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Retrofitting of Plain Cement Concrete Wrapping by using Engineered Cementitious Composites

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Abstract: Retrofitting refers to the addition of new technology or features to the older systems it reduces maintenance costs and increased reliability. Seismic retrofitting is modification of existing structure to make them more resistant to seismic activity, ground motion or soil failure due to earthquake. This paper present various active researches that are taking place around the world on study of ECC by importing Cera Hyperplastic XRW40 and other kinds of fibers and by using various mineral admixtures. The ECC are economical by a reduction in usage of fiber while maintaining the desired characteristics of strength. Material was produced, tested and compared with conventional concrete in terms of workability and strength. These tests were carried out on standard cube, beam and cylinder to determine the strength of concrete which is compared with conventional concrete.

Keywords: Characteristic, ECC, Hyperplast XRW40, Retrofitting.

I. Introduction

Concrete is the most popular construction material because of its special properties such as versatility, durability and easy to handle, due to the especial properties more than 11.4 billion tons of concrete consumed annually worldwide. Ordinary Portland cement, though costly and energy intensive is the most widely used ingredient in the production of concrete mixes. Plain Cement Concrete is a construction material generally used as binding materials. PCC is concrete without reinforcement or reinforced only for shrinkage or temperature changes. PCC possesses a high compressive strength and is not subjected to corrosive and weathering effects. PCC can be easily handled and moulded into any shape. The term plain concrete is used to describe any concrete mass used without any strengthening materials. PCC is a material used to build a wide range of structures, ranging from residential homes to bridges.

The creation of ECC is mainly motivated on micromechanical interactions that occur between ingredients and way of processing. Interaction occurs between fibers and matrix is recognized as key factor which governs ECC behaviour, resulting in interfacial zone modification techniques so as to design desired properties. Fiber ruptures in ECC are prevented and pull-out of fiber from matrix is achieved by the use of suitable mineral admixtures. Thus improving tensile strain capacity 3-7% for ECC containing 2% fiber by volume. Micromechanical interaction recounts macroscopic properties of the microstructure of composite, and forms spine for ECC material design theory. Especially, books for microstructure tailoring of ECC along with material optimization. The Micromechanical models were constructed on the basis of fracture mechanics and deformation mechanism these are the parameters which provide an opportunity for tailoring micromechanical parameters so as to control failure mode, tensile strength and various other parameters. Engineered Cementitious Composites (ECC, also known as “ECC Concrete”), developed in the last decade, may contribute to safer, more durable, and sustainable concrete infra-structure that is cost-effective and constructed with conventional construction equipment. With 2% by volume of short fibers, ECC has been prepared in ready-mix plants and transported to construction sites using conventional ready-mix trucks. The mix can be placed without the need for vibration due to its self-consolidating characteristics. The moderately low fiber content has also made shotcreting ECC viable. Furthermore, the most expensive component of the composite, fibers, is minimized resulting in ECC that is more acceptable to the highly cost sensitive construction industry.

II. Objectives of Engineered Cementitious Composite

- To check the behaviour of ECC concrete under the Compression, Split tensile and Flexure.

- To investigate the effect of sand, super plasticizer and polyvinyl alcohol fiber on behaviour of ECC.
- To investigate the mix design procedure for ECC.

III. Scope of Engineered Cementitious Composite

- More flexible than traditional concrete.
- ECC acts more like metal than glass.
- Traditional concrete is considered a ceramic, brittle and rigid.

IV. Collection of Materials

A. Ordinary Portland Cement

Cement can be defined as the bonding material having cohesive and adhesive properties which makes it capable to unite the different construction materials and form the compacted assembly. Ordinary/normal Portland cement is one of the most widely used type of Portland cement. The name Portland cement was given by Joseph Aspdin in 1824 due to its similarity in colour and its quality when it hardens like Portland stone. Portland stone is white grey limestone in island of Portland, dorset.

i. Uses of Ordinary Portland Cement

It is used for general construction purposes where special properties are not required, It is normally used for the reinforced concrete buildings, bridges, pavements, and where soil conditions are normal it is also used for most of concrete masonry units and for all uses where the concrete is not subjected to special sulfate hazard or where the heat generated by the hydration of cement is not objectionable. It has great resistance to cracking and shrinkage but has less resistance to chemical attacks.

ii. Tests on Ordinary Portland Cement

- Fineness test
- Soundness test
- Setting time test
- Specific gravity
- Consistency test

a) Fineness Test (IS 4031-Part IV-1988)

