# Remedial Treatment of Water Retaining Structures

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## 1.0 Introduction

Generally repairs are carried out to meet one or more of the objectives, like restoration of structure integrity, restoration of original profile and appearance, to arrest deterioration, to seal cracks and arrest the leakages. The remedial treatment of the structure is dependent upon amount of leakage experienced by the structure.

The gravity loads are the major loads, which act on the structure constantly. The structure is in contact with water continuously and is prone to ingress of moisture and other related problems. Adequate care needs to be exercised during construction phase, especially with regard to quality of materials and construction procedures. The shortfall in any of these, leads to distress in these structures.

## 2.0 Causes and Symptoms of Distress

The water retaining structures undergo distress due to one or more of the following reasons such as deficiency in structural designs, deficiency in construction, deficiency in material of construction, atmospheric pollution / hazards, natural hazards and inadequate maintenance. The symptoms of distress can be resultant of a single or a combined symptoms such as dampness and leakage (Fig. 1), active / passive cracks, sagging of members, swelling of concrete, discolouration, white/ brown patches, spalling of concrete, exposure of bars and erosion of surface.

**Fig. 1:** Leakage in a roof terrace water tank

It is important to observe the leakage by loading partially an observing the decrease in level of water and identifying the spots form outside wherever it is possible, but in case of underground structure identifying the leakage spots from external side will not be possible. In such cases the fully filled water retaining structures need to be drained out and after some times the wet spots on the surfaces need to be marked. The non-destructive test method of infrared thermal imaging can be carried out to identify the exact source of leakage.

The water retaining structures in distress have to be investigated in details. The detailed physical observation, assimilation of data, non – destructive tests will help in arriving at the reasons for distress and their extent. Based on these, appropriate restoration measures have to be worked out.

## 3.0 Surface Preparations

Before doing any repair the existing surface of the old concrete walls and the floor of the reservoir should thoroughly be cleaned using a wire brush and any laitance on the surface is removed by chipping. Fine dust is removed using a fine bristled brush. In case of swimming pools all the tiles need to be removed and repair work should be carried out on original concrete surface. Wherever the growth of algae and fungi has taken place, those places need to be removed physically followed by treatment with an antimicrobial solution to eradicate any spores and to inhibit further growth. After treatment leave for 2-3 hrs and then wash down thoroughly with clean water and allow the surface to dry completely before doing any waterproofing work.

## 4.0 Repair Techniques

The selection of repair scheme depends on many factors such as type and extent of damage, environmental conditions, load intensity, accessibility, time constraints, availability of experienced agency, etc. The repairs techniques generally adopted for the restoration of water tanks are:

- Patching techniques
- Substitution of members
- Strengthening of existing members by
  - Shotcreting
  - Wrapping / bonding techniques
  - Encasement with concrete / free flow micro concrete
- Chloride extraction / passivating technique
- Electro – chemical remedies
- Pressure grouting
- Providing waterproof barriers
- Surface protection

## 5.0 Repair Materials

Cement based materials such as polymers concrete / mortar composites (polymer concrete (PC), polymer modified concrete (PMC), polymer impregnated concrete (PIC), etc. can be used as repair material. Due to the very high strength and durability characteristics, the polymer mortar / concrete composites are being increasingly employed in

repairs and rehabilitation jobs. The PMC and PMM are increasingly used for rehabilitation because they are cement based and therefore, give homogeneity to the system and the repair materials, and due to the alkaline nature of the repair material restore the alkalinity of deteriorated concrete and arrest further corrosion.

A variety of micro-fine cementitious material with or without addition of admixtures can be used to produce injection grouts for cracks filling. In case of severe water leakages polyurethane plain or polyurethane foam injection can be carried out to arrest the cracks and leakages.

### 6.0 Patching Techniques

The cleaned surface should be inspected for cracks. Any cracks on the surface are chased into a v-groove and are thoroughly cleaned with air blower and water jet. The cracks are then filled with SBR based polymer modified mortar in the ratio Cement: Sand (1:4) and 5% by weight of cement of polymer. In case of leakage occurring through the horizontal construction joints, the same joint should be cut-off by a saw cutter into a V shaped groove and filled with polymer modified mortar. The openings around the rain water pipes should be packed with cementitious grouts.

The junction of the walls and the slabs should be rounded using cement mortar of 1:4 mix admixed with an integral waterproofing compound confirming to IS 2645 or equivalent integral waterproofing compound @ 200 ml per 50 kg of cement by laying the fillet with same polymer modified mortar.

