Waterproofing of Water Retaining Structures


1.0 Introduction

During the construction of any water retaining structures such as underground water reservoirs or concrete swimming pools, etc., it is essential to ensure the water-tightness of the resulting structures so that the flow of water from inside the structure to outside, and the infiltration of water from the surrounding soil into the structure are effectively prevented. Watertight concrete is achieved by a combination of selective materials, good workmanship and full attention to details both in design office and on site to ensure all water containing and water retaining structures should meet the strictest specifications from the conception to the design and finally the materialization of the project.

There are so many materials available for waterproofing treatment, which are more efficient for water-tightness. When it comes to the waterproofing of swimming pools, constant hydrostatic pressure combined with rigid and porous structure of concrete pose serious challenges for an effective and lasting job. Indian standards are not up to date with latest technology and material for waterproofing of swimming pools & reservoirs.

A water retaining structure may be defined as a hydraulic structure designed to hold back, restrain, or obstruct the flow of water. The treatment of a surface or structure to prevent passage of water under hydrostatic pressure is known as waterproofing of such water retaining structures. The different water retaining structures may be of following types:

• Swimming Pools
• Reservoirs / Water Treatment Structures
• Underground Water Tanks
• Overhead Water Tanks
• Ponds, Water Features and Fountains
• Sewage Treatment Structures

2.0 Design Consideration & Precautions

Suitable precautions should be taken to avoid cracks and leakages in water retaining structures resulting from the following:

• Movements due to shrinkage and creep
• Movements due to variation of temperature and humidity
• Movements due to dissipation of heat generated by the concrete in the process of hydration
• Damage to the concrete by the percolation of chemically aggressive liquids from outside

• Damage due to uneven settlement of foundations
• Cracking of concrete caused by rusting of bars
• Hydrostatic uplift force

To avoid temperature changes as far as possible, the water tank should be built partly into the ground so that the soil is available to cover the roof, if necessary, and to form embankments on the outside so as to enclose the water tank completely in a covering of earth. Special precautions should be taken to guard against evaporation and the movements arising from extremes of temperature before the covering is made.

The design consideration should be made for serviceability, loads, design, durability and joints. In case of durability, the following points such as materials requirement, cementitious component, strength and W/C ratio, additives, embedements and curing components should be considered. Comparatively, in case of joints, the points need to be considered are types of joints, joint spacing, joint materials (water bars, fillers, sealants, bond breaker, reinforcement and dowels), joint design and joint construction considerations.

3.0 Construction Details

3.1 Concreting

The first successful step in construction of water retaining structures is to make a structurally integral protection system comprises of only the reinforced concrete structure that is designed to minimize water penetration by the structure itself. The permeability of the concrete is reduced by introducing water-reducing agents, high performance PCE (Polycarboxylate ether) superplasticizers, and pozzolanic products such as Silica-fume or Aluminosilicate, organic binders or pore blocking additives. A good quality superplasticizer in the concrete mix is a solution of super plasticizing agent & additive in water. It helps in achieving increased workability in all grades of concrete. The water/cement ratio should between 0.40-0.45 with a PCE based superplasticizer. This would reduce size, number and continuity of pores. Pore blockers such as silica fume acts as hydrophobic materials to line the concrete pores and thus reduce capillary absorption by altering the intermolecular forces in the system; concrete - air - water. The minimum and maximum cementitious contents in the mix should be 360 kg/m³ and 400 kg/m³ respectively. In case of water retaining structures in aggressive environment Fly ash should be added by replacing 15-30% of OPC cement and in such cases 28-days compressive strength should be minimum 40 MPa and in normal environment minimum M30 grade of concrete is desirable. Maximum drying shrinkage at 28 days of in-situ concrete should be 420 microstrain. Apparent volume of permeable voids of hardened concrete should be less than 14%.
Internal vibrators should invariably be used, wherever possible. Vibrators should not be used for displacing concrete. Overloading the vibrators by placing too much concrete per vibrator is not good. Over vibrating by using too many vibrators relative to quantity of concrete also is not good. Segregation by excessive vibration or excessive water content should be strictly avoided. Vibrator shall be withdrawn gradually and smoothly, and in a manner which shall not cause suction, voids or air entrapment.

