shall have a very smooth, sound surface by control of formwork, concreteplacement and repair of abrupt surface irregularities by grinding or rubbing of high spots and fillingof voids.

ORDINARY FINISH

An ordinary finish is defined as the finish left on a surface after the removal of the forms when all holesleft by form ties have been filled and all irregular projections and any other minor surface defects havebeen mended. The surface shall be true and even, free from depression fins or projections.

The concrete shall be struck off with a straight edge and floated to true grade. Under no circumstance,the use of mortar topping for concrete surfaces shall be permitted.

GROUT CLEANING

Grout cleaning may be called for on the Drawings or required by the Engineer because of unsatisfactoryappearance. The operation requires that the surface is wetted and uniformly covered with a groutconsisting of 1 part cement to 1.5 parts fine sand. White cement shall be used for all or part of thecement in the grout to give the colour required to match the concrete. The grout shall be uniformlyapplied with brushes or a spray gun and all air bubbles and holes shall be completely filled. Immediatelyafter the application of the grout, the surface shall be vigorously scoured with a cork or other suitablefloat.

While the grout is still plastic, the surface shall be finished with a sponge rubber or other suitablefloat removing all excess grout. This finishing shall be done at the time when grout will not be pulled fromthe holes or depressions. After being allowed to be thoroughly dry, the surface shall be vigorously rubbedwith a dry burlap to completely remove any dried grout. There shall be no visible film of grout remainingon the surface after this rubbing and the entire cleaning operation of any area must be completed on theday it is started. If any dark spot or steak remains after this operation, they shall be removed with a fine-grained silicon carbide stone, but the rubbing shall not be as much to change the texture of the surface.Unless it is required by the Drawings or directed by the Engineer, grout cleaning should be delayed untilthe final cleanup of the Work.

RUBBED FINISH

On removal of forms, the rubbing of concrete shall be started as soon as its condition permits.Immediately before starting this work, the concrete shall be kept thoroughly saturated with water for aminimum period of 3 hours. Sufficient time shall elapse before wetting down to allow the mortar used inpatching to have thoroughly set. A medium coarse carborundum stone shall be used for rubbing a smallamount of mortar on the face. The mortar used shall be composed of cement and fine aggregate mixedin the same proportions as that used in the concrete being finished. Rubbing shall be continued until allform marks, projections and irregularities have been removed, all voids filled, and a uniform surface hasbeen obtained. The paste produced by this rubbing shall be left in place at this time. The final finish shallbe obtained by rubbing with a fine carborundum stone and water until the entire surface is of a smoothtexture and uniform colour.

After the final rubbing has been completed and the surface has dried up, burlap shall be used to removeloose powder. The final surface shall be free from unsound patches, paste, powder and objectionablemarks.

Any surface that has been given a rubbed finish shall be protected from subsequent constructionoperations. Any surface not protected, shall be cleaned and again rubbed, if necessary to secure auniform and satisfactory surface at the own expenses of the Contractor.

On completion of initial rubbing, curing shall be continued.

TOOLED FINISH

Tooled finishing shall be carried out by treating the surface with an approved heavy duty power hammerfitted with a multi-point tool, which shall be operated over the surface to remove 5mm to 6mm of concreteand expose maximum areas of coarse aggregate.

Aggregate left embedded shall not be fractured or loose. 25mm wide bands at all corners and arisesshall be left as cast. The finished surfaces shall have even and of uniform appearance and shall bewashed with water upon completion.

SANDBLASTED FINISH

Sandblasted finishing will be carried out on a thoroughly cured concrete surface with hard, sharp sand toproduce an even fine-grained surface in which the mortar has been cut away, leaving the aggregateexposed.

WIRE BRUSHED OR SCRUBBED FINISH

Wire brushed or scrubbed finish will be performed as soon as the forms are removed and while theconcrete is yet comparatively green. The surface shall be thoroughly and evenly scrubbed with stiff wireor fiber brushes, using a solution of muriatic acid. The proportion of the solution shall constitute of onepart acid to four parts water. This shall be continued until the cement film or surface is completelyremoved and the aggregate particles are exposed, leaving an even-pebbled texture presenting anappearance grading from that of fine granite to coarse conglomerate, depending upon the size andgrading of aggregate used. When the scrubbing has progressed sufficiently to produce the texturedesired, the entire surface shall be thoroughly washed with water to which a small amount of Ammoniahas been added in order to remove all traces of acid.

INSPECTION AND MAKING GOOD

Concrete surface shall be inspected for defects and for conformity with the Specifications and whereappropriate, for comparison with approved samplefinishes. Subject to the strength and durability of theconcrete being unimpaired, the making good of surface defects may be permitted but the standard ofacceptance shall be appropriate to the type and quality of the finish specified to ensure satisfactoryperformance and durability. On permanently exposed surfaces, great care is essential in selecting thematerials and the mix proportions to ensure that the final colour of the faced area blends with the parentconcrete in the finished structure.

Voids can be filled with fine mortar, preferably incorporating Styrene Butadiene Rubber (SBR) orPolyvinyl Acetate (PVA), while the concrete is still green or when it has hardened. Fine cracks can befilled by wiping a cement grout, a SBR, PVA or latex emulsion, a cement/SBR or a cement/PVA slurryacross them. Fins and other projections shall be rubbed down.

PROTECTION

High quality surface finishes are susceptible to damage during subsequent construction operations andtemporary protection may have to be provided in vulnerable areas. The protective measures, amongothers, include the strapping of laths to arrises and the prevention of rust being carried from exposedstarter bars to finished surfaces.

7.1.17 SECOND STAGE CONCRETE

Unless shown on the Drawings or otherwise instructed by the Engineer, second stage concrete shall beof class for major RCC structures.

Block-outs for second stage concrete and the specifications and locations of the embedded parts shallbe in accordance with the Drawings.

The surface against which the second stage concrete are to be placed shall be thoroughly cleaned tomake the surface free from all loose particles, organic substances, oil, grease, rust, plastic materials,wood and defective concrete.

The projected parts of the embedded items or the parts that will remain embedded shall be thoroughlycleaned of oil, grease and rust. All such parts shall be true to dimensions, plumb and levels as shown onthe Drawings and directed by the Engineer.

7.1.18 FACTORY MADE PRE-CAST CONCRETE ELEMENTS

The Engineer shall approve in writing any supplies of pre-cast concrete elements. The Engineer, if he sodesires, may withdraw the approval later on.

All concrete works of such elements shall fully conform all requirements of this Specification.

The supplier shall maintain standard laboratory facilities.

Concrete members, specified to be fabricated as pre-cast concrete units, shall be fabricated withconcrete of the specified class placed into a grout tight mould. If so required, the mould shall be laid on avibrating table and vibration should be applied while concrete is placed.

Members, structurally dependent on a rigid fixing with the adjoining structures, should not in general bepermitted to be pre-cast.

Unless otherwise approved by the Engineer, pre-cast concrete members shall neither be moved from thecasting position until the concrete has attained a compressive strength of 80% of the specified 28-daysstrength, nor transported until it has gained a strength of 90% of the specified 28-days strength.

Extreme cares shall be taken in handling and moving pre-cast concrete members. Pre-cast girders andslabs shall be transported in an upright position. Shock shall be avoided and the points of support anddirections of the reactions with respect to the member shall be approximately the same duringtransportation and storage as and when the member would be in its final position. If the Contractor findsit expedient to transport or store pre-cast units in other than this position, it shall be done at his own risksafter notifying the Engineer of his intention to do so. Any units rejected shall be replaced at theContractor’s own expenses by an acceptable unit.

All details on the handling and transportation of pre-cast members shall be submitted in writing to theEngineer for his approval.

Each pre-cast member is to be uniquely and permanently marked so as to show its type, date of castingand reinforcement.

HANDLING AND STACKING OF PRE-CAST UNITS

The Contractor shall give the Engineer full details of his proposed methods of handling, transportationand stacking of pre-cast concrete units. The Engineer will examine these in details and will eitherapprove the methods or order modifications to ensure that the units are not subject to excessivestresses.

The finally approved methods are to be adhered to at all times and the Contractor shall bedeemed to have included in his rates for all measures required to handle, transport and stack the unitssafely and without undue stressing. However, such approval by the Engineer shall neither relieve theContractor from his full responsibilities and liabilities of safe transportation and installation of any pre-castunits at the designated location as shown on the Drawings or as directed by the Engineer without anydamage nor to make any deviation from the Specifications in fabricating the unit.

7.1.19 CONTROL OF HEAT IN STRUCTURES

The Contractor shall establish measures to control the heat deriving from the hydration of the concrete instructures of major dimensions. Temperature gradients introducing risks of cracking shall not occur andthe temperature shall not exceed 70^{o}C.

The Contractor shall also establish measures to avoid harmful excessive heat generation in massivestructures, such as cooling down aggregates before mixing.

The Contractor shall submit in due time a proposal for the establishment of the aforementionedmeasures to the Engineer for his approval. The measures shall immediately be changed, if requested bythe Engineer even later.

7.1.20 BACK-FILL TO STRUCTURES

All spaces, which have been excavated but are not occupied by the concrete structure shall be back-filled and compacted with materials acceptable to the Engineer or as shown on the Drawings and/or asper the directions of the Engineer.

7.1.21 CLEANING UP

Upon completion of structure and before final acceptance, the Contractor shall remove all forms andscaffoldings, etc. down to 0.5m below the finished ground line. Excavated or garbage materials, rubbishetc. shall be removed from the Site, which shall be left in a neat condition satisfactory to the Engineer.

7.1.22 MEASUREMENT

The concrete of the several different grades and types completed in place in accordance with theSpecifications stated herein and/or as per the provisions of the BOQ and/or as shown on the Drawingsand/or as directed by the Engineer and accepted by the Engineer shall be measured by either the cubicmeter for each class of concrete included in the BOQ or by the unit for each type of pre-cast concretemember listed in the BOQ. In computing quantities, the dimensions used shall be

those shown on theDrawings or ordered by the Engineer; but the measurement shall not include any concrete used for theconstruction of temporary works or which is included in other billed items. No deduction from themeasured quantity shall be made for drainage openings and pipes of less than 300mm in diameter,conduits, chamfers, reinforcement bars and expansion joint filler materials. However, deduction will bemade for the volume of concrete displaced by piles embedded in the concrete.

The quantities of reinforcing steel and other related items as shown in the Contract Documents, whichare included in the completed and accepted structure shall be separately measured for payment as perthe provisions made under the Section on 'Reinforcing Steel' of this Specification.

Formwork and false work shall not be measured separately but shall be deemed to be an integral part ofthe concrete items.

Surface finishes shall not be measured separately but shall be deemed to be an integral part of theconcrete items.

Joints including fillers and expansion joints shall not be measured separately unless they are specified asseparate items in the BOQ.

The number of pre-cast concrete members of each type listed in the BOQ will be the number ofacceptable members of each type furnished and installed in the work.

7.1.23 PAYMENT

The cubic meters of concrete and the number of pre-cast concrete members, measured as providedabove will be paid for at the Contract unit prices per cubic meter or the Contract unit prices per eachmember for each type or class as would be applicable as per the BOQ.

Payment for concrete of the various classes and for pre-cast concrete members of the various typesshall be considered to be the full compensation for the costs for furnishing all materials including theirtransportation and storage, providing all equipment, labourers and incidentals and for doing all worksinvolved in constructing the concrete work complete in place as shown on the Drawings and as specified.Such payment shall also include the full compensation for placing of rod in position, mixing the concretemixture, concrete pouring, compacting by vibrator machine and curing, furnishing and placing expansionjoint fillers, sealed joints, water-stops, drains, vents, miscellaneous metal devices and the drilling of holesfor dowels and the grouting of dowels in drilled holes, unless payment for such works would be specifiedunder another item of the BOQ.

Payment for all types of concrete work shall be considered to be the full compensation for the costs offurnishing and installing and removal of all temporary works like staging, formwork, working platforms,cranes, transporting, placing, compaction, finishing, curing and rendering of the concrete as specified tillthe concrete work becomes self-supporting and can perform its intended functions.

The Contractor's rates shall be fully inclusive of all costs of all laboratory tests to be carried out asspecified under different sub-items unless any payment is separately specified under the BOQ.

The payment shall be the full compensation of all incidentals necessary to complete the Work.

