To Determine the Efficacy of Crystalline Waterproofing System in Concrete

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Abstract – Concrete is a homogeneous mixture of cement, sand and aggregates with the addition of water for curing purposes. Due to this composition concrete is often susceptible to damage and deterioration from the ingress of moisture and other deleterious chemicals. These problems can be resolved by the implementation crystalline capillary pore-blocking technology. Crystalline Technology waterproofs and improves the durability of concrete structures by filling and plugging the pores, capillaries and micro-cracks with a non-soluble, highly resistant crystalline formation. To check the extent up to which the formation of the crystals has taken place and is assisting in making the concrete waterproof need to be checked through a certain methodology. In this study the the water permeability of the crystalline waterproofing system has been checked. The crystalline waterproofing system involved both the application of both admixture as well as coating mechanism. The performance of the different type of crystalline waterproofing technology has been studied in this paper.

***Key Words*: Crystalline, waterproofing, concrete, capillary pore, water permeability, admixture, coating**

1.INTRODUCTION

Buildings in their many shape and forms provide us with the built-up areas of cities, towns and villages in which we ensure our habitat.[1] One of the major functions of building (from a durability point of view) is to exclude or be resistant to excessive moisture ingress. Yet the problem of dampness is faced at every household, commercial and industrial level. From establishments, floor sections and outside pre-cast panels, to water treatment offices and underground urban framework, cement is a standout usually the most generally utilized building and development materials. In any case, concrete because of its structure, a blend of rock, sand, bonding material and water, cement is frequently defenseless to harm and disintegration from water and chemical infiltration. Water enters the building elements either by capillary action or by hydrostatic pressure. [2]Building materials such as bricks, concrete, plaster, timber etc. have moisture content, which under normal conditions is not harmful to the performance of the structure. The rise in the moisture content in these materials to a level where it becomes visible or cause deterioration of the structure is the real dampness. Dampness is moisture content sufficient to cause darkening, staining, mold contamination and cooling of surfaces. Dampness is also in relationship to the surrounding atmosphere.

These malicious impacts can be kept away from using waterproofing innovation, which successfully enhances the toughness and lifespan of concrete structures, accordingly lessening long haul maintenance costs.

1.1 Crystalline Waterproofing System

Crystalline technology improves the durability and performance of concrete structures, lowering their maintenance cost and extending their lifespan by protecting them against the effect of aggressive chemicals. These high performance qualities result from the ways in which the crystalline technology works, when used with concrete.

Crystalline Technology waterproofs and improves the durability of concrete structures by filling and plugging the pores, capillaries and micro-cracks with a non-soluble, highly resistant crystalline formation. In the crystalline waterproofing process the crystalline material applied to the concrete as an admixture or a surface coating travels through the concrete with the help of two mechanisms: osmosis and Brownian motion (diffusion). Like in plants where the leaves consisting of guard cells carries out photosynthesis and growth of the plant through osmosis, in the same manner crystalline process also adopts the process of osmosis. Crystalline as a coating material has to be applied on a wet surface having an open capillary system which helps in developing a suction mechanism and also gives path to the crystalline chemical towards the capillary pores. The capillary pores consist of water molecules behave like a solvent just like in most of the biological cases where water is generally a solvent. The crystalline chemical will behave like a solute of higher concentration and by process of osmosis the water (solvent) will move towards the crystalline chemical (solute). This chemical reaction of crystalline material and the by- product of cement hydration in concrete in the presence of water (solvent) will result in the formation of silicate crystals through the microstructure of concrete where ever moisture is present. The water (solvent) will leave behind temporary vacuum thereby eliminating vapor pressure. This would pull the crystal inwards till balance is achieved. The formation of crystal silicates in the capillary pores will remain dormant until there is any presence of moisture in the future. Whenever more water is encountered in the capillary, the process will be resumed. Crystalline waterproofing system does not remain as a coating but becomes an integral part of the concrete. The progressive movement of the white colored crystals is diagrammatically shown in a simplified sketch. The blue channels represent the saturated Capillaries and the white coloured crystals depict the active components of the crystallization material.

2. Material Properties

Sieve Analysis

Sieve analysis decides the particle size distribution of the coarse and fine totals. This is finished by sieving the totals according to : 2386 (Part I) – 1963. In this we utilize diverse sieves as institutionalized by the IS code and after that pass aggregates through them and subsequently gather distinctive measured particles left over various sieves.

Apparatus utilized – a)A set of IS Sieves of s izes – 80mm, 63mm, 50mm, 40mm,31.5mm, 25mm, 20mm, 16mm, 12.5mm, 10mm, 6.3mm,4.75mm, 3.35mm, 2.36mm, 1.18mm, 600µm, 300µm, 150µm and 75µm.

