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Fundamental Study Over Self Healing Techniques in High Strength Performance Concrete Structures

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Abstract: *In this developing world the concrete is the most extensively used building material in all types of framed concrete structures going under modern construction practices. Because the heavy concrete structures have high strength and durability, so in the long duration there arise possibilities of development of cracks due to number of causing factors. These cracks in concrete structures are not only unpreventable but continue increasing throughout the life span of concrete also and this results to what is the major weakness of concrete. Through these cracks the water and other salts can seep initiating corrosion in between the cracks reducing the life span of the concrete structures. So the repair or rehabilitation of such concrete structures becomes an urgent need of the time. This paper reviews various bio-techniques being used worldwide to rectify these cracks by introducing the self healing bio-agents. These bio-concrete members can easily and successfully rectify the developed cracks. This bio-technique is highly desirable because the remedial action is natural and eco-friendly. This paper discusses the healing of artificial cracks in concrete structures by using different types of bacteriae belonging to Genera Bacillus like Bacillus Megaterium, Bacillus Sphaericus, etc., and to increase the characteristics of concrete to get maximum strength and durability. The compressive strength of concrete can be increased, and the permeability can be reduced by adding bacterial components during mixing of concrete. The bacillus megaterium can increase the compressive strength of concrete and stiffness. The bacterial components having the property of alkali resistance can save concrete from weathering effects also.*

Keywords: *Bio-concrete, bio-technique, artificial, framed structures, bacterial components etc.*

I. Introduction

A. Ordinary Portland Cement

For the experimental works ordinary Portland cement of 43 grade was used and properties like consistency=28%, initial setting time is 30 minutes and final setting time is 10 hours.

B. Coarse Aggregate

Locally available crushed stones of 20mm and down size was used and properties like specific gravity= 2042, water absorption= 0.5%.

C. Fine Aggregate

Locally available sand was used. It should be free from impurities and properties like specific gravity = 2.5 and water absorption = 1%

D. Water

Water is used for mixing and curing was clean and free from injurios amount of oil, acid, alkali, salts, sugar, organic materials or other substances that may be deleterious to concrete.

E. Bacteria

The bacteria used in this study are Bacillus Subtilis. Bacillus Subtilis is a gram positive, rod shaped bacteria, commonly found in soil. Bacillus subtilis is an endospore forming bacteria, and the endospore that is forms allows it to withstand extreme temperatures as well as dry environment. Bacillus Subtilis is not consider pathogenic or toxic is not a decease causing agent.

F. Production of bacterial water

The nutrient broth and other chemicals are mixed with required water. After that the mixed water is boiled for autoclaving process. The boiled water should have the reddish color due to nutrient broth and other chemicals. After the atmospheric cooling the required bacterial cells is transferred from nutrient agar plate to that prepared liquid media. Then the liquid media should be covered with aluminum foil and shake periodically. The reddish color should be changed into light yellow color after 36-48 hours which shows the presence of Bacillus Subtilis in he liquid media. Before mixing into the concrete, concentration of bacteria cells are tested.

II. Literature Review

2.1.1 Bishwajit bhattacharjee et al, (1997)

The empirical model was developed by them in terms of direct factors which were resulting for corrosion. One can use this for extending the life span of corrosion affected concrete structures. They can use this by having the simple knowledge of chloride content, water cement ratio and cement content of concrete samples.

2.1.2 Mani.k et al, (1997)

The corrosion of rebar in concrete is a complex phenomenon. By measuring the rate of corrosion taking into account temperature and humidity statistical analysis of data measured over a period of time may result in the better life span of structure. One of the major parameters is diffusion coefficient of concrete with regard to chloride. A laboratory test method was developed in which chloride ion penetration is accelerated by impressed current in a diffusion cell. The calculation principle is based on ionic diffusion. Using this method one can determine diffusion coefficient in field concrete by obtaining samples from actual structures and testing in laboratory.

2.1.3 Mehta P.K et al, (1997)

He concluded that durability is not only on intrinsic property of concrete. It is not only dependent on environmental conditions but also on design parameters, mix proportions ,and processing methods. Deteroitation of concrete structures before the end of their life span can be prevented by hostolic approach which covers all factors influencing durability.

2.1.4 Sharma Satish Kumar et al, (1997)

He concluded that there are several factors which influence the durability of concrete. Water cement ratio and permeability plays a dominant role in quality of concrete.

