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Experimental Behaviour of Natural Hybrid Fiber Reinforced Slab with Nano Concrete under Static Loading

R. Sakthivel
Research Scholar, Department of Civil Engineering Research,
Karpagam Academy of Higher Education, Coimbatore-641021, India.

Orcid Id: 0000-0003-1608-5902

Dr. N. Balasundaram
Head of Department, Civil Engineering,
Karpagam Academy of Higher Education, Coimbatore-641021, India.

Abstract

Nanotechnology offers construction professional opportunities for designing, engineering and building in new ways and the concrete is enhanced by the addition of fibers and Nano silica. In this experimental the behavior of Reinforced concrete slab structures by using Natural Hybrid natural Fiber (coir & hair) and Nano silica (NHFRC) was determined. The design mix was done for M_{25} grade concrete as per Indian standard. The different percentages of fibers from 0.5% to 2.5% by weight of cement were used in the investigations and the various percentages of Nano silica ranging from 0.2% to 4.5% by weight of cement were used in this experimental research. The Static loading behavior of the NHFRC one-way slab specimens with Nano silica of the different percentages are casted, cured and tested for 7, 14 & 28 days. Hybrid fiber and Nano silica dosages of 0.5%, 1%, 1.5%, 2%, and 2.5% are used. The simply supported condition is given for slab specimen with two points loading in the loading frame setup. The test results are compared with control specimen and NHFRC with Nano silica improves loading performance of slab under static loading.

Keywords: Nano silica powder, Natural hybrid fiber reinforced, Coir fiber, Human hair fiber, Static load.

INTRODUCTION

Natural hybrid fiber reinforced concrete (NHRFC) is most economical to reducing total volume of concrete and the amount of steel required for confined structural member. In addition of hybrid fibers in concrete improve the tensile characteristics by inhibiting crack growth and increase in energy absorption capacity, flexural strength and ductility. Different types of fibers were used in concrete such as artificial fibers, metallic fibers, glass fibers, lathe fibers, polymeric fibers, mineral fibers, and naturally occurring fibers, among these natural fibers (coir and human hair) are economical and easy availability. It has been shown recently that many researchers investigated the mechanical properties of the hybrid concept with two different fibers incorporated in a common cement matrix, and the hybrid composite can offer more attractive engineering properties, because the presence of one fiber enables the more efficient utilization of the potential properties of the other fiber. Addition of Nano material (Nano silica) to the concrete matrix to increase the compression strength of the concrete and reduce the porosity between the cement particles. Nano Silica is used for improving the concrete properties in fresh and hardened states. The adding of two or more different types of fibers in concrete is called Hybrid Fiber Reinforced Concrete and it is used as secondary reinforcement. In this experimental coir and human hair are used as hybrid fiber reinforcement to the concrete specimen.

OBJECTIVE

- The objective of this paper is to determine the behavior of natural hybrid fiber reinforced concrete slab with control specimen under static loading.
- To conduct static loading test for natural hybrid fiber reinforced concrete slabs with various percentage of fibers, Nano silica powder used.
- To compare results of natural hybrid fiber reinforced concrete slab and NS specimen with control specimen

NANO SILICA POWDER

Addition of Nano particles improves the properties of the concrete in micro level. The Nano silica particles are introduced into concrete in the form of powder to improve the compression strength. Its fine size fills voids between aggregates and cement particles are secondly they react pozzolanically with CH to produce CSH gel, increasing the binding quality and decreasing the capillary porosity of concrete.

Figure a. Nano silica power

FIBRE REINFORCED CONCRETE (FRC)

FRC is the mostly used construction material in practical field. Adding fiber to the concrete is said to be fiber reinforced concrete. By adding fibers of different materials and volume tensile strength will be improved. The most economical fiber is natural fibers. Low volume fractions of fibers (< 1%) are used to reduce minor cracking. Moderate volume fractions (between1% to 2%) increase flexural strength, fracture toughness and impact resistance. High volume fractions (greater than 2%) lead to strain hardening of the composites. The shape and length of the fibers also play a role in the effectiveness of fibers in improving the properties of the concrete.

HYBRID FIBER REINFORCED CONCRETE (HFRC)

The addition of two or more different types of fibers in concrete matrix is called Hybrid Fiber Reinforced Concrete. (HFRC) is one in which more than one or two types of fibers are used as secondary reinforcement. In this project coir and human hair are used as hybrid fiber reinforcement to the concrete slab specimen. These hybrid fibers composite can offer more attractive engineering properties, because the presence of one fiber enables the more efficient utilization of the potential properties of the other fiber.

