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Experimental Study Comparison of Performance of Concrete with Waste Paper, Steel Fiber and Carbon Fibers

[1] Prof. Mayura M. Yeole, [2] Rushikesh K. Jadhav, [3]Saurabh G. Rakshe, [4] Harshal M. Shinde, [4] Kaustubh S. Chougule
[1][2][3][4][5]Department of civil engineering, Pimpari chinchwad college of engineering & research, Pune, India

***Abstract:*-- The compressive, tensile and flexural performance of reinforced concrete structures is investigated with inclusion of waste paper, steel fibers and carbon fibers. The mass content of the additives used are 10%, 15% and 20% of total mix proportion. Twenty-seven cubes were tested under uniaxial compression and nine beams are tested under four-point bending. Also, 27 cylinders are tested for determination of tensile strength. The size of the cubes considered are 150 x 150 mm. Test results for all the three additives for axial compressive strength, tensile strength and ultimate strain of concrete significantly, will be presented in this project with the detail study of the material flexural behaviour. In flexure, the fibers increase the lateral load bearing capacity and the deflection several times larger than the concrete cubes. In flexure, fiber inclusion can affect the failure mode of the composite structure significantly. This experimental investigation is carried out under mix proportions i.e. M20 and the results of the durability tests are compared with the same mix proportionated concrete cubes. The beams for flexure made of Papercrete, steel fibres and carbon fibers are compared with the conventional concrete beams under four-point bending test. The size of beams under compression loading considered are 2000 x 100 x 200 mm. The main aim of this project is to increase the awareness of the use of natural and waste fibers as construction materials in the construction industry.**

Index Terms:- Carbon fibres, Steel fibres, Waste paper, four-point bending test, durability tests, mix proportions, concrete, cement, deflection.

1. INTRODUCTION

a) Papercrete-

The necessity of providing low-cost, sustainable housing has led to greater interest in alternative construction materials. A term has been coined for a relatively new material basically made of waste paper, cement, and water. It is called "papercrete." Papercrete is a slightly misleading name. It implies a mix of paper and concrete, hence paper-crete. But more accurately, only the Portland cement part of concrete is used in the mix – along with other admixtures. Although some people add sand and other additives to improve its behaviour under compressive load, the basic components are still the same. The combination of these materials produces a new construction material, which may provide a way to produce affordable housing on a large scale.

b) Steel Fibers-

Also, Steel fibers are added with concrete to increase the structural properties, particularly tensile and flexural strength. The extent of improvement in the mechanical properties achieved with SFRC over those of plain concrete depends on several factors, such as shape, size, volume, percentage and distribution of fibers.

Fig 1.1: Various steel fibre profile

c) Carbon Fibres-

Carbon Fiber cement-matrix composites are structural materials that are gaining in importance quite rapidly due to the decrease in carbon Fiber cost and the increasing demand of superior structural and functional properties. These composites contain short carbon Fiber typically 5 mm in length, as the short Fiber can be used as an admixture in concrete (whereas continuous Fiber cannot be simply added to the concrete mix) and short Fiber are less expensive than continuous Fiber. However, due to the weak bond between carbon Fiber and the cement matrix, continuous Fiber [2±4] are much more effective than short Fiber in reinforcing concrete. Surface treatment of carbon Fiber (e.g. by heating

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or by using ozone, silane, SiO2 particles or hot NaOH solution) is useful for improving the bond between Fiber and matrix, thereby improving the properties of the composite. In the case of surface treatment by ozone or silane, the improved bond is due to the enhanced wettability by water. Admixtures such as latex methylcellulose and silica fume also help the bond.

I. AIM

The main aim of this project is to increase the awareness of the use of natural and waste fibers as construction materials in the construction industry.

II. OBJECTIVES OF THE STUDY

- To study the physical properties of concrete mixed with waste paper, steel fibers and carbon fibers by conducting durability tests
- To study the flexural behaviour of concrete mixed with waste paper, steel fibers and carbon fibers by experimental investigations conducting four point bending tests.
- To conduct split tensile strength test on of concrete mixed with waste paper, steel fibers and carbon fibers
- To compare the flexural performance of concrete mixed with waste paper, steel fibers and carbon fibers composite beam with conventional steel reinforced concrete (SRC) beams.

III. LITERATURE REVIVEW

1]ClaudiuAciu, Dana Adriana Ilutiu-Varvara, NicoletaCobirzan, AncaBalog [1]The paper presents a study on the recycling of paper waste, which is frequently found in almost all activity areas, in order to obtain an ecological plastering mortar. The materials used, in four mortar recipes, as well as the methods for their preparation are presented. The research leads to the conclusion that the method for the preparation of plastering mortars with paper waste allows for the use of non-polluting technology with low energy consumption.

