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An Experimental Study on the Effects and Properties of Concrete by Replacement of Natural Sand with Robosand as Fine Aggregate

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ABSTRACT

Concrete is the most widely used composite construction material. Fine aggregate plays a very important role for imparting better properties to concrete in its fresh and hardened state. Generally, river sand was used as fine aggregate for construction. Due to the continuous mining of sand from riverbed led to the depletion of river sand and it became a scarce material. Also, sand mining from river bed caused a lot of environmental issues. As a substitute to river sand, Robo sand has been used. In this present experimental study a comparative study has been carried out to check the usability of Robo sand in place of natural sand. This study involves determination of some major properties of concrete like compressive strength, split tensile strength, flexural tensile strength and durability in acidic medium made of both the sands. Based on proposed studies, quality of Robo sand is equivalent to natural sand in many respects, such as cleanliness, grading, strength, angularity, specific gravity. Conclusion have been arrived that Robo sand produced from VSI (vertical shaft impact or) is a suitable and viable substitute to river sand and could be effectively used in making concrete which provides adequate strength and durability for the concrete. In the design of concrete structures, concrete is taken into account by taking its compressive strength value. The compressive strength of the concrete made of Robo sand is observed to be very nearer to the strength of the concrete made of natural sand in the present investigation, there by 100% replacement is reasonable.

Keywords : Robo Sand, Depletion, Compressive Strength, Tensile Strength

I. INTRODUCTION

This chapter contains the general information about Robo sand, its origin, need of manufactured in construction. It also includes the exact meaning of Robo sand, crushed dust, process of manufacturing by various machinery. Natural sands are weathered and worn out particles of rocks and are of various grades or size depending on the accounting of wearing. The main natural and cheapest resource of sand is river. Dams are constructed on every river hence these resources are erasing very fast. Now a day's good sand is not readily available, it should be transported from long distance. Those resources are also exhausting very rapidly. Sand is the one of main constituents of concrete making which is about 35% of volume of concrete used in construction industry. Natural sand is mainly excavated from river beds and always contain high percentage of in organic materials, chlorides, sulphates, silt and clay that adversely affect the strength, durability of concrete & reinforcing steel there by reducing the life of structure, when concrete is used for buildings in aggressive environments, marine structures, nuclear

structures, tunnels, precast units, etc. Fine particles below 600 microns must be at least 30 % to 50% for making concrete will give good results. Normally these particles are not present in river sand up to required quantity. Digging sand, from river bed in excess quantity is hazardous to environment. The deep pits dug in the river bed, affects the ground water level. The sand in the mortar does not add any strength but it is used as an adulterant for economy and with the same it prevents the shrinkage and cracking of mortar in setting. The sand must be of proper gradation (it should have particles from 150μ to 4.75 mm in proper proportion). When fine particles are in proper proportion, the sand will have less voids. The cement required will be less when there will be less void in sand. Such sand will be more economical. Only sand manufactured by V.S.I. Crusher is cubical and angular in shape. Sand made by other types of machines is flaky , which is troublesome in working. There is no plasticity in the mortar. Hence the mason are not ready to work with machine made crushed stone sand. For the same reason inferior river sand may be used. Flaky and angular particles may produce harsh concrete, and may result in spongy concrete. There is standard specification for Fine aggregates (Sand). It is divided in four gradations. Generally known as Zone I, Zone II, Zone III and Zone IV. There is sieve Designation for each grade. Gradation is made as per the use of the sand. V.S.I can produce any zone of sand. But in case of natural sand quality varies from location to location without any control.

1.1. Robo sand :

"Robo sand is defined as a purpose made crushed fine aggregate produced from a suitable source material. Production generally involves Crushing, Screening and possibly Washing, separation into discrete fractions, recombining and blending. At the beginning Robo sand produced (by Jaw crusher, cone crusher, roll crusher, hammer mill) contains flaky and elongated particles. But now Robo sand produced from V.S.I (vertical shaft impact or) is a suitable and viable substitute to river sand and could be effectively used in making concrete which provides adequate strength and durability for the concrete. Having cubical shape, it effectively provides good bonding in concrete. Grading of Robo sand can be controlled i.e required zone of sand can be obtained. Robo sand can be produced with zero fines. As it doesn't contain silt and clay, setting properties of cement are not altered. For big projects where large quantity of aggregate is required, Plants are established near the site so that the cost of transportation can be reduced.

