INVESTIGATING THE PROPERTIES OF M-30 GRADE CONCRET CONTAINING M-SAND AS A FINE AGGREGATE

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Abstract: M-sand is also called artificial sand or crushed sand, prepared by crushing rocks, stones, or larger aggregates into small particles in the quarry. The study is aimed at the complete replacement of conventional material like river sand used as fine aggregate. By using M-sand (manufactured sand/crushed sand). M-sand here acts as a fine aggregate in the cement concrete. Natural fine aggregate is replaced by M-sand to complete mix proportion in the concrete. M-sand shares similar properties as conventional Fine Aggregates and gives good split tensile and compressive strength to the concrete. The results are compared with the control mix of design mix M30. Complete replacement of fine aggregate with manufactured sand concrete makes the construction cost controlled. Compressive strength is the most important property of concrete it is also increasing. Complete replacement of fine aggregate with crushed sand production of concrete increasing. It is dust-free in M-sand which is a good sign to do the replacement. Environment preservation and natural resources conservation is the soul of country development. The application of crushed sand mix for residential building structural members such as column, beam, slab, and foundation and plastering are also elicited. The study brings out the fact that it is also more economical than the typical cement concrete. The findings of this research call for the safe use of manufactured sand. Economical concrete mix is a very useful construction material, which offers a range of economic, technical, and environmental enhancing and preserving advantages and is destined to become a dominant material for construction in the new era.

Index Terms - Compressive strength, split tensile strength, Workability, M-sand, concrete.

1. Introduction

The demand for concrete goes up tremendously day by day. It is a highly used construction material now a day in the world. It is one of the basic requirements for the creation of any infrastructure, buildings, roads, etc. Natural or River sand are weathered and worn out particles of rocks and are of various grades or sizes depending upon the amount of wearing. When fine particles are in proper proportion, the sand will have fewer voids. The cement quantity required will be less. Such sand will be more economical. Concrete requires natural aggregates, which are obtained from quarries. The fine aggregates generally used is the river sand. Such deposits do not require much processing other than size grading. Most of the tropical and subtropical countries still depend upon river sand for fine aggregates. But now it is well understood that indiscriminate sand mining causes irreparable and irreversible damages to the ecological system. Both coarse and fine aggregates are natural resources, once used cannot be replenished. Sand mining causes many problems to flora and fauna also. Excessive sand mining causes unpredicted water course causing floods in surrounding areas, water pollution, etc. If there will be the complete replacement of fine aggregate with M-Sand then there will be carbon dioxide level reduced in the environment, generated at a time of sand mining and transportation. M-sand is the product obtained from hard granite stone by crushing. The Crushed sand is of cubical shape with grounded edges, washed and graded. The size of manufactured sand is less than 4.75mm. Presently, that can be used as a complete replacement for fine or coarse aggregates. But many of the times, it is neglected as an alternative even though they are available huge in quantity in terms of millions of Cu.m. The rising growth of population and economy in India is leading to

industrialization. Urbanization is prominent in various kinds of researches in the engineering fields over recent years. While some of these alternatives push forward the efficiency rate, some of them ease the demand for traditional raw materials. Growing the population of the country requires more creation of the settlement. Thus new techniques and different materials should be constructed of new buildings. Furthermore, a number of the settlement haven of those buildings against natural disaster is the durability of the construction and also thermal conductivity. The use of M-sand in concrete production is good as a point of environmental and financial condition. The result of the study has shown that M-sand has unique properties and is good for comparison to other materials of the building.

2. Benefits of M-Sand over Natural Sand

A huge quantity of concrete is consumed by the construction industry all over the world. In India, conventional concrete is produced by using natural sand obtained from the riverbeds as fine aggregate. One of the important ingredients of conventional concrete is natural sand or river sand, which is expensive and scarce. However, due to the increased use of concrete in almost all types of construction works, the demand for natural or river sand has been increased. To meet this demand of the construction industry, excessive quarrying of sand from river beds is taking place causing the depletion of sand resources. The scarcity of natural sand due to such heavy demands in growing construction activities has forced us to find a suitable substitute. One of the cheapest and the easiest ways of getting substitutes for natural sand is by crushing natural stone to get artificial sand of desired size and grade. The positive use of artificial sand will conserve natural resources. The choice of fine aggregate, whether it is manufactured or natural sand, can greatly impact the fresh concrete properties of a mixture such as workability, pumpability, and finish ability. M-Sand concrete is creating a green environment. It is a cheap substitute to conventional structure concrete methods and materials. It can save labor and natural sources. It also is reducing the mining of rivers and increasing the G.W.T. M-Sand is free from dust and we can control the size of particles as per requirement perfect grading and cubical shape of M Sand gives high strength and great durability to concrete. Less disruptive to the environment, as it reduces sand mining from river beds M-Sand has a higher Fineness Modules Index compared to the natural river sand, which gives good workability for concrete. M-sand is free from silt and clay particles which offer better abrasion resistance, higher unit weight, and lower permeability.

