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Study on strength characteristics of concrete using M-Sand and Coconut Fibers

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Abstract:- **In the current world, concrete has become a very important part of the construction industry and the materials which are used in making concrete have evolved due to better quality of cement and better grade of coarse aggregates. The sand is an important part of concrete. It is mainly procured from natural sources. Thus the grade of sand is not under our control. The methods of removing sand from river beds are causing various environmental issues and river sand is depleting at a faster rate than it is replaced by natural methods. Hence, various replacements for the river sand are being done, one of which is manufactured-sand. It is obtained from various granite quarries. Manufactured-sand or M-sand is slowly replacing the fine aggregate in the concrete as the sand is well graded and gives higher strength of concrete. There are various fibers used for reinforcing concrete which consist mainly of artificial or steel fibers. Some of these fibers are quite costly and sometimes difficult to obtain. So there are many natural fibers which can be used in place of these fibers, one of which is coconut fiber, extracted from the shell of a coconut. Coconut fibers are used in various industries like rope making, coir mattresses etc. Since these fibers are one of the strongest fibers among naturally occurring fibers, they can be used in the concrete mix to increase the resistance in concrete. They are also light weight and easily available and thus can be used in reinforcement of concrete. The studies up till now have tested the use of coconut fibers in normal concrete involving river sand but in this study a particular ratio of M-sand and river sand is used to get the maximum possible strength. Hence, in this project an attempt was made to use M-sand and coconut fiber in concrete. Based on the test results, it can be concluded that combination of M-sand and coconut fibers gave favorable results in strength criteria.**

Keyword: Manufactured sand (M-sand)

INTRODUCTION

In the ever increasing construction industry, concrete forms the basic building block. Concrete consists mainly of three raw materials apart from water. These are cement, coarse aggregate and fine aggregate. Out of these raw materials, cement and coarse aggregate can be easily manipulated to match the needs of how concrete should be made. While as sand, which amounts to about 35% by volume of concrete, is mainly obtained from natural sources like river beds and the quality and texture of sand cannot be controlled. Sand is mainly obtained by mining it from river beds by sand dragging which causes various environmental issues as it disrupts the natural habitat of these rivers. Sand mining is causing depletion of sand from the river beds at an alarming rate. Thus various laws have been imposed on mining of sand from river beds, due to which it is required to look for a replacement of the natural sand which can be found in the form of manufactured-sand or M-sand, fly ash, quarry dust, crushed glass etc. In this research, M-sand has been chosen for replacing natural river sand. M-sand is obtained from granite stone quarries and it acts as a good replacement for the river sand.

Plain concrete is a brittle material. Concrete without fibers develops cracks due to plastic shrinkage, drying shrinkage and changes in volume of concrete. Development of these micro cracks leads to elastic deformation of concrete. In order to meet the required values of flexural strength, fibers are used in normal concrete. The addition of fibers in concrete should control the cracking due shrinkage and also reduce the bleeding of water. Fiber reinforced concrete is the concrete which consists of fibers of steel, plastic, glass, natural fibers [vegetable fibers, leaves, twinges, coir, etc.] as the reinforcing material which generally increases its strength. It contains short discreet fibers that are randomly oriented and uniformly distributed. The properties of this concrete changes with the change in cement, fiber materials, geometries, distribution, densities and orientation. Fiber reinforcement is provided to avoid cracking due to shrinkage. The amount of fibers recommended ranges from 0.1 to 3% of the total volume of the composite. The use of natural fibers is economical as compared to synthetic fibers. Natural reinforcing materials are obtained at low costs and at low levels of energy using local manpower and technologies. Utilization of natural fibers as a form of concrete enhancement is of particular interest to lesser developed regions where conventional construction materials are not readily available or are far too expensive. Coconut and sisal-

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fiber reinforced concrete have been used for making roof tiles, corrugated sheets, pipes, silos and tanks.

Coconut fibers are strong, light in weight. The addition of coconut fiber can reduce the thermal conductivity of the composite specimens. Coconut fiber is economical, readily available and reasonably increases the strength of concrete. There have been some studies on use of coconut fibers in concrete but in this study, a particular ratio of M-sand and river sand in the concrete mix has been used which increases the strength of the concrete. The various samples which were made for the above study were tested for three different strength characteristics which are compression, tension and flexural strength for 7 days and 28 days curing.