Payment for pre-cast units shall include all concrete, formwork, transport and erection and whereapplicable any bolts or other devices and bedding necessary to fix them in their permanent

positions, allincidentals and all other works that will be necessary for full completion from transportation to safeerection of the members at the designated locations as shown on the Drawings or as directed by theEngineer.

Item of Payment	**Unit**
Concrete Class as detailed and as specified in the BOQ.	Cubic meter / Cubic feet
Pre-cast concrete elements as detailed on the drawings and as specified in the BOQ.	Number/Linear meter /Cubic meter / Cubic feet

7.2 FALSE WORK AND FORMS

7.2.1 SCAFFOLDING (FALSE WORK)

Scaffolding is defined to be any temporary structure required to support structural elements of concrete,steel, masonry, or other materials at the time of their construction or erection.

Plans, Drawings and structural calculations in details shall be submitted to the Engineer for approval, butin no case shall the Contractor be relieved of his responsibilities for results obtained by using thisDocument.

All scaffolding shall be designed and constructed to provide the necessary rigidity and strength to safelysupport all loads imposed and produced in the finished structure, the lines and grades indicated on theDrawings. The supports shall be designed to withstand the worst combination of self-weight, formworkweight, formwork forces, reinforcement weight, wet concrete weight, construction and wind loads,together with all incidental dynamic effects caused by placing, vibrating and compacting the concrete. Noharmful cracking should occur in the placed concrete. The Engineer may require the Contractor toemploy screw jacks or hardwood wedges to take up any settlement in the formwork either before orduring the placing of concrete.

All scaffolding, exceeding 20m or six storeys in height, shall be constructed ofnoncombustible or fire-retardant materials.

Scaffolding shall be founded on a solid base, which is safe against undermining, protected from softeningand capable of supporting the loads imposed on it. Scaffolding which cannot be founded on asatisfactory footing shall be supported on piling, which shall be spaced, driven and removed in a mannerapproved by the Engineer.

Horizontal and inclined bracings shall be provided for posts higher than 3m. Spans of beam bottomsshall be supported by posts with maximum 1m apart when steel is used and instructions from themanufacturer/supplier shall be strictly followed. Spacing of the props under beams shall consider theincreased load and shall be posted closer than those under the floor slab.

Scaffolding can, in certain cases, be supported on structures already constructed. In that case, theContractor shall submit in due time to the Engineer in writing all information on the loading from thescaffolding as requested. The Engineer shall consider the loading and submit his approval in writing.

Scaffolding shall be set to give the finished structure the camber shown on the Drawings or specified bythe Engineer. If any weakness develops or the scaffolding shows undue settlement or distortion duringconstruction, the work shall be stopped and any structure affected thereby shall be removed and thescaffolding shall be further strengthened before work is resumed. Suitable screw jacks, pairs of wages orother devices shall be used at each post to adjust scaffolding to grade.

All materials used in the construction of the scaffolding shall conform to the corresponding ASTM or BSStandards or any other equivalent International Standards. Material tests and certificates may berequired by the Engineer. Examinations of welding may also be requested. Test loading of thescaffoldings may be requested for the determination of the flexibility and the strength. All expenses of thetests and examinations of scaffoldings shall be borne by the Contractor on non-reimbursable basis.

Scaffolds shall be made from strong bamboo poles, wooden posts, steel pipes or any other suitablematerials. They shall be adequately tied to vertical members resting on firm floor. Strong ropes shall beused to tie up bamboo poles. In addition, cross-bracing with bamboo or wooden posts shall be providedalong with ties or guys of steel wire or rod not less than 6mm in diameter.

Good, sound and uniform bamboo shall be collected in sufficient quantities for providing scaffolding,propping, temporary staging, ramp etc. The bamboos shall be free from any defects, firmly ties to eachother and joints made smooth. Joining members only with nails shall be prohibited. Bamboos for verticalsupport shall not be less than 75mm in diameter and shall be straight as far as possible. Bamboos maybe used as vertical support for up to a height of 4m, if horizontal bracings are provided at the centre.Splicing shall be prohibited.

After stripping the formwork, the bamboo posts shall be cleaned and stacked vertically in shadeprotected from rain and sun. Defective or damaged bamboo posts shall be removed from the Site.

Timber posts shall be used in supporting formwork upto a height of 6m. The posts shall not be less than80mm in diameter at any place and shall spread to at least 150mm in diameter at the top. The timberposts shall be supported on timber planks at the bottom. Either the bottom or the top of the posts shall bewedged with a piece of triangular wood peg for easy removal. Adequate horizontal and inclined bracesshall be used for all timber centering. All timber posts shall be carefully inspected before use andmembers with cracks and excessive knots and crookedness shall be discarded. The joints shall normallybe made with bolts and nuts. No rusted or spoilt threaded bolts and nuts shall be used.

When steel scaffoldings are used, it shall be painted in a manner that no mark of corrosion shall appearon the permanent concrete structures.

The Engineer shall only select the type of scaffolding. Bamboo scaffolding will only be used, if agreedand allowed by the Engineer. All scaffoldings shall remain in place for a period, which shall bedetermined by the Engineer.

Scaffold shall be dismantled after use piece by piece. Holes in the wall shall be filled up with the samematerials as that of the wall. Filled up holes shall have uniformity in texture and colour with thesurrounding surface. Crash striking shall not be allowed.

Triangular wooden wedges shall be put under the posts for easy dismantling of the members. Timberplanks or steel sheets shall be placed at a time below the vertical or inclined posts covering severalposts.

Materials and joints in scaffolding shall be inspected from time to time both before and after erection forthe soundness, strength, damage due to weathering etc. Inspections shall be made for spillage ofmaterial or liquids, loose material lying on the gangways and proper access to the platform.

The scaffold shall be secured to the building at enough places; no ties shall be removed. Warning sign,prohibiting the use of any defective or incomplete scaffold and working in bad weather and high wind,shall be posted in a prominent place. Inspections shall be made for the observance of theserequirements

7.2.2 FORMWORK

DEFINITION

Formwork is defined to be an enclosure or panel, which contain the fluid concrete and withstand theforces due to its placement and consolidation. Forms in turn be supported on scaffolding.

GENERAL

The work to be performed under this Sub-section includes the furnishing and installing and removing offorms for all cast-in-places concrete work as shown and noted on the Drawings and as specified hereinor as directed by the Engineer.

Forms shall be substantial and sufficiently tight to prevent leakage of mortar. Forms shall be of sufficientrigidity to prevent objectionable distortion of the formed concrete surface due to pressure of the concreteand other loads incidental to construction operations. They shall be properly braced or tied together tomaintain position and shape. Forms and their supports shall be so designed as not to damage previouslyplaced structure.

Relevant provisions of the American Concrete Institute (ACI) issue of ACI 347 on 'RecommendedPractice for Concrete Formwork' or some other generally accepted Standards shall apply for thestructural designing of the formwork, except as they may be modified herein.

MATERIALS

Formwork shall be constructed from sound materials of sufficient strength, properly braced, strutted andshored as to ensure rigidity throughout the placing and compaction of the concrete without visibledeflection. The materials used be of wood, steel or other approved materials and shall be mortar-tight.Formwork shall be so constructed that it can be removed without shock or vibration to the concrete.

Formwork for concrete, permanently exposed to public inspection, shall be faced with plain 28/26 gaugesteel sheet fitted over 38mm thick wooden plank panels suitably braced or steel framing faced withminimum 12/14 BWG mild steel sheet. Formwork for cement concrete blocks shall be fabricated fromM.S. sheet of sufficient thickness to prevent any distortion.

Where metal forms are used, all bolts and rivets shall be countersunk and well-grounded to provide asmooth plane surface.

Where timber is used, it shall be well seasoned, free from loose knots, projecting nails, splits or otherdefects that may mark the surface of concrete.

Form ties shall be prefabricated rod, flat band, or wire type, or threaded internal disconnected type, ofsufficient tensile capacity to resist all imposed load of freshly placed concrete and having externalholding devices of adequate bearing area. Ties shall permit tightening and spreading of forms and shallleave no metal closer than 25mm from surface. Ties shall fit tight to prevent mortar leakage at holes informs. Removable ties shall be coated with non-staining bond breaker. All ties shall be protected fromrusting at all times. No wire ties or wood spreaders shall be permitted. Cutting ties back from concreteface will not be permitted. Ties for exposed Architectural Concrete shall be plastic cone snap ties.

CONSTRUCTION METHOD

The Contractor shall submit for the approval of the Engineer details of the methods and materialsproposed for formwork to each section of the Work. Details of all proposed wrought formwork andformwork to produce special finishes are to be submitted for approval in writing to the Engineer beforeany material is hauled at Site. If the Engineer so requires, samples of formwork shall be constructed andconcrete be placed so that the proposed methods and finish effect can be demonstrated.

All joints shall be close fitting to prevent leakage of grout. At construction joints the formwork shall betightly secured against previously cast or hardened concrete in order to prevent stepping or ridges toexposed surfaces.

Where the Contractor proposes to make the formwork from standard sized manufactured formworkpanels, the dimensions of such panels shall be approved by the Engineer before they are used forconstruction of the Work. The finished appearance of the entire elevation of the structure and theadjoining structures shall be considered when planning the patterns of joint lines caused by the formworkand by construction joints to ensure continuity of horizontal and vertical lines.

Formwork shall be constructed to provide the correct shape, lines and dimensions of the concrete shownon the Drawings. Due allowance shall be made for any deflection, which will occur during the placing ofconcrete within the formwork. Panels shall have true edges to permit accurate alignment and provide aneat line with adjacent panels and at all construction joints. All panels shall be fixed with their joints eithervertical or horizontal, unless otherwise specified or approved.

Formwork shall be provided for the top surfaces of sloping work where the slope exceeds 15o with thehorizontal and shall be anchored to enable the concrete to be properly compacted and prevent floating.Cares shall be taken to prevent air being entrapped. Openings for inspection of the inside of theformwork and for the removal of water used for washing shall be provided and so formed as to be easilyclosed before placing concrete.

FORMWORK FOR EXPOSED CONCRETE SURFACES

All exposed concrete surfaces are to be 'form finish' and shall be cast in any approved formwork andshall be free from honeycomb, fins, projections and air holes. All external angles to form finish concretesurfaces shall be chamfered as directed.

Forms for concrete surfaces exposed to view shall produce a smooth surface of uniform texture andcolour substantially equal to that which would be obtained with the use of plywood conforming to theNational Institute of Standards and Technology Product Standard PSI for Exterior B-B Class I Plywood.Panels lining such forms shall be arranged so that the joint lines form a symmetrical pattern conformingto the general lines of the structure. The same type of form lining material shall be used throughout eachelement of a structure. Such forms shall be sufficiently rigid so that the undulation of the concrete surfaceshall not exceed 3mm when checked with a 1.5m long straight edge or template.

The Contractor shall submit shuttering Drawings and details of pattern and the method of forming jointsin the exposed (form finish) concrete to the Engineer for his approval. All changes and modification madeby the later shall be appropriately incorporated by the former and final approval whereof be obtainedfrom the Engineer.

Unless otherwise stated on the Drawings, wrought formwork shall be used for all permanently visibleconcrete surfaces. Wrought formwork shall be such as to produce a smooth and even surface free fromperceptible irregularities. Tongues and grooved paneled boards, plywood or steel forms shall have theirjoints flushed with the surface. The formwork shall be formed with approved standard size panels. Thepanels shall be arranged in a uniform approved pattern, free from defects likely to be detected in theresulting concrete surface.

In all types of formwork to form finished exposed concrete, only non-steiningmould oil shall be used asapproved by the Engineer.

The respective usage of the same formwork to cast form-finished exposed concrete shall be as decidedby the Engineer and in no case the formwork, not guaranteed to produce the required form-finish to thesatisfaction of the Engineer, shall be used.

The exposed concrete shall have a uniform finish. The finish of the concrete when shuttering andformwork are removed will generally be without any blemish and will be such as will not require touch up.Slight touch up for a small spot or two, if necessary shall be carried out skillfully so as to be synonymouswith the entire surfaces.

The finished surfaces shall be within the specified tolerances and full cover to the reinforcement steelshall be maintained.

FORMWORK FOR NON-EXPOSED CONCRETE SURFACES

Unless otherwise stated on the Drawings, rough formwork may be used for all surfaces, which are notpermanently exposed. Rough formwork may be constructed of plain butt-joined sawn timber. But theContractor shall ensure that all joints between boards shall be grout-tight.

