IS 6494 (1988): Code of practice for water-proofing of underground water reservoirs and swimming pools [CED 41: Waterproofing and Damp-Proofing]

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Indian Standard

CODE OF PRACTICE FOR WATERPROOFING OF UNDERGROUND WATER RESERVOIRS AND SWIMMING POOLS

(First Revision)

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Indian Standard

CODE OF PRACTICE FOR WATERPROOFING OF UNDERGROUND WATER RESERVOIRS AND SWIMMING POOLS

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards on 1 September 1988, after the draft finalized by the Waterproofiing and Damp-proofiing Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 During the construction of underground water reservoirs and concrete swimming pools, 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. This standard is intended to provide guidance to the engineers, contractors and others engaged in building activity in the methods to be adopted for the construction of water-tight underground reservoirs and swimming pools.

0.2.1 This standard lays down provisions relating to membrane type of waterproofing including certain other provisions relating to construction technique, the quality of material, etc, which are important from the point of view of overall waterproofing and which need to be taken into consideration by those entrusted with civil construction work.

0.3 The standard was published in 1972 and the revision of this standard has been taken up to incorporate further changes necessary in view of the revision of various standards referred to in this standard. In this revision the detail procedure to be followed in carrying out chemical injection treatment has been added.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard lays down the procedure to be followed and the precautions to be taken during the construction of underground water reservoirs and swimming pools so as to ensure the water-tightness of the resulting structure. Method of maintenance and rectification of defects noticed during the construction are also covered in this standard.

2. REQUIREMENTS OF STRUCTURE, DESIGN AND CONSTRUCTION DETAILS

2.1 Requirements for Swimming Pools and Underground Reservoirs — These structures should be built so as to comply with the requirements of the best practice pertaining to reinforced concrete, plain concrete or such other form of concrete construction as may be employed [*see* IS : 3370 (Part 1)-1965*]. The requirements laid down under **2.1.1** to **2.1.9** shall also be taken into consideration.

2.1.1 Suitable precautions shall be taken to avoid cracks and leakages resulting from the following:

a) Movements due to shrinkage and creep,

b) Movements due to variation of temperature and humidity,

c) Movements due to dissipation of heat generated by the concrete in the process of hydration,

d) Damage to the concrete by the percolation of chemically aggressive liquids from outside,

e) Damage due to uneven settlement of foundations,

f) Cracking of concrete caused by rusting of bars, and

g) Hydrostatic uplift force.

*Code of practice for concrete structures for the storage of liquids: Part 1 General requirements.

2.1.2 Construction joints should be set at right angles to the general direction of the member (*see* Fig. 1). The position and arrangement of construction joints should be determined at the design stage and indicated on the drawings. Consideration should be given to the limiting number of such joints and to keeping them free from possibility of percolation (*see* **5.5**). The surface-film of the first-placed concrete should preferably be removed while the concrete is still green to expose the aggregate and leave a sound irregular surface. This may be effected by spraying with water or air and water, assisted by light brushing, where necessary. If the concrete has been allowed to harden, it will be necessary to achieve the desired surface by hacking the whole of the surface, care being taken to avoid damaging the aggregate.

2.1.2.1 While the remainder of the concrete should be kept continuously wet, curing of the joint surface may be suspended a few hours before concreting is to be resumed so as to permit no more than superficial drying of the joint surface. Just before concreting is resumed the roughened joint surface should be thoroughly cleaned and made free of all loose matter, preferably without re-wetting, and then treated with a thin layer of cement grout or cement-sand mortar worked well into the surface. The ratios of sand to cement, and water to cement in this grout or mortar should not exceed those in new concrete. Special care should be taken to avoid segregation of the concrete along the joint plane and to obtain thorough compaction.

2.1.2.2 Alternatively, for horizontal joints, the layer of grout or mortar may be omitted, provided that the workability of first batches of concrete placed in contact with the joint is slightly increased.

