Strength and Behavior of Fiber Reinforced Concrete Structural Repair, Restoration and Retrofitting Elements

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Abstract - **The proposed approach, characterized by both quantitative and qualitative criteria, is simple but very effective in simultaneously reducing the seismic damage, amount of FRP to be used, and time of installation. For the considered cases of low- and mid-rise no ductile building structures, the FRP amount reduced approximately by approx. compared to the cases in which FRP was evenly distributed, leading to lower installation cost and less interruption time. Interestingly, although predictive FRP was saved, the damage indices of the FRP retrofitted frames were significantly lower than those in cases of even FRP distribution because FRP effectively served for critical locations. Due to its simplicity and technical/economical effectiveness, the proposed FRP retrofitting approach can be useful for engineering practice.**

In the last few decades, premature deterioration of reinforced concrete (RC) structures has become a serious problem because of severe environmental actions, overloading, design faults, and materials deficiencies. Therefore, repair and strengthening of RC elements in existing structures are very important to extend their service life. There are numerous methods for retrofitting and strengthening of RC structural components such as steel plate bonding, external pre-stressing, section enlargement, fiber-reinforced polymer (FRP) wrapping, and so on. Although these modifications can successfully improve the load-bearing capacity of the beams, but they are still prone to corrosion damage resulting in failure of the strengthened elements. Therefore, many researchers used cementitious materials due to their low-cost, corrosion resistance, and resulted in the improvement of the tensile and fatigue behaviors. Different types of cementitious materials such as fiber-reinforced concrete (FRC), high performance concrete (HPC), high strength concrete (HSC), ultra-high-performance concrete (UHPC), steel fiber-reinforced high strength lightweight self-compacting concrete (SHLSCC), fabrics reinforced cementitious material (FRCM) and so on have been used to strengthen structural elements. This paper summarizes previously published research papers concerning the structural behaviors of RC beams strengthened by different cementitious materials. Shear behaviors, flexural characteristics, torsional properties, deflection, cracking propagation, and twisting angle of the strengthened beams are explained in the present paper. Finally, proper methods are proposed for strengthening RC beams under various loading conditions.

Index Terms - **Reinforced concrete beams, strengthening techniques, Fibre-reinforced cementitious materials, Mechanical strengths, Crack pattern, Twisting angle.**

INTRODUCTION

Demolishing and reconstructing a structure was considered to be an uneconomical and time-consuming process. Hence strengthening of new and existing structures had become popular in the construction field [1]. One of the most commonly used methods for repair and rehabilitation of structures is Retrofitting. Retrofitting is the modification of the existing structure by the addition of a new component for restoring the original capacities in the structure [2]. Strengthening old structures is necessary as old structures were constructed with old design codes that do not consider the post elastic behavior of the structure [3, 4]. Other reasons to strengthen a structure include faulty design or execution, aging of structure, various environmental conditions like corrosion, change in climate, inadequate maintenance, natural calamities like earthquakes and so on [1]. Jacketing is one of the easiest and effective techniques in retrofitting of structures. There is various type of jacketing is available to enhance the strength in structures such as Concrete jacketing, Steel jacketing, Ferro cement jacketing and Fiber Reinforced Polymer (FRP) jacketing [2]. Concrete jacketing is the first method to strengthen the damaged structures. A new layer of reinforced concrete is constructed around the existing concrete for achieving strength. Steel connectors, roughening of the surface and applying epoxy resin are used to make the bond between existing and new concrete material [2]. Steel jacket helps to restore the strength, ductility, and energy

absorption capacity of columns thus it seems to be effective in retrofitting columns [5]. And also, the steel jacket helps to increase the flexural strength and ductile behavior of the lap-spliced column thus increasing the lateral performance of columns [81]. The steel jacket helps to increase the performance of RC structures in the seismic region effectively. But corrosion is the only disadvantage [6, 7]. Ferro cement is a low-cost thin composite material, easily manufactured, easily adaptable and durable.

Fiber Re-in-forced Self Compacting Concrete

Concrete technology has the development of FRC has covered the entire range of Concrete types using different varieties of fibers in plain and RCC. Further development of latest generation 'concretes' in the recent past needs to update knowledge on the behavior of such Concrete with the addition of fibers to make them more efficient and effective. One such latest generation Concrete is Self-Compacting Concrete (SCC).