The finished surfaces shall be within the specified tolerances and full cover to the reinforcement steelshall be maintained.

7.2.3 FORMED SURFACES AND FINISH

The formwork shall be lined with a material approved by the Engineer so as to provide a smooth finish ofuniform texture and appearance. This material shall leave no stain on the concrete and so joined andfixed to its backing as not to impart any blemish. It shall be of the same type and obtained from only onesource throughout the construction of any individual structure. The Contractor shall make good anyimperfection in the finish as required by the Engineer. Internal ties and embedded metal parts will beallowed only with the specific approval of the Engineer.

7.2.4 SIZES OF TIMBER AND OTHER SECTIONS FOR FORMWORK

Scaffolds, formwork and components thereof shall be capable of supporting without failure, at least twotimes the maximum intended load. The following types of loading shall be considered in designing theformwork:

i. Weight of wet concrete : 20 kN/m3.

ii. Live load due to workmen and impact of ramming or vibrating : 15-40 kPa (light duty for carpenterand stone setters, medium duty for brick layers and plasterers, heavy duty for stone masons).

iii. Allowable bending stress (flexural tensile stress) in soft timbers : 8,000 kPa.

The sizes for formwork elements specified in the Table given below are applicable for spans of upto 5mand height of upto 4m. In case of longer span and height, formwork and support sizes shall bedetermined by calculating the load and approved by the Engineer before use.

Sizes of timber and other sections for formwork

Types of Formwork	Members Size in mm
Flat sheetings for slab bottoms, columns and beam sides	25 to 50
Beam bottoms	75x100 to 150x150
Vertical posts	75x100 to 150x150
Bamboo posts	Minimum 75 dia
Timber posts	Not less than 100 dia at mid-length and 80dia at thin end
Joist and ledgers supporting sheetings of slab	50x100 to 75x200
Studs for supporting vertical wall sheetings	50x100 to 150x150
Columns yokes-horizontal cross, pieces supporting vertical sheetings	50x100 to 100x100

7.2.5 QUALITY OF SHUTTERING

GENERAL

The shuttering shall have smooth and even surface and its joints shall not permit leakage of cementgrout.

Ply-board shuttering material shall be well seasoned free from projecting nails, splits or other defects thatmay mark the surface of concrete. It shall not be so dry as to absorb water from concrete and swell andbuldge, nor so green or wet as to shrink after erection.

The timber shall be accurately sawn and plain on the sides and the surface coming in contact withconcrete.

Wooden formwork with metal sheet lining or steel plates stiffened by steel angles shall also be permitted.Where metal forms are used, all bolts and nuts shall be countersunk and well grounded to provide asmooth plain surface.

The chamfers, leveled edges and mouldings shall be made in the formwork itself. Opening for fixture andother fittings connected with the services shall be provided in the shuttering as directed by the Engineer.

Clamps shall be used, to its practicality, to hold the forms together. Where use of nails is unavoidable, itshall be kept to minimum number and these shall be left projected so that they can easily be withdrawn.Use of double-headed nails shall be preferred.

TOLERANCES

The formwork shall be made so as to produce a finished concrete true to shape, lines, levels, plumb anddimensions as shown on the Drawings subject to the following tolerances unless otherwise specified inthis document or Drawings or as directed by the Engineer.

i. Sectional dimension± 5mm
ii. Plumb± 1 in 1000 of height
iii. Levels± 3mm before any deflection has been taken place

Tolerances given above are specified for local aberrations in the finished concrete surface and shouldnot be taken as tolerance for the entire structure taken as a whole or for the setting and alignment offormwork, which should be as accurate as possible to the entire satisfaction of the Engineer. Errors, ifnoticed in any lift/tilt of the structure after stripping of forms, shall be corrected in the subsequent work tobring back the surface of the structure to its true alignment.

7.2.6 PREPARATION OF FORMWORK

GENERAL

The formwork shall be arranged in a manner as to readily be dismantled and removed from the castconcrete without shock, disturbance or damage. Where necessary, the formwork shall be so

arrangedthat the soffit form, properly supported on props only, can be retained in position for such period as maybe required by maturing conditions or Specification.

The surfaces of formwork shall be free from foreign matters, projecting nails and the like, splits or otherdefects, and all formwork shall be cleaned and made free from standing water, dirt, shavings, chippingsor other foreign matter before concrete is placed.

Before placing concrete, all built-in reinforcement bars, anchoring, steel beams, cables, fixing truss,bolts, pipes or conduits or any other fixtures shall be fixed in their correct positions.The cores and otherdevices for forming holes shall be held fast by fixing to the formwork or otherwise. Holes shall not be cutin any concrete without the approval of the Engineer.

All exterior and interior angles on the finished concrete of 900 or less shall be given 12mm – 20mmchamfers unless otherwise shown on the Drawings or directed by the Engineer. When chamfers are tobe formed, the fillets shall be accurately cut to size to provide a smooth and continuous chamfer.

No ties or bolts or other devices shall be built into the concrete for the purpose of supporting formworkwithout the prior approval of the Engineer. The whole or part of any such support embedded in theReinforced Concrete shall be capable of removal so that no part, remaining embedded in the concrete,shall be nearer than 75mm from the surface. Holes left after removal of such supports shall be neatlyfilled with well-reamed dry-pack mortar following the procedures described in the relevant Sub-section ofthis Specification.

All rubbish shall be removed from the interior of the forms before the concrete is placed. After cleaningand prior to placement of reinforcing steel, the formwork in contact with the concrete shall be treated witha suitable non-staining mould oil or suitable approved release agent to prevent sticking of the concrete.Such works shall not discolour or otherwise injure the surface of the concrete. Care shall be taken toprevent the oil from coming in contact with the reinforcement or mixing with the concrete. At constructionjoints, surface-retarding agents shall be used only where ordered by the Engineer.

All formwork shall be inspected and approved by the Engineer before concrete is placed in it. However, this shall not relieve the Contractor from the requirements as to soundness, finish and tolerances of theconcrete specified in this Specification or elsewhere acknowledged as Standard. If, at any period of thework during or after placing the concrete, the forms show signs of sagging or bulging, the concrete shallbe removed to the extent directed by the Engineer, the forms brought to the proper position and newconcrete placed. No allowance shall be made to the Contractor for such extra works.

REMOVAL OF FORMS

Forms shall not be removed without the approval of the Engineer. In the determination of the time for theremoval of forms, consideration shall be given to the location and character of the structure, the weather,the materials used in the mix and other conditions influencing the early strength of the concrete. Extremecares shall be taken to ensure that the method of removal shall not cause overstressing of the concreteor damage to its surface.

Forms shall be removed in such a manner as to permit the structure to uniformly and gradually take thestresses due to its own weight as not to impair safety and serviceability of the structure. All concrete tobe exposed by form removal shall have sufficient strength not to be damaged thereby.

Forms shall not be removed in the cases of footing forms where the removal would endanger the safetyof the cofferdams, forms from enclosed cells where access is not provided, deck forms in the cells thatdo not interfere with the future installation of utilities shown on the Drawings, or other works.

Except for concrete being post-tensioned, no concrete shall be subjected to loading which will induce acompressive stress in it exceeding one-third of its compressive strength at the time of loading, or one-third of the specified characteristic strength whichever is less. It may be possible to use shorter periodsbefore striking forms by determining the strength of the concrete in the structural element.

Forms supporting cast-in-situ concrete in flexure may be struck when the strength of the concrete in theelement is 10 N/mm^2 or twice the stress to which it will be subjected, whichever is greater provided thatstriking at this time will not result in an unacceptable deflection. This strength may be assessed by teston cylinder/cube cured under the same conditions as the concrete in the element as far as possible.

Forms on upper sloping faces of concrete shall be removed as soon as the concrete has attainedsufficient stiffness to prevent sagging. Any repair or treatment required on such sloping surfaces shall beperformed at once.

If the floor is to be used to support construction loads, props should be retained for 28 days unless theContractor can prove the requisite concrete strength by tests.

The form shall be removed slowly, as the sudden removal of wedges is equivalent to a shock load on thepartly hardened concrete.

Materials and plants shall not be stacked on any newly constructed floor unless sufficient support ismaintained to withstand such loads without damaging the floor.

The following table is a guide to the minimum periods that must elapse between the completion of theconcreting operations and the removal of formwork. No formwork shall be removed without thepermission of the Engineer and such permission shall not relieve the Contractor of his responsibilitiesregarding the safety of the structure.

Type and position of Formwork	Approximate period (days)
Side of beams, walls and columns (unloaded)	5
Slab soffits (props supporting)	14
Removal of props to slabs	21
Beam soffits (props supporting)	21
Removal of props to beams	28

Notwithstanding the foregoing, the Contractor shall be held responsible for any damages arising fromremoval of formwork before the structure is capable of carrying its own weight and any incidental loading.

7.2.7 OPENINGS

Temporary and permanent openings in concrete shall be framed neatly with provisions for keys orreinforcing steel as shown on the Drawings or as directed by the Engineer.

7.2.8 DEFECTS IN FORMED SURFACES

Workmanship in formwork alongwith concrete placing shall be such that concrete shall normally requireno repair to surfaces being perfectly compacted and smooth.If any blemish is revealed after removal of formwork, the Contractor shall obtain immediately theEngineer's decision concerning remedial measures to be undertaken. Notwithstanding the specificationsand provisions stated under the Sub-section on 'Finish and Finishing' of this Specification, suchmeasures may include but shall not be limited to the following:

i. Fins, pinholes, bubbles, surface discolouring and mirror defects may be rubbed down with sacks immediately on removal of the form.

ii. Abrupt and gradual irregularities may be rubbed down with carborundum stone and water after concrete has been fully cured.

iii. Deep honeycombed concrete shall be repaired within 24 hours of striking the formwork by cutting back to sound concrete. The concrete shall be cut back at least 50mm behind face reinforcement. Cut edges shall be regular and not feathered. Recasting shall be with the same concrete as the original casting. The Engineer shall approve the formwork and its method of placing in this case also.

iv. Under some circumstances, abrupt and gradual irregularities of shallow honeycombed concrete may be repaired by cutting back and reforming with an approved epoxy resin or mortar in accordance with the manufacturer's instructions.

Regardless of the above repairing measures, any structure containing excessive honeycomb, as wouldbe termed by the Engineer, shall be subject to rejection by the Engineer. The Contractor, on receipt ofwritten orders from the Engineer, shall remove and rebuild such portions of the structure at his ownexpenses.

7.2.9 HOLES TO BE FILLED

Holes on the concrete surfaces formed by formwork supports or the like shall be filled with dry packmortar made from one part by weight of ordinary Portland cement and three parts of specified fineaggregate approved by the Engineer. The mortar shall be mixed with sufficient water only to make thematerials stick together when being moulded in the hands. All construction materials shall conform to therequirements as described previously and under the relevant Sub-sections of the Section on'Construction Materials' of this Specification.

The Contractor shall thoroughly clean any hole that is to be filled and break out any loose, broken orcracked concrete or aggregate and remove any dry cement from the hole. The surrounding

concreteshall be soaked until the whole surface that will come into contact with the dry pack mortar has beencovered and darkened by absorption of the free water by the cement. The surface shall then be dried soas to leave a small amount of free water on it.

The dry pack material shall then be placed and packed in layers having a compacted thickness of notmore than 10mm. Compaction shall be carried out by using a hardwood stick and a hammer and shallextend over the full area of the layer. Special cares should be taken to compact the dry pack against thesides of the holes.

After compaction, the surface of each layer shall be scratched before further loose material is added. Theholes shall be slightly overfilled. The surface shall be finished by laying a hardwood block against the drypack fill and striking the block several times.

7.2.10 APPROVAL OF SCAFFOLDINGS AND FORM

Plans, Drawings and structural calculations shall be submitted to the Engineer on time so that noconstruction of such scaffoldings and forms shall take place before the Engineer's approval is accordedin writing. Such approval shall not relieve the Contractor of his responsibilities for the involved structure.

The Engineer shall have reasonable time for his examination of the Contractor's plans and calculations, ifscaffoldings are introducing temporary loading on new structures in particular. For this purpose, theContractor shall not be allowed any extension of time beyond the stipulated period of the Contract.