2.1 Problem Regarding Natural Sand

In India, conventional concrete is produced by using natural sand, cement, coarse aggregate, and water. One major challenge facing the civil engineering community is to involve the use of high-performance, environmentally friendly materials produced at a reasonable cost. In the context of concrete, which is the predominant building material, it is necessary to identify less expensive substitutes. There is an acute need for a product that matches the properties of natural sand in concrete. In the last few years, it has become clear that the availability of good quality natural sand is decreasing. With few local exceptions, it seems to be a global trend also dwindling sand sources poses an environmental problem and hence government restrictions on sand quarrying resulted in shortage and a significant increase in its cost. So, it is a need of time to find some substitute for natural river sand.

2.2Suitability of M-Sand in Concrete

Sand is a leading material used for proportioning mortar and concrete and plays a most important role in the mix design. In general consumption of natural sand is high, due to the large use of concrete and mortar Rapid extraction of sand from river beds causing so many problems like losing water retaining soil strata, deepening of the river beds and causing bank slides, loss of flora on the bank of rivers. Researchers and Engineers have come out with their own ideas to decrease or fully replace the use of river sand and use recent innovations such as artificial sand. At this time the Government has banned lifting sand from the River bed. Transportation of sand damages the roads. Removing sand from the river bed impact the environment, as the water table goes deeper & ultimately dry.

2.3 General Requirement of Artificial Sand

The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. All the sand particles should have higher crushing strength. The surface texture of the particles should be smooth. The edges of the particles should be grounded. The ratio of fines below 600 microns in the sand should not be less than 30%. There should not be any organic impurities. Silt in the sand should not be more than 2%, for crushed sand. In Artificial sand, the permissible limit of fines below 75 microns shall not exceed 15%. Basically, the size of manufactured sand (M-Sand) is less than 4.75mm.

2.4 Environmental Issues

The excessive burrowing of the sand from the river bed reduces the water head, so less percolation of rainwater in-ground, which results in lower groundwater level. The roots of the tree may not be able to get water. The rainwater flowing in the river contents more impurities. Erosion of nearby land due to excess sand lifting. Disturbance due to digging for sand & lifting, Destroys the flora & fauna in surrounding areas. Their extraction often results in river and coastal erosion and threat to freshwater and marine fisheries and aquatic ecosystem. The connecting village roads will get badly damaged due to over-loading of trucks, hence, roads become a problem to road users and also become accidents prone. Diminishing of natural river beds resulting in not available for future generations.

3. Materials

3.1 Cement

Ordinary Portland cement of 43 grades was used in this entire investigation. Its physical properties are as given in Table1.

Table 1 Physical Properties of Cement

Physical property	Results
Fineness (retained on 90µ sieve) obtained	2%
Normal Consistency	33%
Vicat initial setting time (minutes)	50
Vicat final setting time (minutes)	275
Compressive strength 28days (MPa)	45.6
Specific gravity	2.85

3.2 Aggregate

Aggregates are the very important constituents in concrete. In concrete vary important materials of aggregate just because 72-82% of aggregate are used in concrete for total volume. Generally aggregate are categorized into two categories according to its size - coarse aggregate and fine aggregate. It is defined based on size which is 10mm and 20 mm. generally used in construction purposes 12.5 mm passing and 10 mm retaining sieve aggregate is used. So many tests are conducted to find out properties of coarse aggregate and analyzing according to IS code 383- 1970. Locally available river sand having a bulk density of 1.71 kg/m3 was used and the specific gravity is 2.65. The Fineness modulus of river sand is 5.24. Crushed angular aggregate with the maximum grain size of 20 mm and downgraded was used and having a bulk density of 1.38 kg/m3. The specific gravity and fineness modulus was found to be 2.82 and 8, respectively.