Methodology

1.The test was dried to a steady weight at a temperature of 110 + 5oC and weighed.

2.The sample was sieved by utilizing an arrangement of IS Sieves.

3.On fulfilment of sieving, the material on every sieve was weighed.

4.Cumulative weight going through every sieve is figured as a percentage of aggregate on each sieve to the total aggregate.

5.Fineness modulus was acquired by summing the cumulative weight of totals held on every sieve and divided the whole by 100.

Table 1 Physical Properties of Coarse Aggregates[3]

Test	**Aggregates**	
Loose Bulk Density	**12.5mm and 20mm** 1.36.Kg/L.	
Combined Grading	50%	50%
Specific Gravity	2.7	

Physical Properties of Fine Aggregates [3]

Table 2 Physical Properties of Fine Aggregates [3]

Test	**Results**
Loose Bulk Density	1.3 Kg/lt.
Grading Zone	Zone – III
Specific Gravity	2.63
Fineness Modulus	2.85

Table 3 Physical properties of cement OPC 43[4]

	Tests	Test Results – OPC	Recommended Value
1.	Standard consistency	30	----
2.	Initial setting time	127	Min. 30 mins
3.	Final setting time	480	Max. 600 mins
4.	Specific gravity	3.14	3.0 – 3.15

Water which was used for mixing and curing process was clean and free from any contaminants including alkalis, acid, oils, salt, sugar, organic materials, vegetable growth and other substances. Potable water (of pH value 7.1) was used in the casting of concrete cubes.

3. Experimental Procedure

Final Mix Proportioning for 1m^3 concrete:[5]

Table 4 Final Mix Proportioning for 1m3 concrete:[5]

Cement (in Kg)	Fine Aggregates (in Kg)	Coarse Aggregates (in Kg)	Water (in Kg)
325	695	1269	162.5

Mix Design Ratio - 1 : 2.138 : 3.90

3.1 Waterproofing Admixture

Admixture- Type A

Dosage-**(**As per the guidelines of the manufacturer)The admix added to the concrete was 1% by weight of the cement as per the recommended guidelines. Admix was added during the batching stage. To obtain a homogeneous mixture of the waterproofing admixture with the concrete the admix was first mixed with water and then added to the wet concrete mix.

Admixture- Type B

Dosage (As per the guidelines of the manufacturer)**-** The waterproofing admix added to the concrete mix at the time of batching was 2% by the weight of cement. Admix was allowed to mix with the concrete material for 3 min to a complete homogeneous mixture.

Admixture- Type C

Dosage-As per the specifications given by the manufacturer admix was added to the concrete at the stage of batching after all the components of the mix were added. The admixture was at 1% of the weight of the cement and mixed with the concrete mix for 2 minutes in the concrete mixture.

3.2 Waterproofing coating- Type A

Application Procedure (As per the manufacturer guidelines)

- Coating material was obtained by mixing 5 parts Type A and 2 parts water in a container. The quantity of a material taken for one coat was 78 gm and 30 gm of Coating mix and water respectively including 20 percent wastage.
- They were mixed together until slurry like consistency was obtained.
- With a paint brush this slurry was applied as a coating on the surface of the concrete cubes at the rate of 0.8 $kg/m^2$for one coat. The movement of kept as a circular to cover any missed spots.
- The second coat of coating material was applied while the first coat was still wet.
- The samples were kept undisturbed for the next 48 hours.
- After 48 hours the samples were damp cured for 7 days and left to air dry for the remaining 21 days.

Waterproofing Coating- Type B

Application Procedure (As per the manufacturer guidelines)

- To make the mixture of coating material and water, 5 parts and 2 parts of mixture and water respectively were taken in a container.
- They were mixed together until slurry like consistency was obtained.
- With a paint brush this slurry was applied as a coating on the surface of the concrete cubes at the rate of 0.8 $kg/m^2$for one coat. The movement of kept as a circular to cover any missed spots.
- After a period of 24 hours(when the first coat has dried) the second coat of material was applied in the same manner.
- The samples were kept undisturbed for the next 48 hours.
- After 48 hours the samples were damp cured for 7 days and left to air dry for the remaining 21 days.

