IJMRSETM

e-ISSN: 2395 - 7639

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH

IN SCIENCE, ENGINEERING, TECHNOLOGY AND MANAGEMENT

Volume 9, Issue 8, August 2022

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.580

+91 99405 72462 +9163819 07438 ijmrsetm@gmail.com www.ijmrsetm.com

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580|

| Volume 9, Issue 8, August 2022 |

| DOI: 10.15680/IJMRSETM.2022.0908005 |

AN EXPLORATION ON DURABILITY OF RIGID PAVEMENT (PQC – PAVEMENT QUALITY CONCRETE) BY USING CRYSTALLINE ADMIXTURE CONCRETE

Jeetendra Kumar, Shubender Panwar

CBS Group of Institutions, India

ABSTRACT: This investigation sought to determine how crystalline admixtures influenced the durability of concrete. Chemical admixtures have recently gained a great deal of attention as an alternative strategy for solving durability issues and producing long-lasting, cost-effective structures. Permeability Reducing Admixtures (PRA) are the most effective way for protecting buildings exposed to water and waterborne contaminants, since the permeability of a concrete structure is believed to have a significant influence on its durability. Several compounds have been produced to protect concrete buildings against water penetration, and they have been categorized into PRA based on their chemistry, performance, and use. Hydrophilic Crystalline Waterproofing Admixtures (CWA) were investigated for this study. This study aims to determine how these chemical impacts the durability of concrete. With the use of crystalline admixtures, concrete becomes waterproof. Crystalline admixtures (CA) are hydrophilic, meaning they react with water readily. These compounds are produced by the chemically active components of cement and sand and gravel. Under hydrostatic conditions, the crystalline admixture is a permeability reduction admixture, per ACI Committee 212. (PRAHs). The formation of crack-blocking deposits is the result of the chemical reaction between crystalline admixture, cement, and water. Due to these crack sealing deposits, the density of Calcium Silicate Hydrate (CSH) and the resistance to water penetration in the concrete are both improved. This research studied the use of crystalline waterproofing as admixtures. The use of a crystalline waterproofing addition has enhanced the compressive strength and durability of concrete.

KEYWORDS: PQC, Crystalline Admixture Concrete, Rigid Pavement, PRA, CWA

I. INTRODUCTION

In recent years, the durability of concrete constructions has been a hot topic. Building degradation produced a surge in damage in the second part of the twentieth century; repairs of these concrete structures have been escalated in recent years, raising concerns about their long-term stability. Physical & chemical processes that affect the concrete structure's durability are among the factors that influence its durability. Durability is not a material's inherent feature, rather it is linked to how well it performs under environmental circumstances. In concrete, around 20-30% of the cement particles are anhydrous, which combines with water or moisture to produce hydration materials, which help to close the fracture owing to self-healing potential. Self-healing materials are utilized to improve structural longevity while lowering maintenance & repair expenses. It also protects the structures from costly maintenance during their lifetime. When watertight conditions are required, crystalline admixtures are offered as a suitable option for waterproofing concrete. Their mode of action is based on their capacity to react with water & cement particles, so increasing the density of the solid matrix in concrete & preventing external water from penetrating the structure. Water absorption tests, chloride penetration tests, & permeability experiments were performed to investigate several aspects of concrete's waterproofing capabilities, including crystalline admixture concrete.

Concrete roads are exposed to extreme weather conditions, resulting in rapid degradation & the need for routine repair. Concrete is a porous material that allows water & waterborne pollutants to infiltrate the matrix, causing it to fracture & spall & perhaps resulting in structural collapse. Carbonation, freeze-thaw cycle damage, corrosion from road salts, & sulphate assault are all prevalent problems with road concrete.

II. PAVEMENT QUALITY CONCRETE (PQC)

Pavement Quality Concrete (PQC) Design Mix Requirements

- Target means the flexibility of the PQC mixture should not be less than (4.5 MPa + 1.65s), whereas "s" refers to the standard deviation calculated from a minimum of 30 lines.
- When using Ordinary Port-land Cement (OPC), the maximum free water level should be 0.45, & if Port-land Pozzolana Cement, Port-land Slag Cement, OPC is mixed with fly ash, or GGBFS, maximum free amount of water & cement. should be 0.50.

