

CONCRETE WORKS

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A - CONCRETE WORKS

SECTION – 1 CONCRETE WORKS

1.1 Scope of Work

The Contractor shall provide all labour, equipment, materials and incidentals required to supply mix, transport, and place all ready-mixed and/or cast in-situ concrete and install miscellaneous related items including forms, sleeves, anchor bolts, inserts and embedded items as required.

None of the requirements of this specification shall relieve the Contractor of his responsibility to produce in the Works sound and well-compacted concrete free from voids and cracks.

1.2 General Provisions

Concrete shall be composed of Portland cement, fine aggregate, coarse aggregate, water and admixtures as specified for the work except as otherwise authorized in writing by the Engineer. Ready mix concrete shall be permitted, provided it can be placed within the time requirements specified and complies with all of the provisions hereinafter specified.

Reinforced concrete and workmanship shall conform to the Lebanese Standards NL59 and NL71, and in advanced if some standard is not exist, under-listed Code of Practice and Standards, each in case of application::

- BS 8110 Framed building structures - □ BS 8007 Water Retaining Structures
- BS 8004 Foundations - □ BS 5328 Specifying Concrete including Ready-mixed Concrete

All testing and inspection services required shall be done at no additional cost to the Employer at the field laboratory provided by the Contractor, as instructed by the Engineer. Methods of testing shall comply in detail with the applicable ASTM “Methods of Test” and relevant of standard used NL or BS.

1.3 Submittals

Samples of constituent materials and of concrete as placed shall be subjected to laboratory tests. The Contractor shall submit samples of materials as directed by the Engineer for his approval and all materials incorporated in the Works shall conform to the approved samples. The Contractor shall design the concrete mixes for all classes of concrete as defined in BS 8110 Clause 6.3 and submit his proposal together with the test results of the strength of all classes of the concrete mix design for the approval of the Engineer. The design of the concrete mixes and the concrete strength test shall be made in the field laboratory in the presence of the Engineer's representative. The Contractor is responsible for all expenses incurred in this process.

The use of ready-mixed concrete in any part of the Work shall require the Engineer's written approval.

The Contractor shall satisfy the Engineer as to the sampling, trial mixing, testing and quality of concrete of various grades shall equally applied to ready-mixed concrete, which shall be made and delivered in accordance with BS 5328.

Every additional facility including transport, which the Engineer or persons authorised by him may require for the supervision and inspection of batching, mixing and transporting to Site of ready-mixed concrete shall be provided by the Contractor at no extra cost to the client.

1.4 Quality

The Contractor shall furnish and place concrete as required by these Technical specifications. The concrete to be produced and placed shall be of the highest quality and

uniformity. The Contractor in all phases of his operations shall be subjected to strict inspection to provide concrete construction of excellent quality. Emphasis shall be placed on the uniformity of the concrete aggregate, water-cement ratio, consistency, air content, curing and temperature control of the concrete at the time of placement in its location.

Where screen sizes for concrete aggregates are indicated in USA standard sizes, the Contractor may utilise standard screens having metric dimensions closely approximating these sizes as approved by the Engineer.

Consistency of the concrete as measured by the ASTM C143 "Slump of Portland Cement Concrete" shall be as shown: T1

- Portion of Structure Slump in mm Recommended Range
- Pavement and slabs on ground 50 25 - 75
- Plain footings, gravity walls, slabs and beams 50 25 - 75
- Heavily reinforced foundations, walls,
- Footings and cast in situ piles 75 50 – 100 (concreting in dry condition)
- Thin reinforced walls and columns 75 50 - 100
- Concreting under water 150 125 - 180

Concrete shall be of such consistency and mix composition that it can be readily worked into the corners and angles of the forms and around the reinforcement, inserts, embedded items and wall castings without permitting materials to segregate or free water to collect on the surfaces and due consideration shall be given to the methods of placing and compacting.

No excessively wet concrete shall be permitted for the works and if at any time concrete of consistency beyond the limits of Table 3.1 is delivered to the job, the Engineer may reject the concrete. No additional water shall be added at any time (e.g. while in transit) except that established for the mix design. Failure to comply with this requirement shall be a justification for rejecting the concrete.

The actual acceptance of aggregates and mix design to produce concrete conforming to the specific requirements shall be determined by means of prior laboratory tests made with the constituents to be used on the work to achieve the specified objectives of strength and of appearance according to the standards.

- The ratio between the fine and course aggregates shall be higher than 1:1.5. The proportion of constituent materials and concrete mix shall be in accordance with:

- BS 5328 & BS 8110: Part I - 1985 for framed buildings
- BS 8007 - 1987 for water retaining structures

The Contractor shall produce the method statement and discuss with the Engineer the proposed time, sources of materials and concrete mixes which he proposes to use at least thirty days prior to placing of first batch of concrete. He shall furnish samples of aggregate and cement for testing at a location selected by the Engineer and test them at no extra cost to the Employer and shall permit ample time for the laboratory to develop a proposed design mix or to modify the design of the mix within the limits of these specifications to achieve the desired results.

The limiting strengths, water-cement ratios and cement contents as shown: T2

- Class / Grade Minimum Maximum Minimum Maximum of Concrete Characteristics
Water: Cement Cement Cement Cube Strength at Ratio Content Content 28 day
(N/sq.mm) (kg/cu. M) (kg/cum)
- These cement contents apply to "controlled" concrete subject to specific inspection.in the event Contractor desires to use materials other than those approved originally or materials from the sources originally approved change in characteristics during the

progress of works, the Contractor shall carry out new acceptance tests of these materials to establish new basic concrete mixes and obtaining the approval of the Engineer prior to use at no extra cost to the Employer. Objectionable changes in colour of the structures shall not result from these modifications.

1.5 Acceptance Tests

Conformity of aggregates to this specification and the actual proportions of cement, aggregates and water necessary to produce a concrete conforming to the requirements set forth in T1 and T2 shall be determined by tests made with representative samples of the materials to be used for the work.

Preparation of samples and tests shall be made at the field laboratory in the presence of the Engineer's designated representative. The Contractor at no extra cost to the Employer shall furnish representative samples.

Cement shall be subject to testing to determine that it conforms to the requirements of the specification. Methods of testing shall conform to the appropriate specification, but the Engineer in accordance with the particular need shall determine the place, time, frequency and method of sampling. Samples of fine and coarse aggregates shall be furnished for examination and testing at least three weeks before the Contractor proposes to use them in the work.

Water content of the concrete shall be based on a curve showing the relation between water content and 7 and 28 days compressive strengths of concrete made using the proposed materials. The curves shall be determined by four or more points representing an average value of at least three test specimens at each age and shall have a range of values sufficient to yield the desired data including all compressive strengths shown on the drawings without extrapolation. The water content of the concrete to be used as determined from the curve shall correspond to the test strengths of the laboratory trial mixes as shown:

- Concrete Cube Strength, N/sq. mm
- Minimum Lab. Strength Strength 7 days 28 days C40 28 40 - C35/35A 23.2 35

In no case, shall the resulting mix conflict with the values for maximum water-cement ratios and minimum cement contents as specified in Table T2.

1.6 Materials

1.6.1. Cement

The ordinary Portland cement shall be from an approved source conforming to BS12: 1978 and air entraining cements shall not be used. Cement brands shall be subject to approval of the Engineer. Rapid hardening cement shall not be used without the prior approval of the Engineer. Testing of cement shall be performed in accordance with the provisions of BS 4550 - Parts 2 and 3.

1.6.2. Aggregate

The material characteristic of coarse and fine aggregate for concrete shall be tough, hard, durable and uncoated particles containing no significant harmful organic materials that may adversely impinge on the concrete or reinforcing steel. It shall generally comply with the requirements of BS 882 except where specified hereinafter. Contractor shall provide all data as specified in Appendix A of BS 882. The material shall have a low coefficient of thermal expansion and not contain any materials that are deleteriously reactive with the alkalis in the cement.

The aggregate shall be thoroughly washed with clean water if necessary to fulfill these requirements.

River Sand and Crushed Rock Materials shall be acceptable for Fine Aggregate provided they comply with particles grading in accordance with the BS 882. Beach sand shall not be permitted for use in concrete mixes. No aggregate shall be delivered to site prior to the approval of the Engineer.

A- Both fine and coarse aggregates shall comply with the provision:

- Requirement Test Methods Permissible Limits
- BS 812 ASTM Fine Coarse
- Grading Part 103(dry) Standard Standard
- Material finer than 0.075 mm natural Crushed rock
- Clay lumps and friable particles C142 3% Maximum 2% maximum
- Light weight pieces C123 0.5% maximum 0.5% max.
- Organic impurities C40 Colour standard not darker than Plate No. 3
- Water absorption C128/C127 2% maximum 2% maximum
- Specific Gravity (apparent) C128/C127 2.60 minimum 2.60 minimum
- Shell content: Coarser than 10mm

Structural concrete

Note 1: There is no requirement of shell content in sands passing 2.36 mm sieve size.

Note 2: Aggregates may initially be assessed for its reactivity in accordance with ASTM C289 and if potential reactivity is indicated, then mortar bar tests in accordance with ASTM C227 shall be carried out.

Sampling and testing of aggregates shall be carried out in accordance with the requirements of the appropriate section of BS 812. Frequency of routine testing of aggregates shall be in accordance with Table 3.5. Mineralogical tests are to be carried out as and when directed by the Engineer. Samples of aggregates will be tested at intervals during construction of the works and the Contractor shall provide the necessary equipment and labour.

