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Enhancing The Compressive Strength Of Self Compacting Concrete (Scc) Using Steel Fibers And Recycled Aggregates As Partial Replacement Of Coarse Aggregates

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ABSTRACT:
A concrete's durability and mechanical strength can be affected by unoccupied spaces and macropores created by improper vibration and compaction, which can also be one of the reasons why concrete deteriorates. Okamura first developed Self-Compacting Concrete (SCC) in 1986, and it is a well-considered answer to the issues mentioned above. Concrete that compacts itself under its own weight is known as self-compacting concrete and requires no further effort to do so.

Numerous studies have been conducted to examine the behaviour of plain SCC. Additionally, numerous studies from the past have shown that different fibres can be used to enhance the structural qualities of concrete. But here the combination of steel fiber and recycled concrete aggregates on the flexural behavior of SCC to be investigated.

Steel fibres are added to concrete at several rates (0%, 0.5%, 0.75%, and 1%) and recycled concrete aggregate is used to replace coarse aggregate to a certain extent 25%. Cubes, Cylinders, Prisms and RCC beams were casted. Also founded the properties of fresh and hardened concrete. It had been found that the RCASF 3 mix performed better than the RCASF 1 and RCASF 2 replacement mixes. Results from the experiments and analytical were examined. Results from analytical are slightly lower to those from experiments.

Keywords: Self-Compacting Concrete, Steel Fibers, Recycled aggregates, Compressive Strength, Flexural Strength, Split-tensile strength

I.INTRODUCTION

1.1 GENERAL

Self-compacting concrete (SCC), which has several advantages over normal concrete, has recently become more widely accepted. SCC is a very homogenous and flowable concrete mix that can fill and compact in every corner of the formwork with just its own weight, negating the requirement for outside vibration. The ability of SCC to create strong concrete structures is one of its main benefits. Strong concrete structures are necessary to ensure long-lasting and high-quality concrete constructions. SCC can produce great strength and durability by lowering the amount of voids in the concrete mix and removing the possibility of segregation. Additionally, SCC's improved fluidity makes it possible for it to be used in buildings with intricate and crowded reinforcements.

Additionally, the absence of external vibration lessens noise pollution, which is advantageous for nearby residents and workers. SCC's ability to self-compact also makes construction work safer and more efficient by lowering the requirement for manual labour and the chance of accidents. Overall, SCC utilisation provides several advantages for the construction industry, and its acceptance is likely to increase going forward.

1.1.1 Self Compacting Concrete

Self-Compacting Concrete (SCC) is a kind of concrete that can flow and compact by itself without the aid of outside vibration. SCC is distinguished by its superb homogeneity and finish, high fluidity, and capacity to fill complex forms without segregation or bleeding. SCC is frequently employed in situations where conventional concrete placing methods are impractical or unfeasible, such as crowded reinforcing, complex geometries, or places where vibration equipment has limited access.

SCC can accelerate construction and lower labour costs because only minimum labour is needed to put and finish the concrete. Cement, aggregates,water, and admixtures are the main ingredients of SCC in most cases, just as they are in conventional concrete.

However, SCC frequently contains higher levels of fine particles, which improve the mixture's fluidity and self-compactibility, like fly ash or silica fume. SCC may also contain superplasticizers and viscosity-modifying chemicals to enhance the mixture's rheology and workability.

SCC is frequently employed in situations, such as substantially reinforced structures, complicated architectural shapes, and regions with limited access, where typical concrete installation procedures are challenging or impracticable. Additionally, it offers a number of advantages, such as increased toughness, better surface quality, lower labour costs, and increased safety on construction sites

1.1.2 Steel fiber

In fiber-reinforced concrete, steel fibres are a typical type of fibre. They are short, broken steel filaments that typically have diameters between 0.25 mm and 0.75 mm and lengths between 25 mm and 50 mm. To enhance the mechanical qualities of concrete, such as flexural and tensile strength, toughness, and ductility, steel fibres are added to the concrete mixture. The fibres are equally dispersed throughout the concrete mixture, and when the concrete dries, they form a three-dimensional reinforcing network that helps to disperse stresses and stop cracks from forming.