Concrete technologists have concentrated on investigating the mechanical and durability aspects of SCC incorporating different types of fibers which are:

- Steel fibers
- Nylon fibers
- Poly-propylene fibers
- Elements fibers
- Carbon fibers
- Asbestos fibers

Stress-Strain Behavior

One technique for choosing various. One can anticipate how the material will carry on when it is presented to different working weights. This engages shielded and capable arrangement of essential segments.

The continued with focuses on the Stress-Strain lead of FR-SCC and making models, grant exact desire for their direct. Anticipating the Stress-Strain lead of FR-SCC in restricted states absolutely and imp--roving the present, reveal various segments that influence the Stress-Strain direct

The use of Steel Fiber Reinforced Self Compacting Concrete (SFRSC) in the development of basic components is viewed as an elective answer for the confusion in setting the support and compaction of typically vibrated cement. The fundamental preferred position of SFRSC is the capacity to be appropriately poured set up, filling the formwork corners and little voids between fortification bars by methods for its very own weight. Many research had been done in investigating the basic execution of SFRSC because of the improved designing and mechanical properties. The consolidation of steel strands in the blend has been found to upgrade the solidified properties of self-Compacting Concrete as far as its rigidity, malleability, durability, vitality retention limit and just as break strength.

Concrete is the world's most regularly utilized development improvement material made out of concrete, totals, water, and admixtures. Concrete is a limitless, hearty, ample, solid, and extremely ground-breaking improvement material for development advancement. The making of cement requires its constituents, for instance, concrete, coarse total, fine total, and water [Shetty, 2009]. Concrete is the structure material most ordinarily utilized in development exercises. The development of breaks in solid structures, nonetheless, is normal. Sturdiness and strength of cement generally influenced by arrangement of breaks. (S.S. Blast, 2001).

Cracks are liable for the debasement of the structures. Breaks make it feasible for carbon dioxide, moistness, sulfates, different fluids, and gases to enter the focal point of the solid framework all the more rapidly. Consumption commencement happens in fortified solid structures because of the entrance of dampness, carbon dioxide, and chloride particles through the break in cement to the steel surface, which builds the penetrability of cement. (Neville et. al. 1996).

Basically, cracks occurring in concrete is un-preventable along with it is an inherent weakness of concrete. So, there was a necessity to build up a characteristic biomaterial, a Self-Repairing Technique that can correct the breaks and gaps created in cement. Bio-concrete is a material that can effectively redress breaks in cement. This method is highly desirable due to crakes in concrete and activity of damage repairable is more valuable related to eco- friendly and natural. (Charles Nmai, BASf.com Nov 2018).

Based on the various research carried out around the world, various kind of modification and remediated worked out have been made and overcome the general action of cement has been changed by microbial mineral precipitation coming about because of the metabolic exercises of useful microorganisms in

cement. The complete activity is changed by the involvement mineral precipitation resulting from the metabolic activities of beneficial microorganisms in concrete. The various kind of bacteria operation is also inducing changeable in chemistry of the given solution the use of basic principles of bio mineralogy combines with concrete materials and reproduce the basic and innovative material called Bacteria Concrete (Edvardsen C, 1999).

Concrete is most widely used construction material in the all over world such as main merits properties like formability and durability. Concrete is not quite ideal material when if the structure is subjected to be tension. This is inherent properties of concrete so that another material is strengthening means reinforced concrete. (kryton, june2019)

Research gaps and issues:

- The various gaps and issued for Strength and behavior of steel fiber reinforced self-Compacting Concrete structural elements are given below:
- To find out the effect of inclusion of fiber, glass fiber & carbon fiber on fresh properties and hardened properties of SCC. Which is not proper recommended correctly for various elements.
- Determine tensile strength and mechanical property and structural behavior of Concrete elements.
- To perform various test on crack using structure behavior elements which is not determined properly.

RESEARCH OBJECTIVE

OBJECTIVE OF STUDY

- Subsequent are the major objectives of the dissertation:
- Current research aims to explore the potential of various mineral-producing bacteria for their long-term viability, incorporation, cement survival, and self-healing capacity to fix cracks. (kusuma. K, May 2018)
- To explore the mixed impact of using bacteria & calcium lactate as a healing agent in concrete for compressive strength, flexural strength, and workability.
- Studying of Bacteria (Bacillus Substilis) and Calcium lactate characteristics as a concrete ingredient.
- Carry out mix design as per IS 10262:2019.
- Observe the compressive strength, flexural-strength, and workability of the concrete by adding the Bacteria (Bacillus Substilis) with Calcium lactate as nutrition of bacteria by cement content.
- Visualizing crack healing and characterizing mineral constituents using SEM and XRD tests, including crack healing materials.
- To compare and analysis of normal concrete and bacterial concrete performance based on the test.
- To check the efficiency and potential of bacterial strain to crack remediation and viability.
- To find out the economic feasibility and cost optimization of bacteria concrete.