At the start of the project and whenever there is a change in the source of supply.

- Fine Aggregate

Fine aggregate shall be Natural River sand conforming to BS 882 and marine aggregates shall not be used. Aggregates shall not contain any materials that are deleteriously reactive with the alkalis in the cement. Gradation shall be in accordance with BS 882 excluding grading designation F. Fine aggregate shall be clean, sharp, natural and/or crushed sand. Each batch of aggregate delivered to site shall be kept separate from previous batches and shall be stored for at least three working days before use to allow inspection and tests to be carried out. The Contractor shall mechanically wash aggregate to remove salts and other impurities in order to meet the technical requirements specified.

Fine Aggregate shall comply with the Gradation specified in the Table below:

- Coarse aggregate

Coarse aggregate for concrete shall be prepared as a single sized aggregate and blended to produce normal size grading. Combined grading shall be within the appropriate grading limits envelope given in BS 882. Aggregates that are deleteriously reactive with the alkalis in the cement in an amount sufficient to cause excessive expansion of concrete shall not be used. The Contractor shall mechanically wash aggregate to remove salts and other impurities in order to meet the requirements specified.

The following designated sizes* of aggregate shall be the maximum employed in concrete.

- 40 mm for mass concrete

- ☐ 20 mm for reinforced concrete

* Note: The "designated size" and the corresponding gradations shown represent the end or combined gradation of the coarse aggregate to be used in the final concrete.

Coarse Aggregate shall comply with the following Gradation specified in the Table below:
BS 410

Materials from approved quarries shall be tested periodically for the following characteristic:

- ☐ Gradation
- ☐ Specific gravity
- ☐ Los Angeles Abrasion test
- ☐ Magnesium Sulphate soundness test
 - Combined Aggregates

Approved coarse and fine aggregates for concrete in each batch shall be combined in proportions as specified in BS 882 and to the approval of the Engineer. Under no circumstance materials passing the 0.05 mm sieve shall exceed three percent by weight of the combined aggregate. Combined aggregate gradation used in the work shall be as specified, except when approved or directed by the Engineer otherwise. Changes of material gradation from one to another shall not be permitted during progress of concrete works unless expressly approved by the Engineer.

- Water

Water shall be clean and free from injurious amounts of oils, acid, alkali, organic matter or other deleterious substances and shall comply with the requirements of BS 3148. Potable tap water shall normally fulfil these requirements.

The pH of water employed for concrete works shall be within the limits of 7.0 to 9.0. The temperature of the water to be used for concrete shall be within the range of 50 C to 250 C. Water may be cooled by gradual insertion of crushed ice to lower the temperature to a minimum of 50 C but no ice particles shall be present in the concrete mix.

When subjected to the mortar strength test described in ASTM C87, "Effect of Organic Impurities in Fine

Aggregate on Strength of Mortar", the 28-day strength of mortar specimen made with the water under examination and normal Portland cement shall be not less than the strength of similar specimen made with distilled water.

- Admixtures:

The use of admixtures for concrete mix shall be subject to approval of the Engineer in writing. Admixtures shall conform to ASTM C 494 or BS 5075 – Part 1. The Contractor may be required to use a retarding or water reducing agent and retarding admixture conforming to ASTM C494 under certain circumstances with the approval of the Engineer. The following conditions may render such situation.

- ☐ Climatic conditions contributing to early setting of concrete
- ☐ Temperature of concrete is 30°C or above
- ☐ Time between introduction of cement to the aggregate and placing of concrete exceeds 45 minutes

The employment of admixtures for concrete mix shall be at the discretion of the Contractor and at no additional cost to the Employer. Compatibility of all proposed admixtures shall be tested with proposed cement and aggregate in accordance with ASTM C494. The amounts and types of additives used shall be as directed or approved by the Engineer and may be varied by him according to the location of the work or for other reasons.

- Storage of Materials

(i) Aggregates

Non-graded uniform aggregates of different sizes shall be stored separately in order to prevent mixing of one another and also to avoid contamination. Materials of similar grading but from different sources or different types shall not be stored together unless approved by the Engineer. Aggregate stockpiles shall be provided with impervious beds laid to facilitate drainage and any adjacent roads shall be adequately formed to prevent drainage water entering into the stockpiles and bin loading areas.

Aggregate stockpiles shall be covered by a structure or structures, which shall remain in position throughout the Contract and this cover shall effectively protect the stockpiles from rainwater. Duplicate stockpiles shall be provided for each single size of aggregate and worked on alternate days to allow all aggregates to drain for at least 16 hours prior to its utilization. Aggregate in stockpiles shall not be contaminated or crushed by over running trucks, bulldozers, or other heavy plants and equipment. The Contractor shall avoid the persistent build-up of fine material at the bottom of the stockpiles. In the event of such build-up occurred, the layer that contains an excess of fine material shall be removed as directed by the Engineer.

(ii) Cement

The Contractor by properly storing loose cement in waterproof bulk silos that minimise the internal condensation shall prevent premature hydration of cement after delivery to site. Cement contained in paper bags shall be stored clear of the ground in a waterproofed structure and stacked not more than eight bags high. The strength of cement tends to reduce significantly after four to six weeks of storage in bags under normal weather conditions and considerably sooner under adverse weather condition or high humidity. Hence, the deliveries of cement in bags shall be properly administrated and used in the order of receipt to site. Cement from different manufacturers and types shall be stored separately.

(iii) Reinforcement

Reinforcement steel shall be stored on site either in racks or on a hard impermeable base so that it remains straight and free from contamination. Any reinforcement that is likely to remain in storage for a long period shall be protected from the weather in order to avoid corrosion and pitting. The corroded, rusted and damaged reinforcement shall be removed from site immediately if directed by the Engineer.

1.7 Measurement of Materials

Materials for mixing of concrete shall always be measured by weighing except when authorized by the Engineer otherwise. The apparatus for weighing of constituent aggregates and cement shall be designed and constructed for this purpose and shall be regularly calibrated. Each single size of coarse aggregate, fine aggregate and cement shall be weighed separately. The accuracy of all weighing devices shall be such that the successive quantities can be measured to within one percent of accuracy. Cement in standard packages (sacks) need not be weighed, but bulk cement shall be weighed in all cases.

The water for concrete shall be measured by volume or by weight. The water-measuring device shall control the volume or weight accurately to half a percent. All measuring devices shall be subject to approval by the Engineer.

1.8 Mixing

Concrete shall be produced by mechanical equipment such as concrete batching plant.

Ready-mixed or transit-mixed concrete shall be transported to the site in watertight agitator or mixer trucks loaded not in excess of the rated capacities for the respective conditions as stated on the nameplate. Central mixed concrete shall be plant-mixed for a minimum of 90 seconds per batch and then shall be truck-mixed or agitated for a minimum of 8 minutes. Agitation shall begin immediately after the premixed concrete is placed in the truck and shall continue without interruption until discharge. Transitmixed concrete shall be mixed at mixing speed for at least 10 minutes immediately after charging the truck followed by agitation without interruption until discharge.

All central plant, rolling stock, equipment and methods shall conform to ACI Standard 214, "Recommended Practice for Measuring, Mixing and Placing Concrete", and ASTM C94, "Ready-Mixed Concrete". The total elapsed time between the intermingling of the aggregates and cement and the start of mixing shall not exceed 30 minutes.

Ready-Mixed Concrete

1.8.1. The use of ready-mixed concrete in any part of the Work shall require the Engineer's written approval.

1.8.2. Contractor shall satisfy the Engineer on the following:

- a. Materials used in ready-mixed concrete comply with the Specification in all respects.
- b. Manufacturing and delivery resources of the proposed supplier are adequate to ensure proper and timely completion.

1.8.3. The specified requirements as to the sampling, trial mixing, testing and quality of concrete of various grades shall apply equally to ready-mixed concrete.

1.8.4. Every additional facility including transport that the Engineer or persons authorized by him may require for the supervision and inspection of the batching, mixing, testing and transporting to Site of ready-mixed concrete shall be provided by the Contractor at no extra cost.

1.8.5. Ready-mixed concrete shall be supplied from an off-site commercial ready-mix plant approved by Engineer.

Each load shall be accompanied by a bond weigh master's certificate listing:

- ☐ Type and strength of the mix being delivered
- ☐ Quantity of each concrete ingredient
- ☐ Admixture quantity
- ☐ Water content
- ☐ Slump
- ☐ Time of loading and departure from ready-mix plant

1.8.6. Unless approved otherwise in advance of batching all concrete of single design mix for any one day's pour shall be from a single batch plant of a particular supplier.

a. Ready-mix concrete shall conform to BS 5328.

b. Transit mixers equipped with automatic devices for recording the number of revolutions of the drum shall be used.

c. No water shall be added during transporting to site or at the site.

d. Each mixer truck shall arrive at the job site with its water container full. In the event that water container is not full and concrete tests give a greater slump than acceptable, the load shall be rejected.

1.8.7. Shade temperature and concrete temperature shall be recorded at the point of discharge

of the mixer and at placement for each load of concrete delivered to site.

1.8.8. Maximum and minimum temperatures and wet bulb temperatures shall be recorded daily.

1.8.9. Perform slump tests in accordance with BS 1881 at the site of pour for each load delivered to site. Concrete installation shall proceed only following satisfactory verification of slump test results.