Waterproofing Coating- Type C

Application Procedure (As per the manufacturer guidelines)

- The concrete surface was pre-wetted before the application of the waterproof coating.
- Once the concrete surface started to get dry flexi-crete was uniformly sprayed over the concrete cubes. The total quantity of Type C material was taken as 108 ml as per the coverage area specified by the manufacturer.
- The coating was reapplied in areas which dried off quickly.
- After a period of 24 hours the second coat of the same coating was applied in the same manner but without pre-wetting the surface.
- The concrete cubes were left undisturbed to be air dried for a period of 7 days.
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3.3Test to Check Water Permeability of Concrete

For Waterproofing Admixture

- The concrete cube specimens of M20 grade were casted prior to this test. The admixture mechanism was applied in the manner explained above.
- The end faces of the concrete cubes containing waterproofing admixture for each sample were lightly chiseled. As per the recommendations of the code.
- The concrete specimen was centered in the specimen cell with lower end resting on the ledge. In order to water seal the apparatus , rubber gaskets were placed on the botton and the top of the concrete cubes inside the specimen cell.
- The water reservoir was filled with water upto the permissible level specified on the container.
- Now with the help of the compressor machine the pressure was brought up to 2 kg/cm^2.
- With the pressure maintained at 2 kg/cm^2 the water inlet valve for the specimen cell was opened and water was allowed to run through the pipe into the specimen cell.
- The pressure was increased with regular increments of 1 kg/cm^2 upto 5 kg/cm^2.
- The total time of the test was maintained at 96 hours to 120 hours.
- The percolation of water was collected in the collecting container.
- If no percolating water was collected in the container the pressure was increased with increments of 1 kg/cm^2 upto 10 kg/cm^2 .

- The percolating water is measured at each pressure increase point.

For Waterproofing Coating

- All apparatus setup like for the waterproofing admixture remains the same.
- With the help of the compressor machine the pressure was brought up to 2 kg/cm2.This pressure was maintained for a period of 96 hours.
- Owing to no percolation or collection of water in the container the pressure was increase to 5 kg/cm2 and the cube specimens were sliced from the middle portion to check the depth of the water penetration inside the concrete cube.
- The pressure was increased upto 10 kg/cm2 with regular increments of 1 kg/cm2 and again the depth of the water penetration was measured.

4 Results

4.1 Compression Strength Test

At 7 days, the strength of mix was approx. 67% as compared to the 28 days strength.

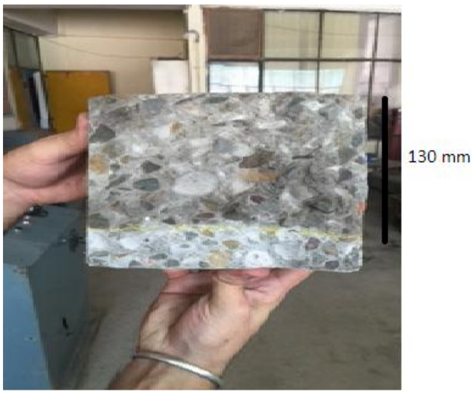
Table 5 Compressive Strength of concrete

Type of Mix	Compressive Strength, in MPa		
	7 days	**28 days**	**Target Strength at 28 days**
Control Mix 1	18	27	26.6

4.2Water Permeability Results

Control Specimens (M20 mix design)

The concrete cubes without any admixture or waterproof coating were subjected to a pressure of 2 kg/cm^2 in the water permeability apparatus for a period of 96 hours. The water penetration depth was observed as 130 mm.



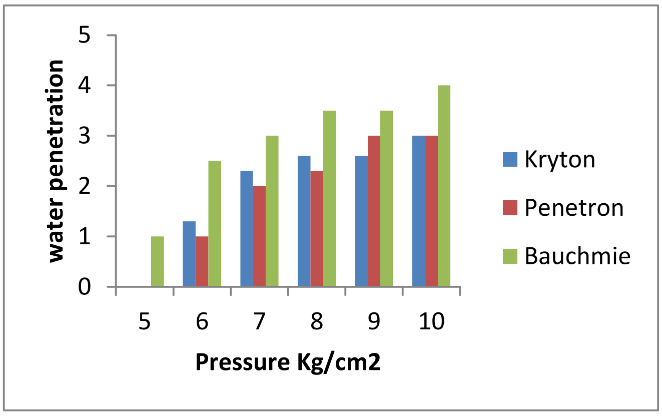
The pressure was further increased to 5 kg/cm^2 for a period of 24 hours and the water penetration depth was recorded as 150mm.

- **Admixture waterproofing**

  Water permeability test was carried out for a period of 4 days (96 hours). The pressure of the water permeability test was periodically increased from 2 kg/cm^2 to 5 kg/cm^2 in the span of 96 hours. For the 5th day the pressure had an increment of 1 kg/cm^2 upto 10 kg/cm^2. .