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580|

| Volume 9, Issue 8, August 2022 |

| DOI: 10.15680/IJMRSETM.2022.0908005 |

- Consistency will be evaluated based on the paving equipment available at the location while creating a trial patch. For PQC work, a mix slump value of 30 to 15 mm is appropriate, however this may be altered based on site conditions & may require clearance.

Optimizing Pavement Quality Concrete (PQC) for durability

Concrete is the utmost global man-made substance on the planet, & it is responsible for transforming advance cities from horizontal-landscapes to vertical-communities.

Concrete is an impermeable & crack-prone matrix that is strong & solid. Waterborne chemicals can seep into the concrete or the underlying reinforcing steel.

Using Crystalline Admixture with green concrete

After completing tests, it was discovered that there was no detrimental influence on the quality of the concrete mix. Additional tangible performance features include:

- **Concrete Water Consumption -** No substantial influence on concrete water demand.
- **Workability -** The workability of concrete treated with Crystalline Admixture was unaffected.
- **Setting Time -** gives concrete a standard setting time.

Improvement in Concrete using Crystalline Admixture

The capacity of concrete to infuse water, carbon dioxide, chloride, sulphates, & other potentially harmful components is a critical aspect in its long-term durability. The examples below demonstrate how Crystalline Admixtures improves durability by minimizing the intrusion of dangerous elements, demonstrating how Crystalline Admixtures improves durability by enhancing various areas of concrete performance: -

- **Permeability –** While obtaining the required total concrete performance requires an ideal W/C ratio, permeability is critical for concrete durability: lower permeability equals better durability. Shrinkage cracking is reduced & micro-cracks are impenetrable with Crystalline Admixture. Over the structure's overhaul life, it offers self-healing of cracks (upto 0.50 mm). Finally, according to ACI specifications for PRAH, crystalline admixture reduces permeability by 70% or more.

- **Corrosion of steel –** Corrosion is a kind of electro-chemical reactions that occur when the electrical energy of a metal & a matrix of cement varies. Chloride metal corrosion is one of the most important components of concrete strength. By lowering the chloride ion permeability, Crystalline Admixtures cement provides a significant reduction in the results of rapid chloride permeability (RCPT) test results (such as the ASTM C-1202 test & each AASHTO T-277).

- **Self-Healing Properties –** Crystalline Admixture is a hydrophilic substance that forms crystals in cracks & gaps when it combines with moisture & concrete minerals. Concrete has an everlasting self-healing potential as a result of this. Crystalline Admixture generates new crystal forms that seal freshly generated micro-cracks whenever additional moisture enters.

- **Freeze / thaw resistance –** Freeze-thaw cycles are a are the main cause of the destruction of exposed concrete structures in cold climates (bridges, roads, etc.). When the water inside the concrete freezes, it expands, producing an internal pressure. This causes cracks, & subsequent melting allows water to penetrate deeper into the newly formed cracks, causing significant damage as the cycle progresses. The length difference caused by ice melting cycles is reduced by 90% in concrete using Crystalline Admixture.

- **Strength of concrete – Depending on the design strenth,** Crystalline Ad-mixture may enhance the compressive strength of concrete.

- **Acid Resistance –** Some projects may succumb to acid assault, resulting in the disintegration of the concrete matrix & a loss of structural integrity. Crystalline Admixture is most often & preferably used solution for waste water treatment facilities because it protects against chemical assault (pH 3-11).

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580|

| Volume 9, Issue 8, August 2022 |

| DOI: 10.15680/IJMRSETM.2022.0908005 |

- **Alkali silica reaction (ASR) –** Some aggregates produce an expansion reply when confronted by alkalis (Na_2O & K_2O) from cement or other sources, causing cracking & disruption. Specially due to increased level of moisture in the concrete, alkali-rich cement & other alkali sources, & aggregate containing alkali reactive elements are all common causes of damage. The moisture content of concrete is reduced by crystalline admixture, which avoids ASR.

- **Sulfate Attack –** When water containing dissolved sulphate enters the concrete, sulphate attack develops. The concrete's composition & micro-structure change as an effect of the reaction. Wide cracks & loss of connection between the cement paste & the joints are examples of this transformation, resulting in increased internal strength. Extensive studies have shown that concrete treated with crystalline admixtures & exposed to sodium sulphate solution does not show any change in length due to the increase. When untreated concrete samples were exposed to the same solution of sodium sulphate, they showed changes in greater length & greater dispersion.