2.1.3 The concrete mix proportions should be so designed as to produce a concrete from the materials available:

a) which has a workability to ensure that, with the means available, it can be satisfactorily placed in the formwork and compacted without risk of segregation, honeycombing or bleeding; and

b) which is sufficiently impervious to water and non-porous.

2.1.3.1 The directions given in **3** of IS : 3370 (Part 1)-1965* may be followed while designing the concrete mix.

2.1.4 The permeability of any uniform thoroughly compacted concrete of given mix proportions is very largely dependent on its water-cement ratio. While an increase in this ratio would lead to an increase in the inherent permeability, the consequences of reducing the water-cement ratio of a mix with a given cement content, that is, failure to achieve complete compaction of the drier mix, are likely to be much more serious. For a given mix made with particular materials, there is a lower limit to the water-cement ratio which can be used economically on any one job. It is essential to select a richness of mix compatible with the available aggregates, whose particle shape and grading have an important bearing on the workability which must be suited to the means of compaction selected. Suitable additives may be added to make concrete dense and workable. Efficient vibrating equipment should be employed for compating the concrete.

2.1.4.1 In practice, it is usually convenient particularly when dealing thin with congested reinforced sections, to specify a cement content sufficiently high to ensure that thorough compaction is in fact obtainable with the means available whilst maintaining a sufficiently low water-cement ratio. In thicker sections, where a reduction in cement content may be desirable to restrict the temperature rise due to cement hydration, a lower cement content is usually permissible, partly because the overall permeability of the section is reduced by the greater thickness and partly because the less congested conditions may permit thorough compaction of a somewhat drier mix.

2.1.5 Concrete should be properly cured. Curing has an important influence on the

*Code of practice for concrete structures for the storage of liquids: Part 1 General requirements.

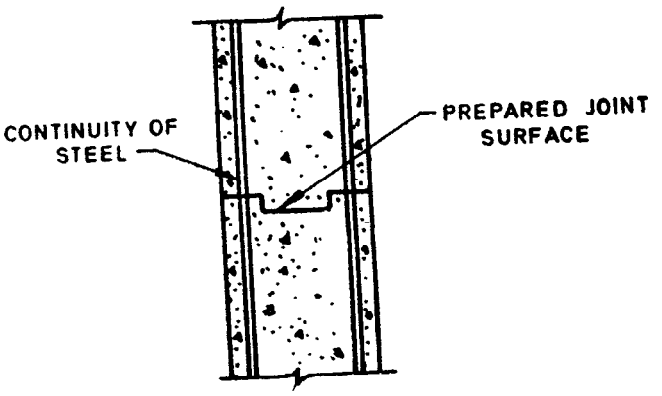


FIG. 1 A TYPICAL CONSTRUCTION JOINT

permeability of concrete and it is necessary to keep the concrete moist, particularly during the first few days.

2.1.6 The permissible stresses in concrete and steel shall be according to the recommendations given in **3.3** and **3.4** of IS : 3370 (Part 2)-1965*.

2.1.7 Slabs in contact with water shall be designed in accordance with the provisions of **3.3.1** of IS : 3370 (Part 2)-1965*.

2.1.8 To reduce shrinkage stresses as far as possible, there should not be less than 0·3 percent of steel in any direction.

2.1.9 In long walls, it is recommended that the walls 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.

2.2 Requirements for Underground Water Reservior Only

2.2.1 To avoid temperature changes as far as possible, the reservoirs may, with advantage, 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 reservoir 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.

2.2.2 The permissible stress in steel reinforcement shall be governed by the provision of **3.4.2** of IS : 3370 (Part 2)-1965*.

2.2.3 Lapping of reinforcement in circular tanks should be so arranged that not more than 25 percent of the bars are jointed at any one vertical section.

2.2.4 If the reservoir was partly underground and partly above ground in the portion exposed to atmospheric conditions, there should not be less than 0·3 percent of steel in either direction.

3. MATERIALS

3.1 Cement — Portland cement conforming to IS : 269-1976† or Portland blastfurnace slag cement conforming to IS : 455-1976‡ or Portland pozzolana cement conforming to IS : 1489-1976§ shall be used.