2] Barry J. Fuller, ApostolosFafitis, Ph.D., F.ASCE, and Jorge L. Santamaria[2] For decades intrepid environmentalists have been building and other structures with a material that recycles wastepaper into an alternative construction material made with cement and other ingredients. They have claimed these "papercrete" structures are strong, durable, and insulating. One solution that has seen increased use in recent years is called as papercrete, which is somewhat of a misnomer in that it is created from waste paper, cement and such other ingredients as sand, fly ash, and Styrofom, to name a few.

3] H. Yun1, H. Jung1, C. Choi [3] These days CO_2 emission which made from construction sites because of cement using is globally issued. On the other hand, people's desire to live eco-environment is continuously increasing. In order to resolve these kinds of matters, this study carried out. Papercrete is a new composite material using waste paper as a partial replacement of Portland cement. By using the waste paper, papercrete is not only reducing the amount of cement using but also making environmentally friendly building materials. This study aimed to evaluate the fundamental mechanical properties such as compressive and splitting tensile strength of papercrete containing waste papers as a partial replacement of Portland cement. And it also analyses the stress-strain relation of papercrete to evaluate the ductile behaviour of papercerte.

4] Matthew West, Ryan Hansanuwat, Mark Lyles, Pablo La Roche Ph.D.[4] This paper describes the development of a low cost, energy efficient prototype house designed for informal settlements of Tijuana constructed from a variety of local manufacturing waste materials. The 35 m2 prototype demonstrates construction techniques using waste car tires and gabion rock cages as a retaining wall system, wood pallets as a roof truss system, waste newspaper blended with Portland cement as a "papercrete" wall system, waste rice sacks integrated into a vegetated roof system, windows made of sewer pipes and dinner plates, and a simple radiant floor heating system using agricultural irrigation tubing. This project is extremely relevant given the increasing number of worldwide urban dwellers with inadequate housing, depleting natural resources for building materials, and greenhouse gas contributions associated with energy intensive building materials travelling great distances. We hope the knowledge attained from this project will ultimately be disseminated into other communities with similar need

5] Fuller, B., and Fafitis, A., Santamaria, J.[5]Papercrete is a new construction material made most often with waste paper, cement and water. People have been using papercrete to build low cost homes without a clear understanding of its structural properties. The purpose of this study is to obtain some mechanical and physical parameters of papercrete by doing several laboratory tests. The samples tested were made following the most common mixes that papercrete makers are using currently.The experimental setup used to test the samples is briefly described and some test results are tabulated in tables. This will allow us to reach some conclusions and make several recommendations for using papercrete to build homes.

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6] P H Bischoff [6]This paper investigates the post cracking response of reinforced concrete tension members made with both plain and steel fiber-reinforced concrete (SFRC). Loading was either monotonic or cyclic, and shrinkage effects are included in analysis of the member response. Tension-stiffening results are used to determine the average tensile response of concrete after cracking, and an expression is developed to predict this smeared behavior as a material property for cracked SFRC, as well as to estimate crack spacing. Specimens with steel fibers exhibited increased tension stiffening and smaller crack spacing's, which both contributed to a reduction in crack widths. The post cracking tensile strength of fiber concrete at the cracks is the determining factor affecting behaviorand is a fundamental material property used to predict tension stiffening and crack behavior for conventionally reinforced SFRC. The uniaxial strength of SFRC immediately after cracking governs serviceability behavior, while the post cracking strength at larger deformations governs strength design and is responsible for tension stiffening after yielding of the reinforcement. Cyclic loading did not have a significant effect on either tension stiffening or crack width control for the specimens tested.

7]Joshua A.McMahonAnnaC.Birely[7]The authors studied that Fiber-reinforced concrete (FRC), particularly steel FRC (SFRC). The stated that it offers the potential to improve the service level performance of structures by controlling the width of cracks and potentially allowing for a reduction in the amount of traditional reinforcing steel. Full-scale tests of hybrid reinforced concrete (continuous reinforcement with SFRC) one-way slab strips were conducted to investigate the interaction of rebar with SFRC. Parameters varied were slab depth, amount of reinforcement, and location of reinforcement. Readings from strain gages on the rebar were used to investigate the impact of SFRC on the service stresses. Crack width measurements were made at regular intervals and compared to strain readings. In SFRC slabs, service stress limits were reached at larger demands than in RC slabs. When service stress limits were reached in SFRC slabs, crack widths were much smaller than common crack width limits, suggesting design for crack widths may be an appropriate method for addressing serviceability in SFRC slabs. Applying the results of the tests to sample bridges, it was demonstrated that SFRC can be used to either decrease the amount of steel in a bridge deck to satisfy service performance requirements or to increase the slab span without the need for additional reinforcement.