LITERATURE REVIEW

Nimitha Vijayaraghavan and A S Wayal (2013) tentatively demonstrated that substitution of regular sand by manufactured sand (or M-sand) when contrasted with reference blend i.e., 0% substitution, uncover higher compressive qualities. In different outcomes 50% replacement with admixture the compressive quality increments by 5.7% and 100% substitution of natural sand by M-sand, the compressive quality increments by 7.03%, which is maximum. The fine aggregates or sand utilized is typically gotten from normal sources exceptionally river beds or waterway banks. Presently a-days because of consistent sand mining the common sand is draining at a disturbing rate. Sand dragging from waterway beds have prompted a few ecological issues. Because of different ecological issues Government has prohibited the dragging of sand from waterways. This has prompted a shortage and noteworthy increment in the cost of normal sand. There is an earnest need to locate a contrasting option to river sand. The main long haul trade for sand is M-sand. M-sand was utilized as fractional substitution of fine aggregates. The bulk density of M-sand was 1.75 kg/m3, specific gravity and fineness modulus was observed to be 2.73 and 7.66, separately. The percentage of particles going through different sieve was compared and natural sand and it was observed to be similar. They concluded as, concrete mix ends up noticeably harsh with increment in extent of M-sand and that the natural sand can be completely replaced by M-sand.

Shreeshail.B.H (2014) in according to the objectives set in the study and the experimental work carried out in the laboratory, the following conclusions were drawn. As the fiber content was increased, the mix became more cohesive. Workability decreased as the fiber content increased. As compared to normal concrete, slump decreased 30% for 1% fiber content. Similarly slump value decreased for 2% and 3% fiber content. As compared to normal concrete, compaction factor value decreased 5% for 75 AR and 10% for 125AR for 1% fiber content. As compared to normal concrete, time taken to change the shape from cone to cylinder increased 75% for 75 AR and 100% for 125AR for 1% fiber content in Vee bee test. Similarly there was increase in time for 2% and 3% fiber content. There was decrease in flow for 2% and 3% fiber content The compressive strength, Split tensile strength and Flexural strength has a increasing trend upto 2%. Later, strength decreased with the increase in fiber content. CFRC with 2% fiber content has higher compressive strength, Split tensile strength and Flexural strength as compared to that of PC. Optimum results were found when 2% of coir by weight of cement fibers were used, there was 6% and 13% increase in compressive strength as compared to normal concrete for 75AR and 125 AR respectively. Split Tensile Strength increased up to 12% for 75 aspect ratio and 29% for 125 aspect ratio with 2% fiber. Modulus of Rupture increased up to 45% for 75 aspect ratio and 50% for 125 aspect ratio with 2% fiber. Cement content can be reduced by using 125AR fibers. This reduces total production of cement content there by resulting in less emission of CO_2.Thus the coir is found effective in reducing environmental pollution.

METHODOLOGY:

In this study, a total of around 90 specimens were made and concrete was both hand mixed and machine mixed. The grade concrete used was M-35. The various steps involved in the preparation of specimens are given below:

- Different mixture of concrete was used in the specimens to get the desired values; these specimens were made in the order of six cubes, four cylinders and two beams for different mix of concrete.
- Initially 100% river sand was used to make the above samples and curing of half of samples was done for 7 days while the other samples for 28 days.
- The different types of concrete mixes involved in specimen making were 100% river sand, 20% river sand replacement with M-sand and similarly 40%, 60%, 80%, 100% replacement by the M-sand.
- After curing of the above samples for 7 or 28 days, tests were done on them to determine the maximum compressive, tensile and flexural strength of the different mixes.
- After testing, the mix of concrete with the maximum values in the above tests was selected to be used for

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coconut fiber reinforcement to get the best possible results.