TYPES OF FIBER

The various types of fibers are commonly used to concrete. Such as asbestos fiber, steel fiber, sisal fiber, Glass fiber, carbon fiber, poly propylene fiber, plastic fiber and natural fibers.

Two types of fibers used in this project. They are, Coir fiber, Human hair fiber

COIR FIBRE (Coconut fiber)

Coconut fiber is extracted from the outer shell of a coconut. The scientific name and plant family of coconut fiber is Coir, Cocas nucifera and Arecaceae (Palm), respectively. There are two types of coconut fibers, brown fiber extracted from matured coconuts and white fibers extracted from immature coconuts. Brown fibers are thick, strong and have high abrasion resistance. White fibers are smoother and finer, but also weaker. Coconut fibers are commercial available in three forms, namely bristle (long fibers), mattress (relatively short) and decorticated (mixed fibers). These different types of fibers have different uses depending upon the requirement. In engineering, brown fibers are mostly used. The fibers recovered from various waste streams are suitable to use as secondary reinforcement in concrete. The advantage of using such rural fibers provides generally a low cost construction than using virgin fibers and the elimination of the need for waste disposal in landfills.

HUMAN HAIR FIBER

Human Hair is a natural fibre that can be found abundantly in all parts of the world. It is a proteinaceous fiber with a strong keratin chains. The basic component of hair fiber is known as keratin. Keratin is proteins consisting of long chain (polymers) of amino acids. Hair contains a high amount of sculpture because the amino acid cysteine is a key component of the keratin proteins in hair fiber. The sculpture in cysteine molecules in adjacent keratin proteins link together in disulfide chemical bonds. These disulfide bonds are very strong and very difficult to break apart. These disulfide chemical bonds linking the keratins together are the key factor in the durability and resistance of hair fiber to degradation under environmental stress. The exceptional properties of human hair such as unique chemical composition, slow degradation rate, thermal insulation, tensile strength. Hence we can say that human hairs are found in relative abundance in nature and are non-degradable there by providing a new era in the field of Fiber Reinforced Composite materials.

In this experimental coir and human hair are used as hybrid fiber reinforcement to the concrete slab specimen. The fiber composite can offer more attractive engineering properties, because the presence of one fiber enables the more efficient utilization of the potential properties of the other fiber.

Hair fiber is used as reinforced material in concrete for the following reasons:

- Tensile strength is high which is equal to that of a copper wire with similar diameter.
- Hair, a non-degradable matter is creating an environmental problem so its use as a fiber reinforcing material can minimize the problem
- It is also available in abundance and at a very low cost.
- It reinforces the mortar and prevents it from spalling.

Table 1: Properties of fiber used in this experimental work

S. No	Fiber properties	Coir fiber	Hair fiber
1	Appearance		
2	Length (mm)	60 to 250mm	60mm
3	Shape	Straight	Straight
4	Diameter (mm)	0.005 to 0.45 mm	100 to 120 µm
5	Aspect ratio	133	75
6	Density (kgm^{-3})	1150	7850
7	Young's modulus	3.7 to 6 GPa	2.74 Gpa
8	Tensile strength	15 to 500 MPa	16 Mpa

Mix design

The basic tests are conducted on fine, coarse aggregate & cement. As their results obtained for Proportion M_{25} grade is arrived at.

Cement = 425.733 Kg/m^3

Fine aggregate = 649.4889 Kg/m^3

Coarse aggregate = 1174.52 Kg/m^3

Water-cement ratio = 0.45

Water content = 191.58 Kg/m^3

Superplastizicer = 0.8% by weight of cement

The proportion for M_{25} grade concrete is designed using Indian standard. The slump obtained was 165 mm, the degree of workability is high as per IS 456-2000.

Basic Standard Tests

The compressive strength, split tensile strength and flexural strength are done for this tests specimens are casting such as cubes of size 150 x 150 x 150 mm, cylinders of size 300 mm height x 150 mm diameter and Prisms of size 500 x 100 x 100 mm respectively. After 28 days curing and the test results were obtained for different percentages of fibers (coir &Human hair fibers).

Compressive test (cube specimen)

During testing, the cube bulged outwards, the crack originated from the bottom and propagated. Then spalling and crushing of concrete occurred. The cube didn't show splitting due to the presence of fiber bonding. The results are shown in Fig.1.