- **Carbonation –** When CO_2 reacts with the $Ca(OH)_2$ in the concrete it generates $CaCO_3$ which degrades the concrete & reduces its alkalinity. Crystalline Admixture enhances carbonation resistance & saves implanted steel by sealing capillaries & fractures.

III. EXPERIMENTAL

The M 40 grade has been employed in this study. As per the data, most road projects use M 40 grade of concrete, & to investigate performance of crystalline waterproofing chemicals, M 40 grade concrete is used. Proposed mix is finalized with Fly Ash, & the total cementitious contents are determined after conducting various trials, & performance is evaluated on the final mix. The Crystalline modified trial mixes & the control mix (without Crystalline Admixture) were done under the same atmospheric conditions & with the same supply of material.

Material consumed in the investigation – the testing was carried out in North India with materials that were readily available.

MATERIALS

Cement

For experiment, Grade 53 Port-land Cement (ordinary) , as defined by IS-12269, was employed; the cement came from Rajasthan.

Fly-Ash

As fly-ash conforms to IS-3812 Part-I, fly ash from NTPC, Dadri (Uttar Pradesh) was utilized.

Coarse Aggregate

The experiment employed coarse aggregate that complied with IS-383:2016, & the aggregate came from Kotputli (Rajasthan).

Water

In the experiment, the water which was used was IS-456:2000 compliant & came from a bore well.

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580|

| Volume 9, Issue 8, August 2022 |

| DOI: 10.15680/IJMRSETM.2022.0908005 |

DESIGN-MIX: CONCRETE

Table 1 – Design-mix: Concrete

Ingredients	Source of Material	Mix/Cum (Control Mix)Mix ID-A	Mix/Cum (Crystalline Admixture)Mix ID-B
Cement	OPC-53 Grade	400	400
Fly Ash	Dadri	100	100
Sand	Yamuna Nagar	694	694
20 mm	Pali (Kotputli)	641	641
10 mm	Pali (Kotputli)	427	427
Admixture	PC Based	2.0 kg	2.0 kg
W/C		0.32	0.32
Fly Ash		20%	20%
Crystalline Admixture		Nil	0.8% by weight of cementitious contents.

TESTING OF CONCRETE

Green concrete Testing

Green concrete testing is carried out in accordance with IS-1199, 9103, & 8142.

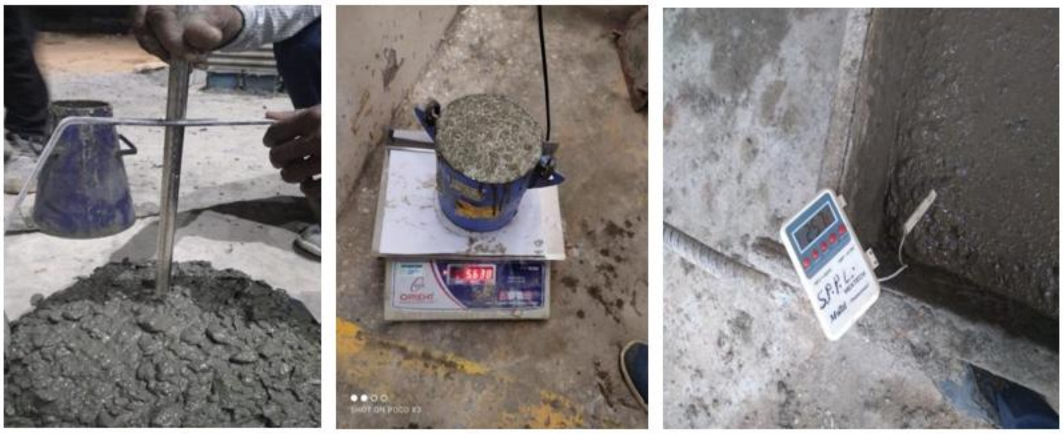


Fig.1: Green concrete testing

Compressive Strength Determination

In this concrete test sample, the sample is placed in a 15cm x 15cm x 15cm mould& the top of the mould is struck-off. There were a total of 54 cubes cast. Each trial mix yields a total of 09 cubes, with a total of 03 trial mixes completed with & without crystalline waterproofing ingredient. Compressive strength being drafted at 7, 28, & 56 days is compared. IS-1199 was used for sample while IS-516 was used for testing.