8] J. Carrillo, J. Cárdenas Pulido, W. Aperador[8]

The study conducted by the author's points out the influence of two corrosive environments at a short term and the fiber dosage on the flexural performance of steel fiber reinforced concrete, SFRC. The experimental program comprised the tests of 54 SFRC specimens having steel fibers characterized by a length/diameter ratio of 65 and fiber dosages of 30 and 60 kg/m^3**.** Regarding the corrosive environments, cylinders and beams were subjected to the action of a watery environment and to an environment of 3.5% NaCl solution (chloride ion) during a period of 60 days. The results were compared with those of cylinders and beams kept in unaltered conditions. For this exposure time that is equivalent to the corrosion initiation phase, it was observed that chloride ions of 3.5% NaCl solution cause degradation in mechanical performance of SFRC; for instance, loss of flexural strength of roughly 10% and reduction of flexural toughness equal to 11%. However, saline exposure caused an increase of the deflection capacity of SFRC for the initiation phase of corrosion, which can improve its ductility and bond capacity between the matrix and embedded steel fibers. Finally, equations have been proposed to describe the effect of watery and saline environments in the initiation phase of corrosion on CRFA subjected to bending stresses.

9] Martin Herbrand, Viviane Adam, Martin Classen, DominikKueres and Josef Hegger[1]**-** In this paper, the strengthening method and the experimental results obtained at RWTH Aachen University are presented. The authors stated that due to Increasing traffic loads and changes in code provisions lead to deficits in shear and flexural capacity of many existing highway bridges. Therefore, a large number of structures are expected to require refurbishment and strengthening in the future. This projection is based on the current condition of many older road bridges. Different strengthening methods for bridges exist to extend their service life, all having specific advantages and disadvantages. By applying a thin layer of carbon textile-reinforced mortar (CCTFS) to bridge deck slabs and the webs of pre-stressed concrete bridges, the fatigue and ultimate strength of these members can be increased significantly. The CCTFS layer is a combination of a corrosion resistant carbon fiber reinforced polymer (CFRP) fabric and an efficient mortar.

10] Zoi C. Tetta, Lampros N. Koutas, Dionysios A. Bournas[3]This paper presents an experimental study on shear strengthening of rectangular reinforced concrete (RC) beams with advanced composite materials. Key parameters of this study include: (a) the strengthening system, namely textile-reinforced mortar (CTFS) jacketing and fiber-reinforced polymer (FRP) jacketing, (b) the strengthening configuration, namely side-bonding, U-wrapping and full wrapping, and (c) the number of the strengthening layers. In

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total, 14 RC beams were constructed and tested under bending loading. One of the beams did not receive any strengthening and served as control beam, eight received CTFS jacketing, whereas the rest five received FRP jacketing. It is concluded that the CTFS is generally less effective than FRP in increasing the shear capacity of concrete, however the effectiveness depends on both the strengthening configuration and the number of layers. U-wrapping strengthening configuration is much more effective than side-bonding in case of CTFS jackets and the effectiveness of CTFS jackets increases considerably with increasing the number of layers.

IV. PROBLEM STATEMENT

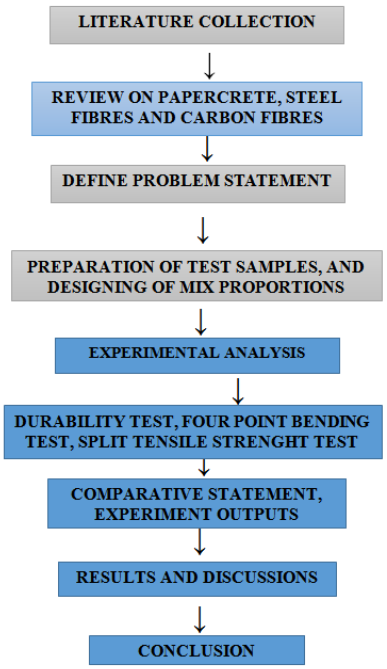
Ecological concerns have resulted in a renewed interest in natural materials, and such issues as recyclability and environmental safety have become increasingly important for the introduction of new materials and products. Structural polymer composites are traditionally utilizing man-made fibres (such as glass or carbon fibres) as reinforcement, but environmental issues have generated a considerable interest in natural fibres. Plant fibres such as flax, hemp, sisal and kenaf are under consideration as environmentally friendly and relatively low-cost alternatives for glass fibres in structural engineering composites. Many researches have carried out work on steel fibers and their results have shown that steel fiber reinforced concrete is more effective than conventional concrete and the steel fibers are very effective in decreasing or eliminating the early plastic shrinkage occurring Hence this project aims to combine the products as additive in concrete gradually by 10%, 15% and 20% and observe the physical as well as strength characteristics.

