

STRENGTH AND MICROSTRUCTURAL BEHAVIOR OF MANUFACTURING SAND BY REPLACING NATURAL SAND

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Abstract: Concrete is made by mixing Cement, sand aggregate a certain amount of water. River Sand is most commonly and locally available and it plays a considerable role in mix design for the preparation of mix. Now a day's when erosion occurs, it effect on the environment. The reduced quantity of natural sand also affects the construction sites and the infrastructural development of any country; hence we have to find best alternative which replace the river sand (fine aggregate), crushed stone (Robo sand or Manufactured sand) is being used in lieu of river sand. With the use of crushed rock, the excess river erosion can be control, which plays an influential character in protection of our environment. Before the use of this alternative in mix mortar, we have to investigate and compare their properties like Specific gravity, Fineness Modulus and Compressive strength with commonly available natural sand. The primary scope of this paper is to thoroughly investigate ,all the important characteristics such as specific gravity, Percentage finer, and then juxtapose it with natural river sand, and studied the micro structural analysis with SEM and XRD and determine the compressive strength by the using the crushed stone in place of natural river sand with percentage 0%, 25%, 50%, 75% and 100%.The investigation was carried out on the specimens of selected grade such as M20, M25 and M30 at the 0.45, 0.50 and 0.55water cement ratios respectively.

Index terms: cement mortar, crushed stone, XRD, SEM.

I. INTRODUCTION

Concrete plays a vital role in construction of all types of concrete structures due to its strength and durability properties [1]. The most commonly and locally available fine aggregate material is river sand. This fine aggregate is most commonly obtained from the mining of river beds. The mined river sand contains high impurities in form of various organic materials, chlorides, silt and clay. These impurities directly affects on the strength concrete and indirectly life of concrete structure [2]. Indiscriminate mining of sand has disastrous environmental consequences .With the limitation on sand extraction implemented by many states, increased demand of good quality sand there is a sparseness of good quality sand and due to this issue, the cost of sand is becoming very high. Thus it very important to choose best alternatives of fine aggregates and evaluate for the use in concrete construction. In view of existing alternatives of fine aggregates, crushed stone of required grain size is most easily available material [3] .Crushed stone are available in all gradations with zero impurities. These crushed stone are called manufactured sand (M sand), which can be use in pace of this locally available natural sand. Manufactured sand (Robo sand) fulfils all the required properties of any fine aggregates. Crushedstonecan be made by crushing of coarse aggregates with the help of Jaw crusher connected with hammer mill; obtained sand contains flaky and elongated particles. Now a day's crushed stone is obtained with 3 stages VSI crushers. The obtained sand finally processed by either dry sieving or wet sieving, which effectively improves grading and reduces the fine powder content's sand provides adequate strength and bonding with coarse aggregates and water in concrete because it contains cubical shape. The properties of cement are not affected because, silt and clay is absent in the crushed stone. The aim of this present paper is to systematically analyze the various properties of crushed stone and then compare it with natural river sand, and the micro structural analysis with SEM and XRD and determine the compressive strength by the using the crushed stone in place of natural river sand with percentage 0%, 25%, 50%, 75% and 100% .The investigation was carried

out on the specimens of selected grade such as M20, M25 and M30 with various the water cement ratios.

S. MuraliKrishnan et al. 2018 systematically studied the characteristics of M60 concrete by using the percentage of cement content with Ground Granulated Blast furnace Slag (GGBS) and fine aggregates with crushed stone and concluded that the characteristics of concrete can be enhanced by using the manufactured sand with natural sand in various proportions.

Kiran. M. Mane et al.2017investigate the behavior of workability of concrete by using 0%,20%,40%,60%,80%,100% different proportion of crushed stone with normal sand so that experimentally proved that the strength can be improved by using crushed stone in place of natural sand.

S.S. Saravanan et al 2017investigatethe strength and durabilitycharacteristicsof mortar mix with the eco-friendly sand replaced by natural sand and then juxtaposedwith the traditional mix. The compressive strength, modulus of ruptures and split strength properties shows nearly 20% more than the traditional concrete.

