Performance Evaluation of Crimped Steel Fiber Reinforced Concrete Using M-Sand For M30 Concrete

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Abstract- In this study, crimped steel fibres and manufacturing sand (M-Sand) were used in an experimental study of fibre reinforced concrete. We know that concrete is weak in tension and strong in compression, and that the fine aggregate used in concrete is typically natural river sand. Our goal is to replace the natural sand with manufactured sand and to increase the compressive and tensile strength of the concrete by adding steel fibre. M-Sand is used as a fine aggregate to get over the problems caused by over-mining of sand. Gravel crushers generate M-Sand, which is homogeneous in size.

Investigating the impact of steel fibres on concrete made with M-sand as the fine aggregate is the primary goal of this study, which also aims to create a high-performance concrete. The compressive and tensile strengths of concrete grade M30 with various steel fibre percentages (0%, 0.3%, 0.6%, 0.9%, and 1.2%), respectively, are proposed to be measured and compared. To make concrete more workable, chemical admixtures are utilised. In order to undertake the study, tests for compressive strength, split tensile strength, and flexural strength are performed.

Keywords- Steel fibre, M-sand, compression test, split tensile test, flexural strength test.

I. INTRODUCTION

Concrete generally uses natural sand as fine aggregate due this more amount of river sand is consumed for the construction we planned to use M sand as fine aggregate m sand in order to attain its uniformity of gradation due to its uniformity the achieve the higher gradation level that means these falls at Zone 2 and these due to not have any impurities such like that natural sand due to the deposition of the clay and slit due to the low tensile strength of concrete its necessary to increase the strength by addition of reinforcement but this may increase the cost but by addition of steel fibre we can increase the strength at low cost. This increase of steel fiber tensile strength stops the development of the micro cracks that would otherwise spread and finally cause the concrete to fracture brittlely.

Mixtures for concrete can be categorized in a variety of ways, frequently based on the specifications used. Generally speaking, there are two types of specifications: "prescriptive" specifications, which specify the proportions of the ingredients and their properties (such as the type of cement, the maximum aggregate size, etc.) in the hopes that doing so will lead to satisfactory performance. An alternative is to utilize a specification that is performance-oriented. Concrete must meet certain requirements for desirable attributes (for instance, strength, workability, or any other property). Based on the aforementioned factors, concrete can be categorized as "designed mix" or "nominal mix" concrete, as per IS: 456-2000.

II. LITERATURE SURVEY

Anup KrushnaraoChitkeshwar and P. L. Naktode (2024) In the research report, the durability characteristics of produced sand concrete were examined. By weight of cement, concrete also contains other elements like zinc oxide. The percentage range for the partial replacement of river sand with m-sand was 25% to 100%. For the concrete, tests for the durability, including ones for water permeability, acid attack, sea water, and sulphate assault, have been conducted. The results for the durability acquired held good results when the river sand was substituted with m-sand by a percentage.

According to the findings, the resistivity increases at a 10% replacement rate for alcofine and a 0.5% replacement rate for zinc oxide. It was discovered that, when compared to standard concrete, replacing m-sand more than 50% of the time results in weight loss.

Ashish Kumar Yadav et.al (2022) By substituting steel fibre and polypropylene fibre individually for some of the fine aggregate in concrete, the study report examined the effects of produced sand. Compressive strength (7 and 28 days), tensile strength (28 days), and new concrete qualities are measured to determine strength. The concrete used for this test was grade M35, and the concrete mixes included Portland pozzolana cement, fine aggregate replacement rates of 15, 30, 45, 60, and 75 percent, steel fibre addition rates of 0.50, 0.75, 1, and 1.25

percent, and concrete mixes containing polypropylene fibre at rates of 0.5kg/m3 and 1kg/m3, respectively. This study examined the effects of manufactured sand by partially replacing fine aggregate in concrete with steel fibre.

