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Experimental Study on Properties of Concrete with Manufactured Sand as a Replacement to River Sand

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ABSTRACT

Concrete is the most widely used construction material in any structure. To meet the requirement of globalization, in the construction of buildings and other structures, concrete plays a major rightful role and an increase in construction activities has led to utilizing the quality of concrete and also an increase in demand for various raw materials in concrete. Concrete is a combination of cement, fine aggregate, coarse aggregates and water. Natural sand deposits are being depleted and causing a serious threat to the environment as well as society. If the usage of sand increases continuously then after some years, we will face serious problems with respective its availability, cost and environmental impact. Recently the government of Andhra Pradesh and Tamil Nādu has imposed restrictions on sand removal from the river beds due to unsafe impacts threatening the states. To overcome these problems, there is a need for cost-effective; alternative and innovative materials nowadays sustainable infrastructural growth demands alternative materials that should satisfy the technical requirements of the fine aggregate. Mix design is designed as per IS Standards. In this research, a mix of 1:1.9:3.1 (M20) was considered. The test specimen was cast for 7 days, 14 days and 28 days. The performance of M-sand was determined by several experiments such as slump test, split tensile strength, flexural Strength, and compressive strength test. The results attained from each test state that as M-sand increases the slump value decreases. flexural strength, compressive strength and split tensile strength of concrete at 7 days, 14 days and 28 days are greater at 60% replacement of M sand by river sand.

1. INTRODUCTION

Currently, India has taken a major initiative on developing the infrastructures such as express highways, power projects and industrial structures etc., to meet the requirements of globalization. In recent years, concrete technology has made significant advances which have resulted in economical improvements in strength of concrete. This economic development depends upon the intelligent use of locally available materials. A huge quantity of concrete is consumed by construction industry all over the world. In India, the 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 of natural or river sand has been increased. To meet this demand of 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 have forced to find the suitable substitute. One of the cheapest and the easiest ways of getting substitute for natural sand is by crushing natural stone to get artificial sand of desired size and grade [1]. The main cause of concern is the nonrenewable nature of natural sand and the corresponding increasing demand of construction industry. Therefore looking for another to river sand had become a necessity. The cheapest and easiest alternative to natural sand is manufacturing sand by crushing rocks/stones in desired amount and grade by suitable method. Sand produced by such means is called as manufactured/ crusher/artificial sand [2]. Priyanka A. Jadhav and Dilip K. Kulkarni puts forward the applications of manufactured sand as an attempt towards sustainable development. The effect of water cement ratio on hardened properties of cement mortar with partial replacement of natural sand by manufactured sand was also reported [3]. M. Prem Anand et. al. have reported the results of experimentally investigation on the effect of M-Sand in structural concrete by replacing river sand and develop a high performance concrete. They also determine and compare the differences in properties of concrete containing river sand and M-sand. They also use steel fibres and chemical admixtures to increase the strength and workability of concrete respectively. The investigations

were carried out using several tests such as workability test, compressive test, tensile test, and flexural test etc [4]. Swapnil S. Fate has studied the effect of use of crushed sand on properties of concrete and review of various operational parameters viz. workability, durability and compressive strength was highlighted in the paper [5]. Martins Pilegis, Diane Gardner and Robert Lark have also reported the results of a laboratory study in which manufactured sand produced in an industry sized crushing plant was characterised with respect to its physical and mineralogical properties. The influence of these characteristics on concrete workability and strength, when manufactured sand completely replaced natural sand in concrete, was investigated and modelled using artificial neural networks (ANN). The results showed that the manufactured sand concrete made in this study generally requires a higher water/cement (w/c) ratio for workability equal to that of natural sand concrete due to the higher angularity of the manufactured sand particles [6]. Rameshwar S. etal. Had initiated to made the concrete economical by replacing the natural sand by crushed sand in the concrete. It was concluded that different Crushed sand gives different results for compressive strength depending on different quarries [7]. Akshay A. Waghmare Akshay G..Kadao, Ayushi R. Sharma and Sunil G. have reported the properties such as workability tensile strength and compressive strength of concrete prepared by replacing natural sand with artificial sand at different replacement level (0%, 20%, 40%, 60%, 80%, 100%).They have also reported the strength and durability performance of concrete made with natural sand and artificial sand[8]. Dr.S.Elavenil and B. Vijaya, have also reported that a well processed manufactured sand can be used as partial or full replacement to river sand and this is the need of the hour as a long term solution in Indian concrete industry until other suitable alternative fine aggregate are developed [9-12]. In the present investigation workability, strength and durability of concrete with manufactured sand as change to natural sand in Proportions of 0%, 20%, 40%, 60% and 100% is studied. The experiments were conducted on M20 and M30 concrete grade with 450 specimens. Slump cone, compaction factor and vee-bee time tests were conducted to determine workability. Results obtained showed that as replacement of natural sand by manufactured sand is increased, there is a decrease in the workability. Compressive strength, split tensile strength and flexural strength tests were conducted to determine strength of concrete. The 60% replacement showed an increase in strength of about 20% and other changes to an order of minimum 0.93% in both the grades. The durability study is conducted by treating specimens for 30 days with 5% concentrated Hydrochloric Acid and the concrete mix with 60% replacement has given good durable properties.