This experiment is carried out to check the proper grinding of cement. The cement which is produced by an industry is checked for its quality, that either it is good for certain type of construction or it does not posses that much strength. For example, for RCC and other heavy load bearing structures such as bridges it is essential that the cement which is being used in the concrete should have the ability to provide the required strength, while in the PCC structures it is not so much critical. The ability to provide strength of a certain type of cement is checked by finding the fineness of that cement, because the fineness of cement is responsible for the rate of hydration and hence the rate of gain of strength and also the rate of evolution of heat.

b) Soundness Test (IS 4031-Part 3-1988)

It is very essential that the cement after setting shall not undergo any appreciable change in volume, because change in volume after setting of cement causes cracks, undue expansion, and as a result disintegration of concrete. Soundness of cement is determined using the Le Chatelier apparatus. This apparatus consists of a split cylinder made of spring brass or other suitable metal.

c) Setting Time Test (IS 4031-V-1988)

Initial setting time duration is required to delay the process of hydration or hardening. Final setting time is the time when the paste completely loses its plasticity. It is the time taken for the cement paste or cement concrete to harden sufficiently and attain the shape of the mould in which it is cast.

d) Specific Gravity Test (IS 2386-3-1963)

The specific gravity is normally defined as the ratio between the weight of a given volume of material and weight of an equal volume of water. To determine the specific gravity of cement, kerosene which does not recent with cement is used.

e) Consistency Test (IS 4031-Part IV-1988)

Consistency Test of Cement is carried out in order to find the percentage of water required for preparing cement pastes for other tests. To determine the quantity of water required to produce a cement paste of standard consistency. The standard consistency is that consistency, which will permit the vicat plunger to penetrate to a point 5 to 7 mm from the bottom of the vicat mould.

B. Fine Aggregate

Fine aggregate used was properly graded to give minimum void ratio and free from deleterious materials like clay, silt content and chloride contamination etc. For the present investigation, locally available river sand (coarse sand) conforming to grading zone II of IS 383:1970 was used as a fine aggregate.

C. Coarse Aggregate

Hard crushed granite stone. Coarse aggregate confirming to graded aggregate of size, 20 mm as per IS 383-1970 was used in the study.

D. Water

Water which fits for drinking purpose is considered for mixing the ingredients, and should be free from suspended impurities and foreign matters such as acids, alkalis. Water plays two key roles in a concrete mix. Firstly, it chemically reacts with constituents of cement to form paste where paste holds aggregates in suspension phase until paste hardens. Secondly, it act as lubricant in mixing of ingredients.

E. Super Plasticizer

This is used to improve the rheological properties of fresh concrete. Super plasticizers are the additives to fresh concrete which helps in dispersing constituents uniformly throughout the mix. This is achieved by their deflocculation action on cement particles by which water entrapped is released and is available for workability. Super plasticizer (Cera Hyperplastic XRW40) shown in Fig. 1 increases slump properties from 5 cm to 20 cm without addition of water and thereby reducing the water requirement by 15-20%. This results in improvement of vital properties like density, water tightness. Where sections are having closer reinforcements, the use of super-plasticizer increase workability and no compaction is required. The permeability of concrete is key property which contributes to durability, the use of super plasticizer (Cera Hyperplastic XRW40) shown in Fig. 1 increases workability maintaining low water to cement ratio.

The permeability of cement paste reduces considerably with reduction in water to cement ratio. Thus super plasticizer can be used effectively to improve various properties of concrete and to avoid defects like honeycombing.

F. Fly Ash

In the coal powered power generating plants the exhaust gases which comes out after burning is treated with electrostatic precipitators and the fine particles that collected in it is known as fly ash and the ash which does not comes out with the exhaust flue gases is termed bottom ash. This Fly ash shown in Fig. 2. Fly ash constitutes substantial amount of silicon dioxide (SiO_2) in the form of both amorphous and crystalline form and calcium oxide (CaO), both being effective ingredients in many coal-bearing rock strata.

G. Fibers

The high performance fiber reinforced cementitious composite is characterized by the presence of fibers in a less quantity compared to FRC. Generally the fiber used in ECC is PVA as shown in Fig. 3. One of the remarkable characteristics of this fiber is capable of strong bonding with cement matrix. The layer of $Ca(OH)_2$ called as Interfacial transition zone is formed round PVA fiber and is formed as white part, and in case of poly propylene, and glass it is not observed. It is known PVA makes complex cluster with the metal hydroxide of cement matrix. It is pursued that Ca+ and OH- two different ions in the cement slurry are attracted by PVA fibers and makes layer of $Ca(OH)_2$ around the fibers and hence the $Ca(OH)_2$ layer plays an important role for bonding strength between the fiber and the matrix. However there is an absence of some surface coating around the Polypropylene fibers and glass fibers which are possessing high tensile strength but they are not coated with any epoxy and they are susceptible for alkali environment of matrix this makes us to do an experimental study by selecting these fibers.