3.2 Aggregates

a) The aggregates should not have an absorption greater than 2 percent, as measured in accordance with 2 of IS : 2386 (Part 3)-1963*.

b) *Grading*

1) The grading should be such as to produce a concrete with the specified proportions and consistency and one that will work readily into position without segregation and without the use of an excessive water content, and can be readily compacted into a dense impervious mass.

2) Fine aggregate should be in accordance with Table 4 of IS : 383-1970† (all zones).

3) The maximum size of coarse aggregate should be as large as possible, but limited to the least of the following dimensions:

i) one quarter of the smallest distance between the opposite faces of the section,

ii) five millimetres less than the minimum cover to the reinforcement, and

iii) five millimetres less than the clear distance between the main reinforceing bars.

3.3 Water — Water shall be free from deleterious materials, reasonably clean and from a source approved by the engineer.

3.4 Steel — Steel reinforcement shall comply with the requirements of IS : 432 (Part 1)-1982‡, IS : 432 (Part 2)-1982§ or IS : 1786-1985‖.

3.5 Bitumen Felt — It shall conform to Type 3, Grade 2 of IS : 1322-1982¶ and Type 2, Grade 2 of IS : 7193-1974**.

3.6 Bitumen Mastic — It shall conform to IS : 5871-1970††.

*Code of practice for concrete structures for the storage of liquids: Part 2 Reinforced concrete structures.

†Specification for ordinary and low-heat Protland cement (*third revision*).

‡Specification for Portland slag cement (*third revision*).

§Specification for Portland pozzolana cement (*second revision*).

*Methods of test for aggregates for concrete: Part 3 Specific gravity, density voids, absorption and bulking.

†Specification for coarse and fine aggregates from natural sources for concrete (*second revision*).

‡Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement: Part 1 Mild steel and medium tensile steel bars (*third revision*).

§Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement: Part 2 Hard-drawn steel wire (*third revision*).

‖Specification for high strength deformed steel bars and wire for concrete reinforcement (*third revision*).

¶Specification for bitumen felts for waterproofing and damp-proofing (*third revision*).

**Glass fibre base coal tar pitch and bitumen felts.

††Specification for bitumen mastic for tanking and damp-proofing (*first revision*).

4. WATERPROOFING TREATMENT

4.1 General Features — The swimming pools and underground water reservoirs have to be made proof against leakage or seepage of water as follows:

a) From inside the structure to the surrounding ground, and

b) From the surrounding ground towards the inside of the structure.

4.1.1 It shall be borne in mind that the practice of using concrete, not in itself watertight, and placing too much reliance on the waterproofing measures is not desirable. Concrete should be watertight in itself and the waterproofiing methods should be looked upon as additional safety devices.

4.2 Preventive Measure 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.

4.3 The ground water shall 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. The provision of drains around the structure near the foundation level is recommended for any site where the ground water table is likely to rise very much above the foundation level. These drains should be graded to an open outlet or storm water sewer or to a sump located in the premises where pumps of suitable capacity should be provided to pump out the water as fast as it gets collected.

4.4 Waterproofing Treatment — For preventing the ground water from percolating through the flooring the waterproofing/damp-proofing treatment indicated in **4.4.1** to **4.4.7** may be given.

4.4.1 After laying the levelling course of lean concrete and allowing it to harden for at least 48 hours, waterproofing membrane should be spread over it, care being taken to provide suitable overlaps and care should be taken to prevent any damage to the membrane.

4.4.2 If bitumen felt is used for the damp-proofing treatment, it shall conform to IS : 1322-1982*. The damp-proofing treatment should be given in accordance with the recommendations given in IS : 1609-1976†.