2.1.5 Wee.T.H. et al, (2000)

One of the main causes of deterioration of concrete structures is exposure to harmful chemicals such as contaminated ground water, industrial effluents and sea water. some of the important chemicals which affect durability are chlorides and Sulphates.

2.1.6 Mackechnie,J.R. et al, (2004)

The chloride conductivity test which was used in south Africa and is sensitive to material ,processing and environmental factors that influence the durability of concrete structures. This technique is very easy to use and reliable estimates of chloride resistance.

2.1.7 CHAVA SRINIVAS et al, (2004)

High volume flyash can be incorporated into M20 grade of concrete. It is observed that ductility of normal concrete is more than that of flyash addition concrete.

2.1.8 Ms.T.Vidhuthalai, et al, (2018)

Bacterial concrete is the self healing concrete in which bacteria are pre added to the concrete mix. Microbial concrete achieve more attention because it is crack and corrosion free which results in strength increment. The properties like durability, permeability and strength of concrete decreases due to cracks. The bacteria used for this purpose is bacillus subtilis. It is a endospore forming bacteria and endospore it forms allows it to withstand extreme temperatures as well as dry environments. Mix proportion M25 1:1:2 is used with water cement ratio 0.45. The 28th day compressive strength was 25N/mm2.To study the crack healing capacity fine cracks were made by giving initial cracking load. continuous examination was done to identify the self healing capacity of bacterial concrete.

2.1.9 Tae-Ho Ahn et al, (2010)

He proposed the applicability og self healing concrete a new method for crack control and enhanced service life of concrete structures. The various mineral admixtures and chemical agents were used for crack healing. The mineral admixtures like hauyne, anhydrite were used. Chemical agents such as $NAHCO_3$, NA_2CO_3 were used. The super plasticizers like Polycarboxy-late. The durability tests on mortar containing natural volcanic Puzzolona, which were immersed in sea water, running water wetting and drying. In all cases structural changes were noted either due to dissolution or by formation of calcium crystals. This volcanic Puzzolona results in reduced permeability due to reduction in porosity with aging. The Pozzolanic action increases the strength by the formation of CSH.

2.1.10 CHITRA.P.BAI et al,

The Bacillus Subtitilus was used with different cell concentrations like 10^5,106,107 cells/ml for preparing the bacterial concrete. Cement was partially replaced by 10%,20%,30% of flyash by weight .concrete of grade M30 was used and different tests such as compressive strength,split tensile were conducted after 28 and 56days curing. The best results were obtained for 10% replacement of flyash and cell concentration of 105 cells/ml.

2.1.11 R.A.B. Depaaand T. Felix Kala et al,

Concrete cubes were prepared with 2.5%,5%,7.5%,10% as a binder in addition to adding cement to concrete and also by replacing 35% and 55%nof cement with GGBF. Different tests were conducted for checking the durability properties of specimens. The specimens are tested for 28days and 70% and 90% of compressive load is applied to generate micro cracks for studying the durability properties. The concrete mix containing cement replaced with 35% GGBFS has given maximum compressive strength.

2.1.12 Salmabanu.luhar, suthar gourav et al, (2015)

Published a paper on self healing concrete. Crack formation is very common phenomenon in concrete structure concrete is a very good material to resist compressive loads. But if the load is applied more than the limit then it leads to cracks. Because of cracks properties like durability, permeability & strength of concrete decreases. There are different methods for repairing the cracks. One of the methods is the use of bacteria for self healing in this paper they found that the stains of genus bacillus will be able to service in high alkaline environment. There are different sizes of cracks which ranges from 0.05mm to 0.87mm, 5mm to 10mm, 200mm to 205mm & 300mm. the bacteria growth also depends upon the ph. The bacteria growth was best in the pH range of 7.5 to 9. Light weight aggregates is also used for improving self healing property of the concrete. Different tests like strength test, gas permeability, water permeability test were conducted and it was proved that bacterial concrete was better than conventional concrete.

2.1.13 Suyog S. Pawar, et al, (2018)

They published a paper on bacteria based self healing concrete. As we know that cracks are developed in concrete due to the low tensile strength. Due to the cracks the life span and durability of the structure get reduced. So that we need to reduce the expansion of the cracks by using advances techniques. One of the new advanced techniques is introducing bacteria for the self healing process. The authors used bacillus pasteurii, Which can produce urea. When we are adding the bacillus pasteurii in to the cracks by the continuous hydration process it can produce urea to fill micro cracks by caco3 precipitation.

