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EXPERIMENTAL INVESTIGATION OF BENDING BEHAVIOUR OF CONCRETE USING STEEL FIBRE AND POLYETHYLENE SHEET

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Abstract - Concrete is most widely used building material in the world, as well as the largest user of natural resources with annual consumption of 12.6 billion tons. Basically it consists of aggregates which are bonded together by cement and water. The major part of concrete besides the cement is the aggregate. Aggregate include sand and crushed stone / Gravel. Use of these conventional materials in concrete is likely to deplete the resources unless there is a suitable substitute. In this project we are using steel fiber and polyethylene sheets. Fiber are generally used as resistance of cracking and strengthening of concrete and also we are wrapping the polyethylene sheet for providing a plastic protection to the concrete. Polyethylene sheet usually increases the lifetime of the concrete .so by using both steel fiber and polyethylene sheet we can achieve the strength more than the target strength we expected.**Key Words: Steel Fiber, Polyethylene Sheet, Compression test, Flexural test.**

1.INTRODUCTION

The maintenance, rehabilitation and upgrading of structural members, is perhaps one of the most crucial problems in civil engineering applications. Moreover, a large member of structures constructed in the past using the older design codes in different parts of the world are structurally unsafe according to the new design codes.. Since replacement of such deficient element of structures incurs a huge amount of public money and time, strengthening has becomethe acceptable way of improving their load carrying capacity and extending their services. Infrastructure decay caused by deterioration of building and structure has lead to the investigation of several processes for repairing orstrengthening purposes. One of the challenges in strengthening of concrete structures is selection of a strengthening method that will enhance the strength and serviceability of the structure while addressing limitation such asconstructability, building operations and budget.

The scope of this work is to increase the mechanical strength of the concrete structure by incorporating polyethylene fiber into it. Initially a concrete test specimen is tested without wrapping with polyethylene fiber.Then the fiber is placed as a single layer in the concrete specimen is tested. Each and every specimen is tested and without polyethylene fiber in order to obtain average strength value of the concrete.

1.1 OBJECTIVE OF STUDY

The Main objective of this study is to compare the flexural, compressive and tensile properties of concrete by wrapped with polyethylene fiber reinforcement layers.

1.2 SCOPE OF PROJECT

2.LITERATURE REVIEW

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2.1STEEL FIBER

To purpose and defend the research work, a number of research papers are analyzed. Following are the excerpts from the different research work performed by number of academicians and researchers.

Milind V Mohod (2012) et al in this experimental investigation for M30 grade of concrete to study the compressive strength and tensile strength of steel fibers reinforced concrete containing fibers varied by 0.25%, 0.50%, 0.75% 1% 1.5% and 2% by volume of cement cubes of size 150mmX150mmX150mm to check the compressive strength and beams of size 500mmX100mmX100mm for checking flexural strength were casted. All the specimens were cured for the period OF 3, 7 and 28 days before crushing the result of fibers reinforced concrete 3 days, 7 days, and 28 days curing with varied percentage of fiber were studied and it has been found that there is significant strength improvement in steel fiber reinforced concrete. The optimum fiber content while studying the compressive strength of cube is found to be 10% and 0.75% for flexural strength of the beam. Also it has been observed that with the increase in fiber content up to the optimum value increase the strength of concrete.

Vikrant Vairagade et al (2012) presented the applicability of previously published relation among compressive strengthtensile strength flexural strength of normal concrete to steel fibers reinforced concrete was evaluated and mechanicalproperties of steel reinforced concrete were analyzed in this experimental study cement sand coarse aggregate water andsteel fibers were used for compressive strength test both cube specimens of dimensions 150mm × 150mm × 150mm andcylindrical specimen of length 200mm and diameter 100mm were cast for M20 grade filled with 0% and 0.5% fibers after24 hours the specimens were to curing tank where in they were allowed cure for 7 days and 28 days. Finally result ofcompressive strength for M20 grade of concrete on cube and cylinder specimens with 0% and 0.5% steel fibers for aspectratio 50 and 53.85 is it observed that for addition of 0.5% fibers shows slightly more compressive strength than normalconcrete.

Prof. Ram Meghe et al (2014) presented the experimental study of the steel fibers reinforced self compacting concreteby addition of different content of steel fibers the result showed that the split tensile strength found to be increasedwith the addition of steel fibers and the optimum fiber content for increasing the split tensile strength was found tobe 1.75% it was been observed that the steel fibers are used in the concrete to give the maximum strength as compared toother fibers such as glass fibers polypropylene fibers. The compressive strength and the flexural strength observed to beincreased as the percentage of steel fibers are increased in the steel fibers reinforced concrete.