According to the findings, M-sand may effectively substitute natural river sand up to a point, and adding fibre reinforcement significantly increases the compressive, flexural, and tensile strength of concrete specimens. However, adding steel and polypropylene fibre has a negative impact on workability. Compressive strength grew by 17% until m-sand replaced 60% of the original material; beyond that, it starts to decline. The ideal dosage of m-sand is 60% by weight of fine aggregate since split tensile strength and flexural strength both exhibit the same trend. Surface roughness in m-sand particles decreased workability, but workability was acceptable for typical concrete up to 60% m-sand content. From 0 to 1% of steel fibre content, the addition of steel fibre results in a better rise in compressive, split tensile, and flexural strength. More than 1% of steel fibre does not more effectively increase mechanical characteristics. The volume ratios of polypropylene fibres exhibited a proportional relationship with the compressive, flexural, and tensile strengths of concrete, with specimens with 1.5 kg/m3 and 2 kg/m3 having the maximum strength values, according to the results of tests on strength properties.

Objectives of the Research

The aim project is to have a study comparison between mechanical performance of crimped SF reinforced concrete in different proportion with additional replacement of natural sand by Manufacturing sand in various proportion for M30 grade concrete mix with that of the normal concrete. The experimental investigation includes the test being carried on hardened concrete. The test carried out are for the workability of concrete, compressive strength, tensile strength, and flexural strength.

- decreasing the amount of river sand used in building and protecting the environment M-Sand is therefore required.
- Study on flexural behaviour of concrete with steel fibre in different proportion.
- Study on properties of hardened concrete on variation of fine Aggregate using M Sand in various proportion.

Cement

UltraTech -53 grade cement confirming to IS 12269-1987 was been used for the current project to complete the investigation process. The laboratory test conducted on cement are as given be below.

Table 1 Properties of Cement.

Properties	Results	Permissible Limits as per IS Standard
Fineness	3%	<10%
Specific Gravity	3.15	3.5
Initial Setting Time	30 min	<30 min
Final Setting Time	550 min	<600 min

Fine Aggregates

The natural sand was obtained from the local origin. The river sand brought was free from all the silt, clay and other impurities. The natural fine aggregate (sand) passed the sieve analysis and was found to comply with Zone II IS: 383(1970). The tabular column in the following image contains the physical characteristics of fine aggregates.

Table Properties of Fine Aggregate

Properties	Result
Shape of aggregates	Angular
Specific gravity	2.67
Fineness Modulus	2.7
Compacted bulk density	1760 kg/m3

Manufacturing Sand (M-Sand)

The Manufacturing sand used is 50% replacement for the natural sand and was brought from , finely crushed basaltic stone. The lab test conducted on the M-sand confines it to Zone II origin and other properties being tabulated below

Table Properties of M-Sand

Properties	Result
Zone of M-sand	II
Specific gravity	2.7
Fineness Modulus	2.75
Bulk density	1705 kg/m3

Coarse Aggregate

The locally available coarse aggregate, crushed basalt stone angular in shape with size 20mm down size were utilized for the project work. The test conducted in laboratory on it and their following values are represented below (within Limits of IS:383-1970)

Table Properties of Coarse Aggregates

Properties	Results
Shape of aggregates	Angular
Specific gravity	2.67
Fineness Modulus	6.75
Compacted bulk density	1760 kg/m3

Water

Portable tap water was used for the preparation of specimens and for the curing of specimens.

Steel Fibres

A metal reinforcement is called steel fibre. Steel fibre for reinforcing concrete is defined as short, discrete lengths of steel fibres with an aspect ratio (ratio of length to diameter) ranging from approximately 20 to 100, with different cross-sections, and that are sufficiently small to be randomly dispersed in an unhardened concrete mixture using the customary mixing techniques. Concrete's physical characteristics can be qualitatively altered by the addition of steel fibres, considerably enhancing the material's tenacity, durability, and resistance to cracking, impact, fatigue, and bending, among other features. According to the manufacturing technique and the shape or section of the steel fibre, it can be divided into five general categories: cold-drawn wire, cut sheet, melt-extracted, mill cut, and modified cold-drawn wire.

III. RESULTS AND DISCUSSION

The samples are tested on grounds of compressive strength, split tensile strength and flexural Strength test. The variation of fine Aggregate is done using M-Sand in proportion 0%, 10%, 20%, 30%, 40% and 50%. The use of Steel Fibre in the mixture is even done in proportion of 0.3%, 0.6%, 0.9% and 1.2% in weight to concrete.