REVIEW OF LITERATURE, ROL:

This paper is presenting systematic literature review SLR of various authors on the application of artificial intelligence in banking sector along with specialization of accounting and finance module sector.

Willem Demuynck (2006) considered bacterial treatment on the surface of mortar/concrete is better than conventional treatment, use sparcina pasteurizing as a form of pure culture and ureolytic mixed culture from sewage sludge biomass, prepared cube immersed in a 1-day old stock culture of S. pasteurizing for 24 hours after that should be immersed in nutrient solution then other specimen mixed ureolytic sludge to mortar cube (0.5-1 mm thick) and immersed in a nutrient solution. The author has done these experiments are sorptivity, gas permeability, oxygen flow rate, contact angle, color measurement. SEM, XRD test analysis revealed caco3 precipitation, Pure culture treated samples have low water absorption. All the test results revealed bacterial treatment gives a promising result than others.

Jianyun Wang, (2011) examined the utilization of a silica gel and polyurethane as the transporter to microorganisms. microorganisms immobilized in silica gel and polyurethane contrasting both and an alternate boundary like porousness, compressive strength mending productivity, the trial result shows that immobilizes in silica gel microbes (25%by mass)

and polyurethane (11%by mass) due to caco3 precipitation, break mortar example recuperated. when immobilizing microorganisms in polyurethane had higher strength recover (60%) and low porousness (10-10 to 10-11m/sec.) contrast and example recuperated by immobilizing microscopic organisms in silica gel have strength recapture just 5% and penetrability 10-7 to 10-9 that outcomes show that polyurethane has more potential as microbe's transporter for self-mending of cement.

Varenyam Achal,(2013)in this research, used a Bacillus sp. Bacteria to enhance the mortar compressive strength and durability, bacillus sp. lead to more than 50% reduction in permeability and porosity, 27.2mm depth of artificial crack healed by using bacteria and sand mixture, Bacteria bind sand particles due to precipitation of caco3, when aid bacteria at 5×107 cells/ml concentration give the optimum result in compressive strength, RCPT(rapid chloride permeability test), porosity test, this bacteria culture on nutrient agar at PH8, prepare the mortar cube with water/cement 0.47 and incorporated the bacterial(aq). While comparing RCPT test results shows bacterial specimen have very low (975.33) and control specimen have moderate (3177) so bacteria-based mortar gives a promising result. XRD, SEM test results shows that caco3 precipitation on a bacterial specimen and Bacillus sp. Lead to a more than 50% reduction in the porosity in the mortar and increase the compressive strength as 40% of control, bacteria enhance the mortar strength and durability.

Amirreza, (2013) in this experimental study, Proteus mirabilis, and Proteus Vulgaris both ureolytic bacteria used in harden and fresh concrete prepare mixed culture (MC) in liquid media apply to culture in harden concrete, and add in fresh concrete. prepared concrete specimen (Portland cement type 3) with bacteria and without bacteria tested their strength, density on 1,7,14, 21, 28 days, broken concrete specimen treated with bacteria for 30 days then tested again their strength density (PUNDIT LAB), ultrasonic pulse velocity test (UPV) when treated with MC forms precipitation of caco3 on cracks, macro crack partially and micro-cracks fully healed and deeper crack evaluated by UPV, The value broken concrete 265m/s (after loading) and after the healing (3473m/s) hence 85% improvement is observed, those cracks treated with microorganism 10% improvement in compressive strength, it was found that MC treatment suitable in broken concrete but fresh concrete did not give the promising results due to high PH.

Haoliang Huang et al. (2015) concentrated practically a wide range of self-mending strategies and systems. (self-recuperating in cementitious material, autogenous self-mending, self-recuperating dependent on mineral admixture, self-mending dependent on microbes, self-recuperating based particle cement agent (epoxy are epitomized pre-implanted in cement) are surveyed. Writing shows that all instrument of self-mending is successful relies on some specific condition, we cannot state that a specific technique for self-recuperating is the best, this relies upon specific condition and circumstance. The creator talked about extra expense for acknowledging self-mending in a solid structure. While we talk about Autogenous self-recuperating because of additional hydration of un hydrated concrete, there is the principle disadvantage in strategy was when blending water to solidify response began and mineral admixture responded quickly so further utilize impractical, in microbes based self-mending give supplement to microorganisms is exorbitant so further exploration continuing utilizing a sugar-based supplement for microscopic organisms, all the microscopic organisms based recuperating give promising outcome yet all have some constraint.