2. ENVIRONMENTAL IMPACT OF SAND MINING

Large scale mining of sand and gravel several folds higher than the natural replenishments, has lead to irreparable damages to the land, water, biotic and social / human environments related to many of the world's river systems. The problem is severe in the case of the rivers in the southwest coast of India, especially in Kerala, where the rivers are small with limited river bed resources. At the equivalent time, the mining of sand is on the rise to meet its ever increasing demand in the construction sector. It is now widely realized that, in spite of the short term gain, the indiscriminate sand mining from the rivers is detrimental to these life sustaining systems, in the long run. Moreover, the effects of in stream sand mining may not be visible immediately because it requires regular monitoring and takes a decade or more to surface and propagate the effects along the river channel in measurable units. In other words, mining may go on for years without apparent effects upstream or downstream, only to have geomorphic effects manifest later during high flows. Similarly, rivers are often said to have 'long memories', meaning that the channel balancing to in stream extraction or comparable perturbations may persist long after the activity has ceased. Sand mining disturbs the equilibrium of a river channel because it block material load moving within a dynamic system and triggers an initial morphological response to regain the balance between supply and transport. Key Impact points on Envoirment due to Mining.

2.1 Changes in bed forms

The river channels are naturally modified into different bed forms depending on the changes in flow energy and sediment discharge.

2.2 Changes in sediment characteristics

Indiscriminate and continued mining of sand from the alluvial reaches of river systems could impose marked changes in the grain size characteristics of river beds, in the long run. As bed materials form an important abiotic component of a river ecosystem, changes in grain size characteristics may lead to changes in biodiversity of the system.

2.3 Changes in water quality / quantity

Indiscriminate mining for construction grade sand and gravel from the active channels and floodplains of river systems can impose serious problems in the surface and sub-surface (groundwater) water resources. High content of suspended particulates in the water column arising as a result of clandestine sand mining operations can cause severe impairments to the river ecosystems.Cases of water table lowering consequent to sand and gravel mining have been documented by several investigators.

2.4 Changes in biological environment

During the past 3-4 decades, river systems of the world have been altered significantly due to in discriminate sand mining. Sand mining has many deleterious direct and indirect effects on the physical, chemical and biological environments of river systems.

2.5 Environmental issues of Mining

The role of minerals and metals in economic development, mainly in the context of developing countries has recieved much attention.This is most important aspect while design the mine layout as it depletion of ground water, lesser availibility of water for industrial, agriculture land, fall of employment to farm workers, threat to livelihood, human rights violations and damage to roads and bridges. It also affects region's fragile ecosystem and rich biological and cultural diversity.

2.6 Air Quality

The main air quality issue with mining is dust particles. A large amount in the concentration of dust can be a health hazard, exacerbating respiratory disorders such as asthma and irritating the lungs and bronchial passages.

2.7 Noise & Vibration

Noise can be an issue because mines normally operate 24 hours a day and sound levels can fluctuate widely. Surface mines mainly generate noise from overburden, excavation and transport, while the major noise source from underground mines is ventilation fans, surface facilities and product transport.

3. MATERIALS

Constituents of concrete: Concrete is to be suitable for a particular purpose, it is necessary to select the constituent materials and combine them in such a manner as to develop the special qualities required as economical as possible. Many variables affect the quality of the concrete produced, and both quality and economy must be considered.

3.1 Cement

JAYPEE Ordinary Portland Cement of 43 Grade confirming to IS 8112-1989 of specific gravity 3.12.

3.2 Fine Aggregate

River sand and Manufactured sand confirming to Zone-II of IS 383.

3.3 Coarse Aggregate

Crushed granite metal with 60% passing 20 mm and retained on 10 mm sieve and 40% passing 10mm and retained on 4.75 sieves was used.

3.4 Water

Potable water confirming to IS: 456-2000.

4. METHODOLOGY AND EXPERIMENTAL INVESTIGATION

The experimental investigation was planned to provide sufficient information about the strength characteristics of manufactured sand concrete and natural sand concrete with and without using nano silica and compare the performances of both types of concrete. Tests were conducted on materials to know their physical properties. Also different tests were performed on manufactured sand concrete to study its workability. Results were analyzed to derive useful conclusions regarding the strength characteristics of manufactured sand concrete with and without using nano silica.M20 concrete has been used as a reference mix.