2.1.14 A Gandhimathi et al,

This paper published about experimental study on self healing concrete. An approach of cracking of concrete is a common phenomenon. Here modern technologies are used for reducing the cracks. Here are used a Bacillus Sphaericus group bacteria. The micro-organisms are used for self healing process. In this process the bacteria Dormat stage for 200 years. In this process cracks can be fill by biologically produce lime stone to heal the cracks. There different tests and different strength are there. the workability test of bacteria results 90mm.compressive strength of bacteria is 10% & 20%.addition of bacillus Sphaericus strength is 13.07% & 13.75% respectively. Tensile strength of concrete is 10% & 20% addition of bacillus Sphaericus as strength 3.15% & 7.25 respectively.

2.1.15 Luciana restuccia , anna reggio et al, (2017)

The Published paper about self healing techniques for cement based materials. in this paper a new self healing technology for cement based materials is proposed. Two different kinds of shells were used such as glass shells and pharmaceutical capsules, the crack breaks this type of shell and these shells release the self healing agent thus heal in the cracks. One of the alternative methods is to use sodium silicate as a self healing agent. It is commonly known as liquid gas. The sodium silicate is able to repair cracks because of its adhesive capacity. The pharmaceutical empty capsules of size 3 and volume of 0.30ml were also used to repair cracks. These capsules were inserted in sodium silicate solution and were used for healing. Thus a new technique of pharmaceutical capsules filled with sodium silicate was proved to be efficient.

2.1.15 Kusuma, Amit Kumar Rai et al,

They were published a paper on self healing concrete. As we know that concrete is a well known constructional material. Cracks in the concrete reduce the strength of the concrete. So that we need to overcome from this problem so we are introducing Bacillus Megaterium bacteria to heal the cracks. We are adding the Bacillus Megaterium bacteria while mixing the concrete. Later found that the use of bacillus Megaterium

bacteria while mixing the concrete. Later found that the use of bacillus Megaterium improves the compressive strength and stiffness of concrete. And also it reduces the water absorption capacity of the concrete compared than conventional concrete. This is bio based and eco friendly technique. During healing process the bacteria produces or forms calcium carbonate ($caco_3$) to fill the cracks.

2.1.16 S. Soundharya et al, 2014

They were published a paper on the study on the effect of calcite precipitating bacteria. On self healing mechanism of concrete, We know very well concrete is a well known building material but the main disadvantage is that cracks formation in the concrete, which reduce the life span of the structure. The cracks can easily allow the water and other liquids like chemicals. If these things reaches the reinforcement material obviously the material get corrode. Then the durability of the structure gets reduced. They have classified bacteria In this paper such as Self healing mechanism of bacteria, Chemical process for cracks remediation are explained. Concrete can give the better results for the self healing. Self healing of concrete can be done by different ways they are;

- Applications of specific calcite precipitating bacteria for concrete repair.
- Usage of synthetic polymer such as epoxy treatment, bio-mineralization of bacteria in concrete.

2.1.17 Rajkumar.C et al, (2001)

The different grades of cement like 33grade, 43grade, 53grade OPC can be used. Sulphate resisting Portland cement can also be used according to IS 12230. In addition to these admixtures such as flyash, GGBS, Rice husk are also used. The flyash can be added up to 35% by mass and not less than 15%. The compressive strength mainly depends on water cement ratio as well as type and class of cement, also on the amount of admixtures. In case of PPC the addition of flyash limits to 15-35%.rice husk ash content depends on burning temperature and holding time. Optimum properties are obtained when rice husk is burnt at a temperature of 5000-7000^{o}C for longer time. The addition of rice husk helps in improving impermeability characteristics of concrete.

2.1.18 Satyanarayan K.S et al, (2003)

The compressive strength of blended cement concrete is lower up to 28days and higher at 56days. The split tensile strength of blended cement concrete is 0.072-0.140 times its compressive strength for high and low grade mixes respectively. The use of GGBS increases the rate of tensile strength in plain concrete. The modulus of elasticity of blended cement concrete is related to compressive strength. The water absorption is also very low in blended cement concrete which indicates higher impermeability.

