

Water Proofing of Metro Railways both in Superstructure and in Tunnels-Quality Control in RCC Works

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Abstract:

In Metro Railways R.C.C. construction is used for constructing dependable, durable, and cost effective infrastructure is provided. The Metro RCC work is properly designed, constructed and intelligently maintained, with improvement in knowledge about design methods and behaviour of material and optimised design methods are now being used for RCC Superstructures and Underground Tunnel work. The control on construction quality is very rigid as expected in design part as compared to routine RCC works in buildings. With the result that no major complaints of water seepage or leakage due to poor RCC work is reported from any Metro work since past 15 years in India. Still in our country the concept of quality control & quality assurance has not achieved its status as an essential expert service, like in foreign countries where this is the most powerful and highest paid team at site whereas in India the quality control is a job carried out like a routine by the lowest technical representative at site and- some time by a semi-skilled mate.

Keywords — **Waterproofing in RCC works, Metro Tunnel & Superstructure, Quality of RCC Works, Leakage/Seepage in Metro Railways, Precautions in water proofing.**

1.0 INTRODUCTION

1.1 The Need for Water-Proof RCC Works

In RCC works, the waterproofing of Superstructure and in Tunnel of Metro Railways is very important since in such a vital transport infrastructure, no leakage or seepage of water from ground or rocks is permitted as per design criteria. Penetration of water in RCC works causes Porosity & due to shrinkage in concrete cracks develop in Concrete & Corrosion of Steel occurs which affects structural safety, durability & stability. Thus in this research paper, the author has dealt on stringent requirements for making RCC works in both the Superstructure and Underground Tunnels water-proof, from planning and construction stage. In Delhi Metro Railways, all planning and construction precautions in RCC work have been adopted to make the Superstructure & underground structure waterproof. The Metro Railways

in Delhi is running successfully for past 15 years without any complaint of negligent waterproofing in its entire network, though many roads are flooded in rainy season.

1.2 Criteria for Water Proofing in Metro Railways Tunnels :

There shall not be any leakage or seepage or no visible film of water on any Tunnel structural element i) In situ base slab ii) In situ walls iii) Diaphragm or concrete piled walls iv) The lower half of bored or cast in situ circular tunnels v) In situ tunnel walls

2.0 COMMON PROBLEMS FOUND IN RCC WORKS:

- Corrosion of Reinforcement.
- Cracking due to shrinkage, spalling and rust staining of concrete. Also associated with steel corrosion, Scaling of concrete.
- Disintegration of top concrete surface exposed to climatic conditions & Sun.
- Seepage, leakage, waterstanding, leaching of chemicals through concrete surface.
- Leakage through expansion joints and resultant damages in adjoining areas

3.0 SALIENT POINTS FOR SOUND WATER PROOFING OF RCC WORKS IN METRO RAILWAYS

- Performance of water proofing system – Integral Water Proofing/ Metal or Brick Coba/Cement Grouting/Polymer or Bituminous based felt/membranes or Box Type Waterproofing Systems.
- Proper Expansion joints/ Construction Joints .
- Construction & treatment of Soffit/surface of all beams, slabs, columns, staircases, RCC parapets & fascia.
- Special attention to areas in dark shadows
- Proper Drainage, sewer, water lines & toilet bases.
- All areas where RCC work exposed to external environment has been done.