- Coconut fiber was obtained locally as described earlier and was soaked in water for about 28 days so the husk would get separated from the fiber.
- After that the fiber was taken out and sun dried for a day.
- Now fibers were taken and cut to a particular length to get the required aspect ratio using a scissor.
- Now the fibers were added to the concrete mix in the percentages of 0.2%, 0.4%, 0.6%, 0.8%, and 1.0% by weight of the cement.
- The amount of curing time involved was 7 days and 28 days for these samples and compression, split tensile and flexural strength were done.

RESULTS:

M-sand replacement:

In the following tests, M-sand is replaced with river sand in the percentages of 20 %, 40 %, 60 %, 80 % and 100 % to find out the mix which gives maximum strength.

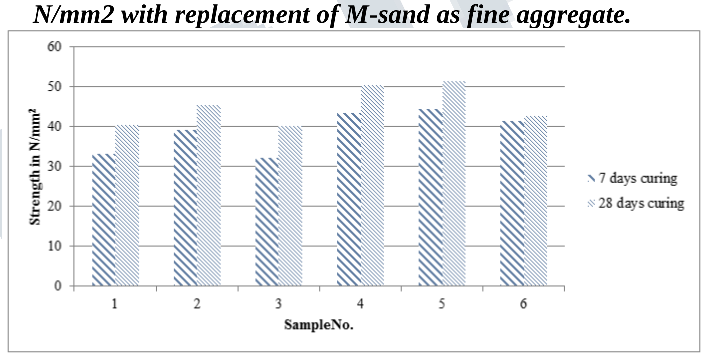
Compressive strength test:

Compressive strength of the samples is found in the compression strength testing machine on the cubic samples for curing times. The first table shows the strength of the samples without any fiber content as the Table 1 shows the mix of concrete with highest strength. The compressive strength is found by dividing the failure load divided by area of the sample. As can be seen from Table 1, the compressive strength of samples increases as the percentage replacement of river sand by M-sand increases up to 80% replacement and then it decreases. The maximum compressive strength of concrete cubes is achieved at 80% replacement of river sand by M-sand whose value is 51.2 N/mm2 at 28 days. The maximum compressive strength attained after 7 days and 28 days was 33 N/mm2 and 40.3 N/mm2 respectively, for 100% river sand.

Table.1 Compressive strength of concrete with replacement of M-sand

S no.	Sample	Test after 7 day curing	Test after 28 day curing
1	100% river sand in the concrete mix	33 N/mm^2	40.3 N/mm^2
2	20% M-sand replaced in the above mix	39 N/mm^2	45.4 N/mm^2
3	40% M-sand replaced in the above mix	32.2 N/mm^2	40.1 N/mm^2
4	60% M-sand replaced in the above mix	43.3 N/mm^2	50.2 N/mm^2
5	**80% M-sand replaced in the above mix**	**47.2 N/mm^2**	**51.2 N/mm^2**
6	100% M-sand replaced in the above mix	41.2 N/mm^2	42.5 N/mm^2

Figure 1 Variation of compressive strength of concrete in N/mm2 with replacement of M-sand as fine aggregate.



Split tensile strength:

Split tensile strength of the samples was found by using the cylinders in compression testing machine and noting the amount of load required for the cylinder to split. The values of the above test are shown in Table 2.

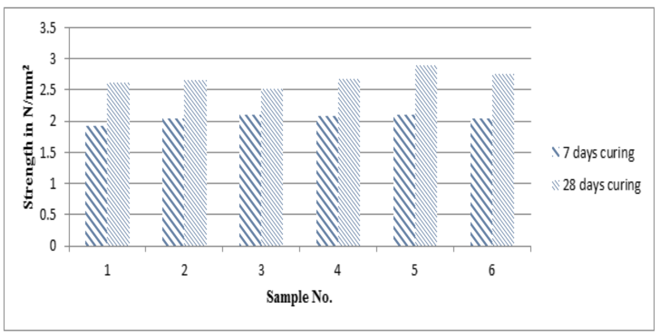
Table 2 Tensile strength values of concrete with replacement of M-sand