2.1.19 Amirreza Talaiekhozan, Ali Keyvanfar et al,

Research development on self healing concrete structural members. In this paper the different process for self healing concrete is the ability of concrete to repair small cracks automatically. Remediating cracks in concrete is more important for its service durability, and structural safety. There are several methods for the self healing of cracks.

- Natural
- Chemical
- Biological processes.

In biological self healing process the use of microorganisms to design self healing concrete has been categorized as biological strategy by several researches. As microorganisms can grow almost every where such as soil, water, oil & industrial waste water Bacillus Pasteurii & Bacillus Sphaericus are the most common microorganisms used in designing self healing concrete. Although self healing process containing natural & chemical are well known to design self healing concrete biological process is a young promising technology. there are many advantages of bacteria such as it is very easy to culture. Isolation of bacteria is not very complex. Inspite of all these advantages the use of the bacteria for self healing of cracks is most economical method.

2.1.20 Ms.B.Arthi (2016) et al,

They published a paper on strength and self healing characteristics of bacterial concrete.

In this paper they have compared the two types of bacteria such as Bacillus Subtilis and Bacillus Licheniformis. They have conducted different tests likes compressive strength, split tensile strength and self healing propertie. Each bacteria of concentration 10^5 cells/ml are added. The tests were performed for 7, 14 and 28 days respectively. The optimum temperature for the growth of bacteria was found to be 25-35^{0}C.

The different tests like slump cone test and scanning electron microscope (SEM) that produce images for scanning. Flexural strength was also conducted for checking the load bearing capacity the slump values obtained for bacterial concrete is less. Thus it is proved to be having good workability.

2.1.21Ms.B.Arthi (2016) et al,

Published a paper on a study on strength and self-healing characteristics of bacterial concrete. In this paper they have given experimental results and influence of two different types of bacteria. Those are Bacillus Subtilis and bacillus Licheniformis. These bacteria can influence the properties of concrete such as compressive strength, split tensile strength and flexural strength ,water absorption and its self healing properties. We need to take care while adding the bacteria. we have to add bacteria of concentration of 10^5 cells/ml. the bacteria can heal the cracks by calcium precipitate. The healed cracks can be observed by using scanning electron microscopy(SEM).

2.1.22 Gaurav Agarval et al, (2017)

As we know that concrete is a homogeneous mixture. The main problems in the cracks are having to repair the cracks. Cracks may lead to decrease the life span of the structure. The advance technology is developed for the repair of the cracks that is self-healing technique by using bacteria. This helps in increasing the strength and durability of the concrete. As per the obtained results there is increase in compressive strength, tensile strength and durability in bacterial concrete as compared with normal concrete. This was the main objective of the bacterial concrete. The different tests were conducted such as compressive strength, split tensile strength. To know the growth of bacterial concrete we are using SEM.

2.1.23 Grammy christian (2017) et al,

The paper published on engineering and durability property of bacteria self healing concrete. They were investigated self healing capacity of fly ash cement system by considering compressive strength, porosity and hydration reaction. Mainly they were focused on formation of shrinkage cracks after 28 days of sample containing fly ash was higher than that of Ordinary Portland Cement. Due to the effect of chloride diffusion co-efficient of sample with 25% fly ash at 91days was significantly lower than that of cement. From the view point of hydration the amount of cementatious materials hydrated after 28 days increased when the replacement of fly ash cement system has the self healing ability for micro cracks that occurs due to the effect of shrinkage.

2.1.24 Jasira Bashir et al,

Have published a paper about bio concrete the self healing concrete. A approach of bio concrete prooved very fruitfull for construction of durable structures and its improve the properties of concrete and reduced the maintanance cost. In this paper it is useful for different microorganism. Here different tests were used for finding the strength of concrete mix. They are compressive strength test,split tensile test and flexural strength test. Here different types of bacteria used for healing and also he use the scanning electron microscopy(SEM)/X-RAY diffraction(XRD). By the process of meta bio logically calcium carbonate precipitation is formed. The test results of bio concrete and conventional concrete showed an eloquent difference.

2.1.25 S.Vijaya Bhaskar Reddy (2018) et al,

Were published a paper on experimental study on mechanical properties of bacterial concrete with fly ash.