V. SCOPE

The scope of the research is focused on determining the accuracy of anecdotal evidence obtained from papercrete makers and from examination of existing structures as well as studying the compressive properties of this new material made of waste paper, cement, and water and additionally with steel fibers and carbon fibers. In addition to the compressive properties, a limited number of additional tests are performed. The objective of these tests is to gain some insight on performance of concrete with the inclusion of different materials such as waste paper, steel fibers, and carbon fibers.

VI. METHODOLOGY

The project study involved two stages. The primary data was gathered through a Literature survey targeted by web searches and review of ebooks, manuals, codes and journal papers. After review the problem statement is defined and sample preparation is taken up for detail study and analysis purposes. This project execution follows the flow chart given below -



Flow Chart

VII. MATERIALS PROPERTIES

Materials used in Concrete -

M-Sand :

Getting good quality of M-sand which should be free from organic impurities. While adding the M-sand to the mix, it should be in uniform size i.e. all the M-sand particles should be fine. The M-sand obtained from local resource is used in production of fly ash based geopolymer bricks. The physical and chemical properties of M-sand obtained by testing the samples as per Indian Standards.

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Fig. M-Sand

Cement:

A cement is a binder substance used in construction that say and harden and can bind other material together. The most important type of cement is used as a component in the production of mortar in masonry, and of concrete which is a combination of cement and aggregate to form a strong building material. Cement used in construction can be characterized has being hydraulic or non-hydraulic, depending upon ability of cement to set in the presence of water. Non-hydraulic cement will not set in wet condition under water, rather, it set as it dries and react with carbon dioxide in the air. It can be attack by some aggressive chemical after setting.

Fig.Cement

Coarse aggregate:

IS 383-1970 defines coarse aggregates as Aggregates most of which is retained on 4.75 mm IS Sieve and containing only so much finer material as is permitted for the various types described in this standard

Coarse aggregates may be described as:

1. Uncrushed gravel or stone which results from natural disintegration of rock,

2. Crushed gravel or stone when it results from crushing of gravel or hard stone, and

3. Partially crushed gravel or stone when it is a product of the blending of uncrushed gravel stone and crushed gravel or stone.

Fig Coarse aggregate

Water:

According to IS 456 : 2000, water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing concrete. The pH value of water shall be not less than 6

Steel Fibre:

The amount of fibres added in the concrete mix is expressed as a percentage of total volume of the composite (concrete and fibres), termed volume fraction (Vf). Vf typically ranges from 0.1 to 3%. Aspect ratio is defines as fibre length (l) by its diameter (d). The aspect ratio of Fibres of a non circular shape can be determines by using an equivalent diameter for the calculation of aspect ratio. However, fibres which are too long tend to ballZ in the mix and create workability problems. Some recent research indicated that using fibres in concrete has limited effect on the impact resistance of the materials. The result of fiber reinforcement concrete indicates that the use of micro fibres offers better impact resistance compared with the longer fibres.

VIII. TESTS ON CEMENT:

1) Standard Consistency -

The standard consistency of a cement paste is defined as that consistency which will permit the Vicat plunger of 10 mm diameter and 50 mm length to penetrate to a point
to 7 mm from the bottom of the Vicatmould Figure 3.1. The experiment was done as per IS 4031-Part IV.

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2) Initial Setting Time

Initial setting time is regarded as the time elapsed between the moments that the water is added to the cement to the time that the paste starts losing its plasticity. Experiment was done as per IS -269:1989, clause 6.3

3) Final setting time

Final setting time is the time elapsed between the moments that the water is added to the cement and when the paste has completely lost its plasticity. Experiment was done as per IS -269:1989, clause 6.3

4) Fineness of Cement

Fineness is a measure of total surface area of cement. For finer cements surface area will be more. Fineness influences the rate of hydration, rate of strength development, shrinkage and rate of evolution of heat. Experiment was done as per IS 4031-Part I-
1996.

5) Density of Cement

Le Chatelier's flask is used to determine density of cement. Kerosene which does not react with cement is used. Experiment is done in Le Chatelier'sflask.

6) Soundness of Cement

The testing of soundness of cement is to ensure that the cement does not show any applicable subsequent expansion. Unsoundness in cement is due to excess of lime, magnesia or excessive proportion of sulphates. Experiment is done by Le Chatelier method. And the value of soundness is 1mm.

Mixing of concrete

IX. RESULTS AND DISCUSSIONS

The results of material testings, compressive strength, split tensile strength test and flexural performance of concrete structures included with fibers are presented in this chapter. The mass content of fibres considered is 10%, 15% and 20% of total mix proportion. In this chapter test conducted on materials, beams, cubes, cylinder will be presented. This experimental investigation is carried out under mix proportions i.e. M20 and the results of the durability tests are compared with the same mix proportionated concrete cubes.

X. REFERENCES

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