3.3 M-sand

Fine aggregate normally consists of manufactured sand. The M-Sand (MS) is a byproduct of the crushing and screening process in the quarries. M-sand produced from hard granite stone by crushing. Quarry generates considerable volumes of quarry fines while crushing the rock into aggregates. It is also referred to as crushed rock sand, stone sand, crusher sand and crushed fine aggregate. The size of manufactured sand is less than 4.75mm. it is washed and graded. Manufactured sands are produced by crushing rock depositions to produce a fine aggregate which is generally more angular and has a rougher surface texture than naturally weather sand particle. The production of M-sand also generates high percentages of micro-fines, particles that pass the 75 µm sieve, ranging from 5% to 20%. Generally, the micro-fines are washed out. The purpose of this study is to conduct a systematic comparison of the effects natural and manufactured sand exert on compressive strength, flexural strength, and split tensile strength.

Physical properties of the manufactured sand are given below in the table –

Table 2 Physical properties of M-sand

S.NO.	Parameter	Test results
1	Specific gravity	2.94
2	Fineness modulus	3.83%
3	Water absorption	0.74%

Details of sieve analysis of natural sand and manufactured sand.

Table 3 Particle Size Distribution

Sieve designation	percentage passing of zone || sand		Grading limit for zone || sand (IS:383)
	Natural sand	M-sand	
4.75mm (No.4)	94.75	100	90-100
2.36mm (No.8)	88.5	88.1	75-100
1.18mm (No. 16)	71.25	68.5	55-90
600 micron (NO.30)	42.5	37.5	35-59
300 micron (No. 50)	11.5	15	8-30
150 macron (No. 100)	1.75	6	0-10

Table 4 specific gravity of courser aggregate

	Natural sand (100%)	Natural sand (50%) Manufactured sand (50%)	Manufactured sand (100%)
Specific gravity	2.64	2.42	2.20

Table 5 Slump value for different % of M-sand

F.A. Replacement by M.S. in %	Slump Value (mm)
0	85
50	81
100	75

3.4 Water

Fresh portable water, which is free from acid and organic substances, was used for mixing the concrete.

4. Experimental Work

The M-sand concrete test using cubes and cylinders of various mixes was tested for compressive, and split tensile strength at 7 and 28 days in S.A.T.I. Vidisha laboratory. In this experimental investigation, the strength characteristics of concrete are calculated using M-sand for the M-30 grades of concrete. The M-sand is partially and fully replaced for fine aggregate. For the present investigation, concrete cubes and cylinders were cast and tested after 7 and 28 days of curing. The chosen mix design is M30 with full and partial replacement of M-sand for 0%, 50%, and 100%. The tests were carried out conforming to Is 516- 1959 to obtain compressive strength of concrete at the age of 7 and 28 days.

5. Test Method

At the end of each curing period, a total of 3 specimens were tested for each concrete property. The compressive strength test was carried out on the 150mm cube specimens, whilst the split tensile strength test was carried out on the 150mm diameter and 300mm height cylindrical specimens as per Indian standard specifications. The tests for compressive, split tensile were conducted using a 2000kN compression testing machine**.**