Concrete is a construction material that is used world wide in construction. Cracks is the most common problem in the concrete. Many investigation proved that cracks are ability to heal themselves. Selection of repair procedures should be such that they should increase strength, increase stiffness, durability and prevent development of corrosive environment. A new technique called bio mineralization in which microbial metabolic activities promote calcium carbonate precipitation. The technique called microbiologically induced crack remediation(MECR). In this process the organism fro inorganic solids are used for self healing. These are different types of bacteria based on shape, gram stain, oxygen requirement. There are different methods to measure cell concentration of bacteria haemocytometry, turbidmetry, dilution plating. Bacterial cells viability, count the CFU'S. The fine aggregate and coarse aggregate used for bacterial are also determined.

2.1.26 P.Gosh et al, (2004)

This study describes the strength improvement of cement mortar by introduction of mineral precipitation. The cells are introduced with different cell concentrations along with water. It is proved that compressive strength was increased 25% at 28 days by adding 10^5cells/ml of water. The strength improvement is mainly due to the growth of healing material with in pores of cement matrix as shown by SEM (scanning electron microscopy). By using coli microorganism there is no improvement in compressive strength.

2.1.27 Massimilisno Marvasi et al, (2019)

Although the calcium carbonate precipitation by microorganisms is quite common, the physiology ad genetics of this formation were not clearly understood. They have chosen Bacterial Subtilis to study the

physiological aspects which results in the calcium carbonate formation. When grown on precipitation medium. Bacillus Subtilis etfa is used for the comparative studies. The results shown that etfa results in decrease of PH in precipitation medium during bio film development. It is also proved that elfa emits on excess of 0.7moles H+/lit with respect to Bacteria Subtilis

2.1.27 Way J.L et al, (2003)

This paper describes the results of reducing the cracks in concrete by using microbiologically induced calcite. The bacteria called Bacillus Pasteurii was used for this propose. The basic principle here is microorganisms hydrolyzes urea to produce ammonia and co2 and ammonia increases the PH leading to the increasing in amount of insoluble calcite. To protect the cells from the high PH of concrete. The microorganism were accumulated in polyurethane Polymer, Lime, Silica fume and then applied in concrete.

Microbiologically induced crack remediation was assessed by comparing the compressive strength of healed concrete specimens and those of control. SEM is used to analyze the microorganisms induced in calcite precipitation. Based on the results it is concluded that MECR has excellent potential remediating cracks.

2.1.28 V Ramakrishna et al, (2001)

He proposed a new technique for reducing cracks in concrete by microbiologically induced calcite precipitation. Microbiologically induced Calcite precipitation comes under the category of bio mineralization. Bacillus Pasteurii is a common soil bacterium which is used for this purpose. MICP is highly desirable chemical reaction because Calcite precipitation is the main result of microbial activities. The technique is mainly used to improve compressive strength & stiffness of cracked concrete the durability of bacterial concrete beams exposed to alkaline, freeze thaw environments were studied. The effects of different concentrations of bacteria on durability were also studied. Microbial calcite precipitation was quantified by x- ray diffraction & checked by SEM a new calcite layer is formed on the surface of concrete. This layer increase its resistance to freeze-thaw attack

2.1.29 N Ganesh Babu, Dr.s.Siddiraju 2016.

Were published a paper on experimental studies on strength and fracture properties of self healing concrete. In this study on attempt is made to arrest the cracks by using bacteria and calcium lactate. The bacteria are added by different percentage into the concrete and there efficiency was checked. The main bacteria used for this study is Bacillus Pasteurii. Various tests like compressive strength, elastic modulus and fracture of concrete were analyzed in this study. The bacteria were introduced into the concrete along with calcium lactate powder which results in the formation of calcium carbonate crystals. The bacteria are added in the form of spores making limestone out of calcium lactate. The spores can survive for 45-50 days. Calcium lactate is also known as Calcium Splat Penta Hydrate. Melting point of this is 239^{o}C. The concrete samples were prepared and different test like compressive strength, elastic modulus were conducted. It is found that there is increase in compressive strength with 5% of bacteria and it is found to be 49.5mpa at 28 days which is more than normal concrete. So the use of bacterial concrete is very useful.

