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Experimental Investigation of Eco Sand in Concrete

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Abstract

Eco sand is a cost effective Eco friendly alternative to traditional sand used in construction. It is finely powdered crystalline silica which can replace conventional sand usage in concrete and mortars. Eco sand ensures a comparatively denser concrete and mortar than those made with conventional sand. An experimental study has been done to achieve high strength concrete using Rich mineral silica (Eco sand) from manufacture of cement as the partial replacement of natural sand (upto30%to 60%) in concrete and studied its mechanical properties and the Experimental results are also shows that the compressive strength.

Keywords: Eco sand (silica sand) partial replacement of river sand by different ratio in structural concrete.

1. INTRODUCTION

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, 60 to 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.

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1.1.Objectives

The main objective of our project is to make a comparative study on the compressive strength, flexural strength, splitting tensile strength of conventional concrete and the concrete in which the fine aggregate is replaced with eco sand. For, this we are using eco sand collected from the cement industries and using it to cast cubes ,cylinders and beams.

In this project, we are replacing the natural sand by 0%, 30%, 40% ,50% ,60% of its weight by the eco sand and compressive strength, flexural strength, splitting tensile strength are to be compared with conventional concrete at 7days, 28days, and 90days of curing. The primary objective of this investigation is to study experimentally the compressive strength, flexural strength, splitting tensile strength of conventional concrete and concrete with eco sand as fine aggregate.

1.2. Need for present this project

Same which is the ingredients for concrete has become scare due to over mining and government regulations. Same time abundant amount of Eco sand are available from the cement industries, if the natural sands are available is very demand that times we go for Eco sand. In this project, sand is replaced by Rich mineral silica (Eco sand) to salve the above problems.Aggregates in the Eastern Province (Type-N) and light-weight pozzollanic aggregates (Type-P) indicated that addition of CKD to cement results in significant gain in strength of the blocks.

2. EXPERIMENTAL INVESTIGATION

2.1.Cement

Ordinary Portland cement 43 conforming to IS: 8112 1989, has been used, it specific gravity 3.15, consistency 39% initial setting time 45 minutes and final setting time 126 minutes.

2.2. Aggregates

2.2.1. 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 1.

Table 1. Physical 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	-

2.2.2. 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.

Table 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%

2.3.Ecosand

2.3.1.Physical Properties of Limestone

Physically, Lime stones are quite impervious, Hard, Compact, fine to very fine grained calcareous rocks of sedimentary nature.

Table 3. Physical Properties of Limestone

Properties	Percentage
Hardness	3 to 4 on Moh's Scale
Density	2.5 to 2.7 Kg/cm^3
Compressive Strength	60-170 N/mm^2
Water Absorption	Less than 1%
Porosity	Quite low
Weather Impact	Resistant

2.3.2.Chemical properties of lime stone

Chemically, they are calcareous rocks principally of calcic minerals with minor amounts of alumina, ferric & alkaline oxides.

Table 4. Chemical properties of lime stone

Properties	Percentage
Lime (CaO)	38-42%
Silica (SiO_2)	15-18%
Alumina (Al_2O_3)	3-5%
MgO	0.5 to 3%
$FeO + Fe_2O_3$	1-1.5%
Alkalies	1-1.5%
Loss On Ignition (LOI)	30-32%

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 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.

Table 5. Comparison of chemical properties of cement, limestone, Ecosand

Properties	Cement %	Limestone %	Ecosand %
Lime (CaO)	60-67	38-42	28.30
Silica (SiO_2)	17-25	15-18	46.10
Alumina (Al_2O_3)	3.0-8.0	3.0-5.0	3.10
MgO (Magnesium Oxide)	0.1-4.0	0.5-3.0	0.40
Fe_2O_3 (Iron Oxide)	0.5-0.6	1.0-1.5	1.10
Loss On Ignition (LOI)	-----	30-32	15.20
Alkalies	0.4-1.3	1.0-1.5	-----
So_3	1.3-3.0	-----	-----