1.9 Transporting

When the concrete mixture is very far from the placement location; slump, temperature and the time shall be recorded frequently on each and every truck transporting concrete at the mixture and the point of the placement. When a truck mixer or agitator is used for transporting concrete to the delivery point, discharge and placing shall be completed within one hour or before 250 revolutions of the drum or blades whichever comes first after the introduction of the cement to the aggregates. Under the circumstance where weather conditions contributing to early initial setting of the concrete or when the temperature of the concrete is 30°C or above, a time less than 45 minutes shall be required between discharge and placing.

When non-agitating hauling equipment is used for transporting concrete to the delivery point, discharge and placing shall be completed within 30 minutes after the addition of cement to the aggregates under normal circumstances and not more than 15 minutes under conditions contributing to easy initial setting of the concrete, or when the temperature of the concrete is 30°C or above. If the above time conditions as to discharge and placing of concrete after introduction of cement cannot be met, the Contractor may be required to use a retarding or a water reducing and retarding admixture. The use of a retarding admixture will be according to ASTM C494 and shall be approved by the Engineer and no extra cost to the Employer.

The re-tampering of concrete or mortar that has partially hardened and mixing with or without additional cement, aggregate or water shall not be permitted. The Contractor shall dispatch trucks from the batching plant in a manner that they shall arrive at the site of the work just before the concrete is required, thus avoiding excessive mixing of concrete while waiting for placing successive layers of concrete.

Precautions shall be taken in hot weather to prevent loss of slump. Mixer drums shall, when possible be shaded, lagged and materials shall be kept as cool as possible.

1.10 Field Tests

Sets of three field control test specimen shall be selected at random by the Engineer during the progress of the work in conformity with ASTM C31, "Making and Curing Concrete Compressive and Flexural Strength Tests Specimens in the Field". The total number of specimen taken on the project may average one set per 20 cubic meters of each class of concrete and in general not less than one set of specimens shall be taken on any day that concrete is placed. The Contractor shall be responsible for covering the expenses in taking and transporting the concrete specimen to the laboratory. The test results shall conform to the recommendations given in BS 8007: 1987 "British Standard Code of Practice for design of concrete structures for retaining acquires liquids". If it appears that the laboratory cured specimen will fail to conform to the requirements for strength, the Engineer shall have the right to order changes in the concrete mix sufficient to increase the strength to meet these requirements. The strengths of any specimen cured on the job are intended to indicate the adequacy of protection and curing of the concrete and may be used to determine as to when the forms may be stripped, shoring removed or the structure placed in service. In the opinion of the Engineer, the strength of the job cured specimen are excessively below those of the

laboratory cured specimen, then the Contractor may be required to improve the procedures for protecting and curing concrete.

The Contractor shall provide for all costs in the making of such tests including allowing free access to the work for the selection of samples, providing moist storage facilities for specimen, affording protection of the specimen against injury or loss through his operations, and furnishing material and labour required for the purpose of taking and testing of samples. The Contractor shall make slump tests in the field as and when instructed by the Engineer in the presence of the Engineer's representatives.

The Engineer may request that dynamic testing or loading test to be executed when the results of the laboratory test are not satisfactory for completed works. The Contractor at his own cost shall carry out testing and inspection work.

1.11 Inspection and Control

The preparation of forms, placing of reinforcing steel, embodiment items, conduits, pipes, and sleeves, batch mixing, transportation, placing and curing of concrete shall be subject to the inspection of the Engineer including testing in the laboratory.

1.12 Concrete Appearance

Concrete placed for every part of the work shall form a homogeneous structure that when hardened will have the required strength, durability and appearance. Formwork, mixtures and workmanship shall be such that concrete surfaces, when exposed, shall require no finishing. When concrete forms are stripped, the concrete surfaces when viewed in good light from 6 meters away shall be pleasing in appearance and shall show no visible defects.

1.13 Forms

Forms preferably of metal shall be used for all concrete work including footings. Forms shall be so constructed and placed that the resulting concrete will be of the shape, lines, dimensions, appearance, and to the elevations indicated on the drawings and conforming to ACI347, "Recommended Practice for Form work". The Contractor shall submit shop drawings together with calculations for formwork and temporary works as requested by the Engineer at no additional cost to the Employer. Forms of all cast-in-place concrete shall be made of metal, wood or other approved material. Wood forms shall be constructed of sound lumber or plywood of suitable dimensions free from knotholes and loose knots. Plywood shall be sanded smooth and fitted with tight joints between panels. Metal forms shall be of an approved type for the class of work involved and of the thickness and design required for rigid construction. All exposed concrete surfaces shall be formed preferably with metal forms and plywood forms may be considered under special circumstances.

Edges of all form panels in contact with concrete shall be flushed within 0.8 mm and forms for plane surfaces shall be such that the concrete will be plane within 2 mm each 4 meters.

Forms shall be tight to prevent the passage of mortar, water or grout. Forms shall generally be constructed as that the finished concrete conforms to ACI 117 "Standard Tolerance for Concrete Constructions and Materials".

Molding or bevels shall be placed to produce a 20mmx20mm chamfer on all exposed projecting corners, unless otherwise noted on the drawings. Similarly chamfer strips shall be provided at horizontal and vertical extremities of all wall placements to produce "clean" separations between successive placements as shown on the drawings.

Forms shall be sufficiently rigid to prevent displacement or sagging between supports under all conditions and shall be so constructed that the concrete shall not be damaged by their

removal. The Contractor shall be entirely responsible for their adequacy. Forms shall be oiled before reinforcement is placed with approved non-staining oil or liquid form coating not having a paraffin base.

All surfaces that have been in contact with concrete shall be thoroughly cleaned, damaged places repaired, projecting nails withdrawn and intrusions or protrusions smoothen before reusing the form materials. Form ties encased in concrete shall be designed carefully to ensure that after removal of the protecting part, no metal shall be within 25 mm of the face of the concrete and that part of the tie to be removed shall be at least 12 mm in diameter or be provided with a wood or metal cone at least 12 mm in diameter and 25 mm long. Form ties in concrete exposed to view shall be of the cone-washer type. Through-bolts or common wire shall not be used for form ties. It is using plastic spacer to assure this condition.

The Engineer may inspect the forms to ensure its appropriate condition, cleanliness, joint preparation and to ascertain that all reinforcement and embedded items are adequately supported in the proper location prior to placing of concrete. This inspection shall not relieve the Contractor of his responsibility for the adequacy of the forms or for the completeness and accuracy of embedded items. Holes and seams in the forms shall be addressed adequately to prevent escape of water and mortar. Forms in the vicinity of joints shall be re-tightened just prior to placing the next lift of concrete. The Contractor shall maintain the forms tight and in intended position during concreting. Any adjustment necessary to the forms during casting of concrete shall be attended promptly.

1.14 Casting Sequences, Placing and Compacting

(i) Concreting Program

The Contractor shall submit for the approval of the Engineer a complete concreting program showing the timing of concreting of individual pours with dates before commencement of the work.

(ii) Placing

Exterior concrete slabs shall be pitched or crowned to prevent stagnant water and facilitate easy drainage. Unless otherwise permitted, the work shall be so executed that a section began on any day shall be completed in daylight of the same day.

Transport of concrete from mixer to place of final deposition shall be performed as rapidly as practicable by methods that prevent separation of concrete ingredients and displacement of reinforcement and thereby avoid re-handling. Partially hardened concrete shall be rejected and not deposited in the works. Concrete shall be transported from the mixer trucks by skips, barrows, buckets on cranes, chutes, or conveyor belts. All equipment used to transport concrete shall be clean and free of debris and contaminants. In selecting the method or methods proposed for transportation, consideration shall be given to the effects of the method on the properties of the concrete that may not result in inferior concrete caused by segregation produced during transport.

Bottom opening skips or buckets shall not be used for transporting concrete over long distances because of the possible consolidation, bleeding or loss of slump that may result. Buckets or skips shall be capable of free discharge of low slump concrete with gate mechanisms, which permit full control over the discharge with no appreciable segregation. Chutes shall be Unshaped and of such size as to ensure a continuous flow of concrete in the chute. Chutes shall be metal or metal lined with sections have approximately equal slopes and flat chutes shall not be used in any event. The slopes of chute shall be within 250 and 450 to guarantee no segregation of concrete ingredients. The concrete in chute shall

discharge into a hopper when the placing operation is intermittent. Concrete shall be deposited at or near its final position of placement. Chutes shall be provided with a baffle and down pipe at the discharge end to provide a vertical drop thus minimizing segregation. Free fall of concrete shall be limited to a maximum height of 500 mm. In case the delivery hose of the concrete pump or the skip bucket cannot maintain this free fall limit, tremie-pipe of diameter less than 100 mm shall be used. The discharge pipe shall be kept full of concrete during placing as far as practicable and its lower end shall be kept buried in the newly placed concrete. The forms shall not be jarred and no strain shall be placed on the ends of projected reinforcement bars subsequent to initial setting of the concrete. Chutes, hoppers, spouts, and other equipment shall be thoroughly cleaned before and after each use. The water and debris shall not be discharged inside the form.