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580|

| Volume 9, Issue 8, August 2022 |

| DOI: 10.15680/IJMRSETM.2022.0908005 |

Fig.2: Compressive Strength Determination

Flexure Strength & Split Tensile Strength Determination

In this test, a sample of concrete for flexure strength is placed in a 70 x 15 x 15 (cm) mould& the top of the mould is struck off. In contrast, a split tensile strength cylindrical mould with the height of 30 cm & a diameter of 12 cm. [20] A total of 36 beams & cylindrical moulds were cast. Each trial mix yields a total of 03 beams & cylinders, with a total of 03 trial mixes conducted with & without crystalline admixture. At 7 & 28 days, the flexibility & power separation of the variable & the separation of the strength of the variable & the separation of the variable strength & the separation of tens IS 1199 were used for the sample, & IS 516 was used for testing.

Fig. 3: Sample preparation for Split Tensile Strength

Crack Filling Ability of Concrete

A self-made tool was used to test the self-healing capabilities of concrete cracks. One impermeability specimen was compressed to cause a fracture to propagate through the specimen's height, after which it was enclosed in a PVC cell & the annular space between the specimen's circumference & the PVC cell was sealed with epoxy glue. Water was injected into the test assembly via a manometer tube until the water level in the tube reached 4 meters. The tube's free end was attached to a pressure source, & a test pressure was supplied to the test specimen & sustained. Water flow through specimens was measured every 24 hours, & water leakage was seen on the open end of the specimens. Testing was began after 75 days of casting & observation was performed for up to 7 days to acquire the average value for 03 samples of each experimental mix created with & without crystalline admixture.

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580|

| Volume 9, Issue 8, August 2022 |

| DOI: 10.15680/IJMRSETM.2022.0908005 |

IV. RESULTS & DISCUSSION

Tables provide the results of all experimental mixes conducted with crystalline waterproofing admixture & control concrete. The test findings for both the control & crystalline admixture mixes are listed here, with full descriptions of the test outcomes.

Table 2 – green concrete Result

Property of Concrete	Mix -ID- A (Control Mix)	Mix-ID- B (Crystalline Admixture Mix)	Remarks
Workability (Slump)	70 mm (After 90 Minutes)	90 mm (After 90 Minutes)	Increase in workability of concrete.
Bleeding (%)	2%	1.5%	Decrease in Bleeding of concrete.
Initial Setting Time (Hrs)	450 Minutes	475 Minutes	Increase in setting time.

It was discovered that employing a crystalline waterproofing additive improved the workability of concrete. Concrete bleeding is reduced, & the mix becomes more cohesive; however, the initial setting time of the concrete is bit lengthier.

HARDENED CONCRETE PROPERTIES

Tables provide the results of all experimental mixes conducted with crystalline admixture & control concrete. The test findings for both the control & Crystalline admixture mixes are listed here, with full descriptions of the test outcomes.

Table 3 – Hardened Concrete properties

Property of Concrete	Mix ID- A (Control Mix)	Mix ID- B (Crystalline admixture Mix)	Remarks
Compressive Strength (IS-516:1959)			
7 Days	41.75 MPa	43.20 MPa	3.5 % Increase in strength
28 Days	54.37 MPa	56.90 MPa	4.50% Increase in Strength.
56 Days	57.50 MPa	59.80 MPa	3.9 % Increase in strength
Flexure Strength (IS-516:1959)			
7 Days	4.70 MPa	4.90 MPa	4.2% Increase in strength
28 Days	5.70 MPa	6.0 MPa	5.2 % Increase in Strength.
Split Tensile Strength (IS-5816:1999)			
7 Days	3.60 MPa	3.90 MPa	8.3 % Increase in strength
28 Days	4.90 MPa	5.10 MPa	3.9 % Increase in Strength.

The use of crystalline admixture enhances concrete strength, as well as other mechanical properties such as flexibility & strong separation strength.