Table 6. Physical properties of Ecosand

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

Table 7. Chemical properties of Eco sand

Properties	Percentage
Lime (CaO)	28.30%
Silica (SiO_2)	46.10%
Alumina (Al_2O_3)	3.10%
MgO	0.40%
Fe_2O_3	1.10%
Moisture	5.80%
Loss On Ignition (LOI)	15.20%(other mineral oxides)

4. Mix proportions

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in 2 states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance. The compressive strength of hardened concrete which is generally considered to be an index of its other properties, depends upon many factors, e.g. quality and quantity of cement, water and aggregates; batching and mixing; placing, compaction and curing. The cost of concrete is made up of the cost of materials, plant and labour. The variations in the cost of materials arise from the fact that the cement is several times costly than the aggregate, thus the aim is to produce as lean a mix as possible. From technical point of view the rich mixes may lead to high shrinkage and cracking in the structural

concrete, and to evolution of high heat of hydration in mass concrete which may cause cracking.

Table 8. Mix Design details

Grade M 30	Cement Type	Cement	Sand	% of sand	Eco sand	% of Eco sand	CA	CA 40% 12.5 mm	Water	Density
1	OPC	444.44	765.494	100	0	0	1079.42	1079.42	200	2289.354
2	OPC	444.44	535.84	30	222.64	30	1079.42	1079.42	200	2289.354
3	OPC	444.44	459.297	40	303.870	40	1079.42	1079.42	200	2289.354
4	OPC	444.44	382.747	50	379.847	50	1079.42	1079.42	200	2289.354
5	OPC	444.44	306.225	60	455.817	60	1268.19	507.28	189	2289.354

5. OBSERVATION

5.1.Slump Cone Test

The slump test is most commonly used method of measuring consistency of concrete. The apparatus for conducting the slump test essentially consists of a metallic mould in the form of frustum of a cone having the internal dimensions are 20cm bottom diameter, 10cm top diameter, 30cm height.

Table 9. Workability of concrete

Percentage of Ecosand	Slump (mm)
0%	40
30%	40
40%	40
50%	50
60%	50

5.2. Compression test

As per IS 9013:1978 compression test was carried out on cube specimen. The compression test is carried out on specimens cubical in shape. The cube specimen is of the size10 x10 x 10cm. Cylindrical test specimens have a length equal to twice the diameter. Smaller test specimen may be used but a ratio of the diameter of the specimen to maximum size of aggregate, not less than 3 to 1 is maintained. Compressive strength at 7 ,28 and 90 days was found out. From the experimental result compressive strength of concrete was found. Variations of the compressive strength also shown in the table from the maximum compressive strength.

Table 10. Compressive strength details

Mix M30	% of Eco Sand Replacement	Compressive Strength 7^{th} day N/mm^2	Compressive Strength 28^{th} day N/mm^2	Compressive Strength 90^{th} day N/mm^2
1	0%	26.6	32.60	36.0
2	30%	24.66	31.66	35.60
3	40%	24.88	31.00	34.56
4	50%	24.12	30.00	33.43
5	60%	23.55	29.00	32.22

5.3. Split tensile test

The cylindrical specimens were tested for split tensile strength at an age 7, 28, and 90 days. The maximum load applied was then recorded. Any un usual type of failure was noted. The size of the specimen is 10cm diameter and 20cm height. From the experimental result tensile strength of concrete was found. Variations of the split tensile strength also shown in the table will give the maximum tensile strength.

Table 11. Split tensile strength details

Mix M30	% of Eco Sand Replacement	Splitting Tensile Strength 7^{th} Day N/mm^2	Splitting Tensile Strength 28^{th} Day N/mm^2	Splitting Tensile Strength 90^{th} Day N/mm^2
1	0%	2.08	3.80	4.12
2	30%	2.10	3.18	3.50
3	40%	1.67	3.18	3.42
4	50%	1.50	3.18	3.33
5	60%	1.30	2.80	3.23

5.4 Flexural strength

The beam specimen were tested for flexure strength at the end of 28 days. The specimen size was 10 x 10 x 20cm.The axis of specimen carefully aligned with the axis of the loading. The load was applied without shock and increasing continuously. The load was increased until the specimen failed and the maximum load applied to the specimen was recorded. Unusual fractures were recorded. From the experimental result flexural strength of concrete was found. Variations of the flexural strength also shown in the table will give the maximum flexural strength.