2.1.30 Ojas Pravin Rahate et al, 2016

They have published a paper on applicability of concrete treated with self healing concrete bacterial agent. An approach of concrete structure provides a developing of country. Healing of concrete here they used bacteria such as bacillus psceudofirmus, bacillus sarconima pasterurii. In that these cracks formation such as micro cracks as well as macro cracks. It is a major issue features the structure. It can prove an exceptional solution for both pre planning and renovation of the formation of cracks. In this method when bacteria exposed to moisture the bacteria fill the cracks with forming limestone. When healing the structural strength is retained. This method is also use full for the production of the blocks or bricks.

2.1.31 K. Keerthana, A. Rajani et al 2016

Were published a paper on comparative study on bacterial concrete using bacillus Sphaericus and Escheria coli. As we know the cracks is the most common phenomenon in concrete structures. There are different types of bacteria used for self healing. In this study the two types of bacteria called bacillus Sphaericus and Escheria were used and different tests like compressive strength test, flexural strength test were conducted , and bacterial concrete was checked for every 7, 14 & 28 days respectively. The photographs for mechanisms of healing were taken and it was proved that Bacillus Sphaericus gives high compressive strength than Escherichia coli.

2.1.32 S Vijaya Bhaskar reddy et al 2018

A review paper on experimental study on mechanical properties of bacterial concrete with flyash. A approach of fast developing the country. Concrete has ultimate load bearing capacity steel bars induced in structure to carry tensile load. Concrete protect the steel reinforcement from corrosion. Here the ingress of water and chlorides ions takes place and deterioration of the structure starts with corrosion of the steel. To increase the strength and durability of concrete, here we have conventionally using epoxy injection or later treatment method. Here he used bacteria such as bacillus pasteurii. It can improve the resistance of concrete to alkali or sulphate attack, during shrinkage etc. Here he replaced the partial replacement of fly ash instead of cement. It can improve the long term durability of the concrete combined with ecological benefits. Here different strength is also effected the strength such as compressive strength, split tensile strength, flexural strength, Partial replacement of fly ash instead of cement content by 10%, 20% & 30% respectively.

2.1.33 Etaveni. Madhavi et al, 2016

Were published a paper on strength properties of bacterial concrete with partial replacement of GGBS and fly ash. In this study the bacteria called Bacillus Pasteurii is used for making the bacterial concrete the material like cement, fine aggregate are checked with different tests before they have been used from the tests the specific gravity of coarse aggregate is found to be 2.84 & fine aggregate was found 2.62. The main advantage of using these bacteria is this bacteria does not affect on workability. Partial replacement of GGBS (ground granulated blast furnace slag) and fly ash can improve the properties of concrete. The addition of fly ash has improved the strength of bacterial concrete by 14% while that of GGBS has improved the strength by 18-20%. Thus this is one the best method to reduce the cast of bacterial concrete.

2.1.34 H.S Patil et al,(2008)

The application of microorganisms for the repair of cracks has become a latest technique in this developing world. This bacteria has ability to produce endospores so as to ensure extreme environmental conditions. The crack healing was checked by comparing compressive strength of treated mortar cubes to that of controlled cubes. environmental scanning electron microscope was used to check the involvement of bacteria in calcite precipitation. X-ray diffraction was used to check the areas of healing. In this study it is observed that MECR increases compressive strength byb12-13%. This technique is highly recommended for heritage structures.

2.1.35 Yash Sunnel Khandekar 2016

Have published a paper on applicability of concrete treated with self healing bacterial agents in this paper they describe some methods to reduce harmful gases produced by brick manufacturing mechanisms of healing and applicability of bacterial concrete on roads. The method of self healing is alternative methods for production of concrete blocks this is eco friendly and reduces the pollution levels. Due to heavy traffic on roads the weak & rear of roads can takes place. And The effect the durability of roads. By using bacterial concrete we can reduce the wear & tear of roads. The capsules of bacteria & calcium lactate are introduced into the concrete during construction. After the cracks formation the bacteria becomes active & starts the healing process by formation of limestone. The healing process was checked for every 7, 14 & 28 days respectively. Thus by the use of bacterial concrete we can reduce the pollution levels & also the wear & tear of transportation facilities.

2.1.36 D.R. Seshu et al,(2000)

An experimental study was carried out on the behavior of fiber reinforced concrete. The compressive strength of FRC depends on both volume fraction and ratio of the fibers. These two parameters are commonly used in terms of Refraction index(RI).The results proved that the FRC improved peak stress and peak strain and also the ductility of concrete.

2.1. 37 Ashish Babarao Gawande et al, 2016.

