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"Crack Proof Concrete": A Review

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Abstract – *Concrete is the second most consumed liquid in the world after water. Concrete has broad range of use within Construction Industry, however concrete is brittle, non elastic and weak in tensile strength. Due to this properties cracks forms at the surface and within the concrete structure which slowly deteriorates the quality of concrete and reduces the life of structure. This paper mainly focuses on methods and techniques which are modernly developed to deal with the problem of cracking in concrete.*

Key Words: Concrete, Admixture, bacteria, fiber, permeability, crack formation, Self healing Concrete.

1. INTRODUCTION

Concrete is highly used material in construction industry with its advantages of high compressive strength and durability, but concrete is poor in withstanding tensile stresses and shrinkage which are one of the major cause in cracking of concrete. However cracks less than 0.2 mm are unproblematic [1] but this cracks forms a path for external impurities like chlorides, sulphates and other salts to enter into concrete which causes further deterioration.

1.1 Causes of Cracks

There are various types of cracks in Concrete, Sometimes cracks are formed even before hardening of concrete. This types of cracks are caused due to Construction movements, Plastic & Autogenous shrinkages.

After hardening Cracks are formed mostly due to Thermal stress, Corrosion of reinforcement, Drying Shrinkage and creep over the period of time.

In case of pavements, cracks are formed due to Mechanical loading which induces stress in concrete. [4]

2. Techniques used for crack reduction

There are various methods available today to reduce cracking of concrete. Methods such as use of Fiber as reinforcement in concrete, Chemical Admixtures, Use of Cement Composites, Rubber as a replacement of aggregates, Use of Bacteria to generate minerals which is further used to seal the crack.

2.1 Fiber Reinforced Concrete (FRC)

Fiber reinforced concrete (FRC) is a method of using fibers of glass, nylon, steel, polypropylene. FRC is used to reduce cracks due to Plastic Shrinkage, Drying Shrinkage, Thermal Stress and to reduce Permeability in concrete. FRC has shown resistance to greater impact and abrasion as compared to conventional concrete. Use of FRC is dependent on Length/Diameter ratio. By volume it is preferred in 0.1 to 3% in the batch of concrete. FRC is also used in High Performance Concrete (HPC) i.e. Concrete which provides high compressive strength up to 200 MPa. [6]

Fig. 1 :- Fiber Reinforced Concrete

Advantages of Fiber Reinforced Concrete:-

- Improves Structural Strength and Durability
- Reduction in crack width and size

2.2 Chemical Admixtures

During Recent times various chemical admixtures have been produced to improve characteristics of concrete. Among them there's Shrinkage Reducing Admixtures(SRA) and Permeability Reducing Admixtures(PRA). SRA works to reduce Surface Tension of the water pore pulling them inwards and indeed reduce the Drying Shrinkage. When PRA is added to batch of concrete after hardening can detect the presence of water in cracks which helps in producing crystalline based minerals which further seals the crack.

Chemical Admixtures such as "Masterlife 300D" by BASF has shown results that can seal a hairline cracks (Crack width less than 0.4mm) within 60 days of detection.[3]

2.3 Use of Cement Composites and generating Self healing capsules

In a Study in Republic of Korea, The researchers have generated capsules of self healing material for concrete.

As Concrete is made of Inorganic components the researchers have used inorganic chemicals and further formed the capsules.

The capsules consists of Core material(CM) which is Ordinary Portland Cement(OPC) which are further mixed with Kneading Agents(KA). KA are inorganic chemicals which are mixed with Core materials and capsules are formed. KA are mostly fast evaporating liquid chemicals such as methyl alcohol (CH4O), chloroform (CHCl3), dichloromethane (CH2Cl2), and acetone (C3H6O). The KA are mixed in Percentage proportion with cement. Wall Materials(WM) which are applied on wall after finishing also plays an important role. The Wall materials(WM) used were Liquid Rubber, Acryl based material such as poly-methyl acrylate and silicate based materials such as Sodium Silicate.

This study results found out that mixing optimum amount of KA can enhance property of Concrete such as Compressive strength, reduction in permeability in concrete and improves workability of concrete.

