Experimental Study on Partial Replacement of Natural Sand with Robo Sand

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Abstract

Today, the Indian construction industry faces one of the major problems of natural fine aggregate. The court then granted a total ban on the excavation of fine aggregate from the river in order to affect the environment and change the direction of the river. Cement, sand and aggregate are the basic needs of any construction industry. Sand is used as a raw material for mortar and concrete and plays an important role in the design of mixtures. Currently, there are days of river erosion, and due to environmental issues, there is a shortage of river sand. The availability or lack of river sand affects the construction industry. Therefore, new alternatives to river sand need to be found to avoid excessive river erosion and environmental damage. Many researchers have found a variety of alternatives to sand, one of which is quarry stone powder (artificial / robo / M-SAND). By using this robot sand with sand in various ratios, you can get the concrete mixture you need. The replacement of natural fine aggregate is done with 20%, 40% and 60% artificial fine aggregate, and the compressive strength of the concrete cube is also known. This article outlines the various alternatives to natural sand in concrete preparation and aspects of the physical and mechanical properties and strength of concrete.

Keywords: *Artificial/Robo/M –SAND, Natural sand, cement, concrete, course aggregate, Physical Properties, Mechanical Properties, Curing, Compressive strength.*

INTRODUCTION

Cement, sand and aggregates are essential needs for the construction sector. Sand is an important material used in the manufacture of mortar and concrete and plays a very important role in the design of mixes. In general, the amount of natural sand consumed is high due to the heavy use of cement and mortar. Therefore, the demand for natural sand is very high in developing countries to cope with the rapid growth of infrastructure. In developing countries such as India, where there is a shortage of good quality natural sand, particularly India, the depletion of natural sand deposits poses a serious environmental and social threat. Rapid extraction of sand from river beds causes many problems, including loss of water to retain soil layers, deepening of river beds and landslides on river banks, loss of vegetation on river banks, water turbulence and agricultural disruptions. To lower the water table of wells. Here are some examples. The heavy exploitation of river sand for construction purposes in Sri Lanka has caused some damaging problems.

The best combination is because various river sand alternative options such as offshore sand, quarry dust, filtered sand, physical and fine chemical properties affect the length, functionality and strength of concrete. It is the main component of concrete and cement. River sand and pit sand are generally most commonly used for mortar and concrete. Optimize the proper type and quality of adjacent sites, as natural sand has recently become a very expensive material due to the demands of the construction industry, as natural sand accounts for 75-80% of total aggregate and roughness. It is important to do. To this end, research has begun on cheap and readily available alternatives to natural sand. Instead of natural sand, use fly ash, quarry or limestone powder, silica stone powder, filtered sand and copper slag to partially or completely replace the natural sand in the cement and mortar mixture. Offshore sand is used in many countries, including the United Kingdom, Sri Lanka and mainland Europe, but most of the documents related to the use of this alternative in India and Singapore are found to some extent primarily in the construction sector. I will.

Due to lack of sand in the river, the Andhra Pradesh government has restricted natural sand mining in the Godavari River and the Madras High Court has restricted sand mining in the Corbury and Tamirabarani rivers. We have launched a public awareness program on the use of Robosand / M-Sand by the Government of Telangana on the use of artificial sand instead of natural sand (T. Harish Rao, Minister for Irrigation, Marketing and Justice). Facts like India are almost the same in other countries. Therefore, concrete and mortar aggregates need to be found instead of river sand in construction activities, which is even more important today. Researchers and engineers have come up with unique ideas to reduce or completely replace the use of river sand, such as M-sand (manufactured sand), robotic silica or sand, crushed rock sand, filtered sand, and treated and extracted sand from other reservoirs and dams from reservoirs. On the other hand, some of the major limitations of the above materials are the lack of required quality. Today, the growth of today's sustainable infrastructure requires not only the technical requirements of the best aggregates, but also a large number of locally available alternative materials.

Indian standards are widely used today to ensure the construction quality of buildings and other structures, which today rely heavily on concrete structures. Due to the shortage of coarse sand and gravel from natural resources, the Bureau of Standards of India, the country's national standards body, has developed a number of alternatives aimed at promoting the use of various wastes without harming the environment and conserving natural resources. . . Quality. These measures, together with the Concrete Code (IS 456), allow the National Building Code of India to remove slag from the steel industry, ash from thermal power plants and crushed bricks and tiles. - Waste from the production of clay bricks and tiles in conventional cement concrete as an alternative to natural sand / gravel subject to Codex requirements. The code promotes the use of fly ash and granular crushed blast furnace slag as an alternative to plain and reinforced cement concrete to traditional Portland cement. This component restores fly ash and slag by 35% and 70%, respectively, providing significant savings in natural limestone reserves, which could otherwise be degraded by the use of ordinary Portland cement without replacement. Not only that, the code highlights how the durability of concrete can be enhanced with these additional semantic materials. The Indian Mixed Concrete Design Standard (IS 10262) has been updated to include guidance and examples for designing concrete mixtures using fly ash and slag. The Indian Standard Code of Practice for RMC (IS 4926) sets out the requirements for manufacturers of premixed concrete to maintain the required quality of concrete made with fly ash and slag.