Precautions shall be taken to protect concrete during transport in hot weather. The elapsed time between mixing and placing shall be kept to a minimum and where possible, trucks waiting to discharge shall be kept in the shade. "Cold Joints" shall be avoided and if they occur, shall be treated as bonded construction joints by using epoxy to the approval of the Engineer. The application of the epoxy shall be as recommended by the manufacturer. The surfaces of the previously placed concrete at construction joints shall be thoroughly cleaned of foreign materials and laitance, and weak concrete shall be roughened with suitable tools to expose a fresh face. The construction joints shall be thoroughly saturated with water at least two hours before and again shortly before the new lift of concrete is deposited. The construction joints shall be given a thorough coating of cement grout mixed to the consistency of a very heavy paste after glistening water disappeared from surface. The surfaces shall receive a coating at least 5 mm thick, well scrubbed in by means of stiff bristle brushes wherever possible. New lift of concrete shall be deposited on the wet surface of previously placed cement grout.

The concrete shall be deposited in layers by maintaining a plastic surface approximately horizontal until the completion of the predetermined casting level. The vertical lifts of concrete shall not exceed 600 mm and preferably 450 mm. The consolidation of concrete by vibrators shall be extended to at least 150 mm into the preceding layer of the same lift.

The successive layers of concrete in the same lift shall be placed while the preceding layer is still in plastic stage in order to avoid cold joints. In the event of underlying layer has stiffened just beyond the point where it cannot be penetrated by the vibrator, proper bond can still be obtained by thoroughly and systematically vibrating the new concrete into contact with the old. In thin sections such as wall panels concrete shall be placed using suitable hoppers, spouts with restricted outlets, or otherwise as required or approved by the Engineer.

(iii). Compacting

Concrete shall be thoroughly compacted during and immediately after depositing by means of suitable tools. Internal type mechanical vibrators shall be employed to produce the required compaction and quality of finish. Suitably experienced operators under close supervision shall be utilized for compaction and vibration shall be continued sufficiently to produce homogeneity and optimum consolidation without permitting segregation of the solid constituents. Mechanical vibrators shall be supplemented by proper wooden spade puddling approximately adjacent to the forms to remove bubbles and honeycombs. All vibrators shall operate at not less than 10,000 vibrations per minute (170 Hz) and be of adequate capacity. At least one vibrator shall be available for every 8 cubic meters of concrete placed per hour. In addition, one spare vibrator in operating condition shall be on the site. Particular care shall be taken in the regions of water-stops.

Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted and withdrawn out of the concrete slowly and no poker holes shall be left after withdrawal of vibrator. The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete, but over vibration shall be avoided to prevent segregation. Vibration shall not be continued at any one point to the extent that localised areas of grout are formed. Application of vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective. 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 shall not 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. Concrete slabs on the ground shall be well tamped into place. Foundation material shall be wetted, tamped, vibrated, and rolled until thoroughly compacted prior to placing concrete. Concrete shall be deposited continuously in layers of such thickness that no concrete will be deposited on surface that has hardened sufficiently to cause the formation of seams and planes of weakness within the section. If a section cannot be placed continuously, construction joints may be located at points as provided for in the drawings or as approved by the Engineer.

1.15 Curing and Protection

The Contractor shall protect all concrete work against injury from outside elements and defacement of any nature during construction operations. All concrete, particularly exposed surfaces shall be treated immediately after concreting or cement finishing is completed, and shall be provided with continuous moist curing for at least 7 days regardless of the ambient air temperature. Walls and vertical surfaces may be covered with continuously saturated burlap or by other approved means. Horizontal surfaces, slabs, and other items shall be inundated with pool of water to a depth of 1.2 cm and kept continuously wet with the use of sprinklers.

Finished surfaces and slabs shall be protected from the direct rays of the sunlight to prevent shrinking and cracking.

1.16 Placing Concrete under different Weather Conditions

Care shall be taken to prevent rapid drying and plastic cracking of newly placed concrete due to excess temperature over 30°C. The temperature of the concrete as placed shall not exceed 30°C. The Contractor shall make precautions to reduce the temperature of concrete by mechanical refrigeration using ice as a part of mixing water or alternative method acceptable to the Engineer. The fresh concrete shall be shaded as soon as possible after placing and curing by use of fog spray shall be started as soon as the surface of fresh concrete is sufficiently hardened. Placing of concrete shall not be permitted if, in the opinion of the Engineer, the Contractor does not have proper facilities available for placing, curing and finishing in accordance with the specifications. The Contractor shall comply with the recommendations of ACI 305 "Hot Weather Concreting".

Concreting shall not commence during the times of heavy rainfall. When directed by the Engineer to continue placing concrete during times of rainfall, the Contractor shall protect the work by covering to prevent water collecting in pools or washing away the concrete surface. Only sufficient area shall be uncovered at a time as will permit the deposition of one load of concrete.

1.17 Removal of Forms

The period of time elapsing between the placing of concrete and the striking of form work shall be approved by the Engineer after consideration of the loads likely to be imposed on the concrete and shall in no case be less than the period shown below:

Type of Structure Minimum Period before Stripping in days (exclusive of the day of concrete placement) Sides of foundation, column, wall, beam and slab, Under-sides of beam and slab Stripping of formwork within the time limits listed above does not relieve the Contractor from his responsibility for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

1.18 Failure to Meet Requirements

In the event of the strengths shown by the test specimen made and tested in accordance with the above provisions fall below the values given in Table 3.3, the Engineer shall have the right to request necessary changes to the mix proportions to apply to the remainder of the work. With the strength of evidenced by core and/or load tests, the Engineer shall have the right to request the Contractor strengthening or replacement of those positions or portions of the structure that failed to develop the required strength.

The cost of all such core borings and strengthening or concrete replacement required because strengths of test specimens are below those specified shall be entirely at the expense of the Contractor.

When the tests on control specimens of concrete fall below the required strength, the Engineer shall permit check tests for strengths to be made by means of typical cores drilled from the structure in accordance with ASTM Methods C42, "Obtaining and Testing Dried Cores and Sawed Beams of Concrete", and C39 "Compression Strength of Moulded Concrete Cylinders". In case of failure of the latter, the Engineer, in addition to other recourses may require at the Contractor's expense for a load tests on any slabs, beams, piles, pile caps and columns in which the particular concrete was used. Load tests need not be made until the concrete has aged 60 days.

1.19 Patching and Repairs

It is intended that the works with a quality forms combined with suitable mixes of concrete and workmanship shall not require any patching on exposed or forms stripped concrete surfaces. As soon as the forms have been stripped-off and the concrete surfaces exposed fins and other projections shall be removed; recesses left by the removal of form ties shall be filled and surface defects that do not impair structural strength shall be repaired. Clean all exposed concrete surfaces and adjoining work stained by leakage of concrete to the approval of the Engineer. Immediately after removal of forms, the Contractor shall remove plugs and break off metal ties as required hereinafter. Holes shall be promptly filled by moistening with water and followed with a 0.15 cm brush coat of neat cement slurry mixed to the consistency of a heavy paste. The hole shall immediately be plugged with a 1:1.5 mixture of cement and fine aggregate slightly damp to the touch (just short of "balling"). The grout shall be hammered into the hole until dense and until an excess of paste appears on the surface in the form of a spider web. The surface shall be trowled smooth with heavy pressure. Extreme care shall be taken to ensure that the color of the grout used to fill these holes the same as that of the parent concrete if necessary using a mixture of white and grey cements in order to obtain the correct shade.

The same sources of cement and sand as used in the parent concrete shall be employed for patching or repairing of exposed surfaces. The colour shall be adjusted if necessary with the

addition of proper amounts of white cement. The surface shall be rubbed lightly with fine carborundum stone at an age of 1 to 5 days in order to bring it even with the parent concrete. Care shall be exercised to avoid damaging or staining the virgin skin of the surrounding parent concrete. The surface shall be washed thoroughly to remove all rubbed matter. Defective concrete and honeycombed areas as determined by the Engineer shall be chipped down reasonably square and at least 2.5 cm deep to meet sound concrete by means of hand chisels or pneumatic chipping hammers. Irregular voids or surface stones need not be removed if they are sound, free of laitance and firmly embedded in the parent concrete subject to Engineer's final inspection. If honeycomb exists around reinforcement, the concrete shall be chipped to provide a clear space at least 1 cm wide all around the steel. For areas less than 3.8 cm deep, the patch may be made in the same manner as described above for filling form tie holes and care being exercised to use adequately dry (non trowel able) mixtures and to avoid sagging. Thicker repairs shall require build-up in successive 3.8 cm layers on successive days, each layer being applied as described above. Such repair shall be carried out with the prior approval of the Engineer who will determine whether the defective area is repairable or whether it shall be rejected.

1.20 Construction and Expansion Joints

1.20.1. Construction Joints

A construction joint is defined as a joint in the concrete introduced for convenience in construction at which special measures are taken to achieve subsequent continuity without provision for any relative movement. The Contractor is advised that water stops are not considered necessary in a properly formed construction joint. However, if the Contractor wishes to install water stops in construction joints to satisfy the requirements of these Specifications then the water stops shall comply with these Specifications and all costs shall be borne by the Contractor.

The Contractor shall submit to the Engineer for his approval, as soon as practicable after the commencement of the Work and not less than one week before the commencement of concreting, shop drawings showing his proposals for placing concrete on which the position and form of all construction joints and lifts shall be shown. No concreting shall be started until the Engineer has approved the method of placing, the positions and form of the construction joints and the lifts.

The construction joints shall be so located as not to impair the structural strength of the completed structure. The position of construction joints and size of formwork panels shall be well co-ordinated that where possible the line of any construction joint coincides with the line of a formwork joint and that in any case all construction joint lines and formwork joint lines appear as a regular and uniform series. For all exposed horizontal joints and purposely inclined joints, a uniform joint shall be formed with a batten of approved dimensions to give a straight and neat joint line. Rebates, keys or notches shall be formed and water stops inserted as required.

