



Addendum No. 05, Item No. 20, Attachment-4

6. Waterproofing

6.1 General

6.1.1 A manufacturer shall have minimum 10 years of experience in manufacturing waterproofing product of the type specified, able to provide test reports showing compliance with the specifications, and able to provide on-site technical representation to advise on installation.

6.1.2 The installation shall be carried out either by the manufacturer or his approved applicator having experience of minimum 10 years in application of waterproofing products in underground structures. The waterproofing shall be carried out by manufacturer's applicators strictly in accordance with the recommendations of the manufacturer.

6.1.3 All waterproofing systems shall be guaranteed for a minimum period of ten (10) years from the date of completion of the Defects Notification Period. The guarantee shall cover the whole of the waterproofing systems and shall be given jointly and severally by the Contractor, Manufacturer and/or Applicator.

The Contractor shall submit additional Performance Bank Guarantee (PBG) for waterproofing works (for 10% of the cost of waterproofing item only) which shall be valid for the entire guarantee period of 10 years. The Contractor shall submit PBG in format acceptable to Engineer 28 days before the completion of the Defects Notification Period.

6.2 Structural Concrete Works

6.2.1 Concrete Joints

- a) The Contractor shall construct his concrete works so as to minimise the likelihood of water penetration.
- b) Before placing new concrete against concrete that has already hardened, the face of the old concrete shall be treated in accordance with Clause 4.11 of this Division.
- c) Should such concrete be found to leak or to have moist patches, the affected concrete shall be rectified by injection of resin material, breaking out and recasting, or other methods of sealing within the concrete, as approved by the Engineer.
- d) Inside rendering shall not be accepted as a method of making joints watertight.

6.2.2 Water stops

All water stops used in the works shall be of PVC material and of type appropriate to the location. The water stops shall be installed so that they are securely held in their correct positions whilst the concrete is being placed. No holes shall be made through



any water stop except where provided for by the manufacturer.

6.2.3 Fillers and Sealant to Joints

All materials used to fill joints shall be such that they will allow the calculated movements of the joints without extrusion and shall not shrink away from surface of the joints.

The Contractor shall obtain approval from the Engineer for backing strips, fillers and sealants which shall be used in accordance with the manufacturer's recommendation.

All fillers of polysulphide or polyurethane sealant shall comply with BS 4254 or BS 5212.

The appropriate sealant grades shall be used for horizontal and vertical joints. The joints shall be thoroughly cleaned and primed with the appropriate primer before applying the sealant. The sealant shall be of a colour to match as nearly as possible the colour of the adjoining surfaces where it is to be permanently exposed.

The sealing material shall be used and applied strictly in accordance with the manufacturer's instructions. The Contractor shall not smear sealant over adjacent surfaces, and appropriate precautionary measures, including the use of masking tape, shall be taken to avoid this.

6.2.4 Cleaning and Preparation of Surfaces

All cracks on the exposed concrete surfaces of external structural members shall be effectively sealed before applying any waterproofing system. The Contractor shall ensure that surfaces to which waterproofing is to be applied, shall be clean, dust-free and dry. The water stops in the joints shall be provided as shown in the Drawings.

6.2.5 Waterproofing underground structures

The following requirements are applicable to all underground structures where fully bonded PVC membranes, liquid polymer membrane with solvent free hybrid polyurea polyurethane/ polyurea/ polyurethane and crystallization based treatment have been specified:

- a) All components and elements, which are required to make the structures watertight, shall be demonstratable and proven to work together. There shall be a single source of responsibility and performance of the materials and products. Specifically, material and water stops shall be manufactured out of virgin raw materials and only from the same formulation of raw material. The manufacturer shall confirm full, demonstratable and proven compatibility of the entire waterproofing system in writing. The waterproofing system provided shall be installed without damage and protected against construction operations. The Contractor shall carry out a trial application of the waterproofing and submit the report containing the details and method statement to obtain approval from the Engineer.
- b) The water tightness standards applied to all underground structures, shall be in



accordance with the standards defined in Table 6 below:

Table 6: Water Tightness

Structural Element and Areas of Waterproofing	Category as per IS 16471	Description of Category
1) All roof slabs 2) Suspended slab over tracks, concourses, and public areas, areas with sensitive electrical and mechanical plant and areas where leakage would, in the opinion of the Engineer, affect the operation of the MAHSR or other operations within the structure. 3) In-situ, retaining walls and slabs to which finishes are applied 4) In-situ base slabs with no finishes	A	Free from all visible leakage, seepage and damp patches

Note: “Dampness” shall be defined as moist to touch with no visible film of water.