Fig. 1: Cera Hyperplast XRW40

Fig. 2: Fly Ash

Fig. 3: Polyvinylalcohol Fiber

V. Experimental Investigation

A. Ordinary Portland Cement

Before testing of specimen we need to know the properties of cement like consistency, grade of cement, specific gravity, Initial setting time and Final setting time. These are the tests carried in laboratory and the test values are tabulated in Table I. Then sieve analysis for fine aggregate values shown in Table II.

Table I: Properties of Cement

Sr. No.	Property of Cement	Values
1	Normal Consistency (%) (IS 4031-part IV-1988)	28%
2	Grade of Cement	53
3	Specific Gravity (IS 4031-part III-1988)	3.15
4	Initial Setting Time (IS 4031-part V-1988)	0 min
5	Final Setting Time (IS 4031-part V-1988)	60 min

B. Physical Properties for Fine Aggregate

Table II: Result of Sieve Analysis

Size (mm)	Weight Retained (G)	% Retained	Cumulative Retained	% Finer
4.75	65	6.5	6.5	93.5
2.36	80	8.0	14.5	85.5
1.18	418	41.8	56.3	43.7
0.850	135	13.5	69.8	30.2
0.425	170	17.0	86.8	13.2
0.180	123	12.3	99.1	0.9
0.150	3	0.3	99.4	0.6
0.075	4	0.4	99.8	0.2
PAN	2	0.2	100	0

VI. Results and Discussion

Compressive Strength

This tests were carried out in accordance with IS 516-1999 standards conducted on concrete specimen size 150 mm x 150 mm x 150 mm and compressive strength of concrete is tabulated. In Table III Compressive strength for ECC concrete for 7, 14 and 28 days given and also in Table IV Compressive strength for Standard concrete for 7, 14 and 28 days given. The specimens which are submerged in clean fresh water is taken out after 28 days for testing and kept in dry place so that the water is drained well to get better results. The specimen is loaded in the compression testing machine. The load is continuously applied until it fails. The tests were carried out at a uniform stress of 140 kg/minute after the specimen has been centered in the testing machine. Loading was continued till the dail gauge needle just reserved its direction of motion.

The reversal in the direction of motion of the needle indicates that the specimen has failed. The dail gauge reading at that instant was noted which was the ultimate load. The ultimate load divided by cross section area of the specimen is equal to the ultimate cube compressive strength. Fig. 4 shows the Variation of Compressive Strength of ECC and Standard Concrete. The compressive strength calculated by using formula,

$$F_c = P/A$$

Table III: Compressive Strength for ECC Concrete

Days	Strength
7th Day	42.22 N/mm^2
14th Day	53.33 N/mm^2
28th Day	60 N/mm^2

Table IV: Compressive Strength for Standard Concrete

Days	Strength
7th Day	26.6 N/mm^2
14th Day	33.33 N/mm^2
28th Day	37.7 N/mm^2

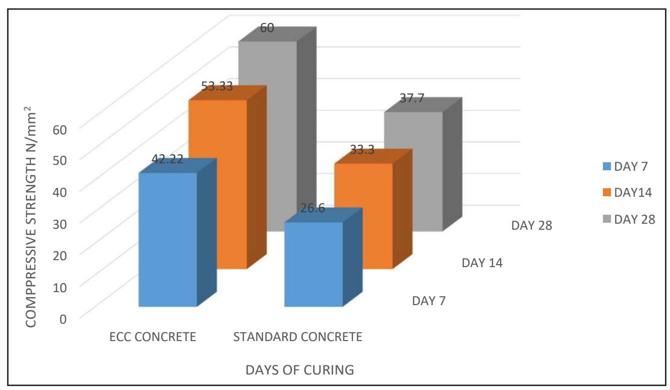

Fig. 4: Variation of Compressive Strength of ECC and Standard Concrete

VII. Conclusion

Concrete is one which extremely accepted as vital component of today's society and is being used in various and different infrastructures that are very critical for the flawless and comfortable function of the world. Due to the property of very strong in compression yet comparably weak in tensile nature of cement concrete resulted in development of Engineered Cementitious Composite with unique and distinctive properties of self-healing, high flexure strength, high compression strength and high split tensile strength. The ECC concrete is 60% greater in compression, split-tensile and flexural test when compared to conventional concrete. The various investigations carried out by several authors related to the development of Engineered Cementitious Composite (ECC) and its applications in the real world proves to be one of the best sustainable concrete materials of the future generations.

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