Concrete cover is very important factor in all water retaining structures. In such structures, the nominal cover to meet the durability requirement as per IS 456-2000 should not be less than 75 mm.

Concrete should be properly cured. Curing has an important influence on the permeability of concrete and it is necessary to keep the concrete moist, particularly during the first few days. Concrete synthesis, placement as well as curing practices should conform to the local regulations of concrete technology for water resisting concrete.

Cracks number and width is controlled from sufficient and properly placed steel reinforcement. In long walls, it is recommended that the walls should be divided into sections not more than 15 m long with a gap of about 30 cm left between sections so that the shrinkage in the long sections may occur as far as possible before the gaps are concreted, and the longer this can be deferred, the better. The use of carefully rebated joints is imperative at these construction joints.

Lapping of reinforcement in circular tanks should be so arranged that not more than 25% of the bars are jointed at any one vertical section. To reduce shrinkage stresses as far as possible, there should not be less than 0.3% of steel in any direction.

Depending on the smoothness of concrete substrate, a levelling mortar layer should be used. Usually these levelling mortars are quite thin (less than 6 mm thick). To reinforce them and increase their adhesion, an SBR latex should be used in the mix. For this purpose, a commonly used mix can be adopted such as Portland cement: Moist sharp sand: SBR latex in the proportion of 1 part: 3 parts: 0.2 – 0.25 parts with clean water as required for achieving a desirable consistency.

### 3.2 Expansion and Contraction Joints

In water retaining structures, free contraction joints deal with early age thermal movements and irreversible drying shrinkage where no load transfer or equalising of deflection in the plane of joint is required.

In concrete swimming pools and reservoirs of small and medium capacities, it is not economical to provide expansion joints and it is not a practice also. In large reservoirs, expansion joints shall be provided at predetermined positions limiting their spacing to not more than 35 m in the case of underground structures or those with fully covered sides, and not more than 28 m in the case of partly exposed structures.

### 3.3 Polysulphides (PS) Sealant at Expansion and Contraction Joints

Polysulphide sealants, based on mercaptan terminated polymers, are high-performance elastomeric joint sealants and are very well-suited for such expansion and contraction joints. They have excellent chemical resistance and weathering properties. Polysulphide sealants provide a durable, flexible, watertight seal for all traditional sealant applications in addition to more aggressive immersion application. They have excellent chemical resistance for which they are very well-suited in case of large water reservoir and sewage treatment structures. They should not be exposed to high temperature and they will not adhere to substrates with contamination and traces of bitumen. Use of shalitex board as a backup material should be avoided. Pouring grade version must only be applied in horizontal joints. Application should be started only after 30 minutes of priming the substrate for Gun & Pouring Grade sealant.

### 3.4 Construction Joints

Construction joints should be set at right angles to the general direction of the member. As far as possible, vertical joints should be avoided. This can be done by completing a layer of concrete not more than 60 cm high in a continuous operation working around the circumference in both directions from the starting point and repeating the process for the day's operation. Before closing day's operation, a rebate should be formed in the concrete on the top surface of the wall forming 'key' to get construction joints as shown in Fig. 1 for the next day's operation. Before the next operation is started, all timber spoils, laitance, scum or loose concrete should be removed by hacking the surface and then scrubbing off with a wire brush to remove all loose mortar or aggregates. Thereafter, before resuming the concreting operation, the surface should be thoroughly washed and wetted with water, and then a thin coat of cement sand grout of cement mix, as that in concrete, should be applied. As an additional precaution, water bars may be used at such joints. But sufficient care should be taken when PVC water strips are being used. Otherwise, while pouring concrete from a height, these strips may get bent and thereby restrict the passage of concrete, causing large size pores and honeycomb concrete.