6.2.6 Fully Bonded PVC membrane below Base Slab and behind Confined Retaining Walls:

- a) System and properties of materials:
 - (i) Minimum 2.00 mm thick fully bonded PVC membrane, with hot air welded overlaps of minimum 100mm with a weld size of min 75mm; conforming to basement waterproofing protection to Grade 3 as per BIS 16471.
 - (ii) The membrane shall be installed by the manufacturer/applicator after approval has been obtained from the Engineer.
- b) The above waterproofing membrane shall have minimum requirement of properties as specified below:
 - (i) Resist hydrostatic pressure of over 50m head of water as per ASTM D 5385.
 - (ii) Puncture Resistance of over 1200 N (+ 5% to 10%) as per ASTM E154.
 - (iii) Peel Adhesion to concrete of 880 N/m as per ASTM D 903.
 - (iv) Tensile strength ≥ 20 MPa (longitudinal direction), ≥ 18 MPa (transverse direction) as per ASTM D412.
 - (v) Percentage of Elongation $> 275\%$ (longitudinal direction), 250% (transverse direction) as per ASTM D 412.
 - (vi) UV Exposure limit - 45 days pass. Minimum adhesion to concrete after 45 days UV exposure shall be 800N/m as per ASTM D 903.



c) Codes and Standards for reference:

Code and Standard Number	Code and Standard Title
BIS 16471	Protection of Below Ground Structures Against Water from the Ground
ASTM D5385	Standard Test Method for Hydrostatic Pressure Resistance of Waterproofing Membranes
ASM E 154	Standard Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, as Ground Cover
ASTM D 903	Standard Test Method for Peel or Stripping Strength of Adhesive Bonds
ASTM D 412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
DIN 16726	Plastic Sheets Testing
ASTM D 2240	Standard Test Method for Rubber Property—Durometer Hardness

6.2.7 Spray-applied liquid coating for Unconfined Retaining Walls and Roof Slab - External side (in contact with ground/water)

a) System and properties of materials

Fully bonded spray-applied liquid polymer two component, solvent free, hybrid polyurea polyurethane/ polyurea/ polyurethane applied elastomeric seamless membrane of minimum 2 mm Dry Film Thickness shall be used. Dry Film Thickness (DFT) to be achieved in minimum 2 coats (of two different contrasting colours), over and above one coat of a solvent free two component epoxy primer. No sand broadcast layer is permitted in the system. The system must be such that it is thixotropic, can be applied by airless spray; as well as the same product shall be capable of being applied manually only for local detailing and patch repairs (maximum area 1 m²). Wet Film Thickness (WFT) measurement shall be done at every 10 to 12 m² during application to check thickness and thereby not requiring destructive testing for thickness measurement. The product shall be applied in accordance with the manufacturer's instructions.

b) The waterproofing membrane shall have following minimum properties:

- (i) Tensile strength > 15 MPa as per ASTM D 412.
- (ii) % Elongation > 300% as per ASTM D 412.
- (iii) Bond strength on concrete > 2 MPa as per ASTM D 7234.



- (iv) Minimum crack bridging capability of over 2.5 mm.
 - (v) Resist hydrostatic pressure of over 50m head of water as per ASTM D5385.
 - (vi) Specific Gravity of 1.15 ($\pm 10\%$).
- c) The waterproofing system shall be suitably protected prior to backfilling with a protection board with minimum thickness of 25 mm complying to the specifications mentioned at clause 6.2.10 below.
- d) Codes and Standards for reference:

Code and Standard Number	Code and Standard Title
ASTM D 412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension
ASTM D 7234	Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesin Testers.