Elson John et al (2014) in this study it was observed that the physical properties of the concrete after adding the differentvolume fractions of fibers are used in the concrete. In the mix design is carried out as per 10262:2009 the proportioning iscarried out to achieve strength at specified age, workability of fresh and durability requirements. The materials selected forthis experimental study includes normal natural coarse aggregate, manufactured sand as fine aggregate, cement, Super plasticizer both end hooked steel fibers and portable drinking water. The physical and chemical properties of each ingredient has considerable role in the desirable properties of concrete like strength and workability finally the test result of compressive strength split tensile strength and flexural strength it can be seen that in the presence of steel fiber there is an increase in compressive strength split tensile strength and flexural strength the small in fiber specimen compared to the non fibers specimens.

AhsanaFathima et al (2014) presented the experimental study on the effect of steel fibers and polypropylene fibers on the mechanical properties of concrete, experimental program consisted of compressive strength test, split tensile strength test and flexural strength test on steel fiber reinforced concrete polypropylene fiber reinforced concrete three types of fibers used of length 30mm crimped steel fibers of length 25mm and endure 600 polypropylene of length 50mm with aspect ratio 50. The main aim of this experiment is to study the strength properties of steel fibers and polypropylene. Fibers reinforced concrete of M30 grade with 0%, 0.25%, 0.5% and 0.75% by volume of concrete.

V. T. Babar et al investigated the shear strength and ductility of fiber reinforced concrete beams by using hooked steelfiber without stirrups. In this investigation, the test beam specimens of 125 mm in width, 250 mm in depth, and 1150mm in length are cast and steel fibers are varied from 0.5 % up to 2 % volume fraction The longitudinal steel is keptconstant, while shear span-to-depth ratio (a/d) is varied in the range 1, 1.25, and 1.5. All the beam specimens are testedunder two-point loading up to failure, and failure load, first crack load, and central deflection are recorded concisely andprecisely. The test specimens were cast using cement, fine aggregate, coarse aggregate, water, and Hooked steel fibers.
The materials, in general, confirmed to the specifications laid down in the relevant Indian Standard codes. For grading offine and coarse aggregate, sieve analysis was carried out. Ordinary Portland cement of 53-grade confirming to IS12269:1987 was used throughout the experimental work. The maximum size of coarse aggregate used was 20 mm alongwith 12.5 mm of same parent rock in 60-40 % fraction. Locally available Krishna river sand was used as fineaggregate. The specific gravity of sand was 2.85 and fineness modulus was 2.7.Hooked end steel fibers of length 60 mmand diameter 0.75 mm were used throughout the experimental work. Reinforcing steel of grade Fe 500 wasused as tensile reinforcement.

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Nitin Kumar et al (2015) presented the use of steel fibers as reinforcement material with concrete. In this study, themixing of various materials weather chemicals natural or official for improving the strength and durability of parent substance. Critical investigation for M 40 grade of concrete having mix proportion 1:4:3 with water cement ratio 0.35 tostudy the compressive strength flexural strength, split tensile strength of steel fibers reinforced concrete containing fibersof 0%, 1%, 2% and 3% volume fraction of hooks the result shown that steel fiber reinforced concrete increase strengthtoughness ductility and flexural strength of concrete.

2.2 POLYETHYLENE FIBER

M. Elzafraneyetal. [2005]This study has incorporated use of recycled plastic aggregate in concrete material for a building to work out its performance with regards to thermal attributes and efficient energy performance in comparison with normal aggregate concrete. The plastic content concrete was prepared from refined high recycled plastics to meet various requirement of building construction like strength, workability and finish ability etc. Both buildings were subject to long and short term monitoring in order to determine their energy efficiencies and level of comfort. It was observed that recycled plastic concrete building having good insulation used 8% less energy in comparison of normal concrete; however saving in energy was more profound in cold climate in building with lower insulation. They recommended that efficiency of energy can further be increase if recycle plastic of high thermal capacity is used. They have suggested the use of recycle plastic aggregate concrete being economical and light weights are having high resistance to heat. The author should also incorporate the comparison of both buildings with regards to durability and strength