Table 12. Flexural strength details

Mix M30	% of Eco Sand Replacement	Flexural Strength 7^{th} Day N/mm^2	Flexural Strength 28^{th} Day N/mm^2	Flexural Strength 90^{th} Day N/mm^2
1	0%	1.37	2.10	3.50
2	30%	1.10	2.00	3.25
3	40%	0.98	1.87	3.22
4	50%	0.82	1.80	3.12
5	60%	0.71	1.60	3.23

5.5.Durability test

5.5.1.Acid test

Test carried out according to ASTM G20-8 to obtain weight loss of different type of concrete. From the result it will be observed that weight loss. And comparing the to the conventional concrete and Eco sand partialy mixed concrete . Compressive strength after acid attack was shown in Table 13.

Table 13. Durability for acid attack

Mix M30	% of Eco Sand Replacement	Durability test (HCL)			Compressive Strength 30 day(MPa)	Compressive Strength 60 day(MPa)
		Before weight(kg)	After weight(kg)	%of loss of weight		
1	0%	2.654	2.569	3.2	26.45	32.76
2	30%	2.756	2.651	3.8	24.47	31.67
3	40%	2.976	2.851	4.2	24.34	31.45
4	50%	2.542	2.425	4.6	24.76	30.43
5	60%	2.643	2.409	5.0	23.45	29.34

5.5.2.Sulphate test

Test carried out according to ASTM G20-8 to obtain weight loss of different type of concrete. From the result it will be observed that weight loss is nearly equal for conventional HPC and quarry dust HPC also same as with steel fibre concrete. Quarry dust and silica fume are the substance which has good resistance to sulphate. So that sulphate test on quarry dust HPC will shows the good result. From the result we can found that sulphate attack in quarry dust concrete will be very less after long durability. Compressive strength after sulphate attack was shown in Table 14.

Table 14. Durability for sulphate attack

Mix M30	% of Eco Sand Replacement	Durability test (SULPHATE)			Compressive Strength 30day(MPa)	Compressive Strength 60 day(MPa)
		Before weight(kg)	After weight(kg)	%of loss of weight		
1	0%	2.678	2.671	0.25	26.33	32.54
2	30%	2.580	2.570	0.37	24.23	31.32
3	40%	2.550	2.535	0.55	24.12	31.56
4	50%	2.600	2.584	0.60	24.34	30.34
5	60%	2.610	2.593	0.64	23.56	29.76

5.5.3.Alkaline test

Test carried out according to ASTM G20-8 to obtain weight loss of different type of concrete. From the result it will be observed that weight loss is nearly equal for conventional HPC and quarry dust HPC also same as with steel fibre concrete. Quarry dust and silica fume are the substance which has good resistance to alkaline. So that alkaline test on quarry dust HPC will shows the good result. From the result we can found that alkaline attack in quarry dust concrete will be very less after long durability. Compressive strength after alkaline attack was shown in Table 15.

Table 15. Durability for alkaline attack

Mix M30	% of Eco Sand Replacement	Durability test (NAOH)			Compressive Strength 30 day(MPa)	Compressive Strength 60 day(MPa)
		Before weight(kg)	After weight(kg)	%of loss of weight		
1	0%	2.564	2.551	0.50	26.56	32.43
2	30%	2.876	2.858	0.60	24.83	31.34
3	40%	2.554	2.534	0.75	24.28	31.98
4	50%	2.342	2.323	0.80	24.56	30.78
5	60%	2.654	2.631	0.85	23.87	29.67

6. 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. Increasing level of Ecosand produce increased resistance of cracking.
9. Eco sand solved the disposal problems of these materials at madukkari plant in coimbatore.
10. Eco sand reduces consumption of natural sand by up to 50% and hence reduces ecological footprint.

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