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An Experimental Investigations on Rich mineral Silica (ECOSAND) in Concrete (RMSC)

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***Abstract*—** Rich mineral silica (Ecosand) being waste material generated from manufacture of cement from industry. It can be used to increases efficiency in concrete. An experimental study has been done to achieve high strength concrete using Rich mineral silica (Ecosand) from manufacture of cement as the partial replacement of natural sand (upto 50%) in concrete and studied its mechanical properties .Experimental results are also shows that the compressive strength, flexural strength, splitting tensile strength and structural behaviour of beam of rich mineral silica(Ecosand) and natural sand such that the combination of two aggregate can be increased efficiency in concrete. The combined grading of fine aggregate of tested results shows closest to zone III and zone IV.

***Keywords*—**compressive strength, ecosand, efficiency, normal concrete,Partial replacement.

I. INTRODUCTION

1.1. GENERAL

In its simplest form, concrete is a mixture of paste and aggregates. The paste, composed of Portland cement and water, coats the surface of the fine and coarse aggregates. Through a chemical reaction called hydration, the paste hardens and gains strength to form the rock- like mass known as concrete. Within this process lies the key to a remarkable trait of concrete: it's plastic, malleable and can be shaped when newly mixed, strong, retains shape and durable when hardened. The key to achieving a strong, durable concrete rests in the careful proportioning and mixing of the ingredients. A concrete mixture that does not have enough paste to fill all the voids between the aggregate will be difficult to place and will produce rough, honeycombed surfaces and porous concrete. A mixture with an excess of cement paste will be easy to place and will produce a smooth surface: however, the resulting concrete is likely to shrink more and be uneconomical. A properly design concrete mixture will possess the desired workability for the fresh concrete and the required durability and strength for the hardened concrete. Typically, a mix is about 15 to 20 percent cement, 60to 75 percent aggregate and 5 to 10 percent water. Cement is used in making cement concrete. It is very popular convenient product finding a place in most type of construction.

1.2 BACK GROUND OF THE PROJECT

Cement manufacturing consists of raw meal grinding, blending, pre-calcining, clinker burning and cement grinding. In short, limestone and other materials containing calcium, silicon, aluminium and iron oxides are crushed and milled into a raw meal. This raw meal is blended and then heated in the pre-heating system (cyclones) to start the dissociation of calcium carbonate to oxide. The meal goes further into the kiln for heating and reaction between calcium oxide and other elements to form calcium silicates and aluminates at a temperature up to 1450 oC: so-called clinker burning. The cyclone system is attached to the rotary kiln by a riser duct. Secondary fuel is fed to the riser duct, the main fuel mixture, coal/petcoke, fires the kiln. Reaction products leave the kiln as a nodular material called clinker. The clinker will be inter ground with gypsum and other materials to cement. Limestone is calcareous sedimentary rocks formed at the bottom of lakes and seas with the accumulation of shells, bones and other calcium rich goods. It is composed of calcite ($CaCO_3$). The organic matter upon which it settles in lakes or seas, are preserved as fossils. Over thousands and millions of years, layer after layer is built up adding weight. The heat and pressure causes chemical reaction at the bottom and the sediments turn into solid stone, the limestone. The rock which contains more than 95% of calcium carbonate is known as

high-calcium limestone. Recrystallised limestone takes good polish and is usually used as decorative and building stone. A part of calcium molecules if being replaced by magnesium, it is known as magnesium lime stone or dolomite limestone. Limestone that will take a polish are considered marbles by most people, but technically, if there are still shells visible or the structure is not crystalline, it is still a limestone.

1.3 RICH MINERAL SILICA (ECOSAND)

Limestone, Bauxite ore and iron ore some of the ingredients in manufacture of cement. All these compounds contain silica and hence the composition of silica in cement may go higher. Hence the excess silica is removed using some techniques like "Froth Floatation" which is dumped out as Eco sand. Floatation rejects are very fine particles. So it can be mixed with sand at an optimum level to get a better grading of aggregates. Floatation's reject being waste material in manufacture of cement can be used to increases efficiency in concrete. The Direct replacement of natural sand in

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conventional mix designs used in laboratory has given better results. It has been used replacement percentage of 10% to 50% by weight of fine aggregate and has got improved compressive strength, flexural strength, splitting tensile strength in all the five cases. Experimental study shows that the compressive strength, flexural strength, splitting tensile strength , of Eco sand and natural sand such that the combination of two aggregate can be increased in all the five cases. The grading of aggregate is closest to zone ii or zone iii and zone iv of Eco sand and natural sand for adaptation of that combination in concrete mixes.

II. EXPERIMENTAL INVESTIGATION

2.1CEMENT:

Portland pozzolana cement (fly ash based) conforming to IS: 1489 (part 1) 1991, has been used, it specific gravity 3.15, consistency 39% initial setting time 45 minutes and final setting time 126 minutes.