Zainab Z. Ismail et al. [2007]They have conducted comprehensive study based on large number of experiments and tests in order to determine the feasibility of reusing plastic sand as partial replacement of fine aggregate in concrete. They conducted tests on concrete samples for dry/fresh density, slump, compressive and flexural strength and finally toughness indices on room temperature They have collected waste plastic from plastic manufacture plant consist of 80% polyethylene and 20% polystyrene which was crushed (varying length of 0.15-12mm and width of 0.15-4mm). Concrete mix were produce with ordinary Portland cement, fine aggregate (natural sand of 4.74mm maximum size), coarse aggregate (max size below 20mm) and addition of 10%, 15% and 20% of plastic waste as sand replacement. Their test results indicate sharp decrease in slump with increasing the percentage of plastic, this decrease was attributed to the presence of angular and non uniform plastic particles. In spite of low slump however, the mixture was observed with good workability and declared suitable for application. Their tests also revealed the decrease in fresh and dry density with increasing the plastic waste ratio; however increase was reported in dry density with time at all curing ages. Decrease in compressive and flexural strength was observed by increasing the waste plastic ratio which can be related to decrease in adhesive strength between plastic waste particles with cement. However, load-deflection curve of concrete containing plastic waste showed the arrest of propagation of micro cracks which shows its application in places where high toughness is required. The study has shown good workability in spite of low slump but w/c content kept constant in all samples. They should have reduced the watercontent in order to improve the strength when workability was not an issue.

A Bhogayata et al. [2012] They have studied the environment friendly disposal of shredded plastic bags in concrete mix to be use in construction industry which have dire need for alternative material to be use in lieu of conventional materials. Different test results were analyzed after testing on 48 x concrete cubes(150mm x 150mm x150mm) prepared from varying percentage of polyethylene fibers (0.3, 0.6, and 0.9 to 1.2% of volume of concrete) with conventional concrete material to prepare mixes. Two type of plastic bag fibers were used, one cut manually (60mm x 3mm) and another shredded into a very fine random palettes. Cubes were tested for 7&28 days compressive strength and compaction. They concluded that good workability was shown by the mix added with shredded fibers due to its uniform and higher aspect ratio evenly sprayed in the mix. Addition of plastics up to 0.6% is considered suitable after which reduction in compressive strength and compaction is seen affected. They observed that strength loss was less in concrete having shredded fibers of plastic as compare to hand cut macro fibers. Their research focus was only on comparative study of compressive strength but no work was carries out on other concrete properties like tensile strength, modulus of elasticity and density of concrete.

P. Suganthy et al.[2013] This study investigate the application of pulverized fine crushed plastic (produce from melting and crushing of high density polyethylene) as replacement of fine aggregate in concrete with varying known percentages. Their main focus was on optimum replacement of natural sand by pulverized plastic sand. Five concrete mixes were produced from specified concrete materials having replacement of fine aggregate (sand) by 0, 25, 50, 75 and 100% respectively to study the test graph results of various concrete properties. The results showed increase in water/cement ratio with increase replacement of sand with plastic particles to achieve desired 90mm concrete slump. They have also observed from the results that gradual decrease in strength of concrete specimen for plastic replacement up to 25% but afterward the decrease in strength israpid which shows suitable replacement up to 25% of sand with plastic pulverized sand. They have also concluded after testing of specimen (having different proportion of plastic replacement) for Ultimate and yield

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strength that both strength decreases with increase replacement of sand with pulverized plastic particles. Their study lacks detailed testing of properties of concrete because only compressive strength and w/c ratio tests will not be sufficient to study the matrix as a whole to be suitable for construction. No efforts were made to explore the use of admixtures in controlling of compressive strength reduction in a mix containing pulverized plastics.

KhileshSarwe.[2014] This study presents the results of addition of waste plastics along with steel fibers with an objective to seek maximum use of waste plastic in concrete. Two different categories of mix were casted in cubes (150mm x 150mm x 150mm), one with varying percentages of plastic wastes (0.2%, 0.4%, 0.6%, 0.8% and 1% weight of cement) and another mix of plastics waste/steel fibers (0.2/0.1, 0.4/0.2, 0.6/0.3, 0.8/0.4 and 1/0.5 % by weight of cement) to study the compressive strength at 7 and 28 days strength. The combine mix of plastic waste and steel fibers has shown more strength as compare to concrete mix prep only with plastic waste. He has reached to conclusion that a plastic waste of 0.6% weight of cement when used with steel fiber of 0.3 % (weight of cement) has shown the maximum compressive strength. This study has really focused on addressing the issue of reduced compressive strength with addition of plastic waste. Steel fibers when used along with plastic wastes will affect all the properties of concrete but the researcher only focused on compressive strength property which is insufficient to give clear picture of concrete behavior.