All non movable joints e.g. new-to-aged concrete, floor-to-wall joints and casting interruption joints should be preventively sealed with water bars. The same is valid for all through-wall penetrations.
3.6 Waterbar

The construction joints as well as movement joints if provided should be laid watertight, preferably with the provision of PVC water bars. A water bar looks like a rope, which should be compressible or swellable to one of the different sizes in case of water retaining structures. They are made of different materials like hydrocarbon-based polymers, hydrophilic rubber, bentonite-based butyl rubber and other materials such as pigments and fillers, adhesion promoters and many additives. The preformed construction joint sealant is available in non-swellable (SW20X20) or swellable of 5 x 10 mm or 5 x 20 mm sizes. It is used to seal cold construction joints in swimming pools and reservoirs, which are in constant touch with water. Such joints are susceptible to water leakages in horizontal, vertical, inclined and curved profiles and can be taken care by water bars since they are highly adhesive, flexible and swellable having controlled expansion and withstanding ability to hydrostatic and hydraulic water pressure. The typical step-by-step method of water bar installation is shown in Fig.3 and the details of application in horizontal and vertical sections are shown in Fig. 4 and Fig. 5 respectively.

3.5 Treatment at Fixtures like Pipes & Conduits

The pipes and special fixtures should be fixed in position before concreting operation so that these are built in at the time of construction. These special fixtures should be provided with puddle collars for proper grip with concrete and also to act as a water bar around the periphery of such fixtures.

- Preferably, pipe inlets will be formed in-situ during the casting of the concrete and sealed using expanding waterbar (Fig. 2).
- Where it is necessary to install pipes after the casting of the concrete, these can be sealed using a PU sealant.
- Holes or cut outs in concrete done for fittings of underwater lights, pipe openings for the filtration plant etc. must be grouted with non-shrink cementitious grouts before the waterproofing coating is taken up for application.

![Fig. 1: Construction joints](image1)

1. Plain cement concrete
2. Flexible waterproofing coating/membrane
3. Protective screed
4. RCC raft
5. Protective method on vertical surface

C1. First construction joint minimum at 300 mm above raft top
C2. Subsequent construction joint (As minimum as possible)

![Fig. 2: Waterbar around pipe joints](image2)

- Concrete grout
- Waterbar
- Pipe

![Fig. 2: Waterbar around pipe joints](image3)

a. Clean the surface  b. Apply primer 20 mm wide
c. Uncoil Waterbar  d. Place in position
e. Pour concrete  f. Finished waterproof joint

![Fig. 3: Installation of Waterbar](image4)
4.0 Waterproofing System
4.1 General Features
The swimming pools and underground water reservoirs have to be made waterproof against leakage or seepage of water as follows:
• From inside the structure to the surrounding ground
• From the surrounding ground towards the inside of the structure

Preventive measures for reduction of surface water entering into adjacent ground - Where possible, the grounds should slope away from the structure for a distance of about 3 m to divert the surface run-off and to prevent water from standing near or against the side walls. The surfaces near the side walls should preferably be paved. On sloping sites, it would be desirable to construct a cut-off land drain on the high side to lead water around the structure to a lower level.

The ground water should be prevented from remaining in contact with the side walls or the flooring for long periods by installing a system of drainage around the foundation of the structure or beneath the floor or both together.

4.2 Selection of Waterproofing Material
Waterproofing products provide a number of options for the waterproofing of water-retaining structures. The choice of waterproofing system will depend on a number of factors, such as the type of water (e.g. potable water or effluent) to be retained and the construction type/ material used to build the structure.

The different types of waterproofing of water retaining structures are generally classified under following four categories:
• Capillary Waterproofing
• Flexible Cementitious Waterproofing
• Liquid Applied Polymer Coatings
• Sheet Membranes

In case of capillary, waterproofing takes place by crystallization. Soluble salts react with water and forms crystals which blocks the voids to prevent any moisture migration. It fills voids in concrete to resist water penetration and it is also vapour permeable. But the major drawback of this type is that it cannot survive any cracks. Mainly used in mass concrete structures where chances of a through and through crack formation are low.