Slump Cone Test

Table Slump COne Test Results

Workability mm				
Mix	0.3% SF	0.6% SF	0.9% SF	1.2% SF
M30	79	82	85	84
M30+10% M-Sand+0.3% SF	77	82	83	82
M30+20% M-Sand+0.3% SF	77	80	81	80
M30+30% M-Sand+0.3% SF	79	83	84	83
M30+40% M-Sand+0.3% SF	80	85	86	85
M30+50% M-Sand+0.3% SF	79	84	85	84

Compressive Strength

Table Compressive Strength of concrete with 0.3% Steel Fibre

Compressive Strength of Concrete with 0.3% Steel Fibre			
Mix	3 days	7 days	28 days

M30	19.35	25.25	41.75
M30+10% M-Sand+0.3% SF	18.02	23.79	40.25
M30+20% M-Sand+0.3% SF	19.25	24.08	40.75
M30+30% M-Sand+0.3% SF	19.95	24.65	41.58
M30+40% M-Sand+0.3% SF	18.26	23.25	39.55
M30+50% M-Sand+0.3% SF	18.01	22.85	37.45

Table Compressive Strength with 0.6% Steel Fibre

Compressive Strength of Concrete with 0.6% Steel Fibre			
Mix	3 days	7 days	28 days
M30	19.35	25.25	41.75
M30+10% M-Sand+0.6%SF	18.72	24.49	40.95
M30+20% M-Sand+0.6%SF	19.95	24.78	41.45
M30+30% M-Sand+0.6%SF	20.65	25.35	42.28
M30+40% M-Sand+0.6%S	18.36	23.95	40.25

F			
M30+50% M-Sand+0.6%SF	18.1	23.05	38.92

Table Compressive Strength of Concrete with 0.9% Steel Fibre

Compressive Strength of Concrete with 0.9% Steel Fibre			
Mix	3 days	7 days	28 days
M30	19.35	25.25	41.75
M30+10% M-Sand+0.9% SF	19.32	25.09	41.55
M30+20% M-Sand+0.9% SF	20.55	25.38	42.05
M30+30% M-Sand+0.9% SF	19.56	24.55	40.85
M30+40% M-Sand+0.9% SF	18.26	23.91	39.9
M30+50% M-Sand+0.9% SF	18.24	23.85	39.79

Table Compressive Strength of Concrete with 1.2% Steel Fibre

Compressive Strength of Concrete with 1.2% Steel Fibre			
Mix	3 days	7 days	28 days
M30	19.35	25.25	41.75
M30+10%	20.12	25.89	42.35

M-Sand+1.2%SF			
M30+20% M-Sand+1.2%SF	21.35	26.18	42.85
M30+30% M-Sand+1.2%SF	22.05	26.75	43.68
M30+40% M-Sand+1.2%SF	20.36	25.35	41.65
M30+50% M-Sand+1.2%SF	18.35	24.12	40.14

Split Tensile Strength Test of Concrete

Table Split Tensile Strength Test with 0.3% Steel Fibre

Split Tensile Strength of Concrete with 0.3% Steel Fibre			
Mix	3 days	7 days	28 days
M30	1.9	2.12	2.8
M30+10% M-Sand+0.3%SF	1.9	2.1	2.8
M30+20% M-Sand+0.3%SF	2.1	2.2	2.9
M30+30% M-Sand+0.3%SF	2.2	2.3	3
M30+40% M-Sand+0.3%SF	2	2.2	2.8

M30+50% M-Sand+0.3%SF	1.8	2.2	2.7

Table Split Tensile Strength with 0.6% Steel Fibre

Split Tensile Strength of Concrete with 0.6% Steel Fibre			
Mix	3 days	7 days	28 days
M30	1.9	2.12	2.8
M30+10% M-Sand+0.6%SF	1.9	2.1	2.8
M30+20% M-Sand+0.6%SF	2.1	2.2	2.9
M30+30% M-Sand+0.6%SF	2.2	2.3	3
M30+40% M-Sand+0.6%SF	2	2.2	2.8
M30+50% M-Sand+0.6%SF	1.8	2.2	2.7