In comparison to conventional concrete, the use of steel fibres in concrete can offer a number of benefits, including improved durability, increased resistance to impact and fatigue loading, and decreased susceptibility to cracking due to shrinkage or temperature changes. Additionally, steel fibres can improve structural performance, enabling the design of thinner and lighter concrete components.

It is crucial to remember that adding steel fibres to concrete may also bring some difficulties, such as making mixing and laying the concrete more challenging and wearing down mixing and placing equipment more quickly.

1.1.3 Recycled Concrete Aggregate

The recycled concrete aggregate (RCA) is made when concrete buildings are demolished and recycled. Concrete that has been crushed and graded and treated to remove impurities like rebar and other metal items as well as to generate pieces of a uniform size and shape make up RCA. When building roads, embankments or new concrete pavements, RCA can be used as an alternative to natural aggregates in a variety of construction applications. Utilising RCA in construction can lessen the need for new aggregates and the negative effects of aggregate extraction on the environment.

RCA is superior to conventional natural aggregates in a number of ways, including cost, environmental effect, and sustainability. Depending on the quality and grading of the RCA, it also possesses engineering attributes including strength, durability, and workability that are comparable to or better than natural aggregates.
However, the use of RCA does necessitate careful consideration of a number of factors, including the RCA's quality, potential for contamination, and the likelihood that the recycled material will exhibit alkali-silica reactivity In order to make sure that the RCA satisfies the relevant performance requirements for the particular application, proper quality control and testing are essential. Overall, the use of RCA is a promising strategy for sustainable construction, as it helps to reduce waste and preserve natural resources, while providing comparable or better performance than traditional aggregates.

1.2 OBJECTIVES

To determine the properties of fresh and hardened concrete.
To investigate the flexural properties of conventional SCC and steel fiber- reinforced SCC based on recycled aggregate.

1.3 SCOPE

The scope of the present investigation includes:
Analyze the characteristics of steel fiber-reinforced SCC at different steel fibre dosages in order to maximise the dosage of steel fibres.
Create an analytical model to forecast the flexural strength of steel fibre reinforced vibrated concrete (SFVC) using recycled and natural coarse particles.

1.4 NEED FOR STUDY

To study the influence of Recycled Concrete Aggregate effect on flexural behaviour of self compacting concrete.

To investigate how steel fibres affect SCC under flexural behaviour.

To make concrete with a sustainable material.