Flexible Cementitious Waterproofing system is a two-component system, which is a brush-applied and film-forming system. Compared to the capillary waterproofing system, it can survive minor cracks. It is mostly used when protection systems, especially tiles, are applied directly with thin bed application.

Liquid Applied Waterproofing started with liquid polysulphide polymers blended with coal tar, but nowadays, acrylic is very commonly available. However, moisture-curing polyurethanes are the best. Effect of cracking and pin-holing and minimum thickness are very important criteria during application of this system. But it requires experienced applicators to have a controlled application.

In case of modern waterproofing systems crystalline which is a highly alkaline cementitious material is most suitable for water retaining structures. These needle-shaped crystal micro-fibres disperse or suspend well in a wet stage and then start inter-locking with each other forming a complex 3-D network reinforcement during the curing / drying process. When it comes into contact with water, they form crystals and penetrate inside the pores of the concrete and block all capillary pores and cracks inside the concrete. Whenever there is no water, they remain inactive and again become active when it comes in contact with water. They form a permanent self-sealing nature to arrest the cracks and the voids inside the concrete.
The thickness of polymer-modified bitumen membrane or self-adhesive SBS-modified bitumen membrane and EPDM (Ethylene propylene Diene Monomer) membrane varies from 1.2 to 2 mm whereas torch-applied membrane thickness varies from 3 – 4 mm. Whenever, the membrane is used in large reservoir, it should resist a minimum hydrostatic water pressure head of 8-10 Bar.

However, while selecting any waterproofing material for underground reservoirs or swimming pools, one has to check the major functional properties required such as hydrostatic pressure head to resist, presence of aggressive chemicals if any, and service life of the waterproofing system. The thickness of the coating/membrane and other properties need to be selected based upon their required performances of the waterproofing systems.

In general, the various properties of the membrane such as water absorption should be 0.10 g/m²/24 h, water vapour transmission rate should be less than 0.05 g/m²/24h. The membrane should have better chemical resistance properties, crack bridging ability of 0.5 mm, elongation between 100-200%, puncture resistance of more than 900 N and adhesion strength from 1.5 to 2 N/mm when used in reservoirs or swimming pools. In case of water tanks the coating should have anti-microbial/anti-fungal/anti-algae properties and effectively prevent the growth of harmful elements that are hazardous to human beings. Such coatings should be non-toxic and eco-friendly that is 100% safe for potable water contact and tested and certified by competent authority.

4.3 Application on Raft Slab and External Walls

4.3.1 Surface Preparation

The surface should be cleaned thoroughly of all contaminants like dust, traces of curing compound, oil and grease. All surface imperfections, protrusions, structurally unsound and loose concrete must be removed and repaired with polymer-modified mortar using SBR latex commonly used waterproofing and repair material.

4.3.2 Priming

All over the blinding concrete or PCC that is properly levelled, polymer-modified elastomeric bituminous coating diluted with water in 1:1 proportion or a solvent based bitumen primer should be applied with a roller or brush over a dried surface. Allow the primer to dry for 8 to 10 hours prior to the application of coating.

4.3.3 Application on PCC Below Raft Slab

APP (Atactic Poly Propylene) / SBS (Styrene Butadine Styrene) modified bitumen-based preformed membrane should be laid by providing an overlap of at least 100 mm. APP / SBS modified bitumen-based membrane should be extended to maximum extend of the full area of the blinding concrete. A geotextile membrane of 120 gsm should be laid as a protection layer over APP / SBS modified bitumen membrane. A screed of 50 mm must be overlaid in M 20 concrete grade, which will facilitate the reinforcement cage to be assembled for the RCC raft to be cast over it.

4.3.4 Application on Retaining Wall

Concrete joints in retaining walls and at raft level should be provided with flexible adhesive strips popularly known as water bars either of a swellable strip of 5 mm X 20 mm size or of a compressible strip of 20 mm X 20 mm size, which shall be placed in joints while concreting of raft slab and retaining walls. 40 mm X 40 mm sized angle fillets must be provided at the corners all around the floor and walls from the external side.