6. Results

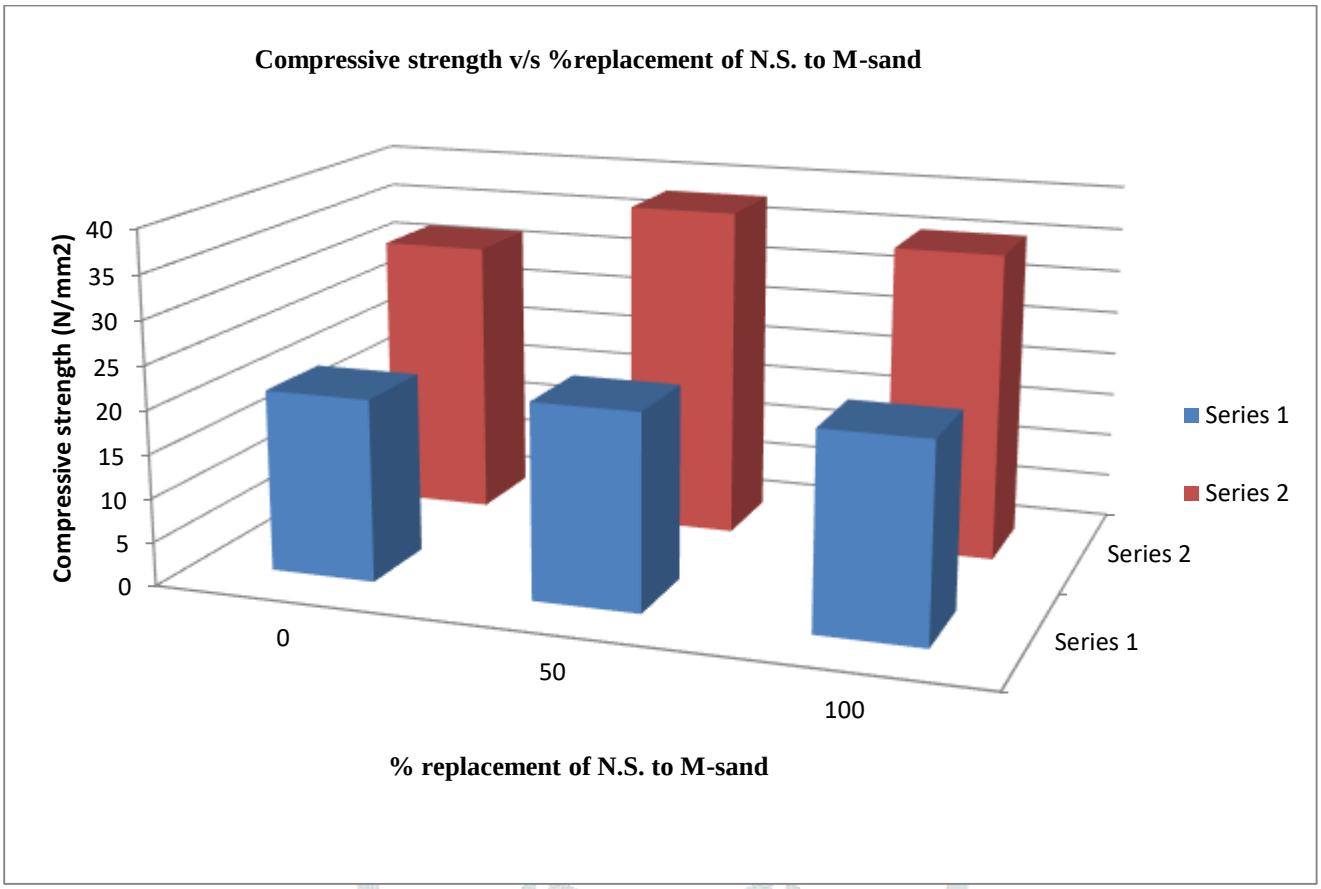
The strength results obtained from the experimental investigations are shown in tables. All the values are the average of the three trials in each case in the testing program of this study. The results are discussed as follows.

6.1 Compressive strength test

It is defined as a property of a material to compressibility. When a compressive force is applied on the cube to find out the bearing capacity of material in this test using compressive strength testing machine 40-tonne loading are provided. The specimen is placed in the machine properly and then starts the machines using a switch on gradually load is applied up to ultimate loading after maxi. Loading concrete specimen was cracks or failure this point should be noted and find out the compressive strength of cube using formula load per unit volume in kilo Newton per meter square or Newton per millimeter square. The standard size of the cube according to IS 456, 150*150*150* Millimeter cube.

Table 6 The Cube Compressive Strength Values For Various Replacement Percentage of M-Sand.

Sample Designation (M-sand in %)	**Average compressive strength @ 7 days (N/mm2)**	**Average compressive strength @ 28 days (N/mm2)**
0	20.815	31.786
50	22.286	38.013
100	22.295	35.251