V.Umamaheswaran et al 2015systematically studiedstrength properties at 28 and 56 days curing periodandconcluded that the strength characteristics are improved at age of 56 days. The test result of durability at 56 days is within the permissible limits and as per the recommendations of code. It gives higher values with crushed sand stone.

II. RESEARCH IMPORTANCE

The purpose of this paper is to systematically analyze the various test results on crushed stone such as specific gravity, fineness modulus and then compare with normal sand and figure out the compressive strength of concrete mix with M20, M25 and M30 grade at different water content 0.45, 0.50, 0.55 and characterizing the mineralogy of concrete with XRD and SEM analysis.

III. MATERIAL

a) Cement:

The Grade and specific gravity of cement is 53 and 3.15 respectively [9]. All the possible moisture in cement was avoided was used throughout the investigation.

b) Fine Aggregate:

- **Natural Sand:** The natural sand with bulk density of 1860 kg/m³. The fineness modulus and specific gravity of natural sand are 2.89 and 2.6 respectively was used throughout the study. [10].
- **Manufactured Sand:** Manufactured sand is obtained from a local supplier and used to replacement of natural river sand.

c) Coarse Aggregate:

The specific gravity of coarse aggregate having the maximum grain size of 20 mm is 2.82 and the bulk density is 1.38 kg/m³[11]. The fineness modulus is 8 respectively [11].

- #### d) Water:
- Water performs major role in making concrete and chemically react with cement. In general portable water is suitable for mixing concrete. Locally available tap water was used in throughout in investigation [12].

IV. EXPERIMENTAL PROGRAMME

The purpose of this present work is to systematically analyze the characteristics of crushed stone and then observe the test results of natural sand and also seeking the compressive strength by the using the crushed stone in place of natural river sand with percentage 0%, 25%, 50%, 75% and 100%. The investigation was carried out on the specimens of selected grade such as M20, M25 and M30 at the various water cement ratios such as 0.45, 0.50 and 0.55 respectively and analyze of the micro structural behavior of concrete mix with the help of SEM and XRD analysis [13-15]. Mortar Mix of different grade is prepared with their respective proportion at 0.45, 0.50, and 0.55 water content, for 0%, 25%, 50%, 75%, and 100% replacement respectively. Three specimen are tested for each water cement ratio with different mixes, Where Mix 1 (reference mix) is made by pure natural river sand, Mix 2 is prepared with 25% manufactured sand (Crushed stone), Mix 3 is prepared by using 50% manufactured sand, Mix 4 is with 75% Crushed stone and Mix 5 is of 100% Crushed stone. The investigations have done under the normal temperature. The specific gravity test for manufactured sand is performed by the Pycnometer method. The test namely, Sieve analysis helps to figure out the fineness modulus and gradation of manufactured sand [16]. Firstly the cement and fine aggregate are mix in dry state, then required amount of water is calculated. The amount of water is then added and prepared a homogeneous mix [17]. Mortar mix of three layers is filled into the mould of size 150*150*150 mm and cubical in shape. Each layers of concrete in the mould must be in equal height. The surplus amount of concrete is removed from the tip and finalized to smooth surface with the help of trowel. The curing period of

the specimens used for test, are 7 days, 14 days and 28 days [18].



Figure 1. Specimen under curing.



Figure 2. Specific Gravity test



Figure 3. Specimen under CTM



Figure 4. Fineness Modulus test

V. RESULT AND DISCUSSION

The following tables give the end results of the entire test which are performed in this investigation and the compressive strength for specimens of different grade. The values of test

results are within the permissible limits and comparable to a good quality natural sand. It is concluded that the strength characteristics can be enhanced with the use of crushed stone as compare to locally available natural river sand increases as compared to traditional concrete with natural sand.