2.3 LITERATURE SUMMARY

From all the above literature reviews, it was evident that steel fiber can be used for the strengthening of concrete and polyethylene sheet will increasethe ductility and life time of the concrete.

3. MATERIAL USED

The materials used for the project is collected and made sun dried before as initial testing and for further usage. The amount of material to be used should be noted in advance based on the preparation of mix design. From the results of mix design the quantity of each component such as cement, FA, CA and water will be finalized, then the collection of materials to be done and to be stored in a specified place free from impurities. Based on the availability of the materials and its condition the following tests were performed.

3.1 CEMENT

Ordinary Portland cement of 53 grade having specific gravity of 3.1 and fineness modulus of 6.5% was used. The Cement used has been tested for various proportions as per IS 4031-1988 and found to be confirming to various specifications of IS 12269-1987.

3.2 FINE AGGREGATE

Fine aggregates are termed as “filler” which fills the voids in concrete. The fractions of aggregates less than 4.75mm are known as fine aggregates. The river sand is used as fine aggregate conforming to requirements of IS: 383-1970 comes under zone II.

3.3 COARSE AGGREGATE

Aggregates fractions larger than 4.75mm are termed as coarse aggregates. The fraction of aggregates used in the experimental work passed in 20mm sieve and retained on 10mm IS sieve comes under Zone II aggregates conforming to IS: 383-1970.

3.4 STEEL FIBER

Steel fiber fractions with the flexural strength of 1.5Mpa are taken. The property of fibers are covered by BS EN 14889, fibers for concrete part1.

Fig.no.3.1: Steel fiber

Steel fibers actually increases the mechanical properties such as material toughness and durability. Steel fibers play a vital role in reducing crack as well as maximum resistance to withstand heavy loads either dynamic or static .It provides better ductility compared with conventional concrete. The properties of steel fibers are shown in Table 3.1.

Table 3.1: Properties of Steel fiber

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3.5POLYETHYLENE

Polyethylene sheets with a density range of 0.926-0.940 g/cm^3 are used as a wrapping material in this project. The polyethylene sheet used in the project is of with a chemical composition of chromium/silica catalysts and with metallocene catalysts.

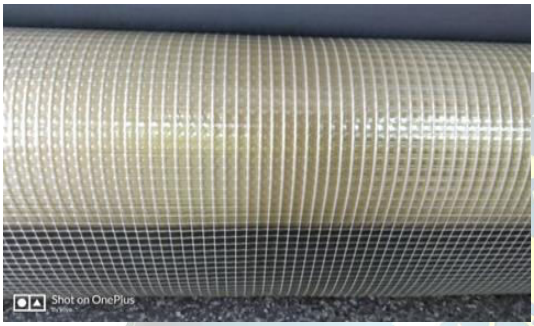

Fig.no.3.2:Polyethylene

Polyethylene consists of nonpolar, saturated, high molecular weight hydrocarbons. Therefore, its chemical behavior is similar to paraffin. The individual macromolecules are not covalently linked. Because of their symmetric molecular structure, they tend to crystalline; overall polyethylene is partially crystalline. Higher crystalinity increases density and mechanical and chemical stability. polyethylene is of low strength, hardness and rigidity, but has a high ductility and impact strength as well as low friction. It shows strong creep under persistent force, which can be reduced by addition of short fibers. It feels waxy when touched.

Sl.No.	properties	Result
1.	Chemical formula	$(C_2H_4)_n$
2.	Density	0.88-0.96 g/cm^3
3.	Melting point	115-135^{o}C(239-275^{o}F;388-408k)
4.	Magnetic susceptibility	-9.67X10^{-6}

Table 3.2: Properties of polyethylene

3.5.1.THERMAL PROPERTIES

Sl.No.	Physical properties	Result
1.	Specific gravity	2.57
2.	Physical form	Hooked end fiber
3.	Size	30mm length,0.75mm

The usefulness of polyethylene is limited by its melting point of 80 ^{o} C. For common commercial grades of medium and high-density polyethylene the melting point is typically in the range 120 to 180^o C. The melting point for average, commercial, low-density polyethylene is typically 105 to 115^o C. These temperatures vary strongly with the type of polyethylene.