DIFFERENT ALTERNATIVE MATERIALS TO RIVER SAND

The world has made it easier to dump dangerous waste that can replace natural sand. Anywhere, position, size, type of construction, concrete base for construction In fact, concrete is the second most consumed material after water and is used almost three tons per year for everyone in the world. India consumes 450 million cubic meters of concrete per year, and India gets 1 ton of it worldwide. We still have a long way to go. But do we have enough sand to do concrete and mortar? Even during the economic downturn, the value of the construction industry has grown an impressive 15% annually and accounted for 7-8% of the country's GDP (at current prices) over the past eight years. Hence, it is uncomfortable for people as ordinary people to talk about the greenness of the industry without finding a helpful answer to this difficult question. Indeed, we are sitting in a garbage garden that can replace sand. Industrial waste and by-products from virtually every industry that pose a threat to the environment, health, agriculture and human health can make a huge contribution to construction work, not only that. But it protects the environment only from an economic point of view. Many researchers have sought alternatives to natural sand and have concluded that there are many types of industrial wastes and the possibility of replacing the very popular natural river sand.

A. Copper Slag

Currently, about 33 million tonnes of copper slag is being produced worldwide, of which India contributes 6 to 6.5 million tonnes. 50% copper slag can be used instead of natural sand to obtain mortar and concrete with the required properties, strength and durability (Khalifa). S. al-Jabri et al. 2011). In India, according to a study by the Central Road Research Institute (CRRI), copper slag partially incorporates up to 50% of river sand into concrete. Paving concrete without losing compressive strength and flexible strength Such strength and concrete show 20% greater strength than conventional cement of the same grade.

B. Washed Bottom Ash (WBA)

India currently produces 100 million tonnes of coal ash, of which 15-20 per cent of the total ash produced in thermal power plants is slag and the rest is fly ash. Fly Ash has found a large number of users. But the unsafe disposal of ash below continues to pollute the environment. The mechanical properties of special concrete, made of natural sand, are replaced with 30 percent ash, with a weight-washed foot, optimized in concrete, achieving the required strength and good strength development model for a long service life.

C. Quarry Dust

Approximately 20 to 25 percent of the waste produced in each crushing plant is quarry dust. The optimum restoration rate for sand with rock dust in terms of compressive strength is 55% to 75%. He said that 100 per cent sand can be replaced when mixed with fly ash (other industrial wastes) and the use of fly ash in concrete requires beneficial by-product removal, better working efficiency, lower cement consumption and better sulfate resistance. Increased resistance and decreased permeability to alkaline-silica reactions. However, the use of fly ash reduced the strength of the concrete at an early stage. Therefore, the simultaneous use of rock dust and fly ash in concrete has the advantage of using such additional materials and eliminating some undesirable effects.

Fig.1. Copper slag

Fig.2. Washed Bottom Ash

Fig.3. Quarry Dust

Fig.4. Construction and Demolition waste

D. Construction and Demolition waste

There is no documentation of the amount of construction and demolition (C&D) waste generated in India. The Delhi Municipal Corporation collects about 4,000 tonnes of C&D waste per day from the city, which is about 1.5 million tonnes per annum in Delhi alone. Although we are reducing all the waste around the city, the demand for natural sand will significantly meet the demand if 1.5 million C&D waste is recycled. Recycled sand from C&D waste and its total strength is 10-15 percent, then ordinary concrete is present and can be used safely in non-structural applications such as flooring and backing. Delhi already has a recycling unit and plans to open more to address the removal problem. Waste produced and discharged by the construction industry, which is an environmental problem, can only be reduced by recycling the waste it generates.

MATERIALS USED

The properties of the various materials used to make concrete (M25) are discussed in the sections below:

1. Cement

In the production of concrete slab panels and cubes, it is used in the testing of general grade 43 Portland cement that can meet all the requirements of IS 8112-1989. See Table I.