Table 1: Properties of Manufactured Sand (Crushed stone) and Natural Sand

Property	Natural Sand[10]	Manufactured Sand
Specific Gravity	2.6	2.63
Fineness Modulus	2.89	3.10

Table 2: Sieve Analysis Data

IS Sieve	% Passing of Natural Sand	% Passing of M-Sand	Grading Limits for Zone II Sand[19]
4.75mm	92.6	92.6	90-100
2.36mm	84.3	84.4	75-100
1.18mm	74.8	75.7	55-90
600micron	42.3	42.3	35-59
300micron	15.1	15.1	8-30
150 micron	6.9	6.9	0-20

Table 3: M20 Grade Compressive Strength of various specimens at various proportion of manufactured sand

Percentage use of manufactures sand	Compressive Strength (MPa) at 7days	Compressive Strength (MPa) at 14 days	Compressive Strength (MPa) at 28 days
Mix 1 (Reference Mix) (pure river sand)	13.27	14.67	17.42
Mix 2 (25% Manufactured Sand)	13.42	14.82	17.70
Mix 3 (50% Manufactured Sand)	13.70	14.89	17.93
Mix 4 (75% Manufactured Sand)	13.85	15.04	18.74
Mix 5 (100% Manufactured Sand)	14.00	15.34	19.48

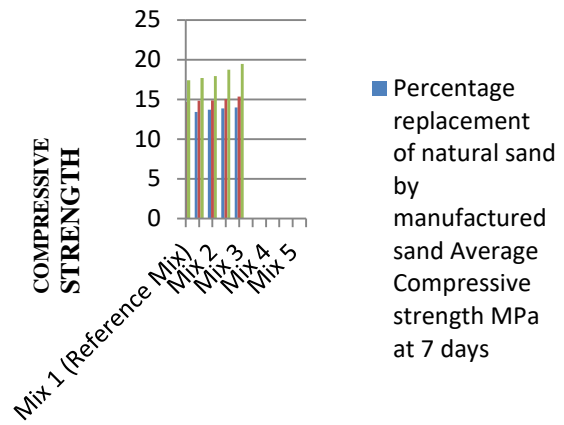


Table 4: M25 Grade Compressive Strength of various specimens at various proportion of manufactured sand

Percentage use of manufactures sand	Compressive Strength (MPa) at 7days	Compressive Strength (MPa) at 14 days	Compressive Strength (MPa) at 28 days
Mix 1 (Reference Mix) (0% Manufactured Sand)	16.45	18.38	19.48
Mix 2 (25% Manufactured Sand)	16.52	18.74	20.59
Mix 3 (50% Manufactured Sand)	16.56	18.82	22.45
Mix 4 (75% Manufactured Sand)	16.67	18.89	23.11
Mix 5 (100% Manufactured Sand)	17.12	19.56	24.37

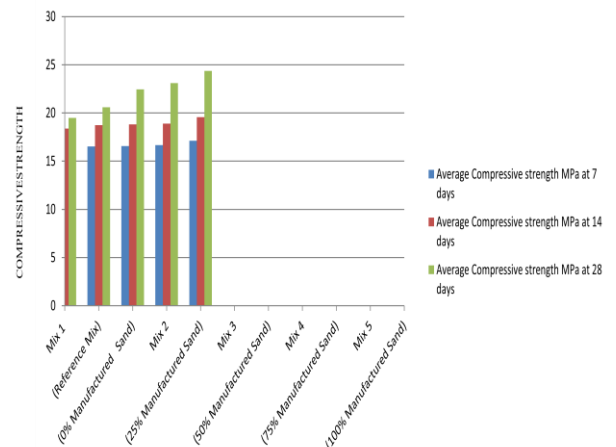
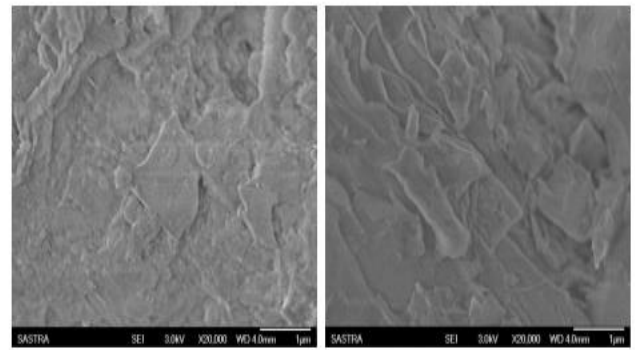