IV. CONCLUSION AND FUTURE SCOPE

The comparison was between normal and FRC-MS (with 1% steel fibres and 50% replacement of natural sand to that of Manufacturing sand) and the test results proved that the inducing of the fibres of crimped steel and natural sand replaced by M-Sand has a greater values on all the aspect of the study made compared to the normal M30 grade design mix concrete. The samples are tested on grounds of compressive strength, split tensile strength and flexural Strength test. The variation of fine Aggregate is done using M-Sand in proportion 0%, 10%, 20%, 30%, 40% and 50%. The use of

Steel Fibre in the mixture is even done in proportion of 0.3%, 0.6%, 0.9% and 1.2% in weight to concrete.

Workability

The strength of concrete of a given mix proportion is seriously affected by the degree of its compaction. It is therefore important that the consistency of the mix is such that the concrete can be transported, placed and finished sufficiently easily and without segregation. A concrete satisfying these conditions is said to be workable. Workability is a physical property of the concrete depending on the external and internal friction of the concrete matrix; internal friction being provided by the aggregate size and shape and external friction being provided by the surface. The workability results were found favourable with the mix.

Compressive Strength

The Compressive-strength of concrete depends on various factors, quality of the aggregate, water-cement ratio, quality of cement, temperature conditions etc. Compressive test is done either on cylinder or cube specimen. Here as per the tabulated results the maximum strength is visible with 30% M Sand and increase in any further percentage reduces the strength of concrete while the most appropriate values of compressive strength if received with 30% M Sand and 1.2% Steel Fibre when cured for 28 days as 43.68 N/mm^2.

Split Tensile Strength

The split Tensile Test determines the tensile strength parameter of concrete which is the important basic property. The concrete is good in compression and weak in tension, it develops cracks when subjected to direct tension. Thus, by inducing certain fibres such as steel, the tensile property of the concrete can be enhanced. The maximum strength is achieved with the concrete mix with 30% M-Sand as fine Aggregate and 1.2% Steel Fibre at 3.1 N/mm^2.

Flexural Strength

The flexural strength of concrete is an important property to be determined especially for changes in the volume of concrete due to temperature variation or shrinkage, for the road slab performed on to the vehicular loads.

The flexural Strength was maximum with 30% M-Sand as fine Aggregate with 1.2% Steel Fibre as 4.62 N/mm2 and with later addition of m sand proportion led to decrement in strength of concrete cubes.

Future Scope

Steel fibre reinforced concrete should only be used in structural applications in a supplemental capacity to prevent cracking, enhance resistance to impact or dynamic stress, and prevent material disintegration, according to the advice of ACI Committee 544.

when flexural or tensile loads will be applied to structural parts. The total tensile load must be supported by the reinforcing steel in order for it to be used. There are several methods for forecasting the strength of beams reinforced simply with steel fibres, but no prediction equations exist for large SFRC beams because these are anticipated to also include conventional reinforcing bars. The American Concrete Institute recently released a comprehensive reference on design considerations for SFRC. The issue is complicated for beams with continuous reinforcing bars and fibres because of the dual actions of the fibres.

(1) They improve the bond between the matrix and the reinforcing bars by preventing the growth of cracks originating from the deformations (lugs) on the bars.
(2) They enable the tensile strength of the SFRC to be used in design because the matrix will no longer lose its load-carrying capacity at first crack.

It is challenging to classify the usage of SFRC throughout the past thirty years because they are so varied and ubiquitous. The most popular uses include airport pavements, bridge deck slab repairs, tunnel linings, pavements and slabs, shotcrete and shotcrete that now also contains silica fume, pavements and slabs, and so forth. Additionally, some experimental work on roller-compacted concrete (RCC) reinforced with steel fibres has been done recently. The list is seemingly endless and is only constrained by the creativeness of the engineers involved. Unfortunately, the fibres themselves are rather expensive; adding 1% steel fibre will almost quadruple the material prices of the concrete, which has tended to restrict the usage of SFRC to specific applications.

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