S no.	Sample	Test after 7 day curing	Test after 28 day curing
1	100% river sand in the concrete mix	1.91 N/mm^2	2.6 N/mm^2
2	20% M-sand replaced in the above mix	2.03 N/mm^2	2.64 N/mm^2
3	40% M-sand replaced in the above mix	2.10 N/mm^2	2.51N/mm^2
4	60% M-sand replaced in the above mix	2.07 N/mm^2	2.67N/mm^2
5	**80% M-sand replaced in the above mix**	**2.1 N/mm^2**	**2.88 N/mm^2**

6	100% M-sand replaced in the above mix	2.03 N/mm^2	2.75 N/mm^2

As seen in the Table 2 above, the split tensile strength of samples increases as the percentage M-sand replacement increases up to 80% replacement of river sand by M-sand. Again, the maximum value of tensile strength is attained at 80% replacement of river sand by M-sand. The maximum value of tensile strength after 7 days is 2.1 N/mm2 and after 28 days is 2.88 N/mm2. The values of split tensile strength for 100 % river sand after 7 and 28 days are 1.91 N/mm2 and 2.6 N/mm2 respectively.

Figure 2 Variation of split tensile strength of concrete in N/mm2 with replacement of M-sand.



Flexural strength:

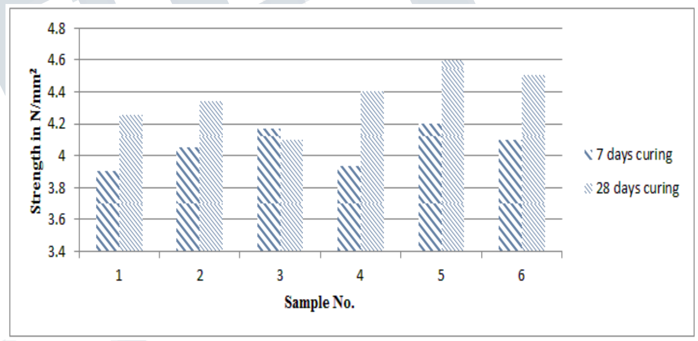
Flexural strength of the specimen was found by taking the beam samples and testing them in flexure testing machine. The values of the test are shown in Table 3. Flexural strength of samples is found by using the formula $\frac{PL}{BD^2}$ where P is the load at which the sample breaks into two in KN, L is the length between the two supports in meters, B is the breadth of the sample in meters and D is the depth of the beam in meters.

Table 3 Flexural strength values of concrete in N/mm2 with replacement of M-sand.

S no.	Sample	Test after 7 day curing	Test after 28 day curing
1	100% river sand in the concrete mix	3.9 N/mm^2	4.25 N/mm^2
2	20% M-sand replaced in the above mix	4.05 N/mm^2	4.34 N/mm^2
3	40% M-sand replaced in the above mix	4.17 N/mm^2	4.1 N/mm^2
4	60% M-sand replaced in the above mix	3.93 N/mm^2	4.4 N/mm^2
5	**80% M-sand replaced in the above mix**	**4.2 N/mm^2**	**4.6 N/mm^2**
6	100% M-sand replaced in the above mix	4.095 N/mm^2	4.5 N/mm^2

As seen in Table 3, maximum flexural strength after 7 days is 4.2 N/mm2 and after 28 days is 4.6 N/mm2. Again this is achieved in the case of 80 % replacement of river sand by M-sand. The values of flexural strength after 7 and 28 days of curing are 3.9 N/mm2 and 4.25 N/mm2 respectively, for 100 % river sand.

Figure 3 Variation of flexural strength of concrete in N/mm2 with replacement of M-sand.



It can be seen from the above three Tables and Figures that the use of M-sand in the concrete instead of river sand has increased the strength of concrete considerably. This is due to the fact that M-sand is better graded than normal sand and replacing it not only helps in preventing the depletion of river sand but also increases the strength of concrete, thus increasing the life of a structure. It can also be seen from the tables 1, 2 and 3 that the best possible ratio between M-sand and river sand is 4:1 as this mix of concrete gives the highest values overall strength in all the three tests on the samples. Hence the mix of concrete used with coconut fiber should be sample 5 to get the best possible results.