1.2. Need for Robo sand :

The Civil engineers, Architects, Builders, and Contractors agrees that the natural sand, which is available today, is deficient in many respect. It does not contain the fine particles, in proper proportion as required. Presence of other impurities such as coal, bones, shells, mica and silt etc makes it inferior for the use in cement concrete. The decay of these materials, due to weathering effect, shortens the life of the work. Now days, Government have put ban on dragging sand from river bed.

1.3.Market name for Robo sand .

It is being called in the market with different names like Artificial sand(as it is artificially produced), Robo sand(as it produced first by the company named Robosilicon ,pvt, limited) ,crushed sand (as it is produced from crushing),Rock sand (as the origin is rock).

1.4. Difference between Robo sand and crushed dust:

There is an ambiguity between the two words Robo sand and Crushed dust. The actual meaning is given below which illustrates that the two are entirely different. Crushed dust is the waste product produced from the stone quarries. The main aim of the stone quarry is to produce coarse aggregate(80mm-4.75mm according to IS 383:1997).

The waste from these plants contain lot of fines(passing through 75μ) along with flaky and elongated particles of size ranging from 4.75mm to 75μ. If properly treated this can be used for producing Robo sand. But treating this waste is an expensive work. Nutshell, it is a by-product. Manufactured sand is purposefully made from parent rock but it doesn't contain fines(silt ,clay),instead it contains uniformly graded cubical particles of size ranging from 4.75mm-150μ.

1.5 Manufacturing process:

Vertical Shaft Impactor principle is used for crushing bigger particles, for shaping the crushed metal (giving better shape of the particle) and for crushing fines aggregates below 4.75 mm. It is best machine Impactor is of cubical shape. Such sand can be used for all types of construction work, Concreting, Plastering etc and is better substitute to river sand. V.S.I. Crushers is a most economical machine for Crushing Stone in Cubical shape and manufacturing artificial sand. In this machine the particles are thrown at a high speed, those particles colloid with each other and shatter in cubical particles. An Anvil ring, Shelf ring (pigeon hole ring) are provided to get the particles edges grounded. The wear cost is a very important criteria in crushing process. Wear cost of other crushing machines such as Roll crushers, Cone crushers, H.S.I(Horizontal Shaft Impactor) is very high compared to V.S.I. Crushers. It is about four to five times more that of VSI crusher. Rotopactor is a most economical machine for manufacturing artificial sand. In this machine the stone are thrown at a high speed, those particles colloid with each other and shatter in cubical particles. Anvils or Shelf ring (pigeon hole ring) are provided. A rubbing action of particles over pigeon ring, grounds the sharp edges and make the texture smooth.

II. TESTS ON MATERIALS

Cement:

Ordinary Portland cement of 53 grade available in local market is used in the investigation. The cement used has been tested for various properties as per IS:4031-1988 and found to be confirming to various specifications as per IS:12269-1987. The tests results on Ordinary Portland cement are shown in Table 1.

S.n	Property	Test
1	Normal consistency	30%
2	Specific gravity	3.047
3	Setting time Initial setting time	35min
4	Fineness of cement(IS	3.5%
5	Compressive strength(1:3 sand mortar cubes) 7 days 28 days	37Mpa

Table-1: Physical properties of Ordinary Portland cement of 53 grade:

Fine Aggregate:

The locally available natural sand and machine made Robo sand are used as fine aggregate. It should be free from clay, silt, organic impurities etc.,. The sand is tested for various properties such as specific gravity ,bulk density etc. in accordance with IS:2386-1963. The grading or particle size distribution of fine aggregate shows that it is close to grading Zone –II.