The retaining wall should be prepared by cleaning the surface and priming it with primer to receive the waterproofing system.

APP / SBS modified bitumen should be applied starting from the bottom of external wall right up to ground level. It has to be ensured that APP / SBS modified bitumen is applied up to at least 300 mm above ground level.

After completion of application, a 4 mm thick bituminous protection board should be placed or a 12 mm thick dimpled HDPE drainage board should be applied for protection. The application details on raft slab and external wall is given in Fig. 6.
like dust, traces of curing compound, oil and grease. All surface imperfections, protrusions, structurally unsound and loose concrete must be removed and repaired with polymer-modified mortar using SBR latex for waterproofing and repairs. At internal side walls and raft junction, cast 40 mm X 40 mm sized angle fillets all around floor (Fig 7).

4.4.2 Application

After complete curing of the raft slab and retaining walls a 1st coat of high performance polymer modified cementitious coating should be applied by maintaining the saturated surface dry condition. While the coat is still wet, a glass fibre mesh of 2.5mm x 2.5 mm of 50 GSM should be embedded over the angle fillets as a reinforcing strip and should be allowed to soak completely. Thereafter one additional coat should be applied for sandwiching the glass fibre mesh immediately. Then a 2nd coat of high performance polymer modified cementitious coating should be applied. After the 2nd coat is completely dried, a 3rd coat of high performance polymer modified cementitious coating should be applied and coarse sand should be sprinkled while the same is still in wet condition. This will provide the key for subsequent tile adhesive materials in case of swimming pools. The schematic diagram of typical waterproofing detailing of a water retaining structure is given in Fig. 8.

4.4.3 Pipe Inserts

Pipe inserts should be wrapped around with leak-proof sealing tape for pipe wrapping to ensure a watertight fitting. Light fitting casings, pipes, inserts, etc., provided in the concrete raft floor and walls should be grouted with a non-shrink grout. Non-shrink grout for pipe fitting of high-performance polymer-modified cementitious coating should be liberally applied around the insert pipes and the around the light fittings sandwiched with an open woven mesh for extra precautions.

5.0 Waterproofing in Internal Areas of Swimming Pools

Swimming pools (Fig. 9) offer an excellent way to relax, exercise and provide enjoyment to an individual. They come in different shapes and sizes. To effectively and safely manage a swimming pool, one should have a pump, basin, water filter, chemical feeder, drains, return and the proper plumbing to transport the water.

The primary function of swimming pools needs to be considered while designing any kind of swimming pool. Whether kids will be playing water sports all summer long or anybody wants to swim laps. It can be built to any size or shape or style as per the budget. There are two major types of swimming pools such as elevated swimming pools generally on rooftop or ground level swimming pools which may be flat or slopped. A flat swimming pool typically is not deeper than five feet. Play pools generally are built for cooling off and relaxing in, playing volleyball, other
water sports, as well as for swimming laps. Slopping swimming pools are generally gradually deeper with a diving board or platform. They have a slope at the bottom as they start from 1 m to about 15 m.

5.1 Waterproofing in Swimming Pools
There are many stressing factors that need to be considered while doing waterproofing in case of swimming pools such as alkaline substrates, water pressure, various chemicals, mechanical abuse, solar radiation, UVs etc. The paint, if any, should be waterproofed, resistant to mildew and discoloration and, if possible, water vapour permeable. It should be both functional and aesthetically appealing.

For internal surface waterproofing, EPDM Membrane below the raft slab and high performance cementitious liquid applied coating on internal surfaces should be used in case of swimming pool before the tiling.

5.1.1 Cementitious Waterproofing Coating
Two-component cementitious coating, composed of high quality cement, properly selected and graded fillers, additives and liquid polymer should be used as a cementitious coating. It is suitable for achieving waterproofing in swimming pools because it provides strong bonding, good waterproofing and provides excellent resistance to hydrostatic water pressure by forming a highly elastic seamless coating over the applied concrete or masonry surfaces. The water proofing detailing in internal surfaces of an elevated swimming pool is given in Fig. 10.