3.1 Commonly Available Waterproofing Compounds/Materials

1. Acrylic& Polymeric Waterproof coatings
2. Aqua Proof (by ACC)
3. Aqua (by Crystal Chemical)
4. Aqua Seal

5. ATACTIC POLYPROPYLENE (APP) modified bitumen
6. BASF Crystalline water proofing compounds
7. Britex 100 (by Britex Chemical Industries)
8. Bitumen Coating With Sand Sprinkled
9. Bitumen Felt Treatment and Glass Fibre Felt
10. Brick Bat Lime Coba
11. Chime Seal by Viscotaq
12. CICO No 3 waterproofing/plugging compound
13. Cico, Puddlo, Impermo
14. Conplast X 421 IC lignosulphates compounds & Brushbonds by Fosroc
15. Dr. Fixit Waterproof Compounds
16. Epoxy Coal Tar (Paribond)
17. Epoxy Painting or Epoxy Injection Grouting
18. Epoxoband H45 by Fosroc
19. High Performance Cementitious Crystalline Concrete Waterproofing
20. Hydralastic 836 compound
21. Leak Proof (by Water Proofing Corp, India)
22. Mastic Asphalt
23. M-Seal & Epoxy In Various Formulation
24. Niticote CM650 by FOSROC
25. Poly Urethane Foam (by Overseas Water Proofing Company)
26. Redgard liquid waterproofing compounds
27. Roof-Con (by De-Rust Chemical Corp)
28. Snowcem
29. Silicon Based Water Repellant (Syltrit 1772)
30. Sika Grout 215, & Sika waterproofing compounds
31. Torque Lock & Epoxy

4.0 WATERPROOFING APPLICATIONS

The Waterproofing materials are installed only by the manufacturer of the products or his approved applicators with necessary warranty. Application of waterproofing system is carried out only upon completion of curing of the concrete. The surfaces to which waterproofing is applied are cleaned, made dust free and dry and are prepared fully in accordance with the manufacturer's recommendations or specifications.

All cracks on exposed surfaces of external structural members are effectively sealed before applying any waterproofing system. Inside rendering is not accepted as a method of making the joint watertight.

Where the polymer membrane with liquid is applied to roof slabs, the membrane is protected with 25mm thick extruded polystyrene boards, which are spot bonded to the membrane. A 6mm polyethylene separating membrane is then laid before covering with a protective concrete slab of lean concrete mix of minimum 75mm thickness. And where the roof slab has been cast against a diaphragm or other face, the protective slab is provided with an up stand at the perimeter to provide a minimum 75mm concrete protection over the turned up membrane. This is to ensure that the membrane termination is protected from damage. Damaged or non-compliant sections of membrane are replaced.

Elastomeric membrane method – Here seamless membrane is used for waterproofing applications which is highly flexible & UV resistant and retains breathing capacity of concrete with low abrasion value.

In the Crystalline waterproofing method the water bearing pores are closed with insoluble crystals and the saturated surface is applied minimum two coatings with crystalline waterproofing slurry. This is very effective method of waterproofing in concrete surfaces.

4.1 WATERPROOFING AT CONSTRUCTION JOINTS

Construction joints are constructed as follows:

- a. All construction joints in external slabs and walls are provided with PVC water stop located at the centre of the element.
- b. In the top surface of base and roof slabs at junctions with diaphragm walls, a 25x25mm recess is cast in the slab and subsequently filled with a high performance water stop grout of the crystalline growth type.
- c. All construction joints in external slabs and walls are cast with a 25x25 recess on the outer face (except the base slab where it is provided on the upper face). The recess is filled with a high performance water stop grout of the crystalline growth type.

4.2 WATERPROOFING TO BASE SLABS OF UNDERGROUND STRUCTURES

Concrete waterproofing admixture adopted is of crystalline type. The admixture with a proven track record of successful application in similar conditions is used. This admixture is applied to the full thickness of the base slab and to the sidewalls of sumps and similar depression of the base slab so as to form a continuous watertight surface.

4.3 WATERPROOFING TO ROOF SLABS

4.3.1 Criteria:

The spray applied liquid polymer membrane shall be suitable for use in an ambient temperature range not greater than 40°C. It shall allow diffusion of water vapours to prevent

any build-up of pressure between the membrane and substrate. The membrane shall meet or surpass the following requirements:-

Total membrane thickness 2.5mm minimum dry film thickness and sprayed in a minimum of two coats of contrasting colours, with the second coat applied to the first coat only after the first coat has cured. Tensile strength 4.0 MPa minimum in any of the three orthogonal planes of the Membrane elongation at break 130% minimum Peel adhesion to concrete (ASTM D4541) 2.0 MPa minimum Static crack bridging 2mm minimum.

The cured membrane shall be chemically resistant to the effects of hydraulic fluids, diesel fuel and diluted mineral acids etc. The substrate shall be prepared and primed in strict accordance with the manufacturer's recommendations and requirements. The membrane shall be of a thixotropic nature and cold applied to ensure consistent thickness is achieved over all substrate irregularities. The materials used must be based upon resin systems that do not react with moisture although the substrate should be dry during application. The liquid polymer membrane shall be continued 1 meter down the vertical side of the roof slab where the roof is cast by bottom up sequence.