2. Natural (River) Sand

Natural sand has an excellent modulus of 2.78 and, after washing in clean water, complies with Zone II according to IS: 383-1970. The specific gravity of this natural sand was found to be 2.55. The water absorption and moisture values obtained for the sand used were 6% and 1.0%, respectively.

3. Artificial sand (Robo sand)

The crushed sand has an excellent modulus of 2.81 and is compatible with Zone II according to IS: 383-1970, used for testing after washing in clean water. The specific gravity of this artificial sand was found to be 2.66. The water absorption and moisture values obtained for the sand used were found to be 6.5% and 1.0%, respectively. See Table II.

4. *Coarse Aggregate*

For testing, 20 mm crushed stone aggregates obtained from a local quarry were used. The best modulus of coarse aggregates was found to be 6.3 with a specific gravity of 2.3, while the water absorption and moisture values for the sand used were 2.5% and 0.5%, respectively.

Table I Typical properties of Cement 43 grade IS 8112-1989

Physical properties	Values of OPC used
Standard consistency	32.5%
Sp gravity	3.15
Initial setting time	>30 min's
Final setting time	<600 min's

Table II Properties of Fine aggregate

Properties	Natural sand	Robo sand
Specific gravity	2.55	2.66
Fineness module	2.78	2.81

5. *Robo sand and properties*

Artificial / robotic sand produced with proper equipment is a good alternative to river sand. The sand should be at the correct level (it should contain particles from 150 microns to 4.75 mm in the correct proportions). The robot is a refined form of quarry sand dust that is extracted from coarse gravel, often in the form of crumbs. The required size of these baby chips is 0-4.75 mm. In fact, both natural sand and robot sand are identical. They do not have many properties such as water absorption. But now they began to prepare specifically for the sand.

6. *General Requirements of Manufactured Sand*

a) All sand particles must have high gravitational strength.

b) The surface texture of the particles should be uniform.

c) The edges of the particles should be primary.

d) The proportion of fine particles less than 600 microns in the sand should not be less than 30%.

e) There should be no organic contaminants.

f) Silt in crushed sand should not exceed 2%.

g) In industrial sand, the allowable limit for particulate matter below 75 microns should not exceed 15%.

7. *Properties of Robo sand*

Table III Average properties from all manufacturing units (Robo silica Pvt. Ltd.)

Organic material content	NIL
Compatiblity with cement	Use with any type of Portland cement and blended cement for various mix designs
Setting time	Normal setting time as river Sand
Yield	Rich mix
Standard mix design for M20 1:2:4 per cum	Cement-330kg Robo sand-660kg , 20mm&10mm Course aggregate -1320kg
Workability	Good
W/C Ratio	0.49 + free water 182 liters per cum. Of concrete

8. *Fineness Modulus and Zone classification*

The results of aggregate sieve analysis are expressed by a number called Fineness Modulu that is obtained by adding the sum of the cumulative percentages by mass of a sample aggregate retained on each of a specified series of sieves and dividing the sum by 100. The specified sieves are: 150µm (No. 100), 300µm (No. 50), 60µm (No. 30), 1.18 mm (No. 16), 2.36 mm (No. 8), 4.75 mm (No. 4), 9.5 mm , 19.0 mm , 37.5 mm , 75 mm , and 150 mm.

Fineness modulus of Natural sand = 278 ÷ 100 = 2.78 Fineness modulus of Robo = 281 ÷ 100 = 2.81

As per the above results the Natural sand(NS) and Robo Sand (RS)both are of Zone –II. And fineness module of Natural sand is 2.78 and Robo sand is 2.81.

Table IV IS classification of zones (IS 383-1970)

IS sieve designation	Percentage passing for			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15

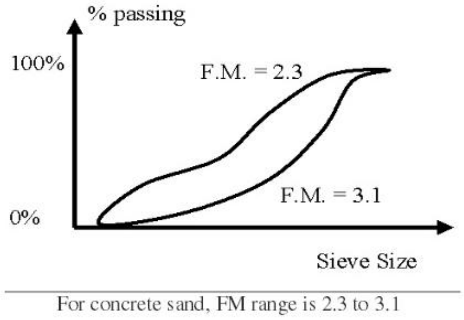

Fig.5. Graph showing fineness modules range for concrete

Fig.6 Sieve Analysis of Fine aggregate and Coarse aggregate

Table V Fineness modulus and Zone classification

Sieve no	Percentage of individual fraction retained by mass		Percentage passing by mass		Cumulative percentage retained by mass	
	NS	RS	NS	RS	NS	RS
10mm	0	0	100	100	0	0
4.75mm	0	0	100	100	0	0
2.36mm	12	0	88	100	12	0
1.18mm	13	43	75	57	25	43
600micron	39	28	36	29	64	71
300micron	20	9	16	20	84	80
150micron	9	7	7	13	93	87
Pan	7	13	0	0	-	-
Total	100				278	281

TYPES OF MIXES

A. Nominal Mixes

Previously, profiles for cement, fines and coarse aggregate ratios. These compounds with a stable cement-aggregate ratio that provide sufficient strength are called nominal compounds. They are simple and, under normal circumstances, have a high level of protection. However, due to the diversity of composite materials, the nominal strength of concrete varies greatly for a given working capacity.