Concrete placed to form the face of a construction joint shall have all laitance removed and the coarse aggregate exposed prior to the placing of fresh concrete. Form retarding agent may be used to achieve easy removal of the surface concrete with the prior approval of the Engineer.

The laitance shall be removed and the coarse aggregate is exposed by "green cutting" - spraying the concrete surface with water under pressure and brushing while it is still green. With the Engineer's prior approval in writing while the concrete is still green the whole of the

concrete surface forming part of the joint shall be hacked to expose the coarse aggregate. Where aggregate is damaged during hacking it shall be removed from the concrete face by further hacking. All loose matters shall be removed and the exposed surface thoroughly cleaned by brushing, air blasting or washing and the surface to which the fresh concrete is applied shall be cleaned and damped. Thereafter, fresh concrete may be placed as described in section 1.14.

- Construction joints shall generally be located as follows:

Columns: Joints in columns shall be made at the underside of floor members and at floor levels. Haunches and column heads shall be considered as part of and continuous with the floor or roof.

Walls: Vertical joints shall be away from corners. Horizontal joints shall be above splays or openings. Construction joints shall be placed at intervals not exceeding 5.0 metres.

Ground slabs: Construction joints shall be placed at intervals not exceeding 5.0 metres.

An order of casting slabs and walls that gives free edges in two directions at right angles shall be followed as far as possible to reduce restraint to free contraction of the immature concrete. The proposed sequence of casting shall be submitted for Engineer's approval before commencement of concreting.

1.20.2. Expansion Joints

Expansion joints are defined as all joints intended to accommodate movement between adjoining parts of a structure and special provision shall be made where necessary for maintaining the water tightness of the joint. Expansion joints shall be formed in the locations and to the detailed dimensions indicated on the drawings. Joints where noted on the drawings shall be provided with PVC water stops, joint filler and joint sealer as specified in the drawings or in somewhere else of this specification.

The Contractor shall submit to the Engineer for his approval as soon as practicable after the commencement of the Work and not less than three weeks before the commencement of concreting, details of his proposals for the installation of water stops. These shall show where joints are to be located and details of the intersections and changes of direction to a scale that shows the position of any joint, or shape of any molded section.

Butt joints shall be employed for joining of water-stop on site in straight runs. Where it is agreed with the Engineer that it is necessary to make on site an intersection, change of direction or any joint other than a butt joint in a straight run, then a preliminary joint, intersection or change of direction piece shall be made and subjected to such tests as the Engineer may require. Flexible water-stops shall be fully supported in the formwork free of nails and clear of reinforcement and other fixtures. Damaged water-stops shall be replaced and during concreting care shall be taken to place the concrete so that water-stops do not bend or distort.

1.21 Field Control

The Contractor shall advise the Engineer of his readiness to proceed with placement of concrete at least 24 hours prior to such operation. The Engineer shall inspect the preparatory works for concreting including the surface preparation of previously placed concrete, the reinforcement, the alignment and tightness of the formwork. No placement of concrete shall be made without the prior approval of the Engineer.

The Engineer may have cores taken from any questionable areas in the concrete work such as construction joints and other locations as required for the determination of concrete quality. The results of tests on such cores shall be the basis for acceptance, rejection or determining the continuation of the concrete work. The Contractor shall co-operate in obtaining of cores by allowing free access to the work and permitting the use of any ladders, scaffolding and such incidental equipment as may be required. The Contractor at his cost shall repair all core holes to the satisfaction of the Engineer.

1.22 Sleeves, Pipes and Other Items

The Contractor shall place no concrete until reinforcing steel, pipes, conduits, sleeves, hangers, anchors, and other required works to be built into the structure have been inspected and approved. Water and foreign matters shall be removed from the forms and excavation. All sub-grade below slabs and footings shall be approved by the Engineer before placing concrete.

1.23 Equipment Bases

All steel leveling and bearing plates, machinery and other equipment and bearing on concrete surfaces shall be bedded on non-shrink grout and where necessary core holes for anchor bolts shall be fully grouted with non-shrink grout. The grout bed shall not be placed until the relevant member has been aligned, leveled, plumbed and finally secured in position. The exact dimensions for all equipment bases shall depend on the dimensions of the actual equipment furnished. No payment change shall be allowed if the dimensions are different from those shown on the drawings.

1.24 Non-Shrink Grout

To aid strength and bonding of multiple layers application of grout the Engineer may order the use of no shrink additive as follows:

Proportions Material Volume Weight

Cement 1.0 1.0 Coarse Aggregate 0.15 0.25 Fine Aggregate 1.5 1.5

Additives as recommended by the manufacturer

Non-shrink grout shall comprise of size-graded aggregate combined with a catalysing agent and water reducing agent. When used in the proportioning of grout, mortar and concrete mixes, shrinkage shall be

counter-acted and basic qualities improved. The Contractor shall demonstrate to the Engineer that the product has successfully been utilised on similar projects for a minimum of five (5) years. Preparation of surfaces, mix proportions, application procedures, and precautions shall be followed in strict compliance with the manufacturer's directions.

The Engineer may order the addition of pea gravel passing a 3/8" screen but retained on a 1/4" screen to the mixture for very heavy (generally formed) applications with the proportions modified as follows:

Proportions Material Volume Weight

Cement 1.0 1.0 Coarse Aggregate 0.2 0.33 Fine Aggregate 1.0 1.0 Pea Gravel 1.5 1.5

Additives As recommended by the manufacturer in case where coarse aggregate is employed in multiple layers on exposed faces, the final 1.2 cm shall be composed of 1:1.5 grouts without coarse aggregate.

SECTION - 2 CONCRETE REINFORCEMENT

2.1 Scope of Work

The Contractor shall provide all labor, materials, equipment and incidentals required for furnishing, fabricating and installing all steel bars, steel wire, and steel supports required for the reinforcement of concrete as shown on the drawings and specified hereinafter.

2.2 Shop Drawings

The Contractor shall submit bar bending schedules for reinforcing steel prepared in accordance with BS 4466. Engineer's review and approval of shop drawings shall apply to the sizes, locations, type of bars and dimensions of bar lap splices only. Dimensions shown on the shop drawings are the responsibility of the Contractor and Engineer's approval of shop drawings shall not constitute approval of dimensions there in.

2.3 Materials

Unless otherwise specified or required, the design, materials, workmanship and erection shall conform to the requirements of BS 8110 and BS 8007.

Reinforcing steel shall conform to BS4449:

- ☐ Hot rolled mild steel 250 N/mm² denoted as "R"
- ☐ High yield steel (hot rolled or cold worked) 460 N/mm² denoted as "Y"

The high yield steel shall be deformed bar type 2. Welded Steel Wire Fabric shall conform to BS 4483.

The Tie Wire shall conform to BS 4482 – 1.6 mm black annealed mild steel. Representative samples of all reinforcing steel that the Contractor proposes to use in the Works shall be submitted before the work commenced to the Engineer for his written approval.

Manufacturer's certificates to be provided by the Contractor shall clearly state the place of manufacture, relevant details of composition, strength and other qualities of steel.

Frequency of sampling and method of quality control shall be in accordance with Appendix C of BS 4449.

Welding if approved by the Engineer in writing shall conform to AWS D 1.4 or BS 5135.

Bar Size Table Nominal Diameter (mm) Weight (kg/m)

6 0.222 Round (Plain)	8 0.395 Round (Plain)	10 0.617 Deformed
12 0.888 Deformed	16 1.579 Deformed	20 2.466 Deformed
25 3.854 Deformed	32 6.313 Deformed	

Reinforcing bars shall be rejected if the weight of a bundle of one size of bars as delivered is underweight by 3.5 percent or more. An individual bar will be rejected if it is underweight by 6.0 percent or more.

2.4 Fabrication

Reinforcement shall be accurately fabricated to the dimensions indicated on the drawings. Particular care shall be exercised not to have stirrups oversized in order to maintain proper coverage of concrete.

Stirrups and tie bars shall be bent around a revolving collar having a diameter not less than two and one-half times respectively of the minimum diameter of the bar. Bends for other bars shall be made around a pin having a diameter not less than 6 times the minimum diameter except for bars larger than 25 mm

diameter, in which case the bends shall be made around a pin of 8 times bar diameter. All bars shall be bent cold. Bars reduced in section or with kinks or bends not shown on the drawings shall not be accepted.

2.5 Handling Materials

Reinforcement shall be stockpiled at the site of the work with bars of the same size and shape fastened in bundles with metal identification tags, giving size and mark, and securely wired on. The identification tags shall be labeled with the same designations as shown on submitted bar schedules and shop drawings. The Contractor shall submit the mill certified report of test for each shipment of reinforcing steel to the construction site. The certification shall contain the results of chemical and mechanical tests required by the Specification. All bars shall be stored off the ground and shall be protected from moisture and be kept free from dirt, oil, or injurious contaminants.

2.6 Installation

The reinforcing bars shall not be welded either during fabrication or erection without prior written approval of the Engineer. If the Engineer approves the welding of reinforcing bars, the Contractor shall submit a sample of a welded piece together with test results of its strength that shall not be less than such reinforcing bar. Any bars that have been welded including tack welds without such approval shall be immediately removed from the work when instructed by the Engineer.