Table 6 performance of waterproofing system

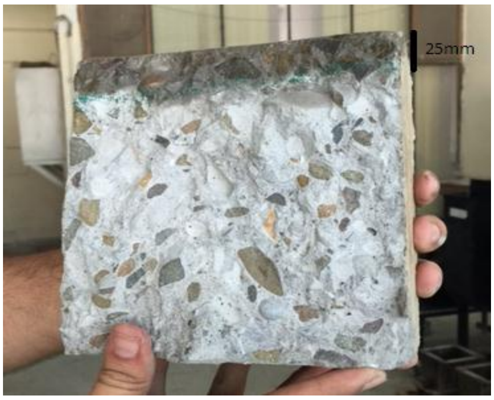
Pressure applied (kg/cm^2)	Water permeability through concrete cube (collection in container in mm)		
	Type B	**Type A**	**Type C**
5	0	0	1
6	1.3	1	2.5
7	2.3	2	3
8	2.6	2.3	3.5
9	2.6	3	3.5
10	3	3	4



Waterproofing Coating

Type A Coating

The concrete cubes coated with Type A coating were tested were tested for the water permeability test. Initially the pressure was maintained at 2 kg/cm^2 for a period of 4 days. On account of no leakage the pressure was increased to 5 kg/cm^2. The average water penetration depth through concrete cubes was recorded as 25mm.

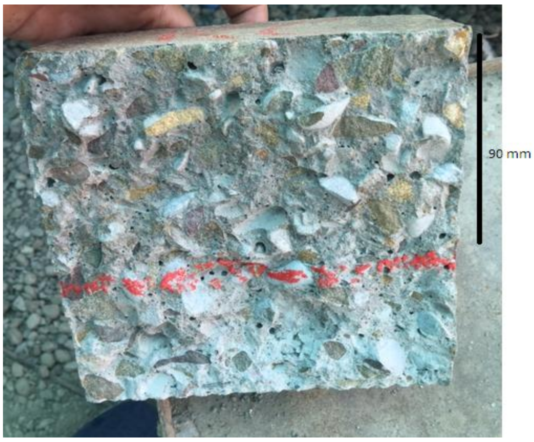


The pressure of the apparatus was further increased to 10 kg/cm^2 with regular increment of pressure from 5 kg/cm^2 . The average water penetration depth through concrete cubes after a period of 24 hours was observed as 80 mm.

The concrete cubes coated with Type A were further subjected to a pressure of 10 kg/cm^2 for 48 hours. The average water penetration depth through the concrete cubes was observed as 150 mm.

Type B Coating

The concrete cubes coated with Type B coating were tested for the water permeability test. Initially the pressure was maintained at 2 kg/cm^2 for a period of 4 days. The average water permeability through the concrete was recorded as 90 mm.



The pressure was again increased to 5 kg/cm^2 with subsequent increments in pressure. The average water permeability through concrete cubes was observed as 150 mm.

Type C Coating

The concrete cubes sprayed with Type C coating were tested for the water permeability test. Initially the pressure was maintained at 2 kg/cm^2 for a period of 4 days. With regular observation and adjusting to the requirements of the objectives the pressure was increased to 5 kg/cm^2. The average water penetration depth at 5 kg/cm^2 was observed as 30 millimeters.

The Type C sample was subjected to pressure upto 10 kg/cm^2 and the average water penetration depth was recorded as 75mm.

The concrete cubes coated with Type C coating were further subjected to a pressure of 10 kg/cm^2 for 48 hours. The average water penetration depth through the concrete cubes was observed as 150 mm

CONCLUSIONS

Waterproofing Admixture

- The results from table and figure suggest that the Type C admixture is a normal waterproofing admixture and has much less resistance to the ingress of moisture as compare to other waterproofing admixture.

- **Type A** indicates the best results when we consider pressure less than 10 kg/cm^2. Beyond this pressure both Type A and Type B have a similar behavior.

Waterproofing Coating

- **Type B** Waterproofing coating shows the poorest results. The water penetration depth under same pressure is considerable as compared to othe class of coating

- **Type C** Waterproofing coating shows the best results when it comes to pressure lesser than 10 kg/cm^2.beyond this pressure the **Type C** and **Type A** coating behave similarly.

REFERENCES

[1] “**Choosing waterproofing Concrete product”<**concretenetwork.com/concrete/waterproofing>

[2] Stock Fabricated material and shape” <globalspec.com/waterproofing membranes>

[3] Indian Standard, ”Method of tests for aggregates for concrete”, IS 383: 1970, Bureau of Indian Standard, New Delhi.

[4] Indian Standard, ”Specification for 43 grade Ordinary Portland Cement”, IS 8112:2013, Bureau of Indian Standard, New Delhi.

[5]Indian Standard,”**Plain And Reinforced Concrete**”, IS 456:2000, Bureau of Indian Standard, New Delhi.