4.MIX DESIGN

4.1 GENERAL

The process of selection suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required strength and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in two states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability therefore becomes of vital importance.

4.2 MIX PROPORTIONS

Cement = 350 kg/m^3
Water = 140 kg/m^3
Fine aggregate = 778 kg/m^3
Coarse aggregate= 1198kg/m^3

5.1 MECHANICAL PROPERTIES

5.1.1 Compression Test (Ref: IS: 516-1959)

Compression test is the most common test conducted to determine almost all the characteristics of concrete. compressive test of concrete depends upon water cement ratio ,quality of concrete material ,quality control during the process of making concrete. compressive strength test normally carried in both cube and beam .In our project we have tested cubes for compression with size of 150mm x150mm x 150mm.The properly mixed concrete is poured in the moulds and tamped properly to avoid voids after 24 hours the moulds are removed and the specimen is put in the water for curing .After that the specimens are

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tested at 7, 14 and 28 days at compression testing machine as per I.S.516-1959.

Fig 5.1 Test Set up for Compressive Strength Test

5.1.2 Flexure Test (Ref: IS: 516-1959)

The tensile strength of the concrete can be measured using flexural strength test.It is also known as modulus of rupture. It represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress, here given the symbol $f_{cr.}$. The flexural strengths of the respective specimens have been obtained from the flexural tests performed on the prism specimens of size 150mm x 150mm x 700mm.The flexural strength are tested using a two point loading frame machine as per standard .

Fig 5.2 Test Set Up for Flexural Strength

The modulus of rupture can be determined by using the formula given below

$$f_{cr} = (P_{max} \times l)/bh^2$$

where,

fcr = Flexural strength

P_{max}= maximum load in (N) kg.

b = width of the prism in mm

h= depth of the prism in mm

l = span of the prism in mm

5.1.3 Split tensile strength Test (Ref: IS: 5816-1999)

Split tensile strength of concrete is usually found by testing plain concrete cylinders. Cylinders of size 150mm x 300 mm were casting using M_{25} grade concrete. Specimens with Conventional Concrete and SCC of two different percentages were casted. During casting the conventional concrete cubes were manually compacted using tamping rods. After 24hours, the specimens were removed from the mould and subjected to water curing for 7, 14, 28 days. After curing, the specimens were tested for compressive strength as per IS: 5816-1999 using a calibrated compression testing machine of 2000KN capacity.

Two packing strips of plywood 3mm thick were provided between the specimen one at top and another at bottom. The specimen was placed on the plywood strip and aligned so that, the central horizontal axis of the specimen is exactly perpendicular to the load applying axis. The second plywood strip was placed length wise on the cylinder and the top platen was brought down till it touched the plywood. The load was applied without shock and increased continuously until the resistances of the specimen to the increasing load broke down and no greater load can be sustained.

Fig 5.2 Test Set Up for Split tensile strength

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Curing days	COMPRESSIVE STRENGTH N/mm^2			
	Mix 1(0%)	Mix 2(0.6%)	Mix 3(0.9%)	Mix 4(1.2%)
7 days	18.61	19.61	20.21	21.674
14 days	24.85	28.92	29.708	31.019
28 days	37.33	47.56	48.704	49.71

Tensile strength of concrete

$f_t=\frac{2p}{\pi dl}$

Where ,

P = Maximum load in N applied to the specimen

L = Measured length in cm of the specimen

D = Measured diameter in cm of the specimen

RESULTS AND DISCUSSION

6.1 GENERAL

This chapter deals with the results obtained from the various experiments conducted to access mechanical properties. The aim of the study is to determine the compressive strength, flexural strength and spilt tensile strength .so the results of test specimens are presented. The discussion on the results also presented in this chapter.

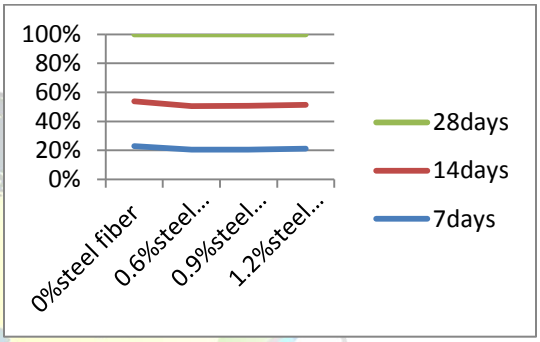
6.2 MECHANICAL PROPERTIES

The mechanical properties of concrete such as compressive strength, flexural strength and split tensile strength are determined from the standard experiments. They are as follows.