The reinforcement bars shall be thoroughly cleaned of loose mill scale, dirt, and other coatings that reduce or destroy bond using sand blasting before being placed in position. The reinforcement bars shall be re-inspected and cleaned when there is a substantial delay in depositing the concrete after reinforcement is in place. Reinforcement shall be accurately positioned as indicated on the drawings and secured against displacement by using iron wire ties of not less than No.18 gauge or suitable clips at intersections. All accessories such as chairs and chair-bars are an integral part of the reinforcement and shall be furnished and installed in sufficient quantity to satisfactorily position all steel in accordance with 8110 "Code of Practice for Designs of Reinforced Concrete Structures" or ACI 315, "Manual of Standard Practice for Detailing Reinforced Concrete Structures".

Except as otherwise indicated on the drawings, bars in slabs, beams and girders shall be spliced in accordance with the table titled "Minimum Lap Splice Lengths" in BS 8110. Splices and laps in columns, piers and struts shall be sufficient to transfer full stress by bond. Splices in adjacent bars shall be staggered if required. Except as otherwise indicated on the drawings, reinforcement shall be installed with clearance for concrete coverage in millimetres as follows:

Footing bottoms 75 mm

Formed surfaces in contact with soil or exposed to the weather or water 50 mm

Columns, beams and walls 40 mm Top and Bottom steel of interior slabs 25 mm

Top and Bottom steel of internal Stairs 25 mm Top steel in reservoir slabs 50 mm

Bottom steel in reservoir slabs 50mm Interior face of walls 40mm

Reinforcement for the slab shall be supported on concrete cubes or wafers of the correct height. Wafers shall contain soft steel wires embedded therein for fastening to reinforcing bars. Wafers shall have a minimum compressive strength equal to that of the concrete in which they are to be placed and shall have been cured as specified for concrete. Masonry units shall not be permitted for supporting steel in bottom mats or elsewhere. The Contractor shall furnish extra steel supports such as channels if required and shall construct blocks of

concrete having the same quality as specified for the structure for use in supporting both top and bottom steel mat. Wood blocks, stones, brick ships, cinder blocks or concrete building blocks shall not be allowed. Alternate methods for supporting top steel in slabs such as vertical reinforcing fastener to bottom and top mats may be used if approved. Alternate methods of supporting bottom reinforcement for slabs and beams not exposed to the weather (such as plastic chairs, but not plastic tipped wire) may be used only if specifically approved by the Engineer.

Reinforcement for vertical surfaces (beams, columns and walls) shall be properly and firmly positioned away from the forms at all points by approved means. Reinforcement, which is to be exposed for a considerable length of time after being placed, shall be painted with a heavy coat of neat cement slurry.

In no case shall any reinforcing steel be covered with concrete until the Engineer has checked quantity and the position of the reinforcement and permission given to proceed with the concreting. The Engineer shall be given at least three days notice of the availability of the set reinforcement for checking.

2.7 Straightening Steel

Reinforcing steel shall not be bent or straightened in a manner that will injure the material. Any use of such injured reinforcing steel shall not be permitted.

SECTION - 3 CONCRETE FINISHES

3.1 Scope of Work

The Contractor shall furnish all labor, equipment and incidentals necessary to finish cast-in-situ concrete surfaces as indicated on the drawings and/or specified hereinafter. The finishes herein specified apply to the surface finish of cast-in-situ concrete, as it is to be in the finished work to receive additional covering such as plastering.

3.2 Work Specified Elsewhere

Painting of concrete, architectural finish coverings, roofing, damp proofing and waterproofing are specified elsewhere. Repairs to existing concrete as required to make it suitable for bonding to new concrete or if it is to remain exposed are specified herein.

3.3 General

All concrete surfaces including those not exposed in the finished work such as those that are buried or covered by other material interior of pipeline structures (i.e. man-holes) in accessible locations shall have all fins burrs and projections removed. The holes and honeycomb areas shall be filled and patched. Care shall be exercised to prevent rounding chamfered edges or obliterating the bevel line when removing the forms or doing any other work adjacent thereto.

Dusting of surfaces with dry materials to absorb moisture or to stiffen the mix will not be permitted.

Sprinkling of water as an aid to troweling shall not be permitted. The top surfaces of all concrete including separate concrete toppings and walls shall be applied with compacted screed and floated. The Contractor shall protect the finished floors from damage by laying protective timbers and minimising traffic over the areas.

3.4 Types of Finishes for Cast-In-Situ Concrete

3.4.1. Cleaned and Patched

All concrete surfaces whether they are exposed or not in the finished work shall be cleaned and patched as specified in Part I - sub-section 3.1.19 "Patching and Repairs".

3.4.2. Vertical Surfaces

Vertical surfaces and the undersides of all slabs and beams shall be finished in accordance with the following schedule unless otherwise indicated on the drawings.

Surface Identification Type of Finish

Exterior surfaces:

Buried Formed	Exposed Carborundum	Painted Rubbed	Tile, etc. Rough
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Interior Surfaces:	Submerged Carborundum	Exposed Rubbed	Tile, etc. Rough
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Painted Rubbed	Miscellaneous:	Stairs except treads	Carborundum
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Equipment pads	Carborundum	Surfaces not readily seen	Formed
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Plastered Rough

3.4.3. Types of Finishes

The following section describes the types of vertical finishes:

(i). Carborundum Finish

Surfaces shall be rubbed with cement or carborundum bricks and water to remove form marks and similar blemishes leaving the surface finish uniformly smooth and washed clean.

(ii). Rough Finish

Concrete surface shall be roughened by means of green cutting, hammering or other means to provide a surface texture that will develop a good mechanical bond. The concrete shall be free from paint, oil, dust or any material that might prevent satisfactory bond. Air and water shall be used to remove loose material. Hammering shall be done by hand or power tools to expose clean virgin concrete (mortar or aggregate) over the entire surface. Not more than 10 percent of the surface (in any unit of area) shall remain un-chipped.

(iii). Rubbed Finish

Any fins on the surface shall be carefully removed with a hammer immediately upon stripping forms and before concrete has changed in colour. While wall is still damp apply a thin coat of medium consistency neat cement slurry by means of bristle brushes to provide a bonding coat within any pits or blemishes in the parent concrete and avoid coating large areas of the finished surface with this slurry.

Apply a dry (almost crumbly) grout comprising one volume cement to 1-1/2 volume of clean masonry sand having a fineness modulus of approximately 2.25 before the slurry has dried or changed colour. Grout shall be uniformly applied by means of damp (neither dripping wet nor dry) pads of coarse burlap approximately 15cm square used as a float. Grout shall be well scrubbed into the pits to provide a dense mortar in the imperfection to be patched. Allow the mortar to partially harden from one to two hours depending upon the weather but avoid direct hot sunlight. If the air is hot and dry keeps the wall damp during this period using a fine fog spray. Cut off all excess grout that can be removed with the trowel when the grout has hardened sufficiently so it can be scraped from the surface with the perpendicular edge of a steel trowel without damaging the grout in the small pits or holes. Grout allowed to remain on the wall too long will get too hard and will be difficult to remove.

Allow the surface to dry thoroughly and rub it vigorously with clean dry burlap to completely remove any dried grout. No visible film of grout shall remain after this rubbing. The entire cleaning operation for any area must be completed the day it is started and never leave any grout on the wall overnight. Allow sufficient time for grout to dry after it has been cut with the

trowel so it can be wiped off cleanly with the burlap. This process removes slight discoloration and stains and gives a uniformly good appearance without effect on a paint coating.

On the day following the repair of pits and blemishes, the walls again shall be wiped off clean with dry used pieces of burlap containing old hardened mortar which will act as a mild abrasive.

There shall be no built-up film remaining on the parent surface after this treatment. However, if such film is present, a fine abrasive stone must be used to remove all such material without breaking through the surface film of the original concrete. Such scrubbing should be light and sufficient only to remove excess material without working up a lather of mortar or changing the texture of the concrete.

A thorough wash-down with stiff bristle brushes should follow the final scrubbing operation in order that no extraneous materials remain on the surface of the wall. The wall should be sprayed with a fine fog spray periodically to maintain a continually damp condition for at least 3 days after the application of the pit repair grout.

Areas larger than 2.5 cm diameter or 1.25 cm deep shall be "day-tamp filled" as for form tie holes. Moisten the hole with water, followed by a 1.6 mm brush coat of neat cement slurry mixed to the consistency of a heavy paste. Immediately plug the hole with a 1:1.5 mixture of cement and sand mixed slightly damp to the touch (just short of balling). Hammer the grout into the hole until dense and an excess of paste appears on the surface in the form of a spider web.

Trowel smoothly with heavy pressure and employ same source of cement and sand as used in the parent concrete. Adjust color if necessary by addition of proper amounts of white cement and/or limestone screenings. Rub lightly with a fine carborundum stone at an age of 1 to 5 days if necessary to bring the surface plane with the parent concrete. Exercise care to avoid damaging the virgin skin of the surrounding parent concrete. Wash thoroughly to remove all rubbed matter. The color matching may be omitted if the surface ultimately is to be painted.

No accelerating admixtures shall be employed in surface treatment. An approved admixture may be utilized (in accordance with the manufacturer's directions) to reduce shrinkage and improve durability of the 1:1.5 mixture.

(iv). Formed Finish

All fins and other projections shall be carefully removed, honeycombing repaired, form ties cut out and holes patched all as specified under Part II - sub-section 2.1.19 "Patching and Repairs".