4.4.3 If bitumen mastic is used for the damp-proofing treatment, it shall conform to IS : 5871-1970*.

4.4.4 The damp-proofing treatment may also be carried out in accordance with IS : 9918-1981†.

4.4.5 The treatment mentioned in **4.4.1**, **4.4.2** or **4.4.3** should be covered over with at least 50 mm thick sand cement screed using 1 : 3 mix and integral waterproofing compound in prescribed proportions. The surface or the screed should be levelled only with a wooden float and should not be trowelled smooth. Before laying the structural concrete, the surface of the screed should be wetted with cement slurry.

4.4.6 After the side walls are constructed and allowed to undergo the specified curing, the inside surface of the walls and the flooring should be made rough with a hacking tool, washed clean with water and wire brushed so as to remove all the loose material, and a waterproof cement plaster 1 : 3 mix with suitable proportion of an integral waterproofing compound should be applied in two coats, the first coat being 12 mm thick and the next 10 mm thick. The second coat should be applied after allowing a time interval of at least 24 h for the first coat to harden.

4.4.7 The outside surface of the side walls should be treated with a waterproof rendering in a similar manner but in this case, only one coat of plaster 12 mm thick may be applied instead of two successive coats.

4.4.8 The rendering should be cured as carefully as the main concrete structure. After the outside coat of plaster has been fully cured and allowed to dry for some time, it may be given a coat of hot bitumen of the industrial grade 85/25 conforming to IS : 702-1961‡ as a further precaution against the seepage of ground water into the tank.

5. WORKMANSHIP

5.1 General and Necessary Features of Workmanship — For obtaining impervious concrete, it is not only necessary to use properly graded aggregate and to employ a suitably designed mix but it is also of utmost importance to see that the concrete is compacted by means of suitable tools. In case of walls or inaccessible portion of the forms, where use of internal vibrator is impracticable, the form should be hammered slowly facilitating proper placement of concrete. The concrete shall be thoroughly worked around the reinforcement, along the embedded fixtures and into corners of forms.

*Specification for bitumen felts for waterproofing and damp-proofing (*third revision*).

†Code of practice for laying damp-proof treatment using bitumen felts (*second revision*).

*Specification for bitumen mastic for tanking and damp-proofing (*first revision*).

†Code of practice for *in-situ* waterproofing and damp-proofing treatment with glass fibre reinforced bitumen.

‡Specification for industrial bitumen (*revised*).

5.2 Internal Vibrators — These 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.

5.3 Construction and Expansion Joints — Joints in concrete structures constitute the possible sources of leakage. Careful attention should therefore, be paid to the design, location and construction of joints in water retaining structures made of concrete [for details, *see* **8** of IS : 3370 (Part 1)-1965*].

5.4 Construction Joints — 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 explained in **2.1.2** for next day's operation.

5.5 Before next operation is started, all timber spoils, laitance, scum or loose concrete shall be removed by hacking the surface and then scrubbing off with a wire brush to remove all loose mortar or aggregates. Thereafter, before resuming 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 precautions, water bars as mentioned in **8** of IS : 3370 (Part 1)-1965* may be used at such joints. But sufficient care shall be taken when such water barriers are used, as otherwise, while pouring concrete from height, these strips may get bent and thereby restrict the passage of concrete, causing large size pores and honeycomb concrete. If it is not possible to take adequate care, it is better not to use the water bar. Concreting with proper measures at joints will itself be sufficient guarantee for water-tightness and the use of water bar will then be not necessary.

5.6 Expansion Joints — 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. The expansion joints may be constructed according to IS : 3370 (Part 1)-1965*. Sufficient care and precautions should be taken in providing them, if not properly done, this is a source of continuous trouble. In large reservoirs, concrete cover slab shall be designed to slide over the top of walls. The wall tops in these cases should be suitably finished smooth and a layer of bitumen felt or paper should be applied.

5.7 Treatment at Fixtures Like Pipes and 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 specials 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.

5.8 In the case of underground water reservoirs and swimming pools, being founded on piles, the damp-proofing/waterproofiing treatment shall be provided to bottom raft using bitumen felt conforming to IS : 1322-1982† or IS : 7193-1974‡ should be provided as shown in Fig. 2. The bitumen felt shall be laid in accordance with the details given in IS : 1609-1976§ or IS : 9918-1981‖ as the case may be.