Among this strength has been increasing in the volume of fibers up to 1.5% with 3% of NS and again decrease in strength was observed after 1.5% of natural hybrid fibers with 3% of Nano silica added. The specimen with 1.5% natural hybrid fibers with 3% of Nano silica showed maximum compressive strength of 33.23 N/mm^2.

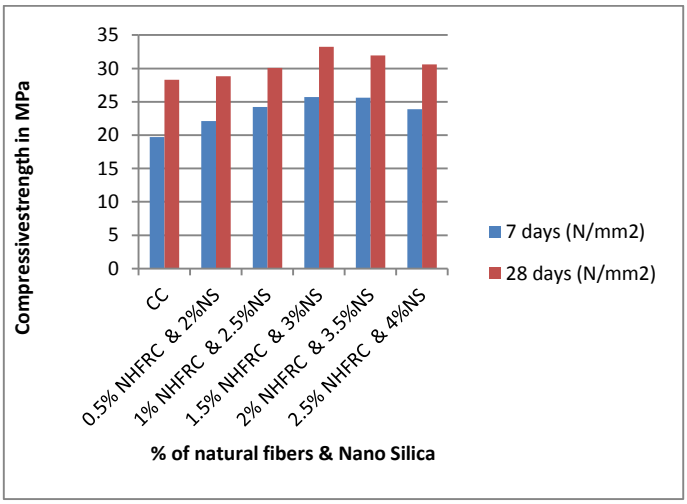


Figure 1: Graphical Representation of cube compression test results

SPLIT TENSION TEST (Cylinder Specimen)

During testing, the cylinder bulged and formed into elliptical cross- section during failure. No spalling of concrete occurred due to the presence of fiber. In this test, an increase in strength was observed up to 1.5% natural hybrid fibers with 3% of Nano silica and the specimen with 1.5% natural hybrid fibers with 3% Nano silica showed maximum split tensile strength of 4.1 N/mm^2. The results are shown in Fig. 2.