Coconut fiber reinforcement:

The highest strength of concrete mix attained in the above tests i.e. 80 % M-sand and 20% river sand is taken. Coconut fiber is added to the mixture in percentages of 0.2%, 0.4%, 0.6%, 0.8% and 1% by weight of the cement and all of the above tests are done on these samples whose results are given below.

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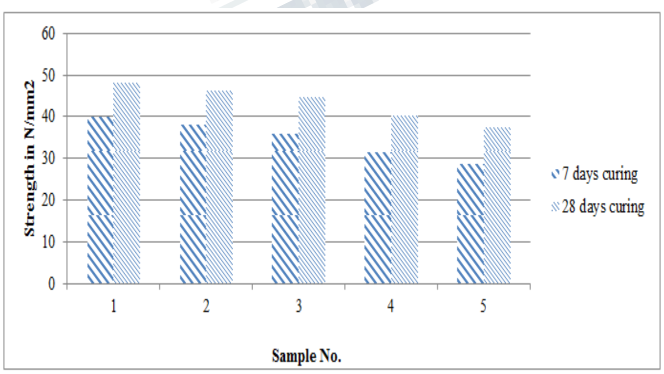
Compressive strength test:

Table 4 Compressive strength of concrete with combination of M-sand and coconut fibers.

S no.	Sample	Test after 7 day curing	Test after 28 day curing
1	**0.2 % fiber by weight of cement +80 % M-sand+20% river sand.**	**39.8 N/mm^2**	**48.0 N/mm^2**
2	0.4 % fiber by weight of cement +80 % M-sand+20% river sand.	38.0 N/mm^2	47.2 N/mm^2
3	0.6 % fiber by weight of cement +80 % M-sand+20% river sand.	36.0 N/mm^2	44.7 N/mm^2
4	0.8 % fiber by weight of cement +80 % M-sand+20% river sand.	31.5 N/mm^2	40.2 N/mm^2
5	1.0 % fiber by weight of cement +80 % M-sand+20% river sand.	28.8 N/mm^2	37.4 N/mm^2

It is obvious from Table 4 that the compressive strength of samples is decreasing as the coconut fiber percentage increases. This can be attributed to the fact that the voids in the samples increase by addition of coconut fiber which in turn decreases the compressive strength. The maximum compressive strength after 7 days is 39.8 N/mm2 and 28 days is 48 N/mm^2. This is attained with the least percentage of coconut fiber addition i.e. 0.2%. It can be further seen in the Figure 4.

Figure 4 Variation of compressive strength of concrete in N/mm2 with combination of M-sand and coconut fibers



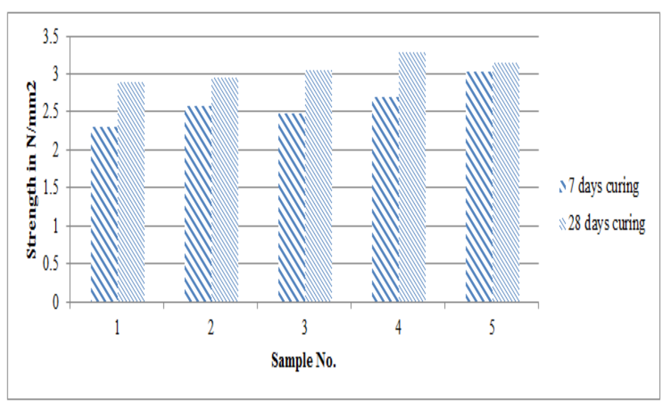
Split tensile strength:

Table 5 Variation of split tensile strength of concrete with combination of M-sand and coconut fiber

S no.	Sample	Test after 7 day curing	Test after 28 day curing
1	0.2 % fiber by weight of cement +80 % M-sand+20% river sand.	2.29 N/mm2	2.89 N/mm2
2	0.4 % fiber by weight of cement +80 % M-sand+20% river sand.	2.57 N/mm2	2.95 N/mm2
3	0.6 % fiber by weight of cement +80 % M-sand+20% river sand.	2.48 N/mm2	3.05 N/mm2
4	0.8 % fiber by weight of cement +80 % M-sand+20% river sand.	2.7 N/mm2	3.28 N/mm2
5	1.0 % fiber by weight of cement +80 % M-sand+20% river sand.	3.02 N/mm2	3.15 N/mm2

As shown in Table 5, split tensile strength of samples increases as the percentage addition of coconut fiber increases. The maximum split tensile strength after 7 days is 3.02 N/mm^2 , attained at 1.0 % addition of coconut fiber and after 28 days is 3.28 N/mm^2, attained at 0.8 % addition of coconut fiber. It can be further seen in the Figure 5.