Coarse aggregate:

The machine crushed annular granite metal of average size of 40mm is used as a coarse aggregate. It should be free from impurities such

as dust, clay particles, organic matter etc the fine and coarse aggregate are tested for various properties as shown in table. The grading or particle size distribution of coarse aggregate shown close to average size of 40mm as per IS:383-1970 and details of sieve analysis are shown in table 3.

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Water:

Water used for mixing and curing shall be clean and free from injurious amount of oils, acids, alkalies, salts ,organic materials or other substances. They may be deleterious to concrete. Portable water is used for mixing as well as curing of concrete as prescribed in IS:456:2000.

Standard concrete Mix design:

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economical as possible. Concrete mix design for M30 grade of concrete using both natural sand and Robo sand was done according to IS:10262-2009 and the final proportion are given in the table 3.1, 3.2.

Calculation of binder content:

The binder or cementations contents per cu.m of concrete is caluculated from the w/b ratio and quantity of water content per cu.m of concrete. Assuming the percentage of replacement of cement by silica fume content is obtained from the total binder contents. The remaining binder content is composed of cement. The cement content is so calculated and is checked against the minimum cement content for requirement of durability above values are adopted.

III. PREPARATION OF THE SPECIMENS

Design parameters : (for M30 grade concrete)

Parameters	Natural sand	Robo sand
Average size of aggregate	40 mm	40mm
Degree of Workability	Slump(100mm)	Slump(100mm)
Degree of quality of Control	Good	Good
Type of exposure	Severe	Severe
Compressive strength of Cement	53 N/mm2	53N/mm2
Selection of W/c ratio	0.45	0.4

3.1 Mixing: Pan- mixing is adopted throughout the experimental work. First the materials cement, Fine aggregate, coarse aggregate, weighed accurately.pan mixer is used as a capacity of 1 cu.f t. The drum is made of steel plates with a number of blades put in inclined position in the drum. As the drum rotates, the materials encountered resistance from the blades and these disturbing effects helps in good mixing of ingredients. The mixing is continued until there is a uniform distribution of materials and the mass uniform in color and consistency. 5-10% of total quantity of water required for mixing, sufficient to wet the drum thoroughly, shall be

introduced before the other ingredients in order to prevent any chocking of cement on the blades or the sides of the mixer. After mixing the concrete is tested for workability using slump cone test.

3.2 Casting of specimens:

For casting the cubes, cylinder and beam specimens a standard cast iron metal moulds of size 150x150x150 mm cubes, 150 mm diameter and 300mm height cylinders and beams of size 150x150x700mm are used . The mould have been cleaned off dust particles and applied with mineral oil on all sides , before concrete is poured into the mould. Thoroughly mixed concrete is filled into the mould in three layers of equal height followed by vibration with needle vibrator. Excess concrete is removed with trovel and top surface is finished to smooth level.

3.3 Compaction of concrete:

Compaction of concrete is a process adopted for expelling the entrapped air from the concrete. In the process of placing and mixing of the concrete , air is likely to get entrapped in the concrete. If this air is not removed fully, the concrete looses strength considerably. In order to achieve full compaction and maximum density with reasonable compacting efforts available at the site, it is necessary to use a mix with adequate workability. In the present investigation, the internal vibration is used for compacting the concrete.

Needle vibrator consists of a steel tube, which is inserted in fresh concrete. Theirs steel tube is connected to an electric mortar through a flexible tube. The size of poker is 40 mm diameter. The frequency of vibration is about 3000 rpm. Compaction of concrete by vibration makes the concrete better quality, higher strength with given cement content with less mixing water.

IV. TESTING OF CUBES FOR COMPRESSIVE STRENGTH

(According to IS: 516-1959)

In the design of concrete mixes, the compressive strength of concrete is generally the main target since it usually represents an overall picture of quality of concrete. The compressive strength is the maximum load per unit area sustained by a concrete before failure under compression. Since the strength development of concrete depends on both temperature .it can be said the strength is a function of summation of product of time and temperature .this summation is called maturity of concrete. The cube specimens cured as above are tested as per standard procedure after removal from the curing tank and allowed to a dry under shade. The cube specimens tested under microprocessor based compression testing machine of 2000KN capacity.