They have published a paper on applicability of concrete treated with self healing bacterial agents. An approach of concrete structure provides the development of country. Here healing of concrete he used bacteria such as bacillus Psceudofirmus & Sarconima Pasteurii. In that these concrete cracks formation as micro cracks as well as macro cracks it is a major issue fractures of the structure. These bacteria can improves an exceptional solution for both pre planning and renovation of the formation of cracks. In this method when bacteria exposed to atmosphere or moisture the bacteria fill the cracks with forming limestone. When healing structural strength is retained, this method is also use full for production of bricks.

2.1.38 Wee.T.H. et al, (2000)

One of the main causes of deterioration of concrete structures is exposure to harmful chemicals such as contaminated ground water, industrial effluents and sea water. some of the important chemicals which affect durability are chlorides and Sulphates.

2.1.39 Ke Ru Wu et al, (2001)

In this study he says that water cement ratio plays an important role when strength of concrete is less than aggregate characteristics. It is necessary to consider the concrete mix at 0.5 water cement ratio to the proportion of mixes. Since this value incorporates the contribution of w/c ratio and aggregates bond in the interface zone. Different mechanism can be used when concrete mixes strength is higher than aggregate strength.

2.1.40 Leusehner et al 2001

Many researches were done to examine the effect of dehydration & rehydration on sporus & molecular mobility of carbon in dormant Bacillus Subtilis spores experiment shows that Phosporus mobility mainly depends on hydration and confined to specific components where acts carbon is immobilized to water in soluble area.

2.1.41 Narayana P.S.S et al, (2004)

This study says that the addition of 5 percentage of micro silica increases compressive strength by 20% the strength of concrete increases with age of concrete. The addition of micro silica has improved the resistance of acid attack and sulphate attack. The percentage of weight loss will be less at 20% addition of silica in H_2SO_4 & Hcl

2.1.42 Chiara Barabesi et al,(2007)

The calcium carbonate precipitation is the results of using bacteria in the concrete. In this study he studied the calcite formation of Bacillus Subtilis. In order to identify the genes involved in bio-mineralization process. One thousand mutants were obtained from the European Bacillus Subtilis and these mutants were scanned. And these mutants help him to control stains which were occurs during the precipitation. Next he has taken cluster of eve genes(ICFA,ysiA,ysiB,etfA) called IcfA operation. the strain carrying five of each genes were produced. All of them were able to produce calcite crystals expect IcfA. Among these etfA was identified as very essential to produce calcite crystals. To verify contra scrimption the reverse transcription-PCR experiments were conducted a link between calcium precipitation and fatty acid metabolism is suggested.

2.1.43 Willem de Muyncle et al, 2008

In this paper the effect of bacterial carbonate precipitation in the durability of mortor specimens with different porosity was studied. The surface treatment is alternative technique for increasing the durability of concrete. The surface deposition of calcium carbonate crystals decreases water absorption by 65-90% depending on type of specimens. the increase in resistance to freezing and thawing were also noticed. the surface treatments protect construction materials from ingress of water & other substances. Due to some negative effects of conventional techniques bacterial induced carbonate mineralization.

2.1.44 Meseret Getnet Meharie et al, (2017)

Were published a paper on factors affecting self healing efficiency of cracked concrete structure.

In this paper they were described about self-healing technique. In this the self healing concrete has ability to fill the cracks automatically or autogenously. In the past years various studies have been conducted for the improvement of self healing technique. This paper describes about the factors which are effecting the self-repairing concrete. Caco3 can be formed by natural process. The better self healing efficiency can be achieved during the early age of concrete.

2.1.45 Z.P.Bhathena et al, (2017)

A review paper on bacterial concrete. A novel approach to increase its durability. In this paper a total of six samples were collected from different sites such as mangrove area. From these samples the calcite precipitating organism which precipitate calcium carbonate by means of precipitations were screened. The screened urease producing isolates were checked for the ability to grow at varying P_H. OTUs were obtained for six different samples after incubations after 7days. The compressive strength of organism within the cement matrix was analyzed as per IS 4031:1988 taken after 3 and 7 days of curing in water. It was observed that their value was higher than the required value of OPC.