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580|

| Volume 9, Issue 8, August 2022 |

| DOI: 10.15680/IJMRSETM.2022.0908005 |

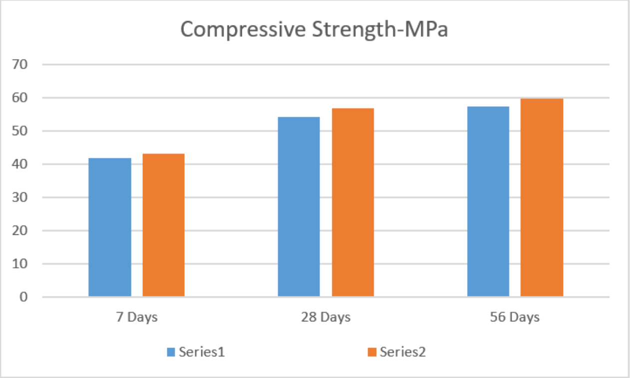


Fig. 4: Compressive Strength between Concrete with CA v/s Controlled concrete

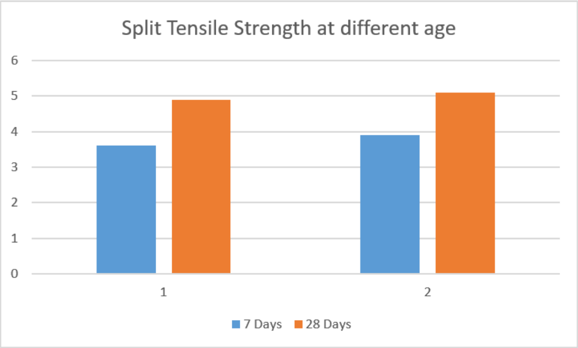


Fig. 5: Split Tensile Strength at different age

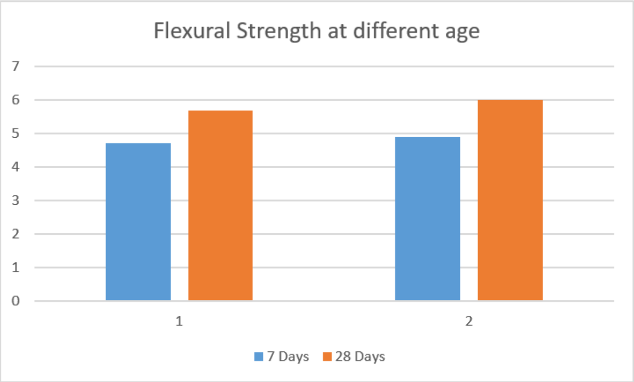


Fig. 6: Flexural Strength at different age

Table 4 – Permeability of Concrete

Property of Concrete	Mix ID- A (Control Mix)	Mix ID- B (Crystalline admixture Mix)	Remarks
Concrete Water Permeability (28 Days)	12 mm	3 mm	Reduction in water permeability up to 75 %

By employing a crystalline admixture, concrete's water permeability is reduced, indicating an increase in concrete's durability.

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580|

| Volume 9, Issue 8, August 2022 |

| DOI: 10.15680/IJMRSETM.2022.0908005 |

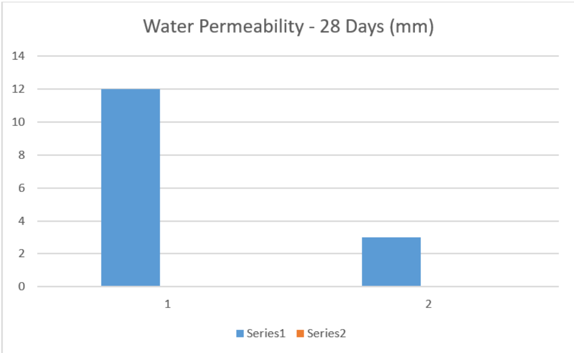


Fig. 7: Concrete Permeability for different mixes

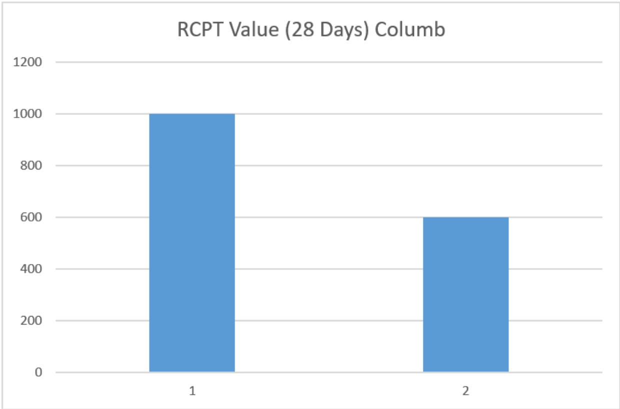


Fig. 8: RCPT value of Concrete for different mixes

Table 5– Durability of Concrete

Property of Concrete	Mix ID- A (Control Mix)	Mix ID- B (Crystalline Admixture Mix)	Remarks
RCPT Value (28 Days) Columb	1000 Columb	600 Columb	40 % Reduce in RCPT Value