SPLITTING TENSILE STRENGTH:

(According to IS :516-1959)

Cylinder Splitting Tension Test: This is also sometimes referred as, “Brazilian Test”. This test was developed in Brazil in 1943. At about the same time this was also independently developed

in Japan.

The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder, along the vertical diameter. Figure 10.6 shows the test specimen and the stress pattern in the cylinder respectively. The loading condition produces a high compressive stress immediately below the two generators to which the load is applied. But the larger portion corresponding to depth is subjected to a uniform tensile stress acting horizontally. It is estimated that the compressive stress is acting for about 1/6 depth and the remaining 5/6 depth is subjected to tension.

The main advantage of this method is that the same type of specimen and the same testing machine as are used for the compression test can be employed for this test. That is why this test is gaining popularity. The splitting test is simple to perform and gives more uniform results than other tension tests. Strength determined in the splitting test is believed to be closer to the true tensile strength of concrete, than the modulus of rupture. Splitting strength gives about 5 to 12% higher value than the direct tensile strength.

DETERMINATION OF FLEXURAL STRENGTH: (According to IS:516-1959)

Direct measurement of tensile strength of concrete is difficult. Neither specimens nor testing apparatus have been designed which assure uniform distribution of the "pull" applied to the concrete. While a number of investigations involving the direct measurement of tensile strength have been made, beam tests are found to be dependable to measure flexural strength property of concrete.

The value of the modulus of rupture (extreme fibre stress in bending) depends on the dimension of the beam and manner of loading. The systems of loading used in finding out the flexural tension are central point loading and third point loading. In the central point loading, maximum fiber stress will come below the point of loading where the bending moment is maximum. In case of symmetrical two point loading, the critical crack may appear at any section, not strong enough to resist the stress within the middle third, where the bending moment is maximum. It can be expected that the two point loading will yield a lower value of the modulus of rupture than the centre point loading.

Pouring of acid to maintain constant acidity at regular interval of 5 days

Cubes immersed in Acid

Comparison of tests results of natural sand with artificial sand

Specific gravity:

The specific gravity value from the table indicates that the specific gravity of natural sand is more than that of artificial sand. Since the specific gravity of natural sand is more, corresponding weight of cubes of size 150x150x150 mm made from this sand is also more than weights of cubes made of robo sand. Weights of cubes made of both sands can be observed in the below table. For the given volume of concrete quantity of manufactured sand required is more compared to requirement of natural sand.

Observed Specific gravities of fine and coarse aggregates:

S.no	Material	Specific gravity
1	Natural sand	2.66
2	Robo sand	2.55
3	Coarse aggregate	2.78

Bulking of fine aggregate (B o t h for natural sand and Robo sand)

% of water	Bulking of natural sand	Bulking of Robo sand
0	21.3	20.3
1	23.9	23.5
2	24.8	26.6
3	25.3	27.6
4	25.6	27.8
5	25.7	27.2
6	25.8	27
7	25	26.9
8	24	26.8

From the above table up to 4% the bulking is observed to be increased. The bulking values from the table shows that the bulking of artificial sand is more than natural sand. Thereby, Mix design by volume batching is difficult with artificial sand.

Compressive Strength:

Compressive strength values of concrete made of both the sands.

Concrete made of	Cube1	Cube2	Cube3	Avera
Natural sand At 7 days At 28 days	930 KN 960	1200 KN 1200	820 KN 100	983.33KN(43.7 MPa) 1053KN(46.8
Robo sand At 7days At 28 days	850 KN 900 KN	900 KN 1050 KN	920 KN 1300	890 KN(39.56 MPa) 1083

V. CONCLUSION

- 100% replacement is reasonable where there is low workability requirement.
- And where there is high workability requirement, partial replacement can be made keeping in view the strength and economy.
- Strength criteria can be fully ascertained with 100% replacement of natural sand with Robo sand.

- For big projects like highways, establishing a plant leads to economy as they require large amount of fine aggregate.
- River beds can be safeguarded by reducing the excavations for natural sand

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