II. METHODOLOGY

2.1 FLOWCHART

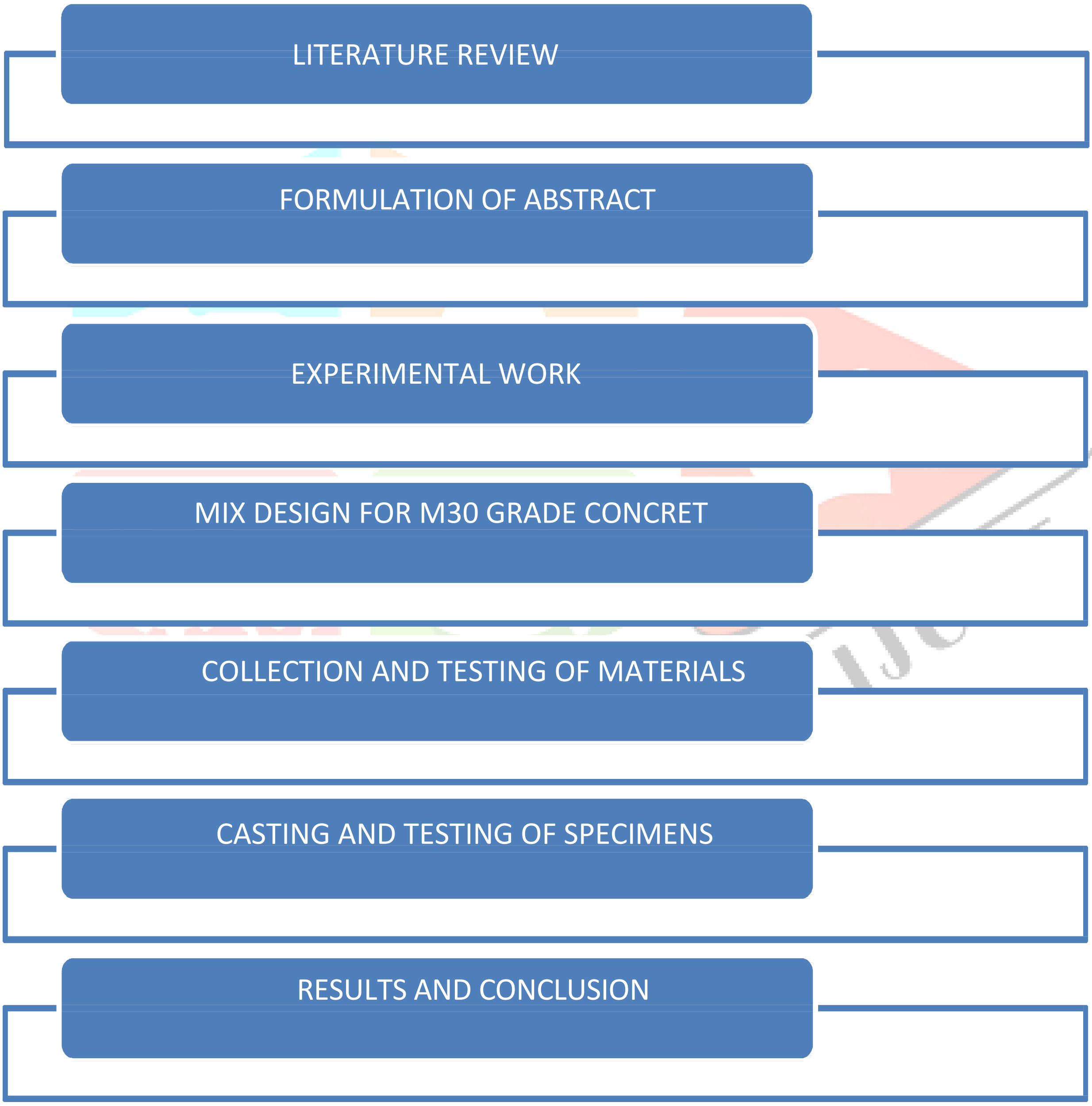

Fig 2.1 Methodology Flowchart

2.2 MIX PROPORTIONS

Mix Proportions for M30 have been developed based on IS 10262: 2019 and the quantities of materials required for the study have been tabulated below. The water cement ratio of 0.43 has been set constant throughout the work.

Table 2.1 Combination of Steel Fiber And Recycled Aggregate

MIX	STEEL FIBER (%)	RECYCLED AGGREGATE (%)
Conventional	-	-
RCASF 1	0.50	25
RCASF 2	0.75	25
RCASF 3	1	25

The different mixes mentioned in the table are:

Conventional - This is the mix without any steel fibers and Recycled Concrete Aggregate.

RCASF1 - This mix includes 0.50% of steel fibers by volume of concrete and the quantity of natural aggregate is partially Replaced by 25 %.

RCASF2 - This mix includes 0.75% of steel fibers by volume of concrete and the quantity of natural aggregate is partially Replaced by 25 %.

RCASF3 - This mix includes 1% of steel fibers by volume of concrete and the quantity of natural aggregate is partially Replaced by 25 %.

Table 2.2 Mix Proportion of M30 Grade of Self Compacting Concrete

MIX	CEMENT (Kg/m3)	FLY ASH (Kg/m3)	WATER (L/m3)	FA (Kg/m3)	CA (Kg/m3)	RCA (Kg/m3)	SP	SF
Conventional	287	155	190	975	737	-	2.65	-
RCASF 1	287	155	190	975	552.75	184.25	2.65	11.73
RCASF 2	287	155	190	975	552.75	184.25	2.65	17.6
RCASF 3	287	155	190	975	552.75	184.25	2.65	23.47

2.3 SAMPLES DETAILS AND CASTING PROCESS

The No. of Cubes, Cylinder, Prisms and RCC Beams to be casted are listed below for each combinations.