6.2.8 Application area of admixtures to concrete – Slab & Retaining wall (in contact with water/ground and as specified in Table 6)

- a) System and properties of materials

Integral full section crystallization based waterproofing treatment consisting of crystalline Admixture shall be added into the concrete of the slab and retaining walls at a dosage rate of 1.5% by weight of the cementitious contents of the concrete (subject to maximum of 4.5 kg per cum.) as per design mix approved by the Engineer. Crystalline Admixture shall conform to ASTM C-39 standard for compressive strength of concrete for Admixtures and shall have Nil water permeability as per BS EN 12390 Part-8 and shall have chemical resistance to withstand pH range between 3 to 11 in constant contact as per ASTM C-267-77. Admixture shall be completely non-toxic as per BS 6920: Section 2.5 and compatible with potable water. Admixture shall not adversely affect the compressive strength of concrete or workability of the concrete in any manner and therefore, shall not require any major change to the existing concrete mix design.



b) Codes and Standards for reference:

Code and Standard Number	Code and Standard Title
BS EN 12390 Part 8	Testing Hardened Concrete. Depth of penetration of water under pressure
ASTM C - 267-77	Standard Test Methods for Chemical Resistance of Mortars, Grouts, and Monolithic Surfacing and Polymer Concretes, American Society for Testing and Materials (ASTM) International.
BS 6920	Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of the water

6.2.9 Starter and construction joint treatment shall be of polybars (non-bentonite) hydrophilic swellable water bar of 25mm x 15mm cross-section or typical with the approval of the Engineer.

System and properties of materials - Solvent free elastic polyacrylic injection resin having the following properties as a minimum requirement:

- a) Chemical Base: 3-part polyacrylic resin.
- b) Density:
 - (i) Component A (Resin) ~ 1.10 kg/l (at +20°C).
 - (ii) Accelerator ~ 1.10 kg/l (at +20°C).
 - (iii) Hardener powder ~ 1.10 kg/l (at +20°C, after dissolution in water).
- c) Viscosity of mixture ~ 3-11 M Pa. s (at 20°C).
- d) Tensile strength > 2.5 MPa.
- e) Elongation > 350%.
- f) Adjustable curing time between 8 and 50 minutes.
- g) Capable of reversibly absorbing (swelling) about 75% by weight and releasing (shrinking) moisture.
- h) High pH value of 9 to 10.
- i) Expansion in water 500% (+5%)
- j) Expansion in concrete 425% (+5%)

6.2.10 Polystyrene boards

The waterproofing membrane shall be protected by a minimum of 25 mm thick expanded high duty polystyrene boards or similar material where the Contractor has obtained approval from the Engineer and shall be as per BS 3837, with an adhesive which has no adverse effect on the material or the polystyrene board. Backfilling shall be carried out progressively as the boards are fixed in position and in any case not



more than one complete board shall be left entirely exposed of the progressive protection wall.

The properties of polystyrene boards shall be as listed in Table 7 below.

Table 7: Physical property requirements

Physical property	Type	Method of test
	SD	
Nominal density (kg/m ³)	115	BS EN 1602
Compressive strength or compressive stress at 10% strain (KPa), minimum level	770	BS EN 826
For civil engineering application, compressive stress at 1% strain (KPa), minimum level	20	BS EN 826
Minimum bending strength in any direction (KPa)	115	BS EN 12089
Burning characteristics: flame spread	Class E is achieved when a flame spread of less than 150 mm is achieved within 20s after an exposure to a small flame for 15s.	BS EN ISO 11925-2
The small scale laboratory test as per BS EN ISO 11926-2 shall be used for assistance in monitoring consistency of production and shall not be a means of assessing the potential fire hazard of a material in use and shall not be the method used for assessing the reaction to fire performance of expanded polystyrene in composites and assemblies. BS EN 13501-1 specifies the use of BS EN 15823 (single burning item test) together with BS EN ISO 11925-2.		

6.2.11 Waterproofing to surface and partially underground structures:

In case of partially underground structures, the water proofing layer shall be taken up to 300mm above the high flood level and turned horizontally into a 20mm x 20mm chase cut into the wall face and sealed with a manufacturer's recommended compound.