2.1.46 Robert Davies et al, (2018)

Were published a paper on large scale application of self healing concrete. As we know that the life span of the structure gets reduced by the cracks. This allows the water, air and Co2 through it. This can cause corrosion of reinforcement and degradation. Cracking in conventional concrete is virtually un avoided because of thermal effects, early age shrinkage and mechanical loading, freeze thaw effects. Cardiff university developed a technique that uses Shape Memory Polymers(SMP) to close cracks in concrete structure. The use of Polyethylene Terephthalate (PET) strips to induce a compressive stress in concrete, which reduces the crack size and enhances autogenously healing.

2.1.47 R.Thirukumara raja vallaban et al(2018)

Were published a paper on bio concrete self healing process. We are using the bacterial concrete to heal the cracks. There are many problems raised after the construction such as weather effect, leakages and bending. The concrete specimen was designed and casted with definite proportions. Various tests were conducted to check the efficiency of the concrete specimen. The obtained results are comparatively better than conventional method.

2.1.48 Ms. T Viduthalai (2018) et al,

Were published a paper on self healing concrete using bacteria. In this they were added bacteria while mixing the concrete. The bacteria and its precipitates modify the microstructure of concrete and then increase the impermeability of cracks and that's means to reduce the passing of water through the cracks. In this project they have used Bacillus Subtilis bacteria. On their investigation they were found that Bacillus Subtilis improves the strength of bacterial concrete. For their investigation they have used M25 mix proportion for the cubes preparations.

The effect on the compressive and split tensile strength due to the mixing of bacteria along with the water absorption on concrete is also investigated. The main aim is to find out the strength in between conventional and bio-concrete cubes.

2.1.49 Stefan Jacobsen et al,

Were published a paper on self healing of high strength concrete after deterioration by freeze/thaw.

In their investigation process different types of experiments have been done on self healing of concrete deteriorated by internal cracking according to 'ASTM C666' procedure. In this process they have prepared different types of cured concrete cubes placed it in a water for 2-3months in water. They have observed compressive strength get reduced to 22-29% on deterioration and after Mc Hendry and Brewer have pointed out to the positive effects of autogenously self healing on frost deterioration.

Abrams studied about autogenously healing of concrete. He placed the cracked specimen at outside for 8years after testing at 28 days heated more than twice of the 28days strength was measured after 8 days. He mixed the concrete with different proportions and placed at various temperature conditions and also in different weathering conditions. And he compared the healing strength of the concrete.

Fagerland said that increase in rate of hydration then automatically degree of saturation get decreased and also different laboratory tests have done for different sizes of cracks. They observed chemical analysis on water before and after passing of water through the cracks. They observed caco3 formed into the cracks during the healing process. At the end of the experiment compressive strength recovered only 5% during healing an initial loss of 22-29% due to freeze/thaw.

2.1.50 E.Schlangen et al,

Have published a paper about recent advances on self healing of concrete. A approach of new developments obtained in research on self healing of cracks in cement based materials and as phalt concrete. In this paper total three projects are there. In these projects bacteria can precipitate calcite in a cracks. Nuvelli (2002) gives there is no agreement between different studies about inside the cracks when healing occurs. Ter heide et al 2005. Gives main focus was regaining mechanical properties of cracks. Van breugel 2007. Discuss the performance of structures. For cement based materials different method can be found. The concrete which starts to expand and fill voids and cracks when trigged by carbonation or moisture ingress. Using different types of bacteria. The bacteria concrete is described in which the main focus is healing of cracks and blocking of path to the reinforcement in order to improve durability.

III. Literature Summary

- ✓ As concrete is mostly used construction material. There are many factors which leads to failure in concrete like cracks. To reduce this failure a new technology has developed that is self healing concrete. in this

concrete bacteria is used while mixing the concrete. which automatically fills the cracks by forming lime. It is a pollution free concrete.

- ✓ This concrete is better than conventional concrete because of its high compressive strength, self healing nature and increase in durability.
- ✓ The strength of self healing concrete by using bacteria are investigated and compared with conventional concrete.

IV. Conclusion

In my research we are going to compare the self healing time in pre-mixed bacterial concrete cubes and introducing the bacteria after formation of cracks. The work is carried out on (M25) & (M40) grades of conventional concrete and bacterial concrete. Different tests like compression test, split tensile strength test were also conducted to compare the strength of bacterial concrete to the normal concrete. As the bacteria is eco friendly we can also use this bacteria for higher grade of concrete and improve the strength. The cost of bacterial concrete is reduced by partial replacement of fine aggregates.

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