Kneading Agents(KA) such as dichloromethane has improved compressive strength properties and Wall Materials(WM) like Liquid Rubber and Sodium Silicate has resulted in reduction of permeable water through Concrete.[2]

Fig. 2:- Self healing Capsules

Advantages:-

- Improved Structural Strength and Durability
- Can last for lifetime of Concrete
- Improved Workability of Concrete

2.4 Use of Rubber as a Replacement For Fine Aggregates

In a Study at India, the researchers have casted Concrete cubes, beams and Cylinders for compression test, flexural test and split tensile test respectively replacing the fine aggregates by 10% to 30%. Fine rubber particles passing through 4.75 mm sieve.

Fig. 3:- Fine Rubber particles

The study results concluded that Concrete with 10% Fine rubber particles has shown increase in tensile strength & Flexural strength of Concrete.

However addition of rubber in concrete has shown reduction in Compressive strength and workability.[5]

Advantages of Rubber Concrete:-

- Light Weight Concrete
- Environmental Friendly Method
- Improved Ductility
- Reduction in Shrinkage properties
- Improved Abrasion and impact resistance

2.5 Use of Bacteria based Self healing concrete (SHC)

Bacteria based self healing concrete uses mineral generating bacteria which in contact with gases present in concrete generate calcium carbonate based suitable filler material. The bacteria used is added as capsules along with food for bacteria in capsules into the concrete. The bacteria present in Concrete when detect cracks reacts with oxygen present in atmosphere which creates Calcium carbonate based filler material which seals the concrete.

$Ca(CH_5O_2)_2 + 7O_2 \rightarrow CaCO_3 + 5CO_2 + 5H_2O$

The Carbon dioxide which is released further reacts with Calcium Hydroxide present in Cement to produce calcium carbonate which heals the cracks.

$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$

The main drawback is bacteria has a limited life in Alkaline nature of concrete and after some time the capsules which are light weighted as compare to aggregates makes the concrete porous which results in low compressive strength after 28 days of curing as compared to Conventional concrete.[1]

Fig. 4:- Bacteria Capsules in Concrete

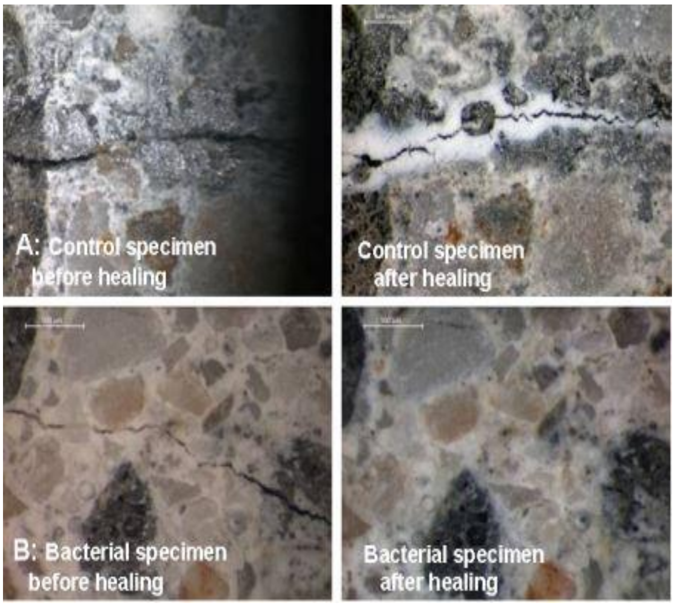

Fig.5:- Process of healing of crack

3. CONCLUSIONS

Various Studies have used various techniques sharing same objective and have shown promising results:-

- The use of macro and micro fibers in Concrete has significantly increased strength and durability of concrete along with reduction in chances of cracks which lead to use of FRC in Industry, Road pavements and Nuclear Facilities.
- Chemical admixtures such as SRA and PRA are effective in reducing cracks and healing the cracks.
- Use of Inorganic Chemicals can further enhance the properties of Concrete along with reduction in cracks.
- Using Rubber as a replacement of fine aggregates can improve elasticity and tensile strength of concrete.
- Use of mineral generating bacteria can improve concrete natural self healing properties.

All this Methods are effective in crack reduction in concrete but needs further improvements to enhance characteristics of concrete in all aspects along with less harm to environment.

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BIOGRAPHIES

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