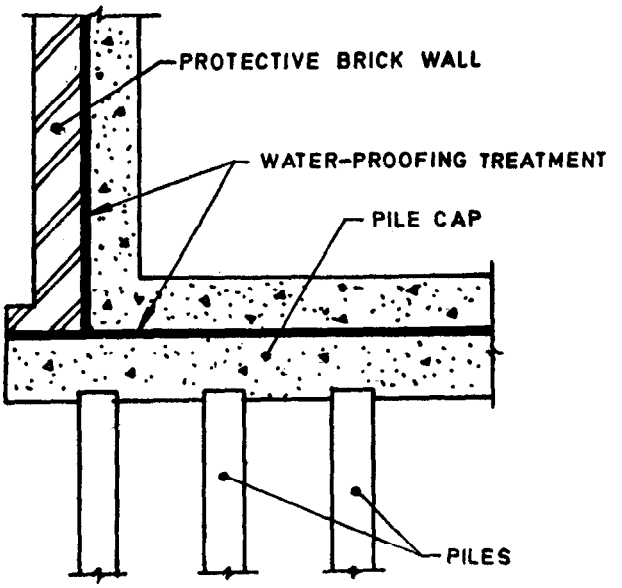


FIG. 2 A TYPICAL SKETCH OF DAMP-PROOFING/ WATER-PROOFING TREATMENT FOR UNDERGROUND WATER RESERVOIRS AND SWIMMING POOLS BEING FOUNDED ON PILES

*Code of practice for concrete structures for the storage of liquids: Part 1 General requirements.

*Code of practice for concrete structures for the storage of liquids: Part 1 General requirements.

†Specification for bitumen felts for waterproofing and damp-proofing (*third revision*).

‡Specification for glass fibre base coal tar pitch and bitumen felt.

§Code of practice for laying damp-proof treatment using bitumen felts (*second revision*).

‖Code of practice for *in-situ* waterproofing and damp-proofing treatment with glass fibre tissue reinforced bitumen.

6. TESTING AFTER CONSTRUCTION

6.1 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.

6.2 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 watertightness. 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.

6.3 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.

6.4 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.

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

6.6 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.

6.7 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.

7. REMEDIAL TREATMENT

7.1 The nature of the remedial treatment will depend on the extent and magnitude of the leakage noticed. In the case of minor seepage taking place through unnoticeable hair cracks, etc, the treatment mentioned under **7.1.1** to **7.1.3** and **7.1.5** is recommended whereas in the case of severe leakage or seepage through cracks, etc, the treatment mentioned in **7.1.4** is recommended.

7.1.1 In case of leakage through the opening of the horizontal construction joint, after emptying the reservoirs, the leaky joint should be properly cut-off preferably by using a power-driven carborundum saw or any other tool so as to get a square or slightly undercut groove. The joint is then filled up with cement mortar or synthetic resin after coated with mastic or bitumen.

7.1.2 *Coating with Sodium Silicate* — The solution made of one part of sodium silicate commercial (sp. gravity 1·8 kg/litre; paste variety of purity containing sodium oxide and silica in the ratio of 1 : 2·6 to 1 : 2·8) and three parts of water by volume is applied copiously with a soft broom over the entire surface. The treatment consists of three coats applied at an interval of 24 h between each coat.