Before concrete is placed, the Engineer shall inspect all formworks and scaffoldings. No concrete shallbe placed until inspection is made and approval is given by the Engineer. Such approval shall not relievethe Contractor of any of his responsibilities under the Contract for the successful completion and thesoundness of the structure.

7.2.11 MEASUREMENT

Formwork and false work shall not be measured separately but shall be deemed to be an integral part ofthe concrete items.

7.2.12 PAYMENT

The Contractor's rates for concrete work, inter-alia, shall be inclusive of all costs of all formwork, falsework and centering and for their subsequent removal. No additional payment will be made to theContractor for these works

7.3 WATER PROOFING POLYTHENE SHEET

7.3.1 DESCRIPTION

Works covered under this item shall consist of supplying and laying in place one layer of polythene sheetof weight in accordance with the applicable Drawings, BOQ and these specifications and/or as directed bythe Engineer.

7.3.2 CONSTRUCTION REQUIREMENT

Sheets shall be laid covering the entire inside area under the Cement Concrete. Before laying the sheets,the surface shall be cleaned to give a surface free from damage, tear or other imperfections and shall belaid such that there is a minimum of 300mm overlap of the adjacent strips.

7.3.3 MEASUREMENT

Measurement shall be taken for payment in square meter of the actual area covered by the sheets andaccepted by the Engineer. No allowance shall be made for overlaps.

7.3.4 PAYMENT

The amount of completed and accepted work measured as provided above shall be made at the Contractunit price per square meter and the payment shall constitute full compensation for furnishing all materials,equipment including their storage, handling and transport and all labours, cleaning, preparing, cutting,laying, fixing and all incidentals necessary to complete the work. No additional payment shall be made forthe overlaps.

Item of Payment	**Unit**
Supplying and laying of polythene sheet	Square meter / Square feet

JOINTS IN CONCRETE

JOINTS IN CONCRETE

8.1 CONSTRUCTION JOINTS

GENERAL

Construction joints are defined as concrete surfaces upon or against which concrete is to be placed andto which new concrete is to be placed, that have become so rigid that the new concrete cannot beincorporated integrally with that previously placed. Construction joints shall be formed wherever there isa discontinuity in placing concrete in external elements of concrete structures. Formed vertical or inclinedconstruction joints as well as unformed joints, which are due to interruption of concrete placement, shallbe made only where located on the Drawings or shown in the pouring schedule or as directed by theEngineer. All exposed faces of construction joints shall be made absolutely straight, leveled or plumbedand normal to the finished surface.

Spacing of construction joints shall be in accordance with good concreting practice as defined in BS8110 or equivalent and enabling adequate precautions to be taken against shrinkage cracking. Placingof concrete shall be carried out continuously. The joints shall be at right angle to the general direction ofthe member and shall take due account of shear and other stresses.

All planned reinforcing steel shall extend uninterrupted through joints. Additional reinforcing steel dowelsshall be placed across the joints, if and when directed by the Engineer. Such additional steel shall befurnished and placed at the Contractor's expenses.

BONDING

Unless otherwise shown on the Drawing, horizontal joints may be made without keys and vertical jointsshall be constructed with shear keys. Surfaces of fresh concrete at horizontal construction joints shall berough floated sufficiently to thoroughly consolidate the surface and intentionally left in a rough condition.Shear keys shall consist of formed depressions in the surface covering approximately one-third of thecontact surface. The forms for keys shall be beveled so that removal will not damage the concrete.

Surfaces of construction joints shall be prepared as early as possible after casting. The preparation shallconsist of the removal of all laitance, loose or defective concrete coatings, sand and other deleteriousmaterials. Preparation shall be carried out preferably when the concrete has set but not hardened byjetting with a fine spray of water or brushing with a stiff brush, just sufficient to remove the outer mortarskin and to expose the larger aggregate without it is being disturbed. Where this treatment isimpracticable and work is resumed on a surface, which has set, the whole surface shall be thoroughlyroughened or scrapped with suitable tools so that no smooth skin of concrete that may be left from theprevious work is visible.

The prepared joint face shall be thoroughly cleaned by compressed air and water jets or other approvedmeans and brushed and watered immediately before depositing concrete. The cleaned and saturatedsurfaces that also include vertical and inclined surfaces, shall first be thoroughly covered with a thincoating of mortar or neat cement grout against which the new concrete shall be placed before the grouthas attained its initial set.

The placing of concrete shall be carried continuously from joint to joint. The face edges of all joints, whichare exposed to view, shall be carefully finished true to line and elevation.

Construction joints in floors shall be located within the middle third of spans of slabs, beams and girders.Joints in girders shall be offset a minimum distance of two times the width of intersecting beams.

BONDING AND DOWELING TO EXISTING STRUCTURES

When reinforcing dowels grouted into the holes drilled in the existing concrete is required at suchconstruction joints, the holes shall be drilled by methods that willnot damage the concrete around theholes. The diameters of the holes shall be 6mm larger than the nominal diameter of the dowels unlessshown otherwise on the Drawings. The dowel bars shall be round mild steel bar of the diameter andlength as indicated on the Drawings and/or as per the directions of the Engineer. The grout shall be aneat cement paste of Portland cement and water or an epoxy. Immediately prior to placing the dowelbars, the holes shall be cleaned off dust and other deleterious materials, shall be thoroughly saturatedwith water, have all free water removed and shall be dried to a saturated surface dry condition. Sufficientgrout or an epoxy shall be placed inside the holes so as not to remain any void after the dowels areinserted. Grout shall be cured for a period of at least 3 (three) days or until dowel bars are encased inconcrete. When an epoxy is used, the mixing and placing shall conform to the manufacturer'srecommendations.

FORMS AT CONSTRUCTION JOINTS

When forms at construction joints overlap previously placed concrete, they shall be re-tightened beforedepositing new concrete. Exposed face edges of all joints shall be neatly formed with straight bulkheadsor grade strips, or otherwise properly finished true to line and elevation.

8.2 EXPANSION AND CONTRACTION JOINTS

8.2.1 EXPANSION JOINTS

GENERAL

Expansion joints are intended to accommodate relative movement between adjoining parts of a structure.Compressible filler shall be placed between the joint faces to provide freedom for expansion for the twoadjacent concrete masses. Care shall be taken to ensure that the material fills the joint completely andthat no concrete or hard material is left in the joint after the second face of the joint has been cast.

MATERIAL

One of the following specifications shall be used as pre-mould fillers:

i. Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction, ASTM 1751.

ii. Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Pavingand Structural Construction ASTM D 1752. Type-II (cork) shall not be used when resiliency isrequired.

iii. Specification for Preformed Expansion Joint Filler for Concrete, ASTM D 994.

The bitumen sheet, laid on the horizontal top surface of the expansion joint keys, shall be a 10mm thickmaterial approved by the Engineer.

METAL ARMOUR

Expansion joint armour assemblies shall be fabricated from steel with the following materials:

i. Steel bars, plates and shapes shall conform to the requirements of ASTM A 36.

ii. Bolts and nuts shall conform to the requirements of ASTM A 307.

iii. High strength bolts, nuts and washers shall conform to the requirements of ASTM A 325.

iv. Steel castings shall conform to the requirements of ASTM A 486 or ASTM A 27.

v. Grey iron castings shall conform to the requirements of ASTM A 48.

vi. Sheet metal shall be of commercial quality.

ARMOUR ASSEMBLIES

All assemblies shall be accurately fabricated and straightened at the workshop, as necessary to conformto the concrete sections. The assemblies shall be installed so that their top surface matches the plane ofthe adjacent finished concrete surface throughout the length of the assembly. Appropriate methods shallbe followed in placing the assemblies to keep them in correct position during the placing of concrete. Theopening at expansion joints shall be that designated on the Drawings at normal temperature or asdirected by the Engineer for other temperatures. Cares shall be taken to avoid impairment of theclearance in any manner.

8.2.2
CONTRACTION JOINTS
GENERA

Joints placed in structures or slabs to provide for volumetric shrinkage of monolithic unit or movementbetween monolithic units are defined as contraction joints. Contraction joints shall be constructed so thatthere will be no bond between the concrete surface forming the joints.

MATERIAL

Material placed in contraction joints shall consist of asphalt saturated felt paper or other approved bond-breaking materials.

8.2.3 POURABLE JOINT SEALANTS

Pourable sealants shall be placed along the top edges of contraction or filled expansion joints. It shallconform to the following considerations:

i. Unless otherwise shown on the Drawings and/or ordered by the Engineer, joint sealants shall be a hot poured rubber bitumen compound for horizontal joints and either a bituminous compound or an elastomeric two parts polysulphide sealant for sloping, vertical and soffit joints.

ii. Bituminous compounds shall comply with BS 2499 for horizontal joints and BS 2499 Type A1 for sloping or vertical joints. Polysulphide compound shall comply with BS 4254.

iii. Joint sealants and the requisite priming materials shall be obtained from manufacturers approved by the Engineer. The application of joint sealant shall not be commenced without the Contractorobtains its approval by the Engineer.

8.2.4 COMPRESSIVE FILLER

Unless otherwise specified, the joint filler shall be of resin or bituminous bonded corks such as 'Hydrocor'manufactured by Expandite Ltd. The filler shall be obtained from a manufacturer approved by theEngineer and shall be stored and fixed in accordance with the manufacturer's instructions.

8.2.5 WATER STOPS

GENERAL

Water stops shall be of the type, size and shape shown on the Drawings and/or as directed by theEngineer. They shall be dense, homogeneous and without holes or other defects.

TYPES

Water stops to be used may be of the following types:

Polyvinyl chloride (PVC) water stops

Where shown on the Drawings, construction (as required and approved by the Engineer),contraction and expansion joints shall be made watertight by the provision of a continuous WaterStop strip of Poly Vinyl Chloride (PVC) manufactured by the extrusion process from an elastomericplastic compound, the basic resin of which shall be Poly Vinyl Chloride. Unless otherwise specifiedor ordered, a two bulb dumbbell section PVC. Water Stop shall be used in construction joints and athree bulb section PVC Water Stop shall be used in expansion joints.

Water Stops shall be of high grade PVC, containing no filler or reclaimed or scrap material. PVCshall comply with the requirements of BS 2571 for PVC Type A, Class 1. The quality of Water Stopsshall comply with the following major requirements:

i. Specific gravity……1.30 (maximum)

ii. Hardness……80 (minimum)

iii. Tensile strength……138 kg/cm2 (minimum)

iv. Elongationduro……225% (minimum)

Rubber water stops

Rubber Water Stops shall be manufactured with synthetic rubber made exclusively from neoprene, reinforcing carbon black, zinc oxide, polymerization agents and softeners. The quality shall conformthe following major requirements:

Neoprene content……70% by volume (minimum)

Hardness……50-60 duro

Tensile strength……..193 kg/cm^2 (minimum)

Elongation……..600% (minimum)

Rubber Water Stops shall be formed with an integral cross section in suitable moulds so as toproduce a uniform section with a permissible variation in dimension of 0.8mm plus or minus. Nosplices will be permitted in straight strips. Strips and special connection pieces shall be well cured ina manner such that any cross section shall be dense, homogeneous, and free from all porosity.Junctions in the special connection pieces shall be full moulded. During the vulcanizing period, thejoints shall be securely held by suitable clamps. The material at the splices shall be dense andhomogeneous throughout the cross-section.

8.2.6 INSTALLATION

OPEN JOINTS

Open joints shall be constructed by the insertion and subsequent removal of a wood strip, metal plate, orother approved material. The insertion and removal of the template shall be accomplished withoutchipping or breaking the corners of the concrete. When not protected by metal armour, open joints inslabs shall be finished with an edging tool. Upon completion of concrete finishing work, all mortars andother debris shall be removed from the open joints.

FILLED JOINTS

When filled joints are shown on the Drawingsor asked by the Engineer, pre-mould type fillers shall beused unless Poly Styrene board is specifically called for. Filler for each joint shall consist of as few piecesof material as possible. Abutting edges of filler material shall be accurately held in alignment with eachother and tightly fit or taped as necessary to prevent the intrusion of grout. Joint filler material shall beanchored to one side of the joint by waterproof adhesive or other methods so as to prevent it fromworking out of the joint but not interfere with the compression of the material.