5.1.2 EPDM Membrane
EPDM rubber-based prefabricated membrane is more suitable in deep swimming pools and under raft of ground level swimming pool. It is used for waterproofing and lining of underground concrete structures of swimming pools because it exhibits a high degree of resistance to water, ozone, UV, weathering, abrasion, extreme temperatures, acids, alkalis and oxygenated solvents. The water proofing detailing in internal surfaces of an ground level swimming pool is given in Fig. 11.

5.2 Tiling in Case of Swimming Pool
Tiles should be applied using tile adhesives of 2-3 mm thick depending upon whether they are glass mosaics or ceramics. After the tile fixing, fill the grooves / tile joints with epoxy-based tile joint fillers.

5.2.1 Tile Adhesives
It should comprise ordinary Portland cement properly selected and graded aggregates, polymer, rheology modifier and additives. It is generally used for fixing of tiles internally and externally over walls and floors in swimming pools with an added application of tile on tile because it gives excellent bonds on cementitious surfaces like concrete, plaster, etc. It forms a waterproof barrier between two surfaces and has excellent ‘grab’ properties of tiles to the substrate.

5.2.2 Waterproof of Tile Joint Fillers
The tile joint filler material should be a fine powder consisting of Portland cement, specially selected polymer, properly selected and graded fine fillers, additives and inorganic chemicals. It is used for grouting of tiles because it has water repellant properties, excellent adhesion (high bonding strength), soft consistency, workability and seals joints permanently. It is non-shrinking, non-toxic and odourless grout used for sealing of swimming pool and water tank joints as well.

5.3 Grouting Steel Rods by Anchorfix Grouts
The railings, handle and all steel rods or pipes need to be fixed with polyester resin anchor fix grouts.

6.0 Waterproofing in Internal Areas of Reservoirs and Water Treatment Structures
In addition to imparting waterproofing properties, products designed for protecting water-retaining structures such as reservoirs (Fig. 12) or water treatment for drinking water applications need to meet additional requirements. These include:
• Safe for use in contact with drinking water
• High resistance to leaching
• Protection from infection
Resistant to attack from condensate
Smooth, easily cleaned surface

First a fillet is formed around the inside-perimeter of the pond using polymer mortar. Once the mortar has cured, two coats of cementitious water proofing coating are to be applied to the sides and floor of the pond. If a tiled finish is required, a render of 3:1 sand: cement should be applied over the second coat of cementitious coating whilst it is still green. This will provide a suitable base for tiles to be fixed using a suitable waterproof tile grout. In common with all cementitious coatings, will cause the water in the pond to have a high pH (typically between 12 and 13) when first filled. To bring the pH down to a more neutral level, the pond will have to be emptied and filled several times until the correct pH is reached.

7.0 Waterproofing in Internal Areas of Underground and Overhead Water Tanks

Overhead water tank should be designed in such a way that the structure itself should be made watertight. In case of underground water tanks the structure should be made watertight additionally at bottom raft and at external surface of the wall. While considering internal surface waterproofing of smaller water tanks like in housing societies, a two component cementitious coating can be used where as for larger water tanks crystalline waterproofing would be more suitable. A two-component epoxy resin based coating specially formulated for internal applications for the waterproofing of water tanks can also be used.

Crystalline or equivalent (injection grouting admixture) should be mixed with dry cement @ 5 kg per 50 kg of cement. Sufficient water should be added to this mix to obtain slurry and grouted under pressure using a pressure grouting pump of 2-10 bar capacity.

The concrete surface should be saturated well with water and a crystallization waterproofing compound should be applied on the clean and saturated surface of the walls and raft slab in 2 coats at 1 kg per m². The coating should be protected with a layer of cement mortar mixed with waterproofing compound with neat finish. The curing should be done after 24h of application of 2nd coat for atleast 5 days. The application detail inside a water tank is given in Fig. 13.