5. TEST RESULTS

5.1 Slump Cone Test

Table 1. Workability of concrete with various percentage of M – sand

Proportions	Slump in mm
Conventional concrete	52
20% M-sand +80% sand	49
40%M -sand + 60% sand	49
60%M -sand +40 % sand	47
80%M -sand + 20% sand	46
100%M -sand + 0% sand	41

Table 2. Result of Compressive Strength of Cubes For 7 Days

% of mixing	Compressive Strength Of Cubes (N/Mm²)			Average Compressive Strength (N/Mm²)
	1	2	3	
Conventional Concrete	21.11	23.11	22.67	22.29
20% M-sand +80% R-sand	23.55	22.95	24.18	23.56
40%M -sand + 60% R-sand	25.89	25.74	24.19	25.27
60%M -sand +40 % R-sand	27.11	25.77	25.98	26.18
80%M -sand +R- 20% sand	21.53	23.68	21.93	22.38
100%M -sand + 0% R-sand	22.74	20.67	20.21	21.20

Table 3. Result of Compressive Strength of Cubes For 14 Days

% of mixing	Compressive Strength Of Cubes (N/Mm²)			Average Compressive Strength (N/Mm²)
	1	2	3	
Conventional Concrete	26.67	25.44	26.81	26.30
20% M-sand +80% R-sand	26.22	26.79	26.19	26.41
40%M -sand + 60% R-sand	27.55	26.62	27.24	27.13
60%M -sand +40 % R-sand	27.98	29.15	27.15	28.09
80%M -sand +R- 20% sand	24.88	26.22	24.08	25.09
100%M -sand + 0% R-sand	25.88	22.33	24.36	24.19

Table 4. Result of Compressive Strength of Cubes For 28 Days

% of mixing	Compressive Strength Of Cubes (N/Mm²)			Average Compressive Strength (N/Mm²)
	1	2	3	
Conventional Concrete	31.29	32.16	30.68	31.37

20% M-sand +80% R-sand	32.51	32.69	31.22	32.14
40%M -sand + 60% R-sand	33.09	33.57	32.97	33.21
60%M -sand +40 % R-sand	35.61	34.86	35.76	35.41
80%M -sand +R- 20% sand	30.21	30.45	31.87	31.4
100%M -sand + 0% R-sand	31.99	30.78	31.43	30.87

Table 5. Result of Split Tensile Strength of Cylinders For 14 Days

% of mixing	Compressive Strength Of Cubes (N/Mm²)			Average Split Tensile Strength (N/Mm²)
	1	2	3	
Conventional Concrete	2.24	2.43	2.39	2.35
20% M-sand +80% R-sand	2.76	2.73	2.58	2.69
40%M -sand + 60% R-sand	2.84	2.86	2.69	2.71
60%M -sand +40 % R-sand	2.97	2.98	2.81	2.92
80%M -sand +R- 20% sand	2.68	2.57	2.49	2.58
100%M -sand + 0% R-sand	2.12	2.42	2.38	2.31

Table 6. Result of Split Tensile Strength of Cylinders For 28 Days

% of mixing	Compressive Strength Of Cubes (N/Mm²)			Average Split Tensile Strength (N/Mm²)
	1	2	3	
Conventional Concrete	2.81	3.29	2.937	2.93
20% M-sand +80% R-sand	3.19	3.06	3.38	3.21
40%M -sand + 60% R-sand	3.31	3.22	3.19	3.24
60%M -sand +40 % R-sand	3.72	3.62	3.57	3.67
80%M -sand +R- 20% sand	3.29	3.13	3.15	3.19
100%M -sand + 0% R-sand	2.95	2.98	2.72	2.87

6. CONCLUSION

Manufactured sand is used in the production of concrete cubes and cylinders by replacement levels of 0 %, 20%, 40%, 60%, 80%, and 100%, respectively, in weight of fine aggregate. Cubes were cured and tested for compressive strength at 7, 14, and 28 days. Cylinders were cured and tested for split tensile strength for 14 and 28 days. Based on the experimental investigation, the following conclusions are made.

- Industrial waste materials are used as partial replacement of fine aggregate at different levels produced concrete with high strength and acceptable structural grade concrete.
- High volume of m-sand replacement is not appropriate because of its properties.
- There will be a good reduction in the cost of concrete by the usage of manufactured sand
- Partial replacement of sand with manufactured sand gives better than ordinary concrete.
- By replacement of fine aggregates, we observed that the maximum compressive strength for 7 days of curing is increased by 15.14% at 60% M-Sand and 40%R-Sand.
- For 14, 28 days of curing the maximum compressive strength is increased by 9.04% and 12.49 % at 60% M-Sand and 40% R-Sand.
- By replacement of 60% M-Sand and 40%R-Sand, we observed that the maximum tensile strength is increased by 19.69% for 14days.
- By replacement of60% M-Sand and 40%R-Sand, we observed that the maximum tensile strength is increased by 20.28% for 28days.
- At 60% M-Sand and 40% replacement of R-sand gives good results when compared with remaining proportions.

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