Table 6 – Crack filing ability of Concrete

Property of Concrete	Mix ID- A (Control Mix)	Mix ID- B (Crystalline admixture Mix)	Remarks
Crack Filling Ability (75 Days)	0.2 mm	0.35 mm	Increase in Crack filling ability of Concrete.

By employing the crystalline admixture, concrete's crack filling ability improves, indicating that concrete's durability improves.

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580|

| Volume 9, Issue 8, August 2022 |

| DOI: 10.15680/IJMRSETM.2022.0908005 |

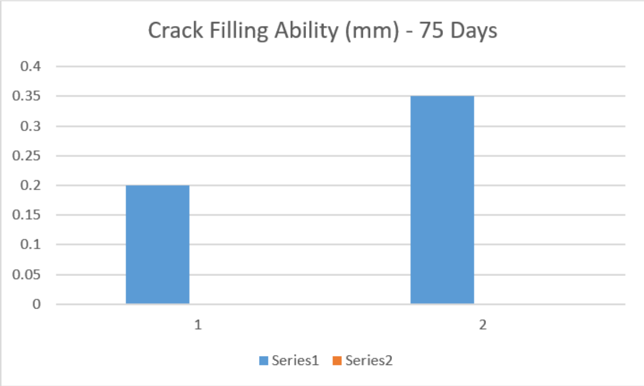


Fig. 9: Crack filling ability of Concrete for different mixes

V. FINAL CONCLUSION & SUGGESTIONS FOR FUTURE WORK

Using the crystalline admixtures improves the properties of new concrete, according to the results of the tests. However, the initial setting time of concrete has bit lengthier. The rate of comprehensive strength development in crystalline admixture concrete is faster at 7 days than in control concrete, but the findings are nearly identical by 56 days. The same effect can be seen in the flexibility of the concrete & the variability of the strength of the strength. When crystalline admixture is added to improve concrete strength, it has been observed that the water permeability of concrete is decreased by up to 75% & the RCPT value is reduced by over 40% in compared to control Concrete

Concrete's durability is determined by a number of parameters, the most important of which is the porosity & permeability of the concrete. The diffusion rate of hostile chemicals is slowed by reducing concrete permeability. Water & corrosive chemicals have a harder time penetrating concrete with lower permeability. Using proven & well-documented crystalline technology, concrete may be transformed into a waterproof material that resists numerous common sources of deterioration & corrosion. Several test results have revealed that crystalline technology enhances the quality & water tightness of concrete, especially in hostile weather situations.

Concrete highways having crystalline admixture will last longer & require less repairs due to their impermeable nature.

Carbonation resistance has been shown in impermeable concrete. It is resistant to freeze-thaw cycles, corrosion, & sulphate assault, making it a long-term solution.

- **Carbonation Testing:** According to the test findings & calculations, concrete samples with a 20mm concrete cover maintain the integrity of reinforcement in concrete structures for a period of time. Controlled Sample (K) = 35 years, & Sample of Concrete with Crystalline Admixture = 105 years.

As a result, compared to untreated concrete exposed to the same carbonation-prone environment, concrete with Crystalline Admixture will live up to 70 years longer.

- **Testing for Freeze-Thaw Cycles:** When compared to the controlled sample, the test findings & calculations showed that concrete with Crystalline Admixture enhanced frost resistance from F200 to F300. This implies that the Crystalline Admixture Concrete sample can resist at least 100 freeze-thaw cycles longer than the control sample. The frost resistance designation F-300 is the maximum.

- **Sulfate Resistance Testing:** The test findings & calculations reveal that Crystalline Admixture Concrete is more sulphate resistant than the control sample & may be utilized in harsh (sulphate) conditions to increase concrete durability & service life.