2.2 AGGREGATES:

i) Fine Aggregate

The physical properties like fineness modulus, specific gravity. Bulk density were studied as per IS: 383-1978, IS: 2386 (part iii)-1963 and the obtained results were as shown in Table 2.1

Table 2.1Physical properties of fine aggregate

Test	Result obtained	As per IS: 383-1978
Fineness modulus	2.53	Fine sand
Specific gravity	2.60	2.55 minimum
Bulk density (Kg/m³)	1600	-

ii) Coarse aggregate

The physical properties of coarse aggregate like fineness modulus ,specific gravity ,bulk density, impact test and crushing strength test were performed as per IS: 383-1978, IS: 2386 (part iii)-1963 and the obtained results were as shown in Table 2.2

Table 2.2 Physical properties of coarse aggregate

Test	Result obtained	As per IS: 383-1978
Fineness modulus	5.0	5 to 7
Specific gravity	2.64	2.6 minimum
Bulk density (Kg/m³)	1580	-
Impact value	32.50	<45%
Crushing value	34.50	<45%

iii) Ecosand

The physical properties like fineness modulus, specific gravity were studied as per IS: 383-1978, IS: 2386 (part iii)-1963 and the obtained results were as shown in Table 2.3.Chemical properties are shown in table 2.4 and Comparison of chemical properties cement, limestone, Ecosand

Table 2.3 Physical properties of Ecosand

Type of aggregate	Bulk specific gravity (SSD*)	Water Absorption capacity (%)	Fineness modulus
Ecosand	2.62	2 %	0.92

Table 2.4 Chemical properties of Ecosand

Properties	Percentage
Lime (CaO)	28.30%
Silica (SiO_2)	46.10%
Alumina (Al_2O_3)	3.10%
MgO	0.4%
Fe_2O_3	1.10%
Moisture	5.80%
Loss On Ignition (LOI)	15.20%(other mineral oxides)

Table: 2.5 Requirement of fine aggregate as per IS: 383 - 1970(Reaff. 2002)

IS sieve Designation in mm	Percentage passing for graded aggregate of nominal size			
	40 mm	20 mm	16 mm	12.5 mm
80	100	-	-	-
63	-	-	-	-
40	95 - 100	100	-	-
20	30-70	95 - 100	100	100
16	-	-	90 - 100	-
12.5	-	-	-	90 -100
10	10 - 35	25 - 5	30 - 70	40 - 85
4.75	0 - 5	0 - 10	0 - 10	0 -10
2.36	-	-	-	-

IS sieve Designation	Percentage passing			
	Zone I	Zone II	Zone III	Zone IV
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	90-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	36-70	55-90	75-100	90-100
600 micron	15-34	35-90	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15
Remarks	Very coarse	Coarse	Medium	Fine

SIEVE ANALYSIS OF FINE AGGREGATE

As per the IS, the grading limits for combined coarse aggregate. Larger the size of the aggregate, higher the strength of the concrete. Consumption of the cement is less; but larger sizes affect the workability. Therefore, the most common size in use for concrete is 20 mm.In case two or more nominal size(some times 20 mm and 12.5 mm coarse aggregate are mixed to have better graded aggregate) with varying grading gre used they should be combined in the proportions to achieve the grading pattern given below. For sand, generally fineness Modulus (FM) is calculated as shown in table2.7. Typical range is from 2.2 to3.2 higher value indicates coarser grading.

The usefulness of FM is in detecting slight variations from same source and its effect on workability as shown below in Table 2.6

Table 2.6 Requirement of graded coarse aggregate of nominal size

Table 2.7 Test result of fineness modulus of fine aggregate (Ecosand + natural sand)

MIX DESIGN OF CONCRETE

The common method of expressing the proportions of ingredients of a concrete mix is in the terms of parts or ratios of cement, fine and coarse aggregates. For e.g., a concrete mix of proportions 1:1.5:3 means that cement, fine and coarse aggregate are in the ratio 1:1.5:3 or the mix contains one part of cement, one and half parts of fine aggregate and three parts of coarse aggregate. The proportions are either by volume or by mass. The water-cement ratio is usually expressed in mass.