SEALED JOINTS

Prior to installation of the pourable joint sealants, all foreign materials shall be removed from the joint.The filler material shall be cut back to the depth shown or approved and the surface of the concrete, incontact with the sealant, be cleaned by light sand blasting. When required, a Poly Ethylene foam stripshall be placed in the joint to retain the sealant and isolate it from the filler material. The sealant materialsshall then be mixed and installed in accordance with the manufacturer's directions. Any material that failsto bond the sides of the joint within 24 hours after placement shall be removed and replaced.

WATER STOPS

Water Stops shall be obtained from a manufacturer approved by the Engineer, and shall be fixed andjoined according to the manufacturer's instructions. All strips shall be stored in a place as cool aspracticable and shall in no case be exposed to the direct sun light.

Water Stops shall be installed with approximately half of the width of the material embedded in theconcrete on either side of the joint. It shall be firmly supported by split stop-end shuttering and in no caseshall Water Stop be pierced to assist in fixing. Special care shall be taken to ensure that the concrete iswell worked against the embedded parts of the strips and is free from honeycomb. Precautions are to betaken to protect any projected portions of the strips from damage during the progress of the works andfrom sunlight and heat.

If, after placing concrete, Water Stops are moved out of position or shape, the surrounding concrete shallbe removed, the Water Stop reset, and the concrete replaced at the Contractor's own expenses. Two 9mm diameter reinforcing bars shall be provided to support the Water Stops and shall be securely held inposition by the use of spacers, supporting wires, or other approved devices.

Flexible Water Stops shall be fully supported in the formwork, free from nails and clear of reinforcementand other fixtures. Damaged Water Stops shall be replaced and care shall be taken to place the concreteso that Water Stops do not bend or distort.

Splicing of Poly Vinyl Chloride Water Stop shall be performed in accordance with the manufacturer'srecommendations. A thermostatically controlled electric source of heat shall be used to make all splices.The heat shall be sufficient to melt but not to char the plastic. Splices shall develop at least 90% of thetensile strength of un-spliced materials and shall withstand bending 180o around a 50mm diameter pinwithout cracking or separating.

The Contractor, at least before the commencement of concrete work, shall submit to the Engineer for hisapproval details of the Contractor's proposals for the installation of water stops. These shall show wherejoints in the Water Stops are to be located and details of the intersections and changes of direction to ascale that shows the position of any joint or shape of any mould section.

As far as possible, jointing of PVC Water Stops on Site shall be confined to the making butt joints instraight runs of Water Stops. Where it is agreed with the Engineer that it is necessary to make anintersection or change of direction of any joint other than a butt joint in a straight run, a preliminary joint, intersection or change of direction piece shall be made and subjected to such tests as the Engineer mayrequire.

Precautions shall be taken so that the Water Stops shall neither be displaced nor damaged byconstruction operations or other means. All surfaces of the Water Stops shall be kept free from oil,grease, dried mortar or any other foreign matters while the Water Stop is beingembedded in concrete.Means shall be used to ensure that all portions of the Water Stop designed for embedding shall be tightlyenclosed by dense concrete.

8.3 MEASUREMENT

Construction Joints shall not be measured. Expansion and Contraction joints shall be measured in linearmeter of the joints considered satisfactory by the Engineer and accepted by him. There will be noadditional measurement for joint fillers, sealed joints, Water Stops, miscellaneous metal devices etc.

8.4 PAYMENT

Payment for construction joints shall be deemed included in the items of concrete and there will be noextra payment for it. For expansion and Contraction joints the amount of completed and accepted worksmeasured as provided above shall be paid at the Contract Unit Price per linear meter and the paymentshall constitute the full compensation for furnishing and placing joint fillers, sealed joints, Water Stops,drains, vents, miscellaneous metal devices including all labour and incidentals for full completion of theWork as per Specifications.

Item of Payment	**Unit**
Expansion joints	Linear meter / Linear feet
Contraction joints	Linear meter / Linear feet

REINFORCING STEEL

REINFORCING STEEL

9.1 REINFORCEMENT FOR RCC

9.1.1 DESCRIPTION

Works covered by this item shall consist of supplying and placing of steel reinforcement in different typesof concrete structures including board cast-in-situ piles and pre-cast concrete piles but not includesreinforcement for pre-stressed concrete. The works shall conform to the specifications, the types, sizesand positions of reinforcement requirements shown on the Drawings and this specification.

9.1.2 MATERIALS REINFORCEMENT

Reinforcing bars discussed under this Section shall be made of Mild Steel or High yield Steel, plain ordeformed, for all Reinforced Concrete Works but excluding Pre-stressing Concrete.

Bars shall be rolled and produced from steel in the form of new and clean billets directly reduced fromingot of properly identified heats of open hearth, basic oxygen or electric arc furnace steel or lots of acidbesmear steel.

REFERENCE STANDARDS

DEFORMED REINFORCEMENT

Deformed and Plain Billet Steel Bars for Concrete Reinforcement – ASTM A 615

Rail Steel Deformed and Plain Bars for Concrete Reinforcement – ASTM A 616

Axle Steel Deformed and Plain Bars for Concrete Reinforcement – ASTM A 617

Low Alloy Steel Deformed Bars for Concrete Reinforcement – ASTM A 706

Deformed Steel Wire – ASTM A 496

Welded Deformed Steel Wire Fabric – ASTM A 497

Zinc Coated (Galvanized) Steel Bars – ASTM A 767

Epoxy – Coated Reinforcing Steel – ASTM A 775

PLAIN REINFORCEMENT

ASTM A 615 M, ASTM A 616 M, ASTM A 617 M, ASTM A 185

SMOOTH STEEL WIRE

Cold – Drawn Steel Wire - ASTM A 82

COLD – WORKED STEEL REINFORCEMENT

IS 1786: 1985, BS 4461: 1978

MILD STEEL PLAIN ROUND BAR

This is a type of bar plain and round in shape of a structural or intermediate grade with yield strength ofnot less than 280 MPa (N/mm^2) i.e. 40 grade.

DEFORMED BARS

Reinforcing steel under this type comprises Mild Steel Grade 40 and High Strength Grade 60 Deformedre-bars with yield strength of not less than 280 MPa (N/mm^2) in case of Grade 40 and with yield strengthof not less than 410 MPa (N/mm^2) in case of Grade 60.

OTHER BARS

Steel welded wire, fabric plain reinforcement conforming to ASTM A 185 may be used, except that forwire with specified yield strength fy exceeding 410 MPa (N/mm^2), fy will be the stress corresponding to astrain of 0.35 percent.

Smooth steel wire conforming to ASTM A 82 may be used in concrete except that for a wire with aspecified yield strength fy exceeding 410 MPa (N/mm^2), fy will be the stress corresponding to a strain of0.35 percent.

Fabricated deformed steel bar mats conforming to ASTM A 184 and deformed steel wire complying withASTM A 496 may be used. Deformed wire for concrete reinforcement shall not be smaller than a nominaldiameter of 5.72mm, and for a wire with specified yield strength (fy) exceeding 410 MPa (N/mm^2), fy shallbe the stress corresponding to a strain of 0.35 percent.

Welded deformed steel wire fabric conforming ASTM A 497 may be used for a wire with specified yieldstrength exceeding (fy) 410 MPa (N/mm^2), fy will be the stress corresponding to a strain of 0.35 percent.

9.1.3 CHEMICAL COMPOSITION

The structural grade shall be made from billets. The ends of the bar shall be machine shearedperpendicular to the axis of the bar. The bars shall be free from injurious defects and shall have aworkman like finish.

The chemical composition should conform to the requirements of ASTM 706-82.

9.1.4 PROCESS

The steel shall have been made by one or more of the following processes:

i. open-hearth
ii. basic oxygen
iii. electric furnace
iv. acid besmear

9.1.5 DIMENSIONAL REQUIREMENTS

The nominal diameter, cross sectional areas and perimeter of a deformed bar are equivalent to that of aplain bar having the same standard weight per unit length. Dimensional requirements of such bars havebeen shown in the Table given below:

Bar Designation No.*	Nominal Dimensions** Diameter, in. [mm]	Cross Sectional Area, in.² [mm²]	Perimeter, in. [mm]	Nominal weight, lb/ft [Nominal mass, kg/m]
3 [10]	0.375 [9.5]	0.11 [71]	1.178 [29.9]	0.376 [0.560]
4 [13]	0.500 [12.7]	0.20 [129]	1.571 [39.9]	0.668 [0.994]
5 [16]	0.625 [15.9]	0.31 [199]	1.963 [49.9]	1.043 [1.552]
6 [19]	0.750 [19.1]	0.44 [284]	2.356 [59.8]	1.502 [2.235]
7 [22]	0.875 [22.2]	0.60 [387]	2.749 [69.8]	2.044 [3.042]
8 [25]	1.000 [25.4]	0.79 [510]	3.142 [79.8]	2.670 [3.973]
9 [29]	1.128 [28.7]	1.00 [645]	3.544 [90.0]	3.400 [5.060]
10 [32]	1.270 [32.3]	1.27 [819]	3.990 [101.3]	4.303 [6.404]
11 [36]	1.410 [35.8]	1.56 [1006]	4.430 [112.5]	5.313 [7.907]
14 [43]	1.693 [43.0]	2.25 [1452]	5.32 [135.1]	7.65 [11.38]
18 [57]	2.257 [57.3]	4.00 [2581]	7.09 [180.1]	13.60 [20.24]

*Bar numbers are based on the number of eighths of an inch including in the nominal diameter of the bars [bar numbers approximate the number of millimeters of the nominal diameter of the bar]

** The nominal dimension of a deformed bar are equivalent to those of a plain round bar having the same weight [mass] per foot [metre] as the deformed bar.

9.1.6 TENSILE PROPERTIES

The tensile properties of the Grade 40 and Grade 60 steel have been shown in the Table given below:

Item	Requirements Grade 40 [300]*	Grade 60 [420]
Tensile strength, min, psi [MPa]	70,000 [500]	90,000 [620]
Yield strength, min, psi [MPa]	40,000 [300]	60,000 [420]
Elongation in 8 in. [203.2 mm], min, %		
Bar Designation No.		
3 [10]	11	9
4, 5 [13, 16]	12	9
6 [19]	12	9
7, 8 [22, 25]	-	8
9, 10, 11 [29, 32, 36]	-	7
14, 18 [43, 57]	-	7

* Grade 40 [300] bars are furnished only in sizes 3 through 6 [10 through 19].

9.1.7 BEND TEST REQUIREMENT

The pin diameter required for performing bend tests shall conform to ASTM A 615. The following tablecontains such requirements:

Bar Designation No.	Pin Diameter for Bend Tests *	
	Grade 40 [300]	Grade 60 [420]
3, 4, 5 [10, 13, 16]	3.5d	3.5d
6 [19]	5d	5d
7, 8 [22, 25]	-	5d
9, 10, 11 [29, 32, 36]	-	7d
14, 18 [43, 57] (90°)	-	9d

* Test bends 1800 unless noted otherwise.
d = Nominal diameter of specimen

PERMISSIBLE VARIATION

For lots from standard weights + 5% for 6mm dia
+ 3.5% for 10mm dia and above

Individual + 6% for all sizes

LENGTH

Length of the bar shall be maximum possible, but each bar shall not be less than 12m in length or 45.36kg in weight whichever is greater.

9.1.8

ASTM CODE REQUIREMENTS FOR DEFORMATIONS

Deformations shall be spaced along the bar at substantially uniform distances. The deformations on theopposite sides of the bar shall be similar in size and shape.

The deformations shall be placed with respect to the axis of the bar so that the included angle is not lessthan 45°. Where the line of deformation forms an included angle with the axis of the bar from 45° to 70°inclusive, the deformations shall alternately reverse in direction on each side, or those on one side shallbe reversed in direction from those on the opposite side. Where the line of deformation is over 70°, areversal in direction is not required.

Average spacing or distance between deformations on each side of the bar shall not exceed 17(seventeen) times of the nominal diameter of the bar.

Overall length of deformations shall be such that the gap between the ends of the deformations on theopposite sides of the bar shall not exceed 12.5% of the nominal perimeter of the bar. Where the endsterminate in a longitudinal rib, the width of the longitudinal rib shall be considered as the gap. Wheremore than two longitudinal ribs are involved, the total width of all longitudinal ribs shall not exceed 25% ofthe nominal perimeter of the bar. Furthermore, the summation of gaps shall not exceed 25% of thenominal perimeter of the bar. Nominal perimeter of the bar shall be 3.14 times the nominal diameter (d_b).