- **Permeability Tests:** When Crystalline Admixture Concrete is exposed to water, a chemical reaction occurs, resulting in the creation of insoluble crystals in all hairline cracks, pores, & capillaries throughout the concrete matrix. Because of the crystalline development inside the concrete matrix, the permeability of the concrete is reduced, making the concrete waterproof/impermeable. When the Concrete having Crystalline Admixture sample was been subjected to the continuous

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580|

| Volume 9, Issue 8, August 2022 |

| DOI: 10.15680/IJMRSETM.2022.0908005 |

pressure of 0.5N/ mm2 for 72 hours, there was no water penetration, whereas the controlled sample had an average water penetration depth of 18 mm, according to the DIN 1048:5 Water Permeability Test.

The Concrete with Crystalline Admixture sample had a recorded hydraulic conductivity of 68 times less than the control sample in the ASTM Standard D5084 Test Permeability Test.

The Concrete with Crystalline Admixture sample was 6 times less permeable than the control sample, according to the CRDC 48/92 ‘’Standard test Method for water permeability of Concrete.’’

According to ACI 201.2R-01, "The ability of hydraulic-cement concrete to withst& weather, chemical attacks, abrasions, or any other destructive process is defined as "the ability of hydraulic-cement concrete to withst& weather, chemical attack, abrasion, or any other degradation process". open to the environment any solid concrete will achieve its original condition, quality & efficiency " Because involvement of water in all chemical & physical processes that arise in concrete, both beneficial & negative, reducing its permeability will result in reduced deterioration & enhanced concrete durability.

VI.FUTURE WORK SUGGESTION

- The long-term behavior of crystalline concrete should be examined.
- The mechanism of crystalline material-cement interaction via product is not well known.
- The compatibility of crystalline materials with other Cement mixing items like Micro-silica, GGBS Slags, & Rice-Ash Husk must be explored.
- A concrete with crystalline material service life model will be studied.
- A cost-benefit analysis of crystalline material consumption will be carried out.

REFERENCES

[1] Li-Wei, Ram Huang &Jie Chen "A study of crystalline mechanism Penetratin sealer materials"

[2] Justin Henshell, “The blindside membrane system is below ground.

[3] A.A Ramezanianpour& V.M Malhotra, (1995). & Concrete. 17 (2), 125-133.

[4] ASTM C1202 - 12, "General Testing for Chloride Ion Concrete Resistance Strength Indication of Power"

[5] Ghosh, R. K. Chadda, L. R., Pant, C. S., & Sharma, R. K. (1973). "Consolidation of alluvial soils with lime & flyash." Indian Road Congress, 35 (2), 489–511.

[6] IS: 456 2000, “Indian Standard code of Practice for Plain & Reinforced Concrete”, Bureau of Indian Standards, New Delhi, India.

[7] IS: 516 1959, “Indian Standard Code for Concrete Strength Testing”, Bureau of Indian Standards, New Delhi, India.

[8] IS: 10262 2009, “Indian Standard code of Guidelines for concrete mix design proportioning”, Bureau of Indian Standards, New Delhi, India.

[9] IS: 1199 1959, “Indian Standard Code for Concept Sampling & Analysis of Concrete”, Bureau of Indian Standards, New Delhi, India.

[10] IS-383: 1970, ”The coarse definition of Coarse & Fine Aggregate is from a natural source of integration.

[11] IS-3812: 2003 Part 1, “Petrol specifications for crushed ash, to be used as a pozzolana in cement & concrete mortar.

[12] DIN-1048 (part 5): German standard for cutting concrete performance.

[13] IS-5816: 1999 "Distinguishing Solid Strength of Concrete Testing Method".