B. Standard mixes

Nominal mixtures with a constant cement-to-total ratio (in terms of volume) vary greatly in strength and can lead to more or less great compounds. For this reason, the minimum compressive strength is included in many specifications. These compounds are called static compounds. At IS 456-2000 standards, concrete mixes are classified into grades M10, M15, M20, M25, M30, M35 and M40. In this post, the letter M and the number N / mm2 indicate the specific 28-day cube strength of the compound. Combinations of M10, M15, M20 and M25 grades for mixed ratios (1: 3: 6), (1: 2: 4), (1: 1.5: 3) and (1: 1: 2), respectively.

C. Design Mixes

In these mixtures, the properties of the concrete are determined by the designer, but the proportions of the mixture are determined by the concrete manufacturer, except that the minimum cement content may be specified. This is a very rational approach to choosing the ratio of the mixture, taking into account the more or less specific properties of the particular material. This approach allows producing concrete with suitable properties very economically. However, the composition of the mixture does not serve as a guide because it does not guarantee the correct ratio of the mixture to the given properties.

D. Factors affecting the choice of mix proportions

- Compressive strength (CS)
- Workability-The workability of concrete for satisfactory placing and compaction is related to the size and shape of section, quantity and spacing of reinforcement and technique used for transportation, placing and compaction.
- Durability
- Nominal size of aggregate- Maximum nominal size of aggregates to be used in concrete may be as large as possible within the limits prescribed by IS 456:2000.
- Quality control-The cement content is to be limited from shrinkage, cracking and creep.

DESIGN MIX (BASED ON BIS METHOD)

Table VI Test data for Materials

Table Head	Table Column Head
Cement used	OPC 43 grade conforming to IS 8112
Specific gravity of cement	3.15
Specific gravity of Coarse aggregate(CA)	2.74
Specific gravity of Fine aggregate(FA)	2.77
Water absorption Coarse aggregate	0.5 percent
Water absorption Fine aggregate	1.0 percent
Sieve analysis Coarse aggregate	Conforming to Table 2 of IS: 383
Sieve analysis Fine aggregate	Conforming to Zone I of IS: 383

A. *Target Mean Strength for Mix Proportioning*

Ft = fck+ 1.65 s

Where

fck = Target average compressive strength at 28days,

fck= Characteristic compressive strength at 28 days,

s= Standard deviation

From Table 1 standard deviation, s= 4 N/mm2 (IS 456 2000)

Therefore , target strength = 25 + 1.65 x 4 = 31.6 N/mm2

B. *Calculation of Cement Content*

Cement content = 182/0.44 = 413.63 kg/m^3 =414 kg/m^3

From Table 5 of IS: 456, minimum cement content for severe exposure condition = 414 kg/m^3> 300 kg/m^3, hence OK.

C. *Calculation for CA and FA*

Volume of concrete = 1 m^3

Volume of cement = 414 / (3.15 X 1000) = 0.1301 m^3

Volume of water = 182 / (1 X 1000) = 0.1820 m^3

Total weight of other materials except coarse aggregate = 0.1301 + 0.1820 = 0.3121 m^3

Volume of coarse and fine aggregate = 1 – 0.3121 = 0.6879 m^3

Volume of F.A. = 0.6879 X 0.33 = 0.2332 m3 (Assuming 33% by volume of total aggregate)

Volume of C.A. = 0.6879 – 0.2334 = 0.4335 m^3

Therefore weight of FA = 0.2334 x 2.55 x 1000 = 595.17 kg/ m^3

Say weight of F.A. = 595 kg/ m^3

Therefore weight of C.A. = 0.4335 X 2.76 X 1000 = 1196 kg/ m^3

Say weight of C.A. = 1196 kg/ m^3

Weight of water =178.542 kg

Water: cement: F.A.: C.A. = 0.44: 1: 1.43: 2.88

D. *The compressive strength for 7 days and change in strength with reference mix*

After curing of cubes for 7 days, the concrete moulds of 150x150x150 mm is tested with a compressive testing machine or universal testing machine. Apply the load gradually without shock and continuously at the rate of 140kg/cm^2/minute till the specimen fails. The results are shown in Table VIII.