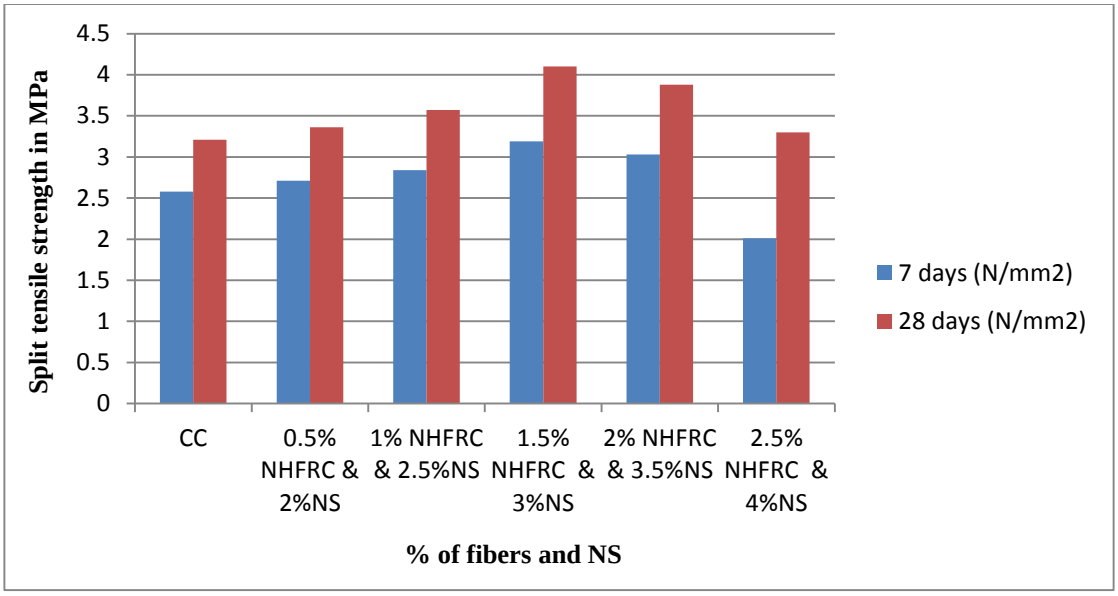


Figure 2: Graphical Representation of Split tension test

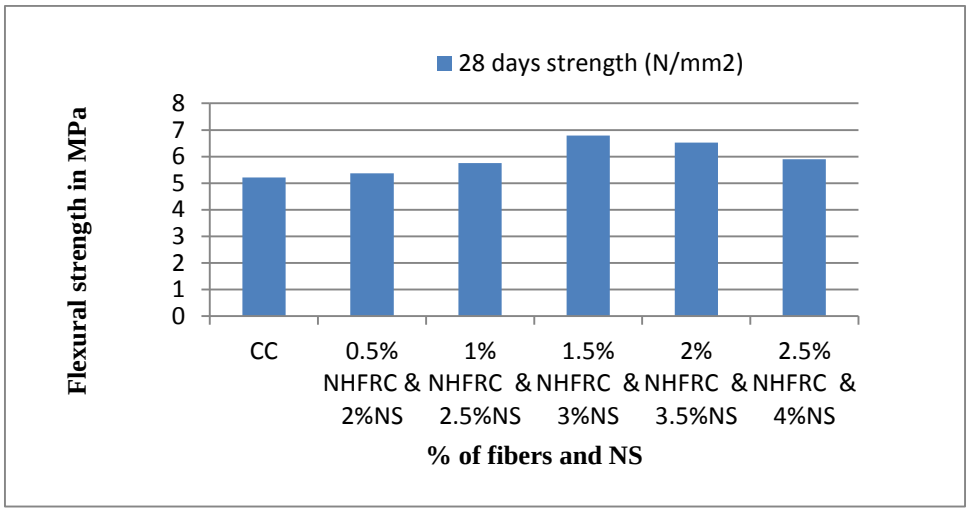


Figure 3: Graphical representation of Flexural strength

PRISM SPECIMEN (Flexural strength test)

During testing, the prism specimens developed flexural cracks and no spalling of concrete occurred due to the presence of fibers. The fiber bonding was clearly seen. Among these results are increases from 0.5% to 1.5% of fiber with 3% of Nano silica and it decreased gradually from 2%. The results are shown in Fig. 3 and specimen with 1.5% natural hybrid fibers with 3% Nano silica showed maximum flexural strength of 6.79 N/mm^2.

EXPERIMENTAL SET-UP FOR SLAB

Specimen Casting of Specimens One- way slabs of size 1000 x 300 x 70 mm with varying percentages (0.5%, 1%, 1.5%, 2% and 2.5%) of hybrid fibers with varying percentages (2%, 2.5%, 3%, 3.5% and 4%) of nano silica respectively and conventional slab without fibers were casted and kept for curing. After 28 days, the slabs were simply supported at their ends and tested by applying static loading subjected to two line loads by means of a hydraulic jack at one-third distances.

SIZE OF THE SPECIMEN AND REINFORCEMENT DETAILS

The dimension of the model slab is shown in Fig. 3(a). For the slab specimen of size 1000 x 300 x 70 mm, 2 nos. of 10 mm diameter bars of Fe 500 as main reinforcement, 7 nos. of 8 mm diameter bars of Fe 500 as distributive rods with 135 mm spacing, and a clear cover of 20mm was provided. The