Main Luo et.al (2015) They have been considered and the thought is that a microbial self-men-ding specialist might be utilized to accomplish the objective of solid break self-recuperating. The capacity of solid break self-recuperating, be that as it may, relies upon numerous variables. The connected conditions were likewise evolved by inspecting oneself mending impacts in various circumstances. Water restoring has been demonstrated to be simply the best cycle for micro-organisms based recuperating concrete. Additionally, the break mending proportion of examples dropped altogether alongside the expansion of the breaking timeframe. At the point when the breaking age was more prominent than 60 days, the break mending proportion was tiny. Later on, more effect factors and the instrument of solid break self-mending under different conditions should be explored before reason-able usage can be considered.5

RESEARCH METHODOLOGY:

- Self-Compacting cement of M30 grade.

- S-CC and assurance of its crisp properties as far as stream capacity, passing capacity and isolation obstruction by utilizing Slump stream, V-pipe, and L-box device.
- Examples to decide compressive, pliable, flexural qualities and break vitality.
- Casting of standard examples to decide compressive, malleable, flexural qualities and break vitality joining components fiber, basalt fiber and carbon fiber of various volume divisions extending from 0.1% to 0.3%. Testing of standard examples for quality assurance after 7days and 28 days
- Retention limit of SCC 3D squares strengthened with various strands following 28 days.
- Strengthened with various filaments at various ages.

The Proposed Damage-Based FRP Retrofitting Approach the hysteretic behaviors of nonlinear elements obtained from ITH analyses are exported for damage analyses, using a damage model. Compared with noncumulative damage models, cumulative damage models are more appropriate for damage analyses of structures subjected to earthquake excitations because the duration, number of cycles, and frequency content of the ground motions play important roles in damaging structures. Design and Analyses of FRP Retrofitted Frames Providing external confinement using FRP wraps is an appropriate retrofitting solution applied to structures whose transverse steel inadequately confines the concrete. FRP wraps are applied to the plastic hinges of columns in the orientation of transverse reinforcement to confine concrete, leading to the enhancement of strength and ductility for concrete. SEISMIC RETROFITTING NEEDED: 1. Explain the concept of Retrofitting performance objectives: 2. Problem faced by the structural engineers. 3. Classification of retrofitting techniques. 4. Retrofit of structures using innovative materials.

RESTORATION, STRUCTURAL RETROFITS, THE RETROFITTING OF CONCRETE STRUCTURES

Restoration: Action taken for restoring the lost strength of Structural elements. Retrofitting: Actions for upgrading the seismic restoring of an existing building. So that if becomes safer under the recurrence of likely future earthquakes. Repair and restoration are applicable to damaged buildings.

Cast-in-place ordinary concrete, fiber-reinforced concrete, shotcrete or gunite, self-consolidated concrete, and advanced mortars (polymeric or fiber enriched) comprise a class of materials widely used for the purpose of retrofit and strengthening of existing structures.

Structural retrofits are designed to protect elements such as foundations, load-bearing walls, beams, columns, building envelopes, windows, structural floors, roofs, and the connections between these elements.

Structural repairs and rehabilitation is a process of reconstruction and renewal of a facility or its structural elements. This involves determining the origin of distress, removing damaged materials and causes of distress, as well as selecting and applying appropriate repair materials that extend a structure's life.

The retrofitting of concrete structures has become increasingly important in view aging and more deterioration of infrastructure. ... Retrofitting is the Science and Technology of strengthening the existing structures or structural elements to enhance their performance with new technology, features and components.