SCC WITOUT SF AND RCA

Cubes 9 nos

Cylinder 9 nos

Prisms 9 nos

SCC WITH 0.50% SF AND 25% RCA

Cubes 9 nos

Cylinder 9 nos

Prisms 9 nos

SCC WITH 0.75% SF AND 25% RCA

Cubes 9 nos

Cylinder 9 nos

Prisms 9 nos

SCC WITH 1.0% SF AND 25% RCA

Cubes 9 nos

Cylinder 9 nos

Prisms 9 nos

Fig 4.2 Cube, cylinder and beam mould with oil applied and casting process

III.EXPERIMENTAL INVESTIGATION

3.1 Compression Strength for cubes

Table 3.1 Average compressive strength of cube at 7, 14 and 28 days

S.No	Mix	Average Compressive Strength In N/mm^2		
		7 days	14 days	28 days
1	Conventional	20.97	28.84	37.45
2	RCASF 1	17.77	24.43	31.73
3	RCASF 2	17.61	24.22	31.45
4	RCASF 3	18.00	24.75	32.15

3.2 Split Tensile strength for Cylinder

Table 3.2 Average Split Tensile strength of Cylinder at 7, 14 and 28 days

S.No	Mix	Average Split Tensile Strength In N/mm^2		
		7 days	14 days	28 days
1	Conventional	1.66	2.28	2.96
2	RCASF 1	1.59	2.19	2.85
3	RCASF 2	1.63	2.24	2.92
4	RCASF 3	1.56	2.14	2.79

3.3 Flexural strength for prisms

Table 3.3 Average Flexural strength of prisms at 7, 14 and 28 days

S.No	Mix	Average Flexural strength in N/mm^2		
		7 days	14 days	28 days
1	Conventional	3.2	3.8	4.93
2	RCASF 1	3.6	4.4	4.41
3	RCASF 2	3.9	4.7	5.12
4	RCASF 3	4.1	5	5.46

IV.RESULTS AND DISCUSSION

4.1 COMPRESSION TEST RESULTS

Table 4.1 Average compressive strength of cube at 7, 14 and 28 days

S.No	Mix	Average Compressive Strength In N/mm^2		
		7 days	14 days	28 days
1	Conventional	20.97	28.84	37.45
2	RCASF 1	17.77	24.43	31.73
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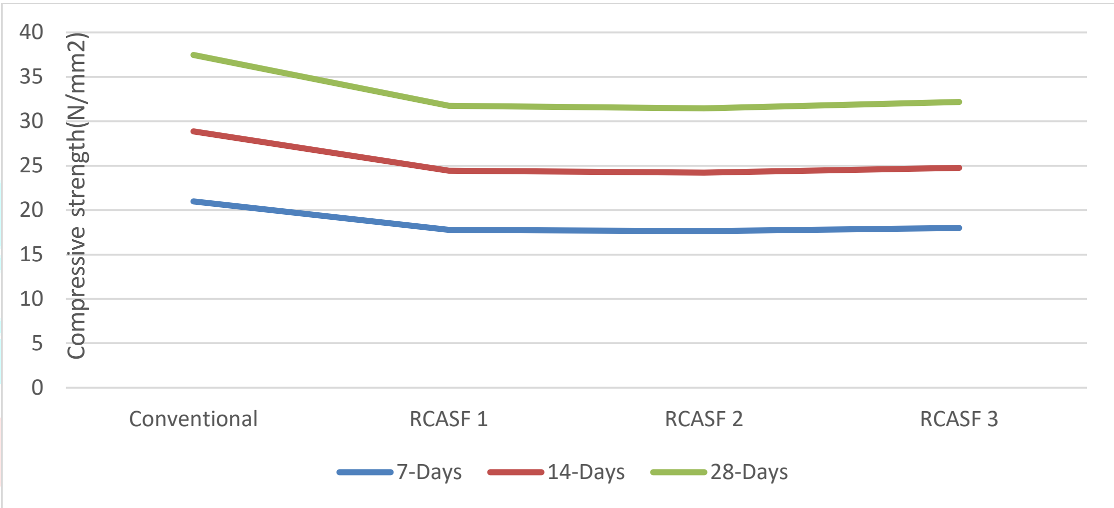

Fig.4.1 Compression test for 7 , 14 & 28 days

According to the graph, RCASF 2 consistently had the lowest average compressive strength at 7 days, 14 days, and 28 days, whereas Conventional mix consistently had the strongest.