Table VII Properties of concrete

Properties	Sample-1a	Sample -2b	Sample 3c	Sample 4d
NS (kg)	10	11	8.58	5.72
Specific gravity NS	2.55	2.55	2.55	2.55
RS (kg)	0	2.6	5.72	8.58
Specific gravity RS	2.75	2.75	2.75	2.75
CS inN/mm^2 after 28 days	23.11	30	32	33.7

a. 0% robo sand
b. 20% replacement with robo sand
c. 40% replacement with robo sand
d. 60% replacement with robo sand

Table VIII The compressive strength for 7 days.(N/mm^2)

Robo sand	Compressive strength N/mm^2	Change in Strength with reference mix
0%	19.99	-
20%	23.11	+3.12
40%	20	+.01
60%	26.66	+6.67

E. Compressive strength for 28 days

After curing of cubes for 28 days, the concrete moulds of 150x150x150 mm is tested with a compressive testing machine or universal testing machine. Apply the load gradually without shock and continuously at the rate of 140kg/cm2/minute till the specimen fails. The result are shown in table IX.

Table IX The compressive strength for 28 days.(N/mm2)

Robo sand	Compressive strength N/mm^2	Change in Strength with reference mix
0%	30	-
20%	31.84	+1.84
40%	32	+2
60%	33.77	+3.77

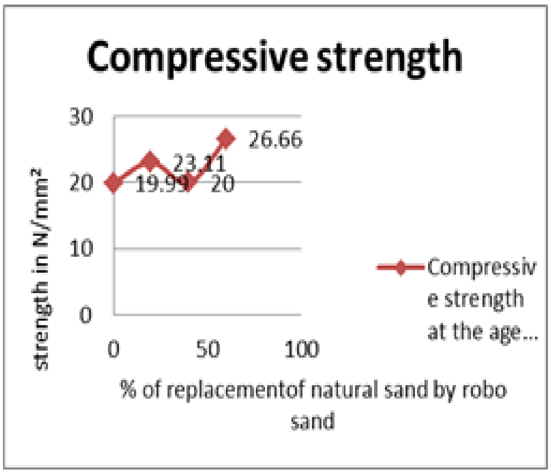

Fig. 7 Graph showing the compressive strength of concrete cured for 7 days

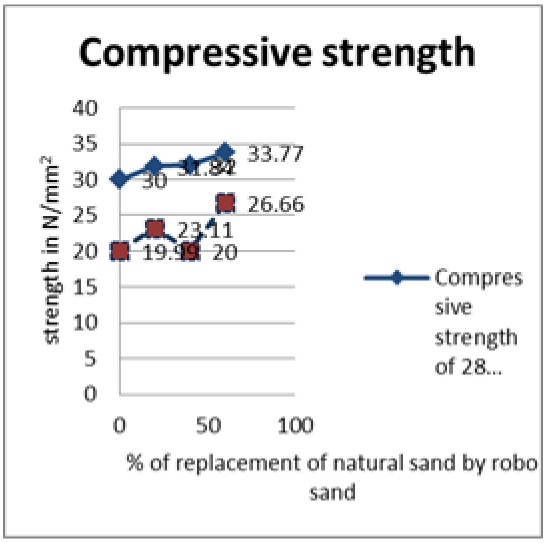

Fig. 8 Graph showing the compressive strength of concrete cured for 7 days and 28 days

CONCLUSIONS

The effect of partial replacement of natural sand with robotic sand on the compressive strength of cement concrete with a water-cement ratio of grade M25 (1: 1.4: 2.88-design mixture) 0.44 has been investigated. The results are compared with a 0% reference mix to replace natural sand with robotic sand. Compressive strength of cement concrete when converted 20%, 40%, 60% by robotic sand shows higher strength compared to the reference mix. The overall strength of the concrete is increased by 0%, 20%, 40%, 60% compared to the reference mix with natural robotic sand.

Sand for robots can be an alternative to natural sand and help maintain ecological and economic balance. The lack of natural sand at reasonable prices makes one look for alternatives. Robot sand is considered a suitable alternative to river sand at a reasonable cost. The robot sand was found to be of good quality and excellent adhesion, which is relatively low for natural sand.

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Price - According to the prices, the use of sand for robots gives effective results, the price of sand for robots on the market is 30-50% lower, which is good for economical production of concrete. Robot sand works just as well as natural sand concrete.

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