Simulate results:

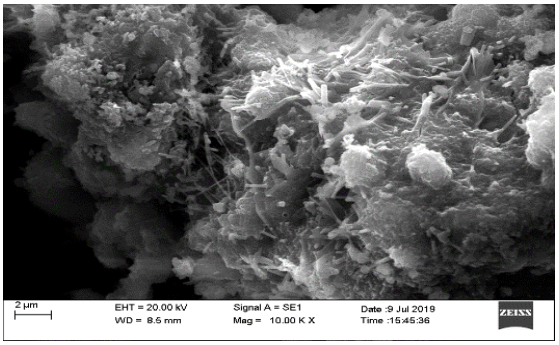
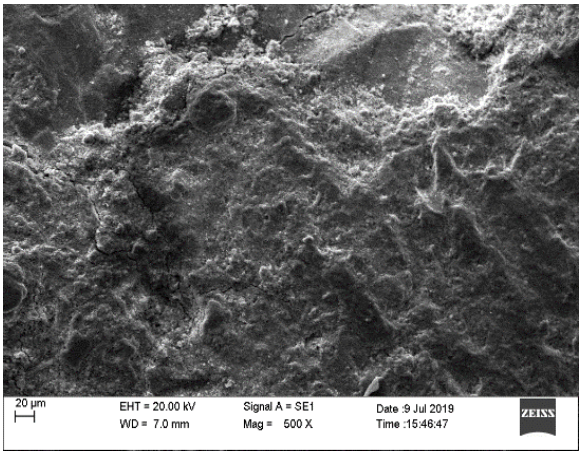


Image 5.1 represent

The present research was undertaken in the perspective of the huge concrete production and the cracking based problems. One alternative to this problem is to use this bacterium (BS) and calcium lactate in helpful products such as concrete durability and self-healing of cracks. The experimental study intended to investigate the Economic feasibility and self-healing of cracks and this method enhance the concrete property. Addition of Bacteria (BS) and

calcium lactate in a concrete matrix with different concentrations of cement content that provides the self-healing power that reduces the maintenance cost of concrete.



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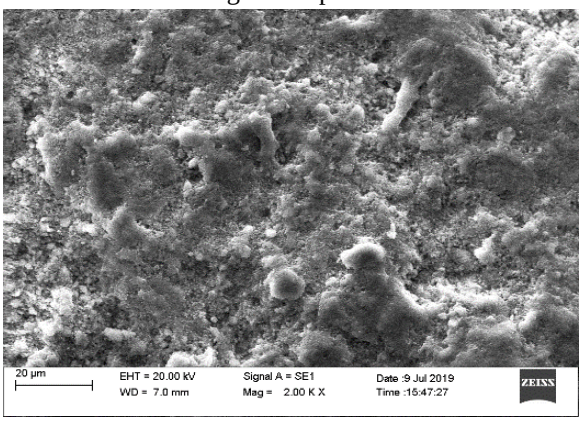

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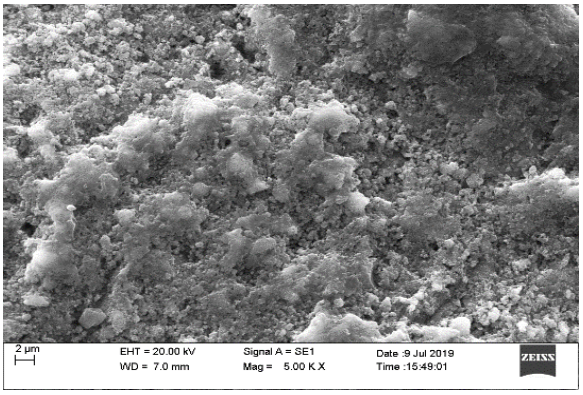

Image 5.4 represent

CONCLUSION

This curt paper presents the proposed FRP retrofitting approach of address building owners' concern on reducing the FRP cost and installation/interruption time. The FRP retrofitting approach is proposed based on the seismic damage distribution in structures, using both quantitative and qualitative criteria. (1) The damage index and the damage mode of retrofitted structures are controlled. (2) The amount of FRP is reduced because FRP is effectively redistributed based on the damage distribution in structures. (3) FRP installation/interruption time is reduced since only critical locations undergo retrofitting. The second advantage directly reduces the FRP material cost while the third advantage indirectly reduces the total retrofitting cost.

FUTURE SCOPE OF STUDY

- The following are some of the areas in which the present work could be extended.
- The study can be extended for the other properties of concrete like permeability, sorptivity test, water absorption test, etc.
- Studies on the prescribed Bacteria and calcium lactate by cement for various aggressive environments may be taken up to know the long-term performance of such concrete.
- Other bacteria and calcium sources may be used for the production of concrete such as sugar-based nutrients for bacteria etc.
- A study may be carried out to look into a reduction in calcium in seawater the various impacts of bacteria and concrete cracks remediated.

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