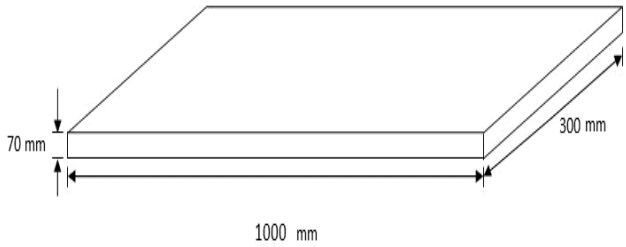


Figure 3(a): Dimensions of the slab specimen

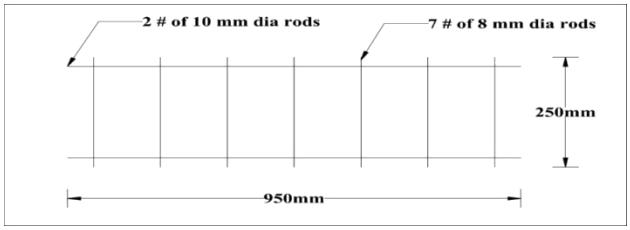
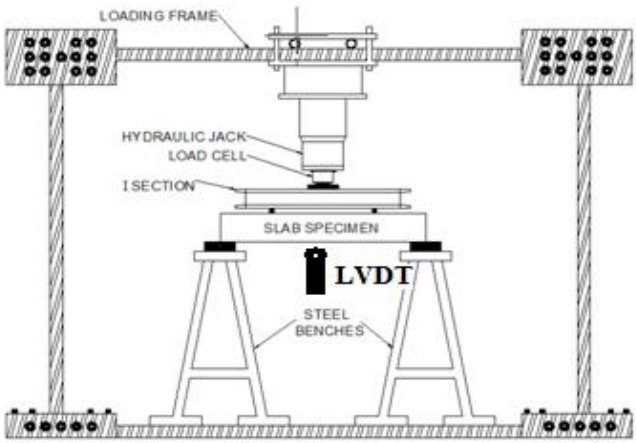


Figure 3(b): Reinforcement details of the slab specimen



LOADING SETUP

Figure 4: Loading setup of slab specimen.

The slabs is tested were placed in the loading frame of capacity 50 tons under simply supported two point loading .The test set up is shown in Fig.4. The slab was marked with number of grids before placing in the loading frame for the observation of crack pattern. The load cell was placed in the loading jack at the Centre of the slab with I beam from which load imparted to the slab can be observed. For finding the deflections under the two point loading, the LVDT (linear variable differential transformers) were placed at the middle of the slab to measure the center deflection and result can be viewed.

TEST RESULT AND DISCUSSIONS

All the slab specimens were tested till collapse. It was observed that the shear cracks appeared from the edge of the specimens and extended towards the top of the specimen with increase in load and vertical cracks at regular spacing were observed with further increase in load. The deflection of the NHFRC slab with NS specimens increased when compared to the control slab.

For the control slab specimen, the first crack appeared directly under roller at a load of 100kN. At the load of 120kN second crack appeared at the center span and the ultimate load was found to be 150kN.

For slab with 0.5% of natural hybrid fiber and 2% of nano silica, the first crack is appeared at both right edge and left edge support of slab at a load of 100kN. At the load of 120kN second crack appeared at directly under roller and the ultimate load was found to be 180kN.

For slab with 1% of natural hybrid fiber and 2.5% of nano silica, the first crack is appeared at both right edge and left edge support of slab when acting 100kN of load. At the load of 120kN second crack appeared at directly under roller. At the load of 140kN third crack is appeared at mid span at bottom of the slab and the ultimate load was found to be 240kN.

For slab with 1.5% of natural hybrid fiber and 3% of nano silica, the first crack is appeared at right and left edge support of the slab when acting 100kN of load and the ultimate load was found to be 260kN.

For slab with 2% of natural hybrid fiber and 3.5% of nano silica, the first crack is appeared at right edge support of slab when acting 120kN of load and the second crack is appeared at both right and left edge support of slab when acting 160kN of load. The ultimate load was found to be 210kN.

For slab with 2.5% of natural hybrid fiber and 4% of nano silica, the first crack is appeared at top surface of slab at near the roller when acting 80kN of load. . The ultimate load was found to be 180kN.

The ultimate load-deflection graph results for all the slabs are shown in Fig. 5.