Figure 5 Variation of split tensile strength of concrete in N/mm2 with combination of M-sand and coconut fibers



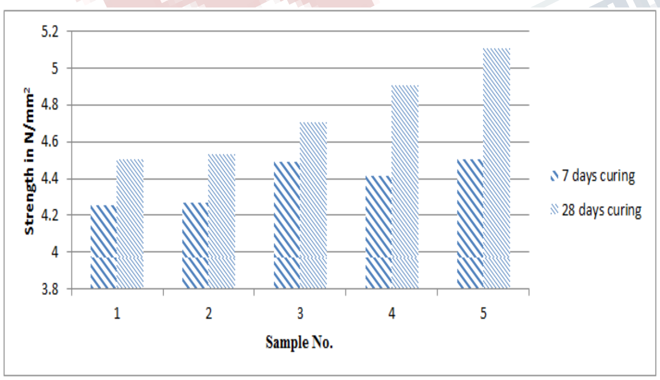
Flexural strength test:

Table 6 Flexural strength of concrete with combination of M-sand and coconut fiber

S no.	Sample	Test after 7 day curing	Test after 28 day curing
1	0.2 % fiber by weight of cement +80 % M-sand+20% river sand.	4.25 N/mm^2	4.5 N/mm^2
2	0.4 % fiber by weight of cement +80 % M-sand+20% river sand.	4.27 N/mm^2	4.53 N/mm^2
3	0.6 % fiber by weight of cement +80 % M-sand+20% river sand.	4.49 N/mm^2	4.7 N/mm^2
4	0.8 % fiber by weight of cement +80 % M-sand+20% river sand.	4.41 N/mm^2	4.9 N/mm^2
5	**1.0 % fiber by weight of cement +80 % M-sand+20% river sand.**	**4.50 N/mm^2**	**5.1 N/mm^2**

As Table 6 shows, the flexural strength of concrete beams also increased with addition of coconut fiber. The maximum value of flexural strength after 7 days is 4.50 N/mm2, attained at 1.0 % addition of coconut fiber and after 28 days is 5.1 N/mm2, attained at 0.8 % addition of coconut fiber. It can be further seen in Figure 6:-

Figure 6 Variation of flexural strength of concrete in N/mm2 with combination of M-sand and coconut fibers



CONCLUSIONS:

- The addition of M-sand significantly increased the compressive, tensile and flexural strengths of concrete with maximum strengths in each case being achieved at 80% M-sand.
- The compressive strength of concrete with above mix increased by about 25 %.
- The split tensile strength increased by about 11 %.
- The flexural strength increased by about 8 %.
- The addition of coconut fibers significantly improved engineering properties of the concrete like tensile strength and flexural strength.
- However, the addition of fibers adversely affected the compressive strength, as expected, due to difficulties in compaction which consequently leads to increase in voids.
- Compressive strength decreased as the percentage of coconut fiber was varied from .2% to 1.0 %.This is due to the fact that addition of coconut fibers increases the void ratio of concrete, which in turn decreases the compressive strength.
- Tensile and flexural strengths both increased significantly with the addition of coconut fiber.
- The maximum tensile strength after 28 days increased by 14% and was achieved at 0.8% coconut fiber.
- The maximum flexural strength after 28 days increased by 11% and was achieved at 1% coconut fiber.
- Coconut fiber has low density. Thus it reduces the weight of concrete and can be used wherever lightweight concrete is required.
- The workability of concrete is also reduced by the addition of coconut fiber.
- High water absorption of natural fiber causes unstable volume and low cohesion between fiber and matrix.
- Natural fiber decomposes rapidly in the alkaline environment of cement and concrete.

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