Table 5: M30 Grade

Compressive Strength of various specimens with different percentage of crushed stone

Percentage use of manufactures sand	Compressive Strength (MPa) at 7 days	Compressive Strength (MPa) at 14 days	Compressive Strength (MPa) at 28 days
Mix 1 (Reference Mix) (0% Manufactured Sand)	20.67	22.74	26.66
Mix 2 (25% Manufactured Sand)	20.82	22.82	27.55
Mix 3 (50% Manufactured Sand)	20.59	22.67	28.06
Mix 4 (75% Manufactured Sand)	21.55	23.48	28.29
Mix 5 (100% Manufactured Sand)	21.63	23.70	28.88

presence of minerals in natural sand and manufactured sand is detected by EDS.

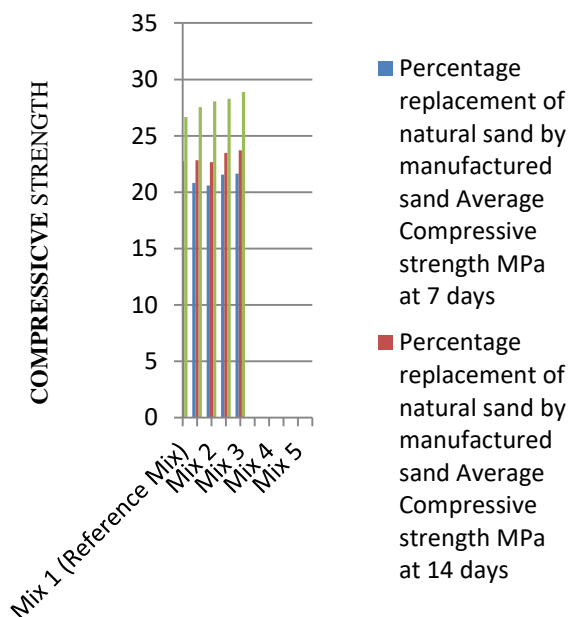


a) Concrete with NS b) Concrete with MS

VII. CONCLUSIONS

- After the study, it is observed that crushed stones are a good replacement for locally available sand and it is a fine crushed aggregate manufactured under normal conditions from a suitable sand source. Manufactured sand fulfills all the criteria of fine aggregates at a reasonable cost as well as an eco-friendly condition [20].
- It is concluded that the strength characteristics of normal concrete can be improved by replacing local sand with crushed stone [21-22].
- It is investigated that the gross strength of the mix increases as the percentage of manufactured sand increases with respect to the reference (Mix 1).
- SEM images confirmed that the manufactured sand particles are elongated and angular in shape, while river sand particles are round or spherical.
- The presence of minerals like silica, calcium, alumina, and oxides in natural sand, as well as in manufactured sand, is detected by EDS.
- XRD analysis confirmed that the crystalline form of silica is the main component present in it.
- The gradation of the crushed stone was good and nice, while it is absent in the case of natural river sand.
- Manufactured sand has fewer impurities and better working properties than natural river sand.
- From the above experimental results, it is concluded that crushed stone is the best option for making concrete.

COMPRESSIVE STRENGTH



VI. SEM AND XRD ANALYSIS

The Scanning Electron Microscopy (SEM) Analysis characterized the micro structural behavior of concrete. Energy Dispersive Spectroscopy (EDS) examines the presence of compounds and elements in prepared specimens of selected grade. The presence of minerals and compounds in the selected specimens is investigated by X-Ray Diffraction (XRD). The micro structural characteristics of concrete with river sand and crushed stone are tested by conducting the SEM combined with Energy Dispersive Spectroscopy (EDS) and X-ray Diffraction (XRD) analysis. SEM images concluded that the shape of manufactured sand particles is elongated and angular, while the natural sand particles are round or spherical in shape. The

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