The repair of a deteriorated concrete structure may involve injection grouting of the cracks, patching up of the deteriorated spalled concrete surfaces and locations, coating of reinforcing bars and concrete surfaces and replacement of deteriorated concrete and reinforcing bars in combination with repair materials. The major problem is corrosion on account of leakage. To prevent the leakage, polymer modified mortar may be used inside the tank. For concrete member with ongoing reinforcement corrosion, impregnation with silane produces a significant reduction in the rate of corrosion of reinforcement. Commonly used repair techniques are guniting using non-shrink cement mortar, jacketing with micro concrete, resin mortar patching and cement mortar patching. Jacketing the members of the staging is the best method for achieving good results. In the case of patching required for large areas, guniting has to -be resorted to for covering the entire surface with sufficient thickness of mortar strengthened with mesh reinforcement.

### 7.0 Pressure Grouting

#### 7.1 Preliminary Preparation

Assess the problem area & suitably mark the spots for drilling grouting holes. If the intensity of running water is high & cannot be controlled, then divert the flow of water using a PVC pipe at the spot of leak.

For heavy dripping, mark the spots in a grid pattern 150 mm centre-centre or in case of spot dripping drill at the point of leakage at an angle of 45° to the plane of grouting.

Drill diameter for a hole should be corresponding to the packers in use (generally 16 mm - 20 mm) & depth of the hole drilled to be 100 mm deep or generally half the thickness of the substrate. Fix alloy packers (non-return type) of dimension 14 mm x 80 mm with a suitable putty. Allow the putty to cure for 24 hrs prior to commencing the injection grouting process.

#### 7.2 Application

Mix the base and hardener in the specified proportions of PU Foam Injection in 10 parts of base: 1 part of hardener. The mixing should be carried out in a completely dry container using a mechanical stirrer. After rinsing the pump using a PU Cleaner, fill the PU mixture into the pumping container and initiate the pumping (Fig. 2) on a low pressure and gradually build up the pumping pressure suitably. Stop pumping if back pressure is sensed or if the grout has oozed out of the adjoining hole. PU foam injection oozes out (Fig. 3) of the grouting hole and hardens primarily in 10-15 minutes.

**Fig. 2:** PU injection in a water retaining structure

**Fig. 3:** PU forming foam after the injection

Complete curing of the PU foam will happen over a period of 24 hours. A secondary injection should be carried out with PU plain injection. Mix base and hardener in the specified proportions of PU plain

injection in 2 parts of base: 1 part of hardener. PU plain injection, resin injection to be pumped once the PU foam has to set in a similar manner as that of foam. This will act as a secondary injection thus completely sealing the leaking cavity. Cut off the extended portion of the packer and seal the surface with suitable putty. Choice of PU injection grout, such as foam/plain, depends on the condition of the substrate and severity of leakage. Incase of severe dampness injection grouting can be made using micro-fine cementitious materials. In this case drill grouting holes at an angle of 45° on the wall adjacent to the area of dampness at a spacing of 500 mm centre to centre or less in a grid pattern.

Fix PVC or MS nozzles (packers) in the grouting holes using epoxy putty and allow the nozzle to set for 24 h. Add water at a ratio of 0.35-0.45 to prepacked cementitious grout mix to a uniform consistency using a mixing paddle. Using a grouting pump, inject cementitious grout through the nozzle at required pressure. Grouting should commence from the lowest possible level & proceed upwards along the grid with the pumping pressure increased gradually. Continue pumping until the grout flows out from adjacent nozzle. Detach the pump & nozzle and seal the grouting hole with epoxy putty.

**8.0 Surface Protection**

After reinstating of spalling plaster in floor/wall and sealing construction joint, a brush application of two coats of cementitious crystalline coating over the plastered surface should be made. The time duration between two coats should be 4 hours and air cure for 24 hours prior to loading of water. Depending on the functional requirement of water retaining structures, suitable protective coating should be applied.

The final waterproof membrane from inside must be done using a non-toxic coating. For this purpose, an epoxy-stearate system (water seal), which is non-toxic and watertight, may be utilized as waterproof coating for the internal surface.

**9.0 Conclusion**

Water retaining structures need to be functional round the clock. Unless there is any stand by services for a continuous water supply in case of water tanks or reservoirs, repair work needs to be carried out within the shortest possible time and the same structures should be in operation. Keeping this in mind, the repair and waterproofing materials should be fast setting. Since all these water retaining structures contain either drinking water or potable water, the repair and coating materials should be water-based and need to be certified by the Central Food Technological Research Institute (CFTRI) for safety in usage.