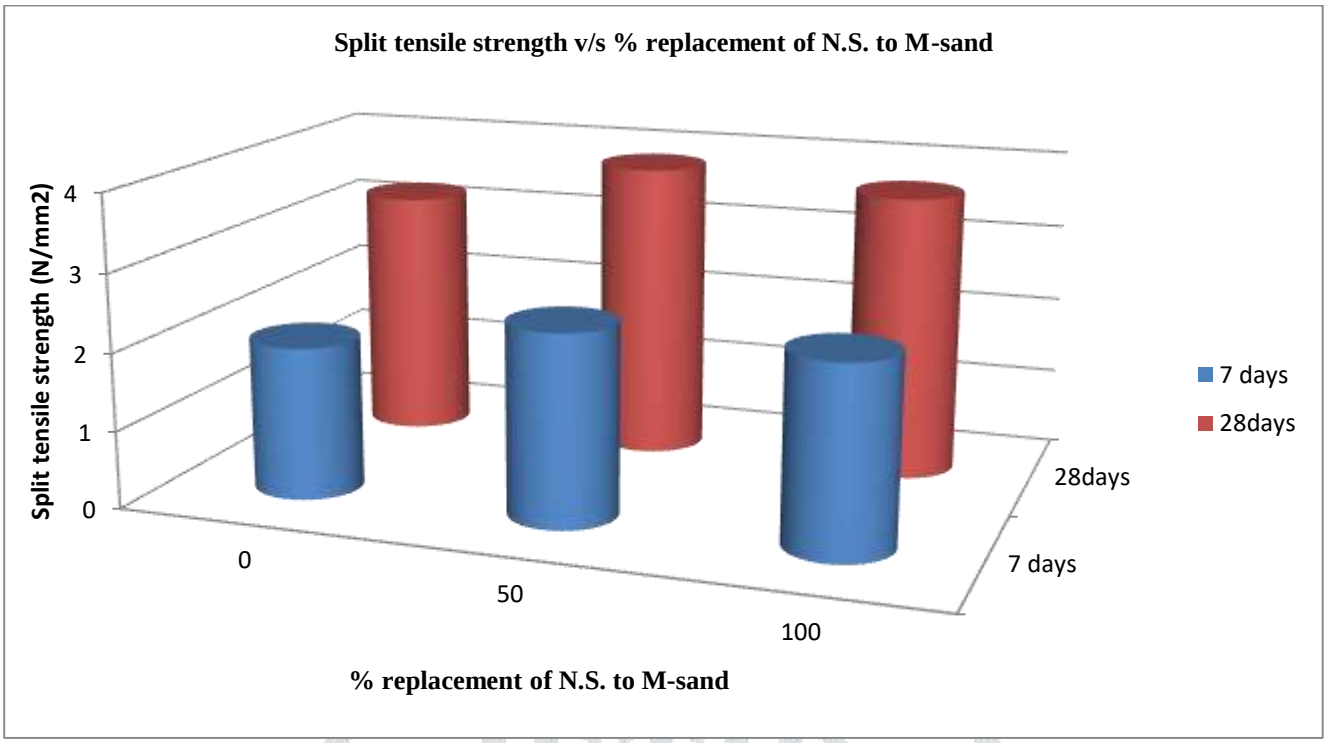
"Figure 1" 7 & 28 Days Compressive Strength for All Mixes

6.2 Split Tensile Strength

It is defined as tensile strength as the most important property of concrete. Split tensile strength test to be conducted for determining the strength of concrete using cylinder specimen. Generally concrete is weak in tension just because of its brittleness properties. So, therefore it can easily show cracks when concrete subjecting to tensile force. Tensile strength values for different percentage of M-sand with fine aggregate shown in the table given below;

Table 7 Tensile Strength Values of Concrete Cylinder

Sample Designation (M-sand in %)	Average tensile strength @ 7 days (N/mm2)	Average tensile strength @ 28 days (N/mm2)
0	1.972	3.233
50	2.477	3.845
100	2.430	3.680



"Figure 2" 7& 28 Days Split Tensile Strength for All Mixes

7. Conclusion

This research fulfills the gap of information on engineering properties of M-Sand effectively benefited to use M-Sand in the concrete industry. The outcomes of the study made the following conclusions;

- It is observed that the compressive strength and split tensile strength are improved by partial replacement of M-sand for fine aggregate.

- From the above experimental results, it is proved that M-sand can be used as a partial replacement for natural sand.

- All the mixes of concrete formed by replacement of natural sand by manufactured sand when compared to reference mix i.e., 0% replacement reveal higher compressive and split tensile strengths.

- In 50% replacement at 7 days the compressive strength increases by 7.067% and split tensile strength increased by 25.608%. And at 28 days of curing compressive and split tensile strength increases respectively 7.110% and 18.980%.

- In 100% replacement at 7 days the compressive strength increases by 19.590% and split tensile strength increased by 23.225%. And at 28 days of curing compressive and split tensile strength increases respectively 10.901% and 13.826%.

- In this investigation, we can find out increasing the % of manufactured sand with fine aggregate decreasing the workability value, and also we can observing that increase the compressive strength value, split tensile value is higher at more than 50% replacement.

- Based on the above discussion it concluded that 5% and more value of replacement at a higher level to 100% replacement of fine aggregate with manufactured sand is optimum value.

- Based on the above discussion it can be concluded that using the M-sand as a replacement of fine aggregate provides a safe healthy and green environment, and it's suitable for all construction work.

- Results show that the river sand can be fully replaced by manufactured sand.

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