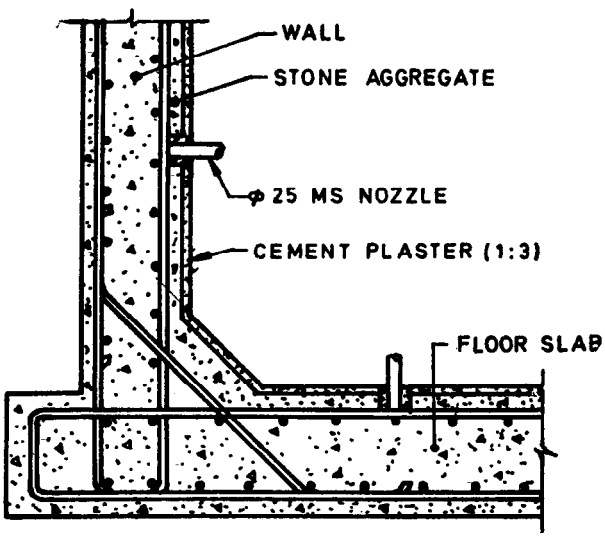
7.1.3 For tank subjected to considerable pressure, bitumen coatings are commonly given. Bitumen conforming to IS : 1580-1969* should be applied to a perfectly dry and clean surface in two coats each 10 mm thick. This is particularly suitable where there is any probability of the concrete cracking due to adoption of high working stresses in the design, lack of provision for settlement, contraction, etc.

7.1.4 *Chemical Injection* — In the case of severe leakage through cracks or seepage of water from surrounding ground in water logged areas, this method as indicated in **7.1.4.1** to **7.1.4.5** may be carried out. The main advantage of this method is that this treatment may be applied at any stage, that is, even if leakage or the seepage problem develops long after the construction. In this case, the removal of the back-fill of earth around the task may be avoided as the treatment may be given from the inside surface.

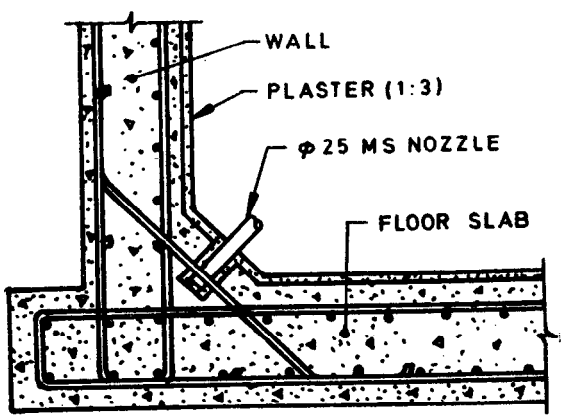
7.1.4.1 Holes about 50 mm dia and 25 to 40 mm deep shall be chiselled in grid pattern at a spacing not exceeding 1·5 metre centre-to-centre all over the base, walls and top slab. In addition, all the construction joints shall be opened by making a groove as to reach the reinforcement.

7.1.4.2 MS grouting nozzles of 25 mm dia shall then be fixed in these holes and grooves (*see* Fig. 3).

*Specification for bituminous compounds for waterproofing and caulking purposes (*second revision*).



3A Floor and Wall



3B Junction

FIG. 3 A TYPICAL SKETCH FOR FIXING OF NOZZLE

7.1.4.3 After the nozzles are fully set, neat cement slurry admixed with water soluble monomer based chemical shall be injected through the network of nozzles with low pressure grout pumps at a pressure not exceeding the designed strength of the concrete. The grouting shall be started at very low pressure and increased gradually to a required pressure. The grouting shall continue till the hole refuses to take any further grout, even at an increased pressure.

7.1.4.4 The water soluble monomer based chemical used shall conform generally to IS : 2645-1975*. In addition, it should conform to the following requirements:

a) It should be soluble in water;
b) The resultant grout solution should not have viscosity greater than 1·2 centipoises;
c) With addition of catalysts, gelation should occur by polymerisation cross linking chain reaction, that is, the water shall be bound into the gel structure and there shall not be any shrinkage of gel afterwards; and
d) The gelatin be such that it can be controlled to required time.

7.1.4.5 The nozzles shall be removed 24 hours after the grouting is over and the holes shall be finished off neatly.

7.1.5 *Guniting* — In the case of leakages from very many points, guniting has to be resorted to for covering the entire surface with sufficient thickness of mortar strengthened with mesh reinforcement.

*Specification for integral cement waterproofing compound (*first revision*).

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Review of Indian Standards

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Amendments Issued Since Publication

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