8.0 Waterproofing in Internal areas of Ponds, Water Features and Fountains

The decorative artificial ponds, water features, fountains, fish breeding ponds or fish tanks are constantly exposed to pressing water. They need to withstand a constant battering from the elements and leaking is common after a few years. Liquid-applied Polyurethane waterproofing systems is more suitable for waterproofing or lining in such structures. Polyurethane resin coating has excellent mechanical, chemical, thermal, UV and natural element resistance properties and safe for uses on surfaces in direct contact with potable (drinking) water. It cures by reaction (cross linking) of the two components. However for longer service life EPDM rubber based preformed membrane is more suitable.

9.0 Protective Coating in Internal Areas of Sewage Tanks

Sewage treatment structures are subjected to severe chemical attack and physical stress. While designing and taking protection measures of RCC structures one has to ensure that no seepage into the earth and ground takes place from sewage tanks. Concrete waterproofing and chemical resistance products for use in sewers and sewage treatment plants need to be specifically designed to cope with the following stresses caused by:

- Continuously changing degree of contamination
10.0 Testing after Construction

It is detrimental to keep the water retaining structures dry for a longer period than 4 weeks, as it may lead to formation of cracks. So it is imperative that before the last casting is completed, water arrangement for testing the tank is ready at site. Immediately after the removal of form work, the tank should be tested. All preliminaries should be completed in advance.

Water should be supplied to the reservoir slowly at the rate of 300 to 450 mm depth of reservoir per day and the result closely observed, both from the angle of structural stability whether any crack is being noticed anywhere in the structure at any time and from the point of view of water tightness. At the end of the operation, that is, when full supply level is reached, all valves shall be closed tightly. The water level in the reservoir should be properly marked on the wall. Leakage through the valves should have been checked and there should not be any drop due to the same. After 24, 48 and 72 h, the levels should be checked and the drops in level will be a measure of water-tightness.

The permissible standard usually adopted is 6 mm drop in 24 h in case of covered reservoir and 12 mm in case of open reservoirs. Necessary adjustment should be made depending on the relative humidity and other local conditions.

If there is no drop, but dampness is observed in the outer surface such dampness may vanish in course of time as the free lime ejected out of cement will be plugging the minor pores causing such dampness. If the intensity of leakage is slightly more, then lime may be added to the testing water.

In case of leakages, the points should be marked and separately treated after dewatering.

It is sometimes difficult to locate the source of leakages in case of underground reservoirs. If it is from the floor, it is hardly possible to locate unless clear cracks are noticed and hence complete floor will have to be treated. So in such case of underground reservoir, the drop in level should be recorded for every 300 mm after keeping the water for 24 h. If at some stage, there is no drop, then it is presumed that floor is in order and the wall above that height is only responsible for leakage. If drops are noticed all through, it may be only the floor which is responsible for the leakage or both floor and the wall. With the presumption that the floor is not in order and the wall is in order, the floor may be set right leaving the treatment of the wall for the future, if necessary.

For all these uncertainties, it is recommended that some additional aids or precautions be taken for underground reservoirs, especially to prevent outside sub soil water to find its way inside when the reservoir is empty.

All the water proofing products should be approved for use in contact with drinking water. Nevertheless, where fish are to be kept in the pond, it is important to take precautions to ensure that the water quality is suitable for the species of fish to be kept.

After the new construction of fish pond and sufficient curing it should be filled with water without any fish. The pond needs to be set for five days and then water to be drained out and washed down all the surfaces with fresh water. Again the pond should be refilled and water to be allowed to stabilize over night before adding a test fish (feeder fish) to assure that the water is now safe for the fishes before adding more expensive decorative fish. If the test fish is still alive after 3 days next step should be followed; but if the fish does not survive then drain the pond and wash down all surfaces with fresh water. Refill the pond and allow the water to stabilize over night again before adding another test fish. Once the pond has proven safe for the feeder fish then decorative fishes are put inside the fish pond.

11.0 Conclusion

Water proofing of any water retaining structures is one of the toughest jobs. A better understanding of material and proper selection of water proofing material for different water retaining structures will ensure durable waterproof system. Nevertheless the joints and pipe openings are most vulnerable which need to be detailed and waterproofed properly.

References

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