Compressive strength for RCASF1, RCASF2, and RCASF3 increases marginally from all ages as the percentage of steel fibres rises from 0.5% to 1%. Among the Replacement mixes RCASF 3 shows better results.

4.2 SPLIT TENSILE TEST RESULT

Table 4.2 Split Tensile Strength of the Cylinder for 7, 14 & 28-days

S.No	Mix	Average Split Tensile Strength In N/mm^2		
		7 days	14 days	28 days
1	Conventional	1.66	2.28	2.96
2	RCASF 1	1.59	2.19	2.85
3	RCASF 2	1.63	2.24	2.92
4	RCASF 3	1.56	2.14	2.79

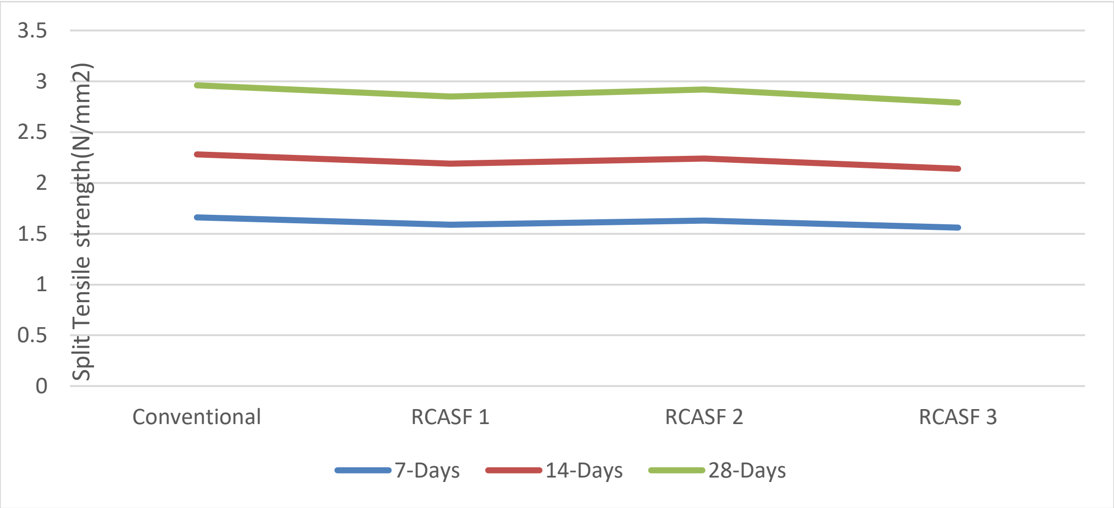

Fig.4.2 Split Tensile test for 7 , 14 & 28 days

The graph demonstrates that for all three time periods, the average split tensile strength was highest for the conventional mix and lowest for RCASF 3.

At 7 days, the RCASF 3 had an average split tensile strength of 1.56 N/mm^2, compared to 1.66 N/mm^2 for the conventional mix. At 14 days, the RCASF 3 had an average of 2.14 N/mm^2, compared to 2.28 N/mm^2 for the conventional mix. At 28 days, the RCASF 3 had an average of 2.79 N/mm^2, compared to 2.96 N/mm^2 for the conventional mix.

According to the graph, the conventional mix may be able to withstand cracking under tensile stress better than the RCASF mixtures.

4.3 FLEXURAL TEST RESULTS

Table 4.3 Flexural Strength of the Beam for 7, 14 & 28-days

S.NO	MIX	Average Flexural Strength In N/mm^2		
		7 days	14 days	28 days
1	Conventional	3.2	3.8	4.93
2	RCASF 1	3.6	4.4	4.41
3	RCASF 2	3.9	4.7	5.12
4	RCASF 3	4.1	5	5.46