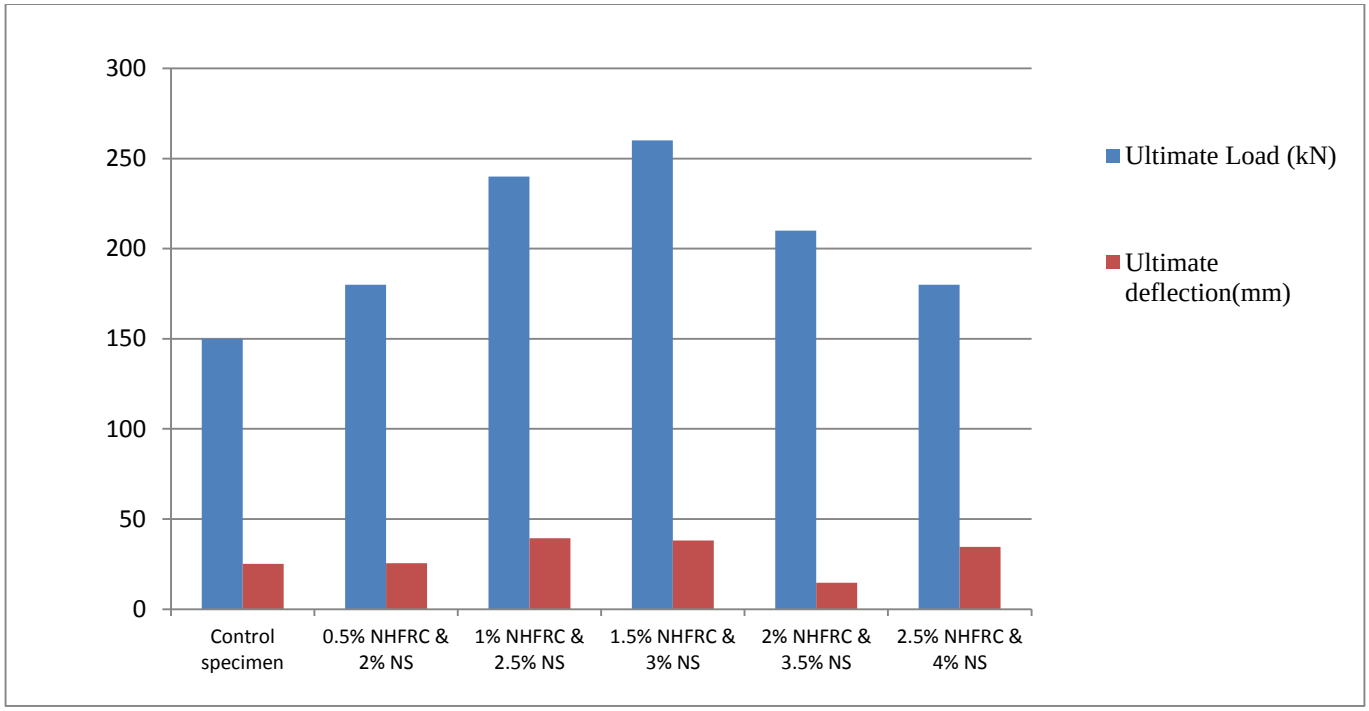


Figure 5: Graphical Representation of ultimate load and ultimate deflection for various slab specimen.

Figure 6: Slab specimen after failure of various percentages

The following conclusion is given for NHFRC & Nano silica slabs subjected to static loading:

- Tension cracks were formed in NHFRC Slabs with Nano silica under the loaded area.
- The cracks originated from the bottom of the slab and propagated towards the top when the load is increased.
- The ultimate deflection for the NHFRC slabs with Nano silica is increased compared to the control specimen.
- It was found that slab with 1.5% NHFRC with 3% Nano silica slab specimen shows an increase of 73.33% in ultimate load and 56.97% in deflection when compared to that of control slab.

REFERENCES

[1] Ashok k. Jain - 'Reinforced concrete limit state design'

[2] Achal Agrawal, (2016) 'A concept of improving strength of concrete using human hair as fiber reinforcement', - International Journal of Innovative Research in Science, Engineering and Technology Vol.5, Issue 5.

[3] Fiore. A, Porco. F, Uva. G, (Jan 2012) 'An experimental investigation on the flexural behavior of scc ferrocement slabs incorporating fibers', - Engineering Structures, Vol. 34, Pages 514-526

[4] IS 456-2000 'Plain and Reinforced Concrete - Code of Practice'.

[5] IS 10262- 2009 'Guidelines for concrete mix proportioning'

[6] Janani. P, (March 2016) 'Mechanical properties of Nano silica concrete', -ISSN (Online): 2319-8753 Vol. 5, Issue 3.

[7] M. S. Shetty, 'Concrete Technology'.

[8] Rajkumar. R, (2016) 'Experimental study on the strength and durability of Nano concrete', - (IJAER) ISSN 0973-4562 Vol. 11, No. 4 pp. 2854-2858.

[9] Ramamurtham .S- 'Design of reinforced concrete structures'.

[10] Sivakumar. A, (July 2011) 'Influence of hybrid fibers on the post crack performance of high strength concrete', - (JCECT) Vol. 2(7), pp 147-159.

[11] Sivaraja. M, M.E., April 2011) 'Application of coir fibers as concrete composites for disaster prone structures', - International Journal of Engineering Science and Technology (IJEST) Vol. 7 No.06, Page 1388 to 1402.

[12] Umesh Pendharkar, (Jan-2016) 'Study of effect of Nanomaterial as cement replacement on properties of concrete', - (IRJET) e-ISSN: 2395 -0056 Vol.03 Issue: 01.