Spacing, height and gap of deformations as to be conformed have been shown in the following table:

Deformation requirements, in. [mm]

Bar designation	Maximum average spacing	Minimum average height	Maximum gap (Chord of 12.5% of Nominal Perimeter)
3 [10]	0.262 [6.7]	0.015 [0.38]	0.143 [3.6]
4 [13]	0.350 [8.9]	0.020 [0.51]	0.191 [4.9]
5 [16]	0.437 [11.1]	0.028 [0.71]	0.239 [6.1]
6 [19]	0.525 [13.3]	0.038 [0.97]	0.286 [7.3]
7 [22]	0.612 [15.5]	0.044 [1.12]	0.334 [8.5]
8 [25]	0.700 [17.8]	0.050 [1.27]	0.383 [9.7]
9 [29]	0.790 [20.1]	0.056 [1.42]	0.431 [10.9]
10 [32]	0.889 [22.6]	0.064 [1.63]	0.487 [12.4]
11 [36]	0.987 [25.1]	0.071 [1.80]	0.540 [13.7]
14 [43]	1.185 [30.1]	0.085 [2.16]	0.648 [16.5]
18 [57]	1.56 [40.1]	0.102 [2.59]	0.864 [21.8]

Note: Any bar that fails to satisfy the aforementioned all requirements is to be treated as plain reinforcement.

9.1.9 BINDING WIRE

Reinforcement binding wire shall be the best black annealed mild steel wire and not less than 1.6mm indiameter in approximation/18 - 22 BWG or 26 BWG galvanized iron wire.

9.1.10 WIRE MESH

Wire mesh shall conform to the requirements of AASHTO Standard Specification M 55 Welded SteelWire Fabric for Concrete Reinforcement.

9.1.11 ORDERING MATERIAL

The name of the proposed supplier of the reinforcement shall be submitted as soon possible to theEngineer for his approval. The Contractor shall submit necessary information concerning the supplier asrequested by the Engineer.

Copies of orders placed shall be submitted to the Engineer.

The manufacturer shall submit all requested relevant data on the steel, i.e. breaking strength, yieldstrength, characteristics on elongation, chemical composition etc., to the Engineer for his approval.

No steel shall be delivered without a certificate guaranteeing the yield stress.

The steel shall be stored and marked in a way that it enables identification of the steel corresponding toeach certificate later on.

9.1.12 TESTS

Test results in addition to those to be submitted by the Contractor and specified above shall be required.

The Contractor shall cut out samples as directed by the Engineer.

The samples shall be tested according to the Engineer's instructions by an approved Testing Institution. Approximately threesamples shall be tested from each 10 tons of reinforcement delivered at the Site. Expenses incurred inconnection with cutting, carrying and testing the samples shall be borne by the Contractor at his owncosts.

9.1.13 CONSTRUCTION METHODS OF REINFORCING BAR

STORAGE AND CARE

All reinforcing steel when received at the Site, prior to its use, shall be stacked off the ground onplatforms, skids or any other support and shall be kept free from dirt, oil and grease. All cares shall betaken to prevent the steel reinforcement from any mechanical injury and surface loss resulting from itsexposition to weather conditions that produce rust. It shall be clean and kept free from loose rust andloose mill scale at the time of fixing in position and subsequent pouring of concrete. However,reinforcement steel may not be rejected on the ground of bonded rust, surface seams, surfaceirregularities and mill scale so long minimum dimensions, cross-sectional area and tensile properties of ahand wire brushed specimen meet the specified physical requirements for the size and grade of steel.

Reinforcement shall be handled and stored in a manner that will prevent bending out of the desiredshape and any accumulation of dirt, oil and paint. When placed in the works, it shall be free from dirt, oil, grease, paint, mill scale and loose or thick rust.

Bar reinforcement shall be shipped in standard bundles, tagged and marked in accordance with theCodes of Practice of the Concrete Reinforcing Steel Institute.

FABRICATION

All bars shall be fabricated following Specifications, methods and procedures stated below. Fabricationtolerances shall be in accordance with ACI 315.

CUTTING AND BENDING

All reinforcement bars shall be cut and bent cold to the specified shape and pertinent dimensions shownon the Drawings using a proper bar bender, operated by hand or power to attain proper radii of bends.The equipment used and methods followed for this purpose shall get the approval of the Engineer.

Bars shall not be bent or straightened in a manner that will injure the material.

Bars partially embedded in concrete shall not be field bent unless otherwise shown on the Drawings ordirected by the Engineer.

Errors in alignment of reinforcement partially embedded in hardened concrete shall not be corrected bybending in place, except as permitted by the Engineer.

Bars bent during transportation or handling shall be straightened before being used in work. It shall notbe heated to facilitate bending.

Fabrication tolerances shall be in accordance with ACI 315.

All plain bars shall have standard hooks at the end, which shall meet the following requirements unlessotherwise specified on the Drawings. When the dimensions of hooks or the diameter of bends are notprescribed, they shall be in accordance with ACI 318 'Building Code requirements for ReinforcedConcrete'. Some of the standard requirements have been specified below:

i. 180° turn plus an extension of at least 4 bar diameters but not less than 60mm at the free end of thebar.

ii. 90° turn plus an extension of at least 12 bar diameters at the free end of the bar.

iii. For stirrup and the anchorage only:

- For 16 mm dia bar and smaller : 90° bend plus an extension of at least 6 bar diameters or 75mm whichever is greater at the free end of the bar.
- For 20mm and 25mm dia bar : 90° bend plus an extension of at least 12 bar diameters or 150mm whichever is greater at the free end of the bar.
- For 25mm dia bar and smaller : 135° bend plus an extension of at least 6 bar diameters at the free end of the bar.
- For closed ties and continuously wounded ties : 135° bend plus an extension of at least 6 bar diameters, but not less than 75mm.

The minimum diameter of bend measured on the inside of the bar, for standard hooks other than forstirrups and ties in sizes 10mmΦ thorough 16mm Φ, shall not be less than the values shown in the tablegiven below.

Minimum diameters of Bend

Bar size	Minimum diameter of bend
10mm ≤d_b≤ 25mm	6d_b
25mm ≤d_b≤ 40mm	8d_b
40mm ≤d_b≤ 55mm	10d_b

* d_b is the nominal diameter of bar, mm

For stirrups and tie hooks, inside diameter of bend shall not be less than 4 bar diameters for 16mm Φ barand smaller. For bars larger than 16mm Φ, diameter of bend shall be in accordance with thespecifications shown in the above table.

Bends for other bars, where full tension in the bar may occur, shall be made around a pin having adiameter not less than 20 bar diameters. Hooks shall conform to American Concrete Institute StandardBuilding Code Requirements for reinforced concrete ACI 316-89, or as shown on the Drawings or asdirected by the Engineer.

PLACING, SUPPORTING AND FASTENING

All bar reinforcement shall be accurately placed, supported and secured in position as shown on theDrawings using approved spacer blocks and chairs prior to any concrete pouring. Displacementtolerance may be allowed within the permissible tolerance limit as shown in the table given below unlessotherwise specified by the Engineer. The reinforcement shall be checked and approved by the Engineerbefore pouring of concrete.

Tolerance for Placing Reinforcement

	Tolerance for depth (d)	Tolerance for Minimum Concrete Cover
d ≤ 200mm	± 10mm	- 10mm
d ≤ 200mm	± 12mm	- 12mm

Notwithstanding the above provisions, tolerance for the clear distance to formed soffits shall be minus6mm and tolerance for cover shall not exceed minus one-third the minimum concrete cover required inthe design Drawings or specifications.

Tolerance for longitudinal location of bends and ends of reinforcement shall be ± 50mm, except atdiscontinuous ends of members where tolerance shall be ± 12mm.

Welding of crossing bars shall not be permitted for assembly of reinforcement unless authorized by theEngineer.

The Contractor shall be responsible for the accuracy of cutting, bending and placing of the reinforcement.Reinforcement will be inspected for compliance with the requirements as to grade, size, shape, length,splicing locations, overlapping length and position after it has been placed.

Before the reinforcement is placed, the surfaces of the bars and the surfaces of any metal bar supportsshall be cleaned of heavy rust, loose mill scale, dirt, grease and other objectionable foreign substances.Heavy flaky rust, which can be removed in firm rubbing with hessian or equivalent treatment, shall beconsidered objectionable. After being placed, the reinforcing bars shall be maintained in a cleancondition until they are completely embedded in the concrete.

Reinforcement shall be accurately placed in the position shown on the Drawings and/or as directed bythe Engineer and shall be securely held by blocking against the forms, by supporting on concrete orapproved metal or plastic chairs or by using metal hangers and by wiring together at intersections usingannealed wire of specified diameter with the ends turned in to the main body of concrete. Bars shall betied at all intersections except where spacing is less than 300mm in any direction when alternateintersections shall be tied. Wire ties shall be securely tied and folded so that they do not project beyondthe planes formed by the reinforcing bars. The adequacy of the supports and ties to secure thereinforcement properly shall be subject to the approval of the Engineer.

Reinforcement supports shall be strong enough to withstand the imposed loads without movement of thereinforcement. They shall be positively attached to the reinforcement and of such size and number as tomaintain the specified cover.

There shall be a clear distance of at least 25mm between the bars and any adjacent embedded metalworks. The Contractor shall ensure that there is no disturbance of the reinforcing bars in concrete thathas already been placed.

Reinforcement binding wire shall be best black annealed mild steel wire and not less than approximately1.6mm in diameter/18 - 22 BWG galvanized iron wire.

Cover blocks required for ensuring that the reinforcement is correctly positioned shall be as small aspossible, consistent with their purpose, or a shape and material acceptable to the Engineer anddesignated so that they will not overturn when the concrete is placed. The concrete cover blocks orspace blocks shall be made of concrete having 1 part cement, 1 part sand and 2 part coarse aggregate.The coarse aggregate would be 6mm downgraded. The blocks would be cast in mould and continuouslycured for 21 days before use. Wire shall be cast in the blockfor the purpose of tying it to thereinforcement. The wire must not be closer than 30mm from the concrete surface. The use of smallstones or wood blocks shall not be permitted.

If concrete cylinder blocks are used for proper spacing of vertical bars in column, the height shall be2.54cm and radius shall be equal to the distance of the centre line of the bar from column face.

Top reinforcement in slabs shall be maintained in position by means of chairs made out of ferrous metaland shall conform to industry practice as described in the Manual on 'Standard Practice of the ConcreteReinforcing Steel Institute'. The diameter and quantity being sufficient to ensure security of thereinforcement shall be used to support access ways, working platforms, or the placing equipment or forconducting of an electric current.

Platforms for the support of workers and equipment and machines shall be placed directly on the formswithout any disturbance of the reinforcing steel during concrete placement.

Before any steel reinforcement is embedded in the concrete, any loose mill scale, loose rust and any oil,grease or other deleterious matter shall be removed. Partially set concrete, which may adhere to theexposed bars during concrete placing operations, shall also be removed.

9.1.14 LATERAL REINFORCEMENT FOR COLUMNS

SPIRALS

Spiral reinforcement for columns shall conform to the following:

i. Spirals shall consist of evenly spaced continuous bar or wire of such size and so assembled as topermit handling and placing without distortion from designed dimensions.

ii. Size of spirals shall not be less than 10mm diameter for cast-in-place construction.

iii. The minimum and maximum clear spacing between spirals shall be 25mm and 75mm respectively.

iv. Anchorage of spiral reinforcement shall be provided by 1.5 extra turns of spiral bar or wire at eachend of a spiral unit.

v. Splices in spiral reinforcement shall be lap splices of 48 spiral diameter, but not less than 300mm.

vi. Spirals shall extend from the top of footing or slab in any story to the level of the lowest horizontalreinforcement in members supported above.

vii. Spirals shall extend above termination of spiral to bottom of slab or drop panel, where beams orbrackets do not frame in to all sides of a column.

viii. Spirals shall extend to a level at which the diameter or width of capital is 2 times that of the column,in case of columns with capitals.

ix. Spirals shall be held firmly in place and true to line.