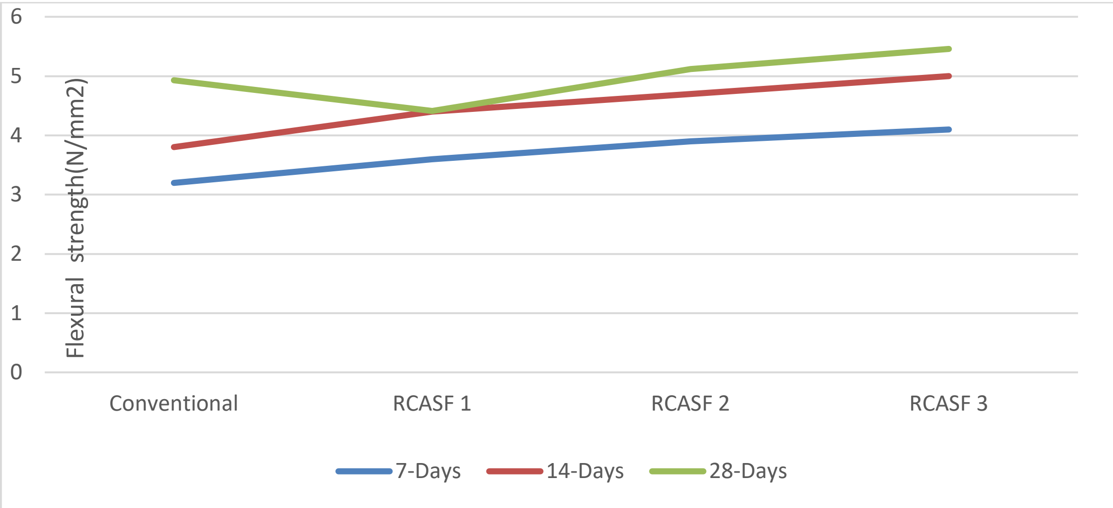

Fig.4.3 Flexural Strength test for 7 , 14 & 28 days

According to the graph, RCASF 3 has the highest average flexural strength, measuring 5.46 N/mm^2. This indicates that compared to the other mixtures, this blend is more resistant to bending when subjected to a weight.

While RCASF 2 had an average flexural strength of 5.12 N/mm^2, the conventional mix had a flexural strength of 4.93 N/mm^2, which is marginally less. With an average flexural strength of 4.41 N/mm^2, RCASF 1 had the lowest flexural strength of the four mixtures.

According to the graph, RCASF 3 might be the best option for applications where flexural strength is crucial. However, it is important to consider other factors as well when choosing a concrete mix, such as the specific requirements of the project and the availability and cost of the materials.

V. SUMMARY AND CONCLUSION

5.1 SUMMARY

From various literature reviewed related to the replacement of recycled Concrete aggregate as an alternate for natural coarse is an efficient way to get rid of surplus concrete waste when used in the appropriate replacement amounts and also the influence of steel fibers on SCC was studied.

The Physical Properties of all the materials used in the concrete has been tested. The properties of Fresh and Hardened SCC were also investigated.

5.2 CONCLUSION

In this study, the flexural behaviour of self-compacting concrete was tested using steel fibres at four different percentages (0.5%, 0.5%, 0.75%, and 10%). Along with the steel fibres, recycled concrete aggregates at a 25% addition were also used as a partial replacement for coarse aggregate.Steel fibres with hooked ends have a much greater impact on concrete's mechanical qualities than steel fibres with straight or crimped ends.

The addition of steel fibres improves the concrete's flexural strength, and the increase in RCA content has an impact on several properties of concrete, limiting the replacement percentage.

According to the material analysis, recycled concrete aggregate has a significantly higher water absorption rate than natural coarse aggregate. The properties of fresh concrete in terms of workability are impacted by the addition of steel fibres.

Of the four mixes, the conventional mix has the highest compressive strength. RCASF 3 mix is one of the Replacement mixes with superior outcomes. Comparing the RCASF 3 Mix to conventional M30 grade concrete, the compressive strength is decreased 14%.

The Conventional mix and RCASF 2 mix gives more or less same results.There is only slight difference in the split tensile results.

Of the four mixes, RCASF 3 mix has the highest flexural strength. When compared to the conventional mix, the load carrying capacity is high. In Prisms, compared to conventional M30 grade concrete, it results in an 11% increase in flexural strength. Better outcomes are obtained with a higher percentage of steel fibre.

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