6.2.1 Compressive Strength

The compressive strength of replacement of waste bottle caps is arrived. The compressive strength value for replacement of waste bottle caps with the addition of steel fibers Table 6.1Shows compression test results.

Table 6.1: Compressive Strength of Cubes with steel fiber and Polyethylene sheet



MIX DESIGN

6.2.2 FLEXURAL STRENGTH

The flexural strength of replacement of waste bottle caps with the addition of steel fibers is arrived.. Table 6.2 shows flexural strength test results.

Table 6.2: Flexural Strength of beams with steel fiber and Polyethylene sheet

Curing days	FLEXURAL STRENGTH N/mm^2			
	Mix 1(0%)	Mix 2(0.6%)	Mix 3(0.9%)	Mix 4(1.2%)
7 days	4.43	5.36	5.46	5.68
14 days	5.25	6.322	6.42	6.60
28 days	6.9	8.24	7.36	8.45

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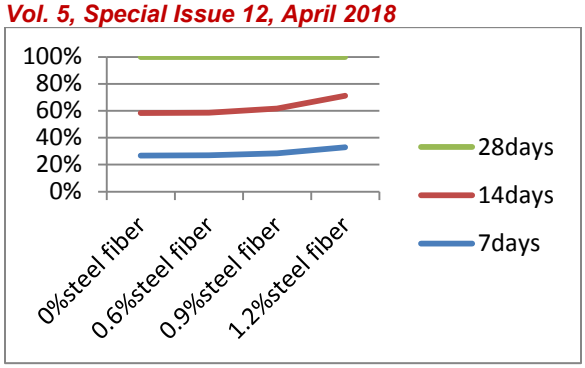

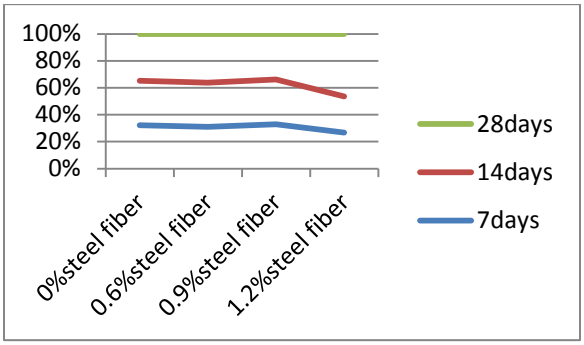

MIX DESIGN

MIX DESIGN

6.2.3 SPLIT TENSILE STRENGTH

The variation of split tensile strength at the age of 28 days with different percentage of waste bottle caps with the addition of steel fibers from the test results, it was observed that the maximum split tensile strength was obtained for mix of 15% replacement of fly ash by waste bottle caps. Table 6.3 flexural strength test results

Table 6.3: split tensile strength of Cylinder with. steel fiber and Polyethylenesheet.

Curing days	SPLIT TENSILE STRENGTH N/mm^2			
	Mix 1(0%)	Mix 2(0.6%)	Mix 3(0.9%)	Mix 4(1.2%)
7 days	4.09	4.22	4.83	4.85
14 days	4.19	4.45	4.87	4.89
28 days	4.4	4.92	4.95	4.98

CONCLUSION

Based on the experimental investigations the following conclusions are arrived.

1. Steel fibers decrease the workability so, use of superplasticer is required.

   As the volume of steel fibers increases, the workability decreases that is slump is reduce.

2. The compressive strength of concrete increases considerably as the volume of steel fibers is increased when it is wrap with polyethylene sheet.
3. Similarly the tensile strength of concrete increases significantly as the volume of steel fiber is increase similar to the grade of concrete.
4. The toughness of concrete is also increased very significantly as it is covered by polyethylene sheet. The crack pattern changes as the failure is more ductile in SFRC as compared tocompression shear crack pattern failure of conventional concrete.
5. The tensile strength will be around 8% of compressive strength.

From the experimental work, we conclude that as we increase the amount of steel fiber covered with polyethylene sheet, there is increase in compressive strength by 44% tensile strength by 74% and shear strength by 43% for optimum dosage of steel

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fiber(1.2% SF) for M25 grade. Beyond this there may be a reduction in the strength.

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