3.4.4. Horizontal Surfaces

The top or final surface of all concrete shall be finished in accordance with the following schedule unless otherwise indicated on the drawings.

Surface Identification Type of Finish

Floors scheduled to be concrete floor Wood float

Reservoirs and tanks interiors Light steel trowel

Exposed roof slabs without built-up roofing Wood float

Exposed roof slabs with built-up roofing Steel trowel

Equipment pads Steel trowel

Tile Light steel trowel

Vinyl asbestos tile Steel trowel

Pavements, walks and ramps Broomed

Buried roof slabs Screeded

Stair treads, interior Broomed

Platforms Broomed

Plastering Broomed

3.4.5. Methods of Finishing

The finishing of concrete surfaces shall not be started until some stiffening of the concrete has taken place. The following section describes the types of horizontal finishes.

(i). Screeds

Screeds shall be set as guides so that slabs can be struck true to the required level or slopes shown. Particular care shall be exercised to prevent forming low or depressed areas that do not drain and result in pounding. Screeds shall be sufficiently rigid to resist distortion during the placing and leveling of the slab and shall be accurately set and protected until they are removed. Screeds and their supports shall be completely removed and their recesses filled.

(ii). Wood Float

Following application of screed on the surface to its required level, a wood float straight edge shall be worked across the surface to make sure high spots and depressions are eliminated. Floating shall be continued just long enough to produce a true and smooth surface and if steel trowel finish is required to bring a small amount of mortar to the surface.

(iii). Broomed

Concrete floors and slabs such as bridge decks and pavements where a non-slippery surface is required shall receive following an application of screed a broomed surface. As soon as the condition of the concrete permits and before it has hardened appreciably (normally within 4 hours after depositing), water, inadvertent film, crude laitance and loose aggregate shall be removed from the surface by means of wire or bristle brooms in such a manner as to leave the coarse aggregate slightly exposed and the surface clean and generally in condition to provide a non-slippery surface. The brooms shall "roll" the film and laitance (if any) from the slab and leave it clean. Avoid "muddying" the surface by brooming too soon. Raking shall not be employed, and large depressions and general unevenness shall not be allowed.

If the surface finish is not properly done and the resulting surfaces are unsatisfactory, the Contractor shall chip the surface to the satisfaction of the Engineer.

(iv). Steel Trowel

Steel troweling may be commenced as soon as the wood floated surface has hardened enough to prevent an excess of fines from working to the surface. This operation is to be performed by power driven troweling machines as approved by the Engineer to produce a dense smooth surface free from blemishes. Troweling too soon or excessive troweling in one operation produces an unsound finish. Where a light steel trowel finish is specified light hand troweling shall be used.

3.5 Cement Plastering

3.5.1. General

Plastering shall consist of Portland cement plaster applied to the limits and lines indicated on the drawings. The thickness of plastering indicated on the drawings is the minimum thickness required and additional thickness shall be required to provide for any unevenness in the masonry surface. In the event the average complete plaster thickness over an area in excess of 5 square meters will exceed 5 cm, a galvanized wire reinforcing square mesh of weight not less than 1.4 kg/sq. m shall be attached to the masonry and plastered into base coat. Before plastering all grounds and corner bends shall be firmly secured in place. Concrete masonry and brick surfaces shall have sufficient roughness to provide proper bond and shall be

dampened by brushing or spraying with clean water followed by a primary coat of Portland cement. Where the finished plastering is to be greater than 2 cm thick, it shall be applied in two coats, a base course of not less than 1.5 cm thick and a finish coat of not to exceeding 0.5 cm thick.

The base coat of plastering shall be of a mix proportion of 350 kg of cement, and one (1) cubic meter of medium sand. The finish coat shall be in the proportion of 280 kg of cement and one (1) cubic meter of medium sand. Leaner mixes shall only be allowed with the permission of the Engineer. The sand shall be clean, durable particles, free from injurious amounts of organic matter and shall conform to the limits of ASTM C144, "Aggregate for Masonry Mortar."

Before the base coat has hardened it shall be evenly scored to assist in bonding the finish coat.

When the base coat has hardened enough to receive the finish coat it shall be dampened and the finish coat applied. The finish coat shall give the appearance of a rubbed finish herein before specified or as otherwise required to match surrounding surfaces. Plastered surfaces shall be shielded from the direct rays of the sunlight for two days and shall be kept moist but care shall be taken not to wash out cement.

3.5.2. Repair of Damaged Concrete

Where concrete is cut and removed to provide for new work, concrete surfaces will be formed which will require finishing. The two surface conditions considered herein are namely, damaged surface that are to be cleaned and plastered and exposed in the finished work; and the surface to be incorporated in the new work. The only requirement for damaged concrete surface not to be exposed is that reinforcing steel be cut off flush with the concrete surfaces. Bonding existing concrete to new structural concrete and damaged concrete against which new concrete is to be placed shall be thoroughly cleaned to remove any loose concrete. Reinforcing steel shall be straightened and incorporated in the new work as required. A neat mix of cement slurry shall be applied to the existing surface just prior to placing new concrete. Plastering of existing concrete damaged in connection with the new work and exposed to view shall be in conformance with the above specification with the added requirement that a bonding admixture be incorporated into the plastering cement. The bonding admixture shall be an additive to the concrete mix made from natural or synthetic rubber or an organic polymer or copolymers and applied in accordance with the manufacturer's instructions.

3.6 Other Surfaces

All exposed edges shall be chamfered as specified on each side unless otherwise noted on the drawings.

Care shall be exercised to prevent rounding these edges or obliterating the bevel line when removing the forms or doing any other work adjacent thereto.

3.7 Cleaning

All exposed concrete surfaces and adjoining work stained by leakage of concrete shall be thoroughly cleaned.

SECTION - 4 CONCRETE JOINTS

4.1 Scope of Work

The Contractor shall provide all labour, material, equipment and incidentals required to furnish and install all joints in structural concrete as detailed on the drawings and specified

herein. Included are the materials required to complete expansion, contraction and construction joints including water-stops, joint fillers and sealant.

4.2 General Requirements

(1). Water Stops

All vertical and horizontal expansion joints in concrete slabs and peripheral walls of structures and conduits conveying or containing liquid shall have water-stops unless specifically noted otherwise on the drawings. This requirement does not apply to construction joints.

(2). Suppliers

All concrete jointing elements herein specified shall be furnished by a supplier that can give satisfactory evidence to the Engineer that they are capable of supplying the quantities for the schedule required and has an organization that is knowledgeable in the installation of these systems. A competent representative of the supplier shall instruct in the installation of these systems.

4.3 Materials

4.3.1. Water-stops

Samples of all materials to be furnished under this Section shall be submitted to the Engineer for approval.

- Materials shall be sourced and supplied by a single manufacturer with a minimum of ten years of production experience of relevant material.

- Manufacturer shall operate a quality system, which is registered to ISO 9001 standard or similar.

- The manufacturer at no additional cost shall provide technical back-up service during installation to the Employer whenever required.

- Material

- a). Unless otherwise specified all water-stops shall be extruded from a high grade elastomeric polyvinyl chloride compound as basic resin and manufactured from virgin materials necessary to meet the performance requirements of this specification.

- b). Comply with the requirements of BS 2782 or US Corps of Engineers specification CRD C572-74.

- c). Suitable for storage, handling, installation and service within a temperature range of 15o C to 50o C.

- d). Shall be dumbbells type both for internal and external rear guard as specified in the drawings. The water-stops shall have dumb bells 250 mm width with a centre bulb, minimum web thickness of 9.5 mm. The centre bulb shall have a minimum inside diameter of 20 mm & minimum outside diameter of 40 mm. The edge rib shall have a dumb bell of minimum of 25 mm diameter. The external or rear guard water stop shall be 250 mm wide with three bulbs. The centre bulb shall be a box section 25 mm wide that is flat to accept a filler board. To prevent the water-stops folding during concreting & assist in keeping firmly in position all water stops shall be provided with steel chips along both edge ribs at spacing not more than 500 mm.

The water stop shall be held firmly to the reinforcement steel to the satisfaction of the Engineer with wire of No.12 gauge.

- e). Intersection & Transition pieces shall be performed factory moulded type and or factory prefabricated type.

- Site jointing shall be limited to butt joints and shall be strictly in accordance with the manufacturer's instructions.
- Joints shall be heat-sealed.

f). Physical Properties:

Property Test Method	Minimum	Requirements	Tensile Strength
Ultimate Elongation	Tear Resistance	Stiffness in Flexure	Hardness, shore A/15
Water Absorption	Specific Gravity	Volatile Loss	Charge
Elongation after accelerated extraction		Tensile Strength after accelerated extraction	
Low Temperature Brittleness		Effect on Alkali after 7 days: Weight	
Hardness Change			
ASTM D 638	ASTM D 638	ASTM D 624	ASTM D 747
ASTM D 570	CRD – C 572	CRD – C 572	ASTM D 792
ASTM D 1203	CRD – C 572	14.5 N/mm ²	ASTM D 2240
			ASTM D 746

Testing shall be carried out in accordance with BS 2782 or US Corps Engineers specification CRD C572-74.