III. TEST, RESULT AND DISCUSSION

3.1. Workability of concrete

The degree of workability required depends on three factors. These are the size of the section to be concreted, the amount of reinforcement, and the method of compaction to be used. For the narrow and complicated section with numerous corners or inaccessible parts, the concrete must have a high workability so that full compaction can be achieved with a reasonable amount of effort. This also applies to the embedded steel sections. The desired workability depends on the compacting equipment available at the site

Concrete mix ratio details

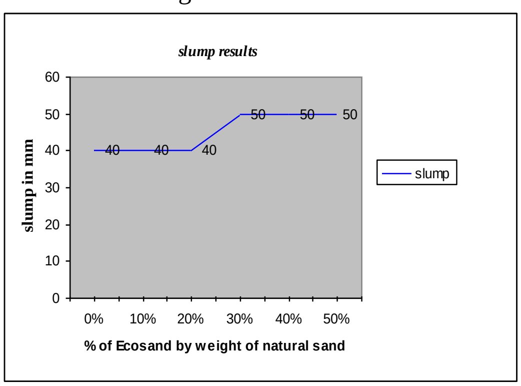
Mix M20	Target cube compressive strength (MPa)	Mix ratio by weight (cement: sand: Eco sand: coarse agg.)	w/c ratio by weight
A	26.60	1 : 1.465 : 0.000 : 3.247	0.50
B	26.60	1 : 1.318 : 0.146 : 3.247	0.50
C	26.60	1 : 1.172 : 0.293 : 3.247	0.50
D	26.60	1 : 0.969 : 0.415 : 3.355	0.50
E	26.60	1 : 0.830 : 0.554 : 3.355	0.50
F	26.60	1 : 0.692 : 0.692 : 3.355	0.50

Workability of concrete

Percentage of Ecosand	Slump (mm)	Compaction factor
0%	40	0.85
10%	40	0.85
20%	40	0.85
30%	50	0.86
40%	50	0.86
50%	50	0.86

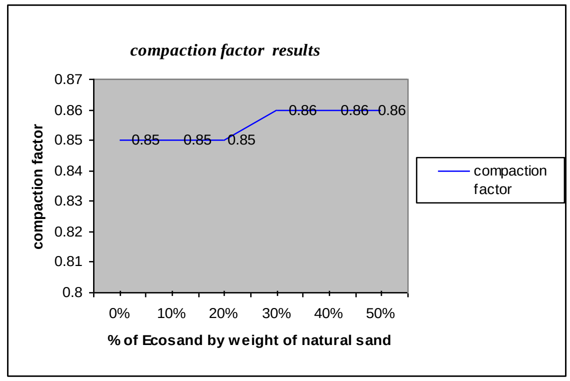
3.2 Slump Test

Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It is not suitable method for very wet or very dry concrete. It does not measure all factors contributing to workability, nor it always representative of the placeablity of the concrete. However, it is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch. The result obtained from the slump test for all the 6 mixes are shown in the table 4.1. The apparatus for conducting the slump test essentially consists of a metallic mould in the form of a frustum of a cone having the internal dimension as under:



3.3 Compaction factor

The compacting factor is one of the most efficient tests for measuring the workability of concrete as per IS: 1199-1959. It is the most precise, sensitive and particularly useful for concrete mixes of very low workability as are normally used. The workability of fresh concrete is expected to be mild.



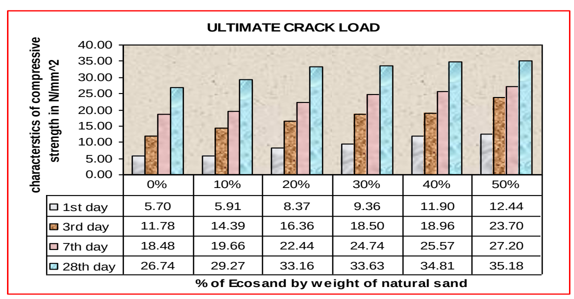
3.4 Compressive strength

The compressive strength is a measure of the concrete's ability to resist loads which tend to crush it. The compressive strength was conducted on the cubes of size 150mm³ were tested as per IS: 516-1959 specifications. The density of the specimens was also determined at the same time. The cubes were tested for compressive strength at 1st day of after 24 hours demoulded and 3rd day, 7th day, 28th day of different curing time and the value of the test result are shown in the below figures: 4.9 to 4.14,4.15,4.16

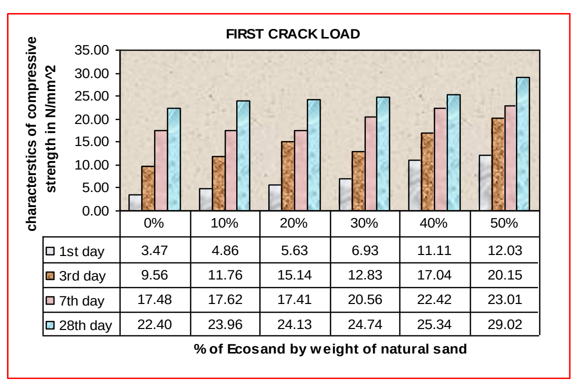
3.5 Calculation for cube compressive strength:

Stress = load / area of cube

Cube compressive strength of concrete for UCL

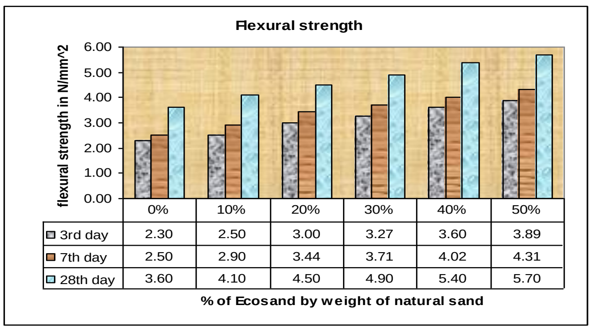


Cube compressive strength of concrete for FCL



3.6 Flexural strength of concrete

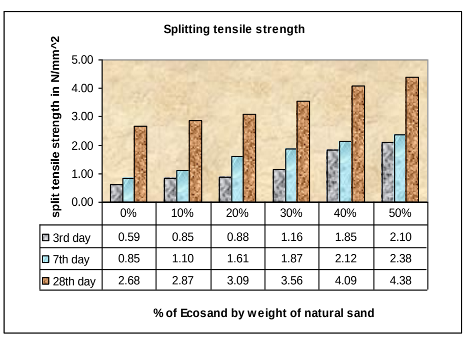
Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by loading 100mm x 100 mm concrete beam with a span length of 500mm. the flexural strength is expressed as modulus of rupture (MR) in MPa. Flexural modulus of rupture is about 10 to 20 percent of compressive strength depending on the type, size and volume of coarse aggregate used. However the bests correlation for specific materials is obtained by laboratory test for given materials and mix design. The MR determined by third point loading is lower than MR determined center point loading, sometimes as much as 15%. The test for flexural strength has been carried out using third point loading.



Flexural strength results

3.7 Splitting tensile strength

To find out the tensile strength, 150mm diameter and 300 mm length cylinder were casted. Indirect tensile test or Brazilian test or Split cylinder test method of finding the tensile strength of concrete. It is easy to perform and gives more uniform strength than direct tension test. The specimen is loaded horizontally between the loading surfaces of the compression testing machine and is loaded until the failure of the cylinder.

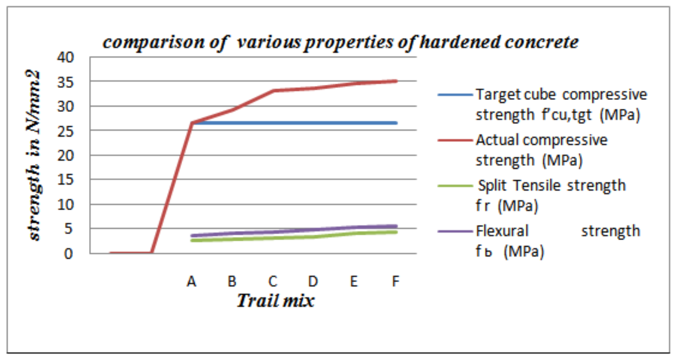


Splitting tensile strength results

IV. VARIOUS PROPERTIES OF HARDENED CONCRETE

Table: 4.1Various properties of hardened concretes

Mix	Target cube compressive strength $f'cu,tgt$ (MPa)	Actual compressive strength (MPa) Cube fcu	Split Tensile strength fr (MPa)	Flexural strength fb (Mpa)	Ratio (fcu / $f'cu,tgt$)
A	26.60	26.74	2.68	3.60	1.005
B	26.60	29.27	2.87	4.10	1.100
C	26.60	33.16	3.09	4.50	1.247
D	26.60	33.63	3.50	4.90	1.264
E	26.60	34.81	4.09	5.40	1.309
F	26.60	35.18	4.38	5.70	1.322
Mean					1.208
Standard deviation					0.166



V. CONCLUSION

The following conclusions are drawn within the limitation of the experimental investigation.

1. Eco sand being industrial by product can be used as partial replacement of fine aggregate in concrete.
2. The combined grading of fine aggregate confirms better packing pattern
3. The cube compressive strength, cylinder split tensile strength, prism flexural strength obtained by using the combination of fine aggregate and Eco sand gives a higher value up to 50%.
4. Low frictional resistance of Eco sand will increase the workability of concrete and hence will reduce admixture requirement
5. The low rates of these industrial by product and also increase in rate of sand day by day shows that usage of these material will prove cheaper.
6. The low rates of these industrial by product and also increase in rate of cement day by day shows that usage of these materials the cement content it may be reduced.
7. The ultimate load carrying capacity of beam with 30% replacement of Ecosand by weight of natural sand higher than that of without Ecosand reinforced concrete beam in flexure test.

8. In all the tests failure of the beams occurred by yielding of the steel in the tensile zone.
9. Increasing level of Ecosand produce increased resistance of cracking.
10. Ecosand solved the disposal problems of these materials at madukkari plant in coimbatore.
11. Ecosasnd reduces consumption of natural sand by up to 50% and hence reduces ecological footprint.

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