TIES

Tie reinforcement for compression members shall conform to the following:

i. All bars shall be enclosed by lateral ties, at least 10mm diameter in size for longitudinal bars 30mmdiameter or smaller, and at least 12mm diameter in size for 35mm diameter to 55mm diameter andbundled longitudinal bars.

ii. Vertical spacing of ties shall not exceed 16 longitudinal bar diameters or 48 tie diameters, or theleast dimension of the compression members.

iii. Ties shall be arranged such that every corner and alternate longitudinal bar shall have lateralsupport provided by the corner of a tie with an included angle of not more than 135°. No vertical barshall be farther than 150mm clear on each side along the tie from such a laterally supported bar.Where longitudinal bars are located around the perimeter of a circle, a complete circular tie isallowed.

iv. The lowest tie in any story shall be placed within one-half the required tie spacing from the top mosthorizontal reinforcement in the slab or footing below. The uppermost tie in any story shall be withinone-half the required tie spacing from the lowest horizontal reinforcement in the slab or drop panelabove.

v. Where beams or brackets provide concrete confinement at the top of the column on all (four) sides,the top tie shall be within 75mm of the lowest horizontal reinforcement in the shallowest of suchbeams or brackets.

LATERAL REINFORCEMENT FOR BEAMS

Compression reinforcement in beams shall be enclosed by ties or stirrups satisfying the size and spacinglimitations as stated above. Such ties or stirrups shall be provided throughout the distance wherecompression reinforcement is required.

Lateral reinforcement for flexural framing members subject to stress reversals or to torsion at supportsshall consist of closed ties, closed stirrups, or spirals extending around the flexural reinforcement.

Closed ties or stirrups shall be formed in one piece by overlapping standard stirrup or tie end hooksaround a longitudinal bar, or formed in one or two pieces laps, spliced with a lap of development length.

9.1.15 SPACING OF REINFORCEMENT

The minimum clear spacing between parallel bars in a layer shall be equal to one bar diameter, but notless than 25mm.

Where parallel reinforcement is placed in two or more layers, bars in the upper layers shall be placeddirectly above those in the bottom layer with clear distance between layers not less than 25mm.

For compression members, the clear distance between longitudinal bars shall be not less than 1.5 bardiameters or 35mm.

Clear distance limitation between bars shall apply also to the clear distance between a contact lap spliceand adjacent splices or bars.

In walls and one-way slabs, the maximum bar spacing shall be three times the wall or slab thickness (h)but not more than 450mm.

For two-way slabs, maximum spacing of bars shall be 2h but not more than 450mm.

For temperature steel only, maximum spacing shall be 5h but not more than 450mm.

9.1.16 SPLICING

GENERAL

All reinforcement shall be furnished in the full lengths indicated on the Drawings unless otherwisepermitted by the Engineer. Except for splices shown on the Drawings and splices for No. 5 or smallerbars, splicing of bars shall not be permitted without the written approval of the Engineer. Splices shall bestaggered as far as possible.

Where the Drawings do not detail laps that will be necessary, the Contractor shall furnish workingDrawings to the Engineer for his approval.

If such additional lap splices are approved, the extra weight occasioned by such lap splices shall not beincluded in the measurement of reinforcement for payment unless provided for in these Specifications.

LAPPED SPLICES

All splices for high yield strength steel bars shall have a lap length as shown on the Drawings or if notshown therein shall be in accordance with the American Concrete Institute Building Code Requirementsfor Reinforced Concrete (ACI 318-89).

All splices for mild steel shall have a lap length as shown on the Drawings or if not shown therein, of notless than 40 diameters of the smaller bar when hooks are used and 50 diameters for bars without hooks.

Lap splices shall not be used for 35mm diameter bars and larger, except when bars of differentdiameters are lap spliced in compression, the splice length shall be the larger development length of thelarger bar, or the splice length of the smaller bar.

Lap splices of bundled bars shall be based on the lap splice length required for individual bars within thebundle, increased in accordance with development of bundled bars. Individual bar splices within a bundleshall not overlap. Entire bundles shall not be lap spliced.

Bars spliced by non-contact lap splices in flexural members shall not be spaced transversely fartherapart than one-fifth the required lap splice length, nor 150mm.

Lap splices shall generally be located at points of minimum tension in bars. Except where otherwiseshown on the Drawings, lap splices shall be made with the bars placed in contact and securely wiredtogether.

WELDED SPLICES

Welding on Site shall be avoided wherever possible, but where suitable safeguards and techniques areemployed and provided that the types of steel including high-yield steels to SS 2 have the requiredwelding properties, it may be undertaken with the acceptance of the Engineer. Before welding anyreinforcement, the Contractor shall supply to the Engineer a Welding Procedure Specification (WPS) andan example of the weld for the type of steel, connection and weld being proposed. If such evidence is notavailable, the Contractor shall demonstrate satisfactory performance by means of testing as agreed bythe Engineer. Unless satisfactory performance of the proposed welded connection is established byeither of the two methods described above, approval for use of the welded connection shall not be given.

In addition and as required by the Engineer, the competence of the operators shall be demonstrated priorto and periodically during welding operations by submission of independent Welder Qualification Records(WQR) for each welder to be used on Site.

Welding may be used in fixing reinforcement in position, for example, by welding between crossing orlapping reinforcement, or between bars and other steel members.

Welded intersections shall not be spaced farther apart than 300mm in the direction of calculated stress,except for wire fabric used as stirrups.

Structural welding shall not be carried out unless specifically shown on the Drawings.

Notwithstanding the above, the Engineer will not permit tack welding of bars, which will be subject tofluctuating stresses in the completed structure.

Welding shall conform to the Structural Welding Code, Reinforcing Steel, AWS D 1.4 of the AmericanWelding Society and applicable special provisions.

Welded splices shall be butted and welded to develop in tension at least 125 percent of specified yieldstrength fy of the bar. A full mechanical connection shall develop in tension or compression, as required,at least 125 percent of specified yield strength fy of the bar. Welded splices and mechanical connectionsnot meeting the above requirements are allowed where area of reinforcement is at least twice thatrequired by analysis shall meet the following:

i. Splices shall be staggered at least 600mm and in such manner as to develop at every section atleast twice the calculated tensile force at the section but not less than 140 N/mm^2 for total area ofreinforcement provided.

ii. Spliced reinforcement may be rated at the specified splice strength, in computing tensile forcedeveloped at each section. Non-spliced reinforcement shall be rated at that fraction of fy definedby the ratio of the shorter actual development required to develop the specified yield strength (fy).

SPLICES OF DEFORMED BARS IN TENSION

The minimum length of lap for tension splices shall be as required for Class A or B splice, but not lessthan 300mm, where the classification shall be as follows:

Class A splice…….1.0L_d

Class B splice…….1.3L_d

* L_d is the development length

Lap splices of deformed bars in tension, shall be Class-B splices except that Class-A splices are allowedwhen the area of reinforcement provided is at least twice that required by analysis over the entire lengthof the splice, and one-half or less of the total reinforcement is spliced within the required lap length. Where area of reinforcement provided is less than twice that required by analysis, welded splices ormechanical connections used shall meet the following requirements. This is also applicable in case ofsplices in tension tie members those shall be made with a full welded splice or full mechanicalconnection.

i. Welded splices shall be butted and welded to develop in tension at least 125 percent ofspecified yield strength fy of the bar.

ii. A full mechanical connection shall develop in tension or compression, as required, at least125 percent of specified yeild strength fy of the bar.

Welded splices or mechanical connections used where area of reinforcement provided is at least twicethat required by analysis shall meet the following:

i. Splices shall be staggered at least 600mm and in such manner as to develop at every section atleast twice the calculated tensile force at the section but not less than 140 N/mm^2 for total area ofreinforcement provided.

ii. Spliced reinforcement may be rated at the specified splice strength, in computing tensile forcedeveloped at each section. Non-spliced reinforcement shall be rated at that fraction of $f_y$defined bythe ratio of the shorter actual development length to ld required to develop the specified yieldstrength fy.

Splices in adjacent bars shall be staggered at least 750mm.

SPLICES OF DEFORMED BARS IN COMPRESSION

The minimum length of lap for compression splice shall be 0.07 fy.db for fy equal to 410 N/mm^2 or less or(0.13 fy – 24)db for fy greater than 410 N/mm^2, but not less than 300mm. For f'c (specified compressivestrength of concrete, N/mm^2) less than 20 N/mm^2, length of lap shall be increased by one-third.

When bars of different diameters are lap spliced in compression, the splice length shall be the larger ofthe development length of the larger bar, or the splice length of the smaller bar.Welded splices or mechanical connections used in compression shall also satisfy the followingrequirements:

i. Welded splices shall be butted and welded to develop in tension at least 125 percent of thespecified yield strength fy of the bar.

ii. A full mechanical connection shall develop in tension or compression, as required, at least 125 percent of the specified yield strength fy of the bar.

END BEARING SPLICES

i. Compression splices for bars required to transmit compressive stress only, may consist of endbearing of square cut ends held in concentric contact by a suitable device.

ii. Bar ends shall terminate in flat surfaces within 1.5° of a right angle to the axis of the bars, and shallbe fitted within 3° of full bearing after assembly.

iii. End bearing splices shall be used only in members containing closed ties, closed stirrups or spirals.

SPECIAL SPLICE REQUIREMENTS FOR COLUMNS.

Lap splices, butt-welded splices, mechanical connections, or end-bearing splices shall be used with thelimitations as stated below. A splice shall satisfy the requirements for all load combinations for thecolumn.

LAP SPLICES IN COLUMNS

i. Lap splices shall conform to the first two requirements stated above under the Sub-section on‘Splices of Deformed Bars in Compression’ and where applicable to (d) or (e) below where the barstress due to factored loads is compressive.

ii. Where the bar stress due to factored loads is tensile and does not exceed 0.5fy in tension, lapsplices shall be Class B tension lap splices, if more than one half of the bars are spliced at anysection, or Class A tension lap splices, if half or fewer of the bars are spliced at any section andalternate lap splices are staggered by ld (development length).

iii. Where the bar stress due to factored loads is greater than 0.5fy in tension, lap splices shall be ClassB tension lap splices.

iv. If spiral reinforcement confines the splice, the lengths required may be multiplied by 0.75, but laplength shall not be less than 300mm.

WELDED SPLICES OR MECHANICAL CONNECTORS IN COLUMNS

Welded splices or mechanical connectors in columns shall also meet the following requirements.

i. Welded splices shall be butted and welded to develop in tension at least 125 percent of specifiedyield strength fy of the bar.

ii. A full mechanical connection shall develop in tension or compression, as required, at least 125percent of specified yield strength fy of the bar.

END BEARING SPLICES IN COLUMNS

End bearing splices complying with the requirements stated above under Sub-section on “End BearingSplices’ may be used for column bars stressed in compression provided that the splices are staggered oradditional bars are provided at splice locations. The continuing bars in each face of the column shallhave a tensile strength at least 0.25fy times the area of the vertical reinforcement in that face.

SPLICES OF PLAIN BARS

For plain bars, the minimum length of lap shall be twice that of deformed bars.

MECHANICAL ANCHORAGE

Any mechanical device capable of developing the strength of reinforcement without damage to concreteis allowed as anchorage.

Mechanical device may be used only when its adequacy can be proven by test results to the satisfactionof the Engineer.

Development of reinforcement may consist of a combination of mechanical anchorage plus additionalembedded length of reinforcement between the point of maximum bar stress and the mechanicalanchorage.

9.1.17 SUBSTITUTIONS

Substitutions of different size bars shall be permitted only with specific authorization by the Engineer andat no additional cost to the Employer. If bars are substituted, they shall have a cross sectional areaequivalent to the design area or larger.

The Contractor shall also provide, also in the case of substitutions, at his own expenses and to theapproval of the Engineer, such necessary detailing of the reinforcement as he require for the execution ofthe work to the Engineer's satisfaction.

9.1.18 CONCRETE COVER TO REINFORCEMENT

Unless specified on the Drawings, the clear concrete cover to reinforcement shall be as tabulated below:

Description of Concrete Element	**Clear Cover (mm)**	
	Normal Exposure	**Saline Water**
Wall and footing		
a) Contact with earth	60	75
b) Expose to weather and water	50	60
Piles		
a) Cast-in-place	75	100
b) Pre-cast	40	50
Beam, Girder, Column	40	50
Building roof and floor slab	25	25

9.1.19 PROTECTIVE COATING

All exposed reinforcing steel at construction joints shall be protected with a brush coat of neat cementmixed to a consistency of thick paint within one week after the placing of the initial concrete, unless it isdefinitely known that the steel will be embedded within 30 days. This coating shall be entirely removed, by light tapping with a hammer or other tools, not more than one week before the placing of the finalpour.