All components of waterproofing system shall be provided by one manufacturer. All materials be supplied to site in unopened packaging, with batch numbers marked and corresponding to the manufacturer's certificates of conformity, and must be used within the product's shelf life. All components of the system exposed to rain within the curing period shall be replaced unless agreed otherwise by the Engineer-in-Charge.

The membrane wet film thickness should be checked every 10 square meter during application of each layer, using a pin or comb gauge. Destructive testing to measure dry film thickness shall be carried out on the cured membrane at every 100 square meters or at every work shift, whichever occurs sooner, and shall be made good to the satisfaction of the Engineer-in Charge.

4.3.2 DIAPHRAGM WALLS

All leaks in the diaphragm wall are sealed properly. At the junctions with the base slab and roof slab a minimum 25x25 recesses are filled with water stop. Additional protection in the form of re-injectable grout tubes, etc. as required is also done.

4.3.3 STRUCTURAL CONCRETE WORKS

(1) Concrete Joints

Notwithstanding the provision of waterproofing system, the concrete works are constructed so as to minimize the likelihood of water penetration. Water prone external concrete surfaces such as roof, terrace garden etc may be treated with a surface applied cement based, crystalline & hygroscopic waterproofing chemical and then covered with a layer of cement mortar (25 to 75 mm) admixed with a mortar plasticizer (commonly known as IRS finish.) All Cracks & dynamic joints shall be filled with flexible and waterproof sealing compound. Before placing any new concrete against old concrete that has already hardened, the face of the old concrete is treated and Concrete shall be cast watertight between construction joints. If such concrete is found to leak or to have moist patches, the affected concrete is rectified by injection of resin material, breaking out and recasting, or other methods of sealing within the concrete. Inside rendering is not accepted as a method of making RCC watertight. To take care of thermal expansion or contraction of concrete all external faces of concrete exposed to rainfall shall be treated with Flexible waterproofing compounds which are Polymer based.

(2) Fillers and Sealants to Expansion Joints

All materials used to fill expansion joints are such that they conform to the calculated movements of the joints without extrusion and do not shrink away from either surface of the joints. Consented-to polysulphide or polyurethane sealants backing strips and fillers shall be used in accordance with the manufacturer's recommendation. Where joints are required to be filled with consented-to polysulphide or polyurethane sealants, the material shall comply with BS 4254 or BS 5212. The appropriate sealant grades shall be used for horizontal and vertical joints, and 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 are used and applied strictly in accordance with the manufacturer's instructions.

5.0 REPAIRS OR REHABILITATION METHODS IN RCC WORKS:

- Pressure Grouting.
- Polymer modified mortars for repairs& maintenance.
- Honeycomb RCC repair system with bonding coat on old concrete.
- Non shrink high strength grouts/mortars.
- Epoxy repair mortars.
- P.U. putty & crack sealing compounds.
- Rust removing systems.
- Ferro cement lining(For repairing damaged concrete areas)
- Placing extra steel & Rich concrete mix by Jacketing method.
- Use of Plasticisers/Super Plasticisers/Admixtures in Repairs.

6.0 CONCLUSION:

Reconstruction or Rehabilitation of RCC Works is not only time consuming but also very expensive and sometimes practically not possible to carry out repairs in RCC. Therefore, Quality in RCC Works has to be ensured in the Original construction time.

Leakage and seepage in RCC in Metro Works (both in superstructure and in underground) & to identify and control the original point of defect and the rehabilitation or repairs in patch work becomes very difficult. Thus the author has explained in detail the planning and construction aspects of detailing of joints in RCC Works which are major source of seepage or leakage. Once scaling in concrete and Corrosion of reinforcement in RCC begins, strength and durability both get affected.

In modern construction technology methods only a single product or method is not generally sufficient but a mixture of various methods and techniques are used for making any important structure waterproof. Structures should have effective and efficient various joints like expansion joints, contraction joints along with strict quality control while preparing, laying, curing and compacting concrete with suitable admixtures, otherwise no waterproofing system will be successful.

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