4.3.2. Joint Filler Board

- ☐ Non-absorbent, semi rigid, cross-linked closed cell, heat laminated polyethylene filler board.
- ☐ Non-tainting and rot proof in accordance with BS 6920
- ☐ Fully compatible with the surface sealant and if elastomeric sealant are used the joint filler shall act as a bond breaker.
- ☐ Sheet form in one layer to the thickness as detailed on the Drawings.
- ☐ Performance Properties:
 - a. Recovery : greater than 98% after 50% compression
 - b. Water Absorption : < 0.05% by volume
 - c. Compressive Strength : min 0.15 N/mm²
 - d. Density : 100kg/m³ ± 5kg/m³
 - e. Extrusion : Nil (three edges restrained & sample compressed by 50%)

4.3.3. Joint Sealant

- 1) Two part poly-sulphide complying with BS 4254 or FS TT-S-00227E Type II, Class A.
 - a) Shall in all cases be carefully selected as appropriate for their intended climatic and Environmental exposure
- 2) Hardness Shore A : min 25
- 3) Movement Accommodation Factor : min 25%
- 4) Polymer Content : min 25% (for normal grade)
- 5) Resistance to weathering, ozone, ultra-violet light, chemicals and biodegradation
- 6) Ability to withstand repeated cycles of compression and expansion over a wide temperature range

4.3.4. Bond Breaker

Forced, non-absorbent polyethylene backing strip or equals as recommended by sealant manufacturer to prevent adherence of sealant to backup material

4.3.5. Slip Membrane

- ☐ Pre-formed low friction bearing strip to form a thin sliding joint minimum bearing capacity of 0.7 N/mm²
- ☐ Extruded from specially formulated polyethylene to form a durable lamina, resistant to most chemicals, solvents and weathering.
- ☐ Applied in two layers with bottom layer bonded to substrate with high quality solvent

borne adhesive based on poly-chloroprene rubber.

- Thickness 1.5 mm
- Coefficient of friction 0.15
- Operating temperature up to 500C.

4.3.6. Sealing Strip Membrane

Expansion joints shall be sealed with a sealing strip system where indicated on drawings. The joints shall be pre-sealed using sealant prior to laying sealing strip membrane. Sealing strip system shall comprise of hypalon high-polymer flexible sheeting bonded to the concrete surfaces on either side of joint using suitable epoxy resin adhesive. The system proposed shall have high performance allow for considerable movement in more than one direction while maintaining a high quality seal. Width of flexible membrane shall be 250 mm and minimum thickness shall be 3.0 mm. Minimum un-bonded width shall be 50 mm centre on the joint to allow for greater movement potentials. Final sealing strip system shall be able to accommodate movement, which results in the de-bonded area being extended up to 100% of the de-bonded width.

Performance properties shall be as follows:

- Density : 1.65 kg/litre (adhesive) 1.50 kg/m² (hypalon Lmm)
- Service Temperature : - 300C to + 700C
- Bond strength to concrete : Dry or Damp = -4N/mm² (concrete failure)
- Tensile Strength : - 6N/mm²
- Peel Strength : - 4.5 N/mm²
- Elongation : > 400%

4.3.7. Waterproof Membrane.

Waterproof membrane shall be self-adhering sheet membrane consisting of rubber modified asphalt compound such as Bituthene 1000 coated to one side of a polyethylene film. The membrane shall have a minimum overall thickness of 1.5 millimetres and a tensile strength of 140kN/sq. cm and shall in all respects comply with the requirements of BS 102.

Primer: Special compound provided by the self-adhering manufacturer formulated for its intended use.

Installation: The reservoir roofs and sump roofs shall be protected with self-adhering water proofing membrane.

Over the cleaned concrete surface the Contractor shall apply primer in manner and using quantities in accordance with the membrane manufacturer's printed instructions. The Contractor shall apply the self-adhering membrane to the concrete without stretching with polyethylene face out after the primer has dried. It shall be smoothed down with a small roller. The contractor shall apply the membrane sheets with 120 mm overlaps at edges and ends, rolled down firmly and completely.

4.3.8. Bearing Strips

The bearing strips shall have bearing core 50 mm or 75 mm made out of Elastomeric neoprene conforming to Standard Specification for Highway Bridges adopted by the American Association of State Highway Transportation or to BS 5400.

Performance properties shall be as follows:

Safe load capacity =100 kN/m length

Overall displacement = 2 ± 10 mm (initial 7 mm followed by working movement of ± 3 mm transverse ± 2.0 mm longitudinal)

The bearing area shall be surrounded with expanded polystyrene to facilitate in-situ pouring of

superstructure concrete. An adhesive shall be used (non solvent type) to fix the bearing pad to the base concrete.

4.4 Installation

Water stops for all joints shall be continuous around all corners and intersections. Splices shall be made in accordance with the manufacturer's recommendations subject to the approval of the Engineer.

Particular care shall be taken to correctly position the water-stop during installation and prevent it being moved or distorted by the concrete placement. The water-stops shall be thoroughly cleaned immediately prior to placing concrete. Adequate provision shall be made to support the water-stop during the progress of the work and to ensure proper embodiment and symmetrical about the joint. When PVC water stops are to be left for future connections they shall be protected by wooden covers.

Joint filler shall be installed at the locations and according to the details shown on the drawings. Joint sealants shall be placed to the width and depth shown on the drawings. Surfaces in contact with sealants shall be clean, dry and firm with all traces of form oil or other coatings removed. Preparation of surfaces, priming, and the handling and preparation of materials shall be in complete compliance with the manufacturer's instructions.

SECTION - 5 TESTING OF CONCRETE STRUCTURES

5.1 General

The contractor in the presence of the Engineer shall carry out hydraulic pressure test or leaking test for pipelines, reservoirs, tanks and conduits prior to acceptance by the Employer. Pressure tests shall ensure that the system as constructed is structurally adequate and sound to withstand the anticipated pressures. The leakage tests shall ensure that leakage either out of or into the units is in compliance within the requirements of these specifications. The contractor shall be responsible for supplying the required potable water for testing. In addition, the contractor shall furnish all labour, fuel, oil, grease and power requirement for testing purposes. The contractor shall furnish suitable temporary service connections, testing plugs or caps, pressure pumps, pipe connections, meter pressure gauges, thrust supports and other equipment required to carry out tests. No water shall be pumped into tanks, conduits or channels or tests commenced in anyway without the Engineer's approval.

5.2 Leakage Tests for Structures

Water retaining concrete tanks, intakes, conduits and channels shall be tested for leakage prior to put into operation. The leak tests shall be performed before the structure is backfilled and application of any water proofing material. Any remedial pre-treatment of the structure for cracks, leaking joints, seepages etc. found shall be attended with the agreed method statement for repairs. Subsequent to proper repairs of all visible leakages, by filling with water to their normal operations level all water retaining structures shall be tested individually. The test procedure shall be in accordance with the BS 8007(1987); section 9.0 or equivalent as approved by the engineer for concrete structures.

Structures shall be adequately cleaned prior to testing and initially be filled with water of accepted quality at a uniform rate of not greater than 2m in 24hours. Stabilizing period of seven days shall be kept for healing autogenously and 24 hours test period shall then be followed to ascertain permissible drop in water level allowing tolerance for evaporation and rainfall. The total leakage for any unit for a period of twenty-four (24) hours shall not exceed

0.1% of the volume of water contained in the unit. In the event of unsatisfactory test results for any of the conduit or channel, the structure shall be carefully examined for any possible defects after emptying. Repairs shall be effected by grouting, cutting out or remaking joints as directed or by any other approved method. The tests shall be repeated until the leakage is within the acceptable limit. When leakage is allowed as infiltration, it will be measured by means of V-notch weir, pipe spigot or by plugs in the end of the pipe to be provided and installed by the contractor in an approved manner and at such times and locations as may be directed by the Engineer.

5.3 Testing of Service Reservoirs

Service reservoirs and other storage are required to be tested for water tightness before being put into service. Each reservoir compartment shall be tested separately with the other compartment empty. The compartment to be tested shall be filled to a test level of about 75mm below the overflow sill with treated water at a uniform rate not exceeding 2 m vertical rise in water level per 24 hours. It shall be then left to stand for at least 7 days to allow for absorption of water into the concrete. The water level shall then be measured and recorded using a hook gauge with vernier control or by other approved means of no less accuracy and the water allowed to stand under the test for 7 days. The water level shall be measured and recorded at least once each day during this period. During the 7-day test period, the effects of evaporation from the water surface can be reduced by closing all air vents and access openings except for one vent left open for pressure balance.

Any flows in the under-drain and wall drain systems shall be measured and recorded throughout the test, from a time at least 24 hours before beginning to fill, until 24 hours after emptying or on completion of a final water level measurement. Taking such measurements in chambers on the drain systems normally require safety precautions appropriate to confined spaces. The outfall of all pipes connected to the reservoir shall be inspected during the test to ensure that all isolating valves are shut tight. Any significant leakage through them shall be measured. In some circumstances it may also be necessary to keep records of evaporation losses from the water surface.

The test may be deemed successful if the drop of water level over the 7-day test period does not exceed the lesser of $1/500 \times$ average water depth or 10mm, after deducting any measured leakage through valves and making allowances for any evaporation or condensation. If the test fails, any increase in under-drain or wall drain flow during the test period shall be investigated to identify, if possible, the part of the reservoir that leaked. The test compartment shall then be emptied and closely inspected for faults likely to cause the leakage.

It shall be understood that the reservoir leakage investigation can be troublesome and time consuming.

The interior of the reservoir – especially any joints – shall be closely inspected before filling with water, and care is needed in setting up and using the flow measurement devices.

is higher than 5 mg/l after twenty-four (24) hour, the