9.1.20 BUNDLED BARS

i. Groups of parallel reinforcing bars bundled in contact to act as one unit, shall be limited to four inany one bundle.

ii. Bundled bars shall be enclosed within stirrups or ties.

iii. Bars larger than 35mm diameter shall not be bundled in beams.

iv. Individual bars within a bundle terminated within the span of flexural members shall terminate atdifferent points with at least 40 times the nominal diameter of bar staggered.

v. Where spacing limitations and minimum concrete cover are based on nominal bar diameter, a unitof bundled bars shall be treated as a single bar of a diameter derived from the equivalent total area.

vi. Minimum concrete cover shall be equal to the equivalent diameter of the bundle, but need not begreater than 50mm.

9.1.21 INSPECTION

The Contractor shall notify the Engineer when the steel has been placed in position and ready forconcrete placing. No concrete shall be placed until the Engineer inspected the steel and given hisapproval in writing.

9.1.22 MEASUREMENT

The quantity of reinforcement to be measured under this Section shall be the computed weight inkilogram of material used and accepted as shown on the Drawings provided that the quantity shall notinclude the reinforcement in any item of works. In computing the weight to be measured, the theoreticalweights of bars of the cross section shown in this Specification shall be used.

The computed weight shall not include the extra materials incurred, when bars larger than thosespecified are used or the extra materials necessary for splices, when bars shorter than those specifiedare used even with the permission of the Engineer. It shall not also include the weight of any devicesused to support or fasten the reinforcement in correct position.

9.1.23 PAYMENT

This work measured as provided above, shall be paid for at the Contract unit price per kilogram ofreinforcement for the particular Bill of Item. The payment shall be considered to be the full compensationfor furnishing, fabricating, splicing and placing of the reinforcing steel, supports and binding wire, cuttingand bending, all labours, equipment, tools and incidentals necessary to complete the works prescribed inthis Section.

No separate payment shall be allowed for chairs, laps, splices, separators etc. The costs of these shallbe considered included in the unit rate.

Item of Payment	**Unit**
Mild steel reinforcing bars	Kilogram
High yield steel reinforcing bars	Kilogram

9.2 WELDING

9.2.1 GENERAL

All welding shall be performed by certified welders and in accordance with the American Welding Society (AWS) D1.1 'Structural Welding Code' or similar approved standard.

The principal forms of welding metals are as follows:

i. Electric arc welding
ii. Gas welding

The electric arc welding process is the most important and is most extensively used for mild steelsranging from light articles with a wall or thickness of 16 gauge to heavy fabrications. This is a processwhereby the metal of the two members to be welded is fused together through hit generated by anelectric arc. Fusion should be complete over the whole area of the joint surface.

Gas welding is done using oxy-acetylene flame and is not adapted to structural steel works, but isgenerally used for small jobs. The flame produced by burning oxy-acetylene is fed through a blowpipe, which is ignited at its tip. The flame is played on the two pieces to be welded until the metal becomes hotenough to fuse together adding additional metal to the joint as necessary by melting in to it a suitableelectrode.

Unless otherwise specified, all welding shall be performed following the Shielded Metal Arc Process withlow hydrogen electrodes for manual welding.

The Contractor shall be responsible for the quality of the welding performed by his welding organization.All welding by the Contractor shall be carried out by the electric arc method using coated electrodes orother means whereby the air is excluded from the molten metal and where applicable, automaticmachines with correct procedure control shall be used.

9.2.2 WORKMANSHIP AND VISUAL QUALITY REQUIREMENTS

In addition to conforming with the procedural and quality requirements set forth in the Structural WeldingCode and/or these Specifications, all manual welding shall meet the following requirements forworkmanship and visual quality.

i. Each weld shall be uniform in width and size throughout its full length and each layer of weldingshall be smooth, free of slag, cracks, pinholes and undercut and shall be completely fused to theadjacent weld beads and base metal. In addition, the cover pass shall be free of coarse ripples,irregular surface, non-uniform bead pattern, high crown, deep ridges or valleys between beadsand shall blend smoothly and gradually into the surface of the base metal.

ii. Butt Welds shall be slightly convex, of uniform height and shall have full penetration.

iii. Fillet Welds shall be of specified size with full throat and with each leg of uniform length.

iv. Repair, chipping or grinding of welds shall be done in such a manner as not to gouge, groove, orreduce the base metal thickness.

9.2.3 WELDING REPAIRS

All weld defects which are determined unacceptable, shall be removed by chipping, grinding, arc or flamegouging, following which the area shall be properly prepared for welding, repaired by an approvedqualified welding procedure and re-tested as necessary. The Contractor shall establish the cause of alldefects and show that such defects have been corrected before welding will be permitted. All repairingshall be done by and at the expenses of the Contractor.

9.2.4 PEENING

The Contractor shall not be allowed to peen welds without prior approval of the Engineer.

9.2.5 ELECTRODES

All electrodes shall be purchased in sealed containers and shall be thoroughly dry when used.Electrodes, taken from sealed containers, shall be used within four hours. Electrodes not used within fourhours shall be stored in electrode storage ovens. The electrode storage oven temperature shall be inaccordance with the electrode manufacturer's recommendations. Electrodes with wet or damagedcoatings shall not be used.

A simple test indicate the quality of an electrode or welding or welding wire can be made by laying thewire flat on a clean surface and applying the welding flame to it for a distance of about 8 - 10cm bymoving the flame backward and forward until the wire becomes red and then slowly melting the wire,moving the flame in such a manner so that the wire melts only half-way through its diameter. If theflame is withdrawn as soon as the rod metal begins to melt, the impurities can readily be seen beingthrown off in the form of sparks, or a boiling action in the case of inferior metal. When cold, an inferiormetal will contain numerous spongy, volcano-like irregularities. A good metal welding rod will melt andflow evenly without any disturbing actions.

Cracks may occur in welding alloy steels owing to the rapidity with which these harden. This may largelybe avoided by preheating the parent metal at 300oC or above in advance of welding to lower the normalcooling rate.

The maximum diameters of electrodes for welding have been shown in the following table:

Average thickness of plate or section	**Maximum gauge or diameter of electrode to be used**
Less than 5mm	3.2mm – 10 SWG
5mm to Less than 8mm	4mm – 8 SWG
8mm to Less than 10mm	5mm – 6 SWG
10mm to Less than 16mm	6mm – 4 SWG
16mm to Less than 25mm	9mm
25mm and over	9mm

The maximum width of any bead of welding, other than a cover pass, shall not exceed 3 times thediameter of the electrode being used.

Subject to the approval of the Engineer, electrodes shall be carefully selected in order to provide metalwelds with mechanical properties similar to those of the metal being welded, except that for weldinghigher strength steel to lower strength steel, the electrodes shall be chosen to provide metal welds withmechanical properties comparable to those of the lower strength material.

9.2.6 CUTTING AND EDGE PREPARATION

Members of structural steel and miscellaneous metal works, which are to be joined by welding shall becut accurately to size and where required, shall be rolled or pressed to the proper curvature inaccordance with dimensions shown. The edges of these members shall be sheared, flame-cut ormachined to suit the required type of welding and to allow thorough penetration. The cut surfaces shallexpose sound metal, free from laminations, surface defects caused by shearing or flame-cuttingoperations, or other injurious defects. The surface to be welded shall be free from rust, grease, paint andother foreign matter for a distance of at least 150mm back from the edge of the weld.

9.2.7 GRINDING WHEELS

Grinding wheels, which leave a deposit detrimental to subsequent welding will not be permitted. Grindingwheels, which are determined by the Engineer to be detrimental to welding shall not be used.

9.2.8 QUALIFICATION OF WELDERS AND WELDING OPERATORS

All welders and welding operators assigned to the work shall have passed the qualification test forwelding operators as specified in the AWS Structural Welding Code. If, as determined by the Engineer,the work of any welder appears questionable, such welder will be required to pass additional qualificationtests to determine his ability to perform the type of work on which he is engaged. Such additionalqualification tests for welders and the physical tests of the welded specimens shall be made in thepresence of the Engineer. If required, the Contractor shall furnish to the Engineer a certified copy ofreports of the results of physical tests of specimens welded in the qualification tests. Fulfillment of suchqualification shall be at the expenses of the Contractor.

9.2.9 WELDING METHODS

GENERAL

Methods which are essentially required to be followed while welding are as follows:

i. Welds should be made in the flat position as far as practicable.

ii. Freedom of movement of one member should be allowed as far as possible.

iii. The work should be securely held in position by means of spot welds, service bolts, clamps or jigsbefore commencing welding so as to prevent any relative movement due to distortion, wind or other causes.

iv. The parts to be welded must be thoroughly cleaned and proper flux used. Any paint or rust and loose mill scales, etc. should be removed from the surfaces to be welded and surrounding materials for a distance of at least 12mm from the weld. A coating of boiled linseed oil may be permitted. Steel to be welded should not be painted or oiled until after erection, unless all ends to be welded are left bare.

v. The sequence of welding should be such that when possible the members, offering the highestresistance to compression, are welded first.

Extreme care shall be taken to ensure that correct welding sequences and procedures are observed toavoid any strains and internal stresses arising in welding.

WELDING OF STAINLESS STEEL

Unless otherwise specified, all welding shall conform with AWD D1.1. Electrodes used for welding ofstainless steel shall be Series E308 and electrodes used for welding of stainless steel to carbon steelshall be Series E309.

Welders and welding operators assigned to the work shall have passed the qualification test for weldingoperators as specified above under 'Qualification of Welders and Welding Operators' of this Sub-section.

WELDING OF REINFORCEMENT

Electric Arc Butt-welding is most suitable for bars of diameter greater than 20mm and lap welding forsmaller diameters and lap welding with longitudinal beads for 6mm to 40mm diameters. However,reinforcement, specified to be welded, shall be welded by any process the Contractor can demonstrateby bend and tensile tests, which will ensure that the strength of the parent metal is not reduced and thatthe weld possesses a strength no less than that of the parent metal. The welding procedure establishedby the successful weld tests shall be maintained and no departure from this procedure shall bepermitted. Following the establishment of a satisfactory welding procedures, each welder to be employedon the work shall carry out welder performance qualification tests on reinforcing bars of the same metaland size as those on the works.

Welds in positions other than those shown on the Drawings and/or as directed by the Engineer shall notbe permitted.

9.2.10 DEFECTS IN WELDED JOINTS

The usual defects in welded joints are:

i. Lack of penetration or fusion of the metal to the bottom of the joint or welded members.

ii. Laps in the metal of the weld not properly fused together.

Defects are most likely to occur at the root of the weld and in this position they are liable to have themaximum effects in reducing the strength of the weld.

9.2.11 INSPECTION AND TESTING OF WELDS

The metal in a good weld when cold should show its original color. If the metal has a rusty or dull redcolor or appears crystallized, it is an indication that the heat has become too high and the metal hasbeen burnt. A good weld will show an evenness of ripples or waves and well-formed beads with goodfusion along the edges of the welds. There should be no unfilled cavities, small pockets of slags or burntmetal and small air or gas pockets.The strength of a welded joint may be taken only about 75 per cent of the stress usually allowed forcommon works, although tests have shown that if the welding is properly done it is possible to developthe full strength of the members jointed.

The following tests shall be carried out on the procedure, qualification, test plates and production testplates:

i. Tensile and bend tests: all welds shall be subject to visual inspection.

ii. The procedures of visual examination shall conform to the requirements of the ASME Boiler andPressure Vessels Code.

The following defects are unacceptable unless otherwise noted:

i. Dimensional defects such as insufficient throat or leg length, excess convexity, excess or insufficient reinforcement.

ii. Undercuts, overlap, blowholes, slag inclusion, seams and excess weave.

iii. Any crack or liner indication.

Plates with laminations discovered during gas cutting, welding or any other time shall be rejected, unlessapproval to repair the plate is obtained from the Engineer.Welds may also be subject to anyone or a combination of the examinations as may be required toestablish the soundness of welds.The inspection procedures for testing of all welds shall be prepared on the above basis by the Contractorand submitted to the Engineer for approval before any fabrication work is started.

9.2.12 MEASUREMENT AND PAYMENT

Welding shall not be measured and no direct payment shall be made. All costs of welding shall bedeemed included in the related items of the Bill of Quantities unless otherwise it has been specificallymentioned in the BOQ.