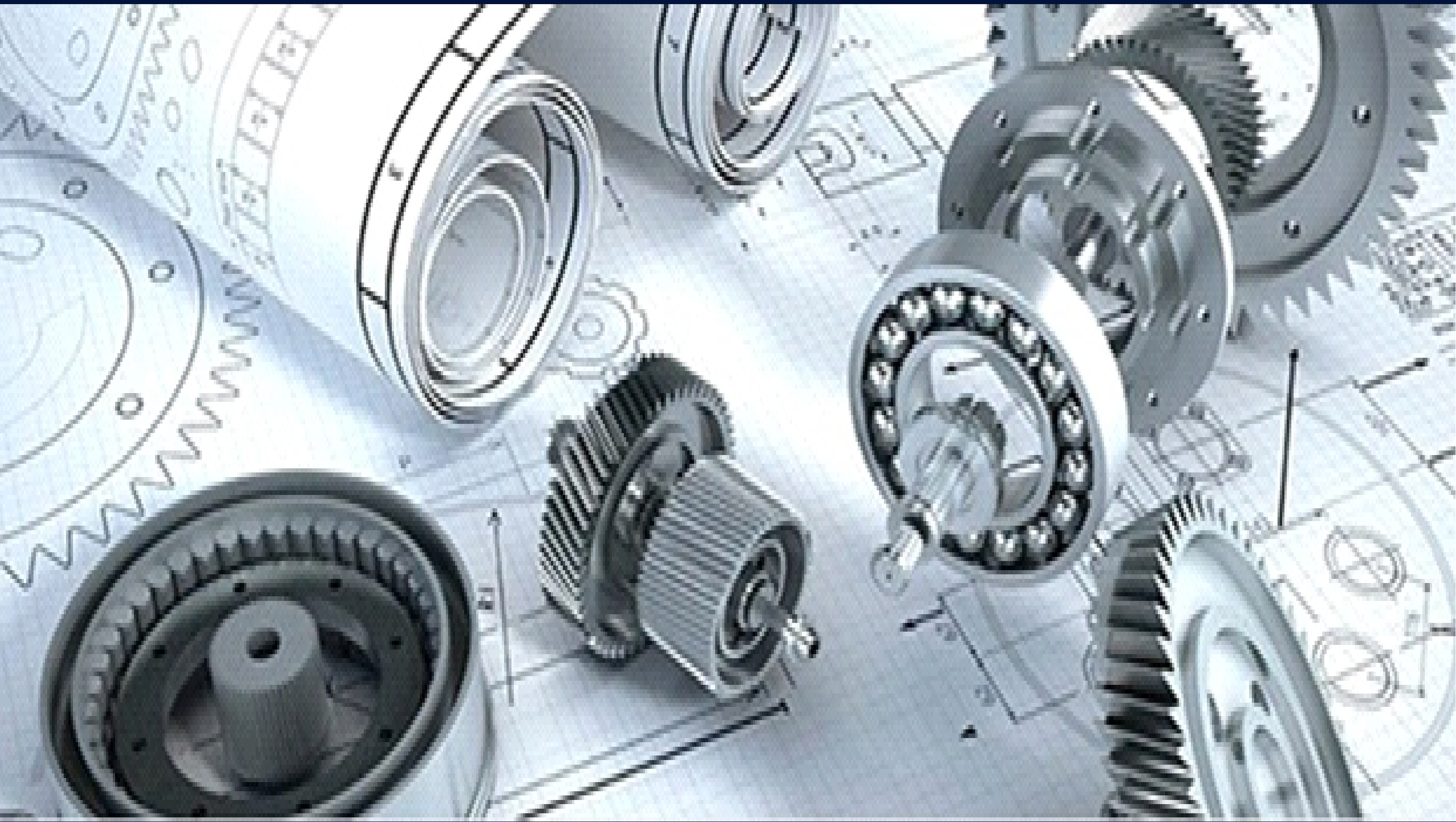
[14] 1322: 1993 “Specification of bitumen materials for waterproofing & moisture protection (fourth edition)”

[15] 4911: 1986 "Glossary related to bituminous waterproofing & moisture protection of buildings (initial review)"

[16] 5121: 1969 "Security code for stacking & other deep foundations"

[17] 6461 (Part 7): 1973 “List of words related to concrete concrete: Part 7 Mixing, laying, bonding, curing & other construction features”

[18] ISO / TR 16475: 2011 “Guidelines for repairing leaks in concrete structures”in concrete structures”



INNO SPACE

SJIF Scientific Journal Impact Factor

Impact Factor: 7.580

doi crossref

निस्केयर NISCAIR

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH

IN SCIENCE, ENGINEERING, TECHNOLOGY AND MANAGEMENT

+91 99405 72462 +91 63819 07438 ijmrsetm@gmail.com

www.ijmrsetm.com