Optimization of Partial Replacement of Fly Ash with Cement and Fine Aggregate with Eco Sand in Normal Concrete

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Abstract: ***Eco sand is a very fine particle, which is a by-product from the cement manufacturing industry by semi-wet process and it can be a good alternative for natural river sand. Due to its very finely powdered crystalline silica particles present in that which can replace up to 50% of conventional sand usage in concrete and mortars. It can be used in the concrete by replacement of fine aggregates by a certain percentage which gives much more efficiency. In this paper, the hardened properties like cube compressive strength, cylinder split tensile strength, and prism flexural strength are studied with various replacements cement with fly ash like 0 % and 30% and sand with eco sand-like 0%,30%,40%,50% and 60%. The results are compared with conventional concrete specimens. Experimental results also show that the hardened properties of concrete are increased by a certain amount when compared with the normal placed concrete specimens. During the study Due to replacement of fine aggregate with eco sand for workability conditions by some amount of chemical admixtures have been added.***
Keywords : Ecosand, Compressive strength, Flyash

I. INTRODUCTION

A. General

Generally concrete is the most consuming material in worldwide in the construction field. Nowadays production of cement goes on decreasing due to the shortage of raw materials. Many researchers found different materials for the replacement of cement in the concrete like fly ash, silica fume, GGBS, stone dust, rice husk ash, etc., Usage of mineral admixture in concrete gives more advantage in construction field mainly due to the advantage of cost and energy saving, protection of environment and conservation of resources. The fly ash is the most commonly used mineral admixtures used in the concrete where it is available in huge amount of quantities in many countries. In this study we considered fly ash as one of replacement material for the cement. Aggregate occupies almost of the 75% volume in concrete. Therefore we tried to replace the fine aggregates with waste material as eco-sand. The Eco sand is the product obtained during the cement manufacturing process and this material have a property of fine particles and it can be replaced with natural sand. Eco sand has been collected from ACC cements, madukarai, near Coimbatore. The main important constituent of the eco sand is crystalline silica white in colour. Eco sand has been tested in a laboratory and the safe against limits of deleterious materials and soluble silica for alkali-aggregate reactivity as per IS 383 are found. Eco sand ensures a comparatively denser concrete than those made only with natural sand or quarry fines. In this paper, we found the material properties for cement, aggregates, water, fly ash and eco sand are tabulated. During the study hardened properties and workability properties are studied with various replacements cement with fly ash like 0 % and 30% and sand with eco sand-like 0%, 30%, 40%, 50% and 60%. The results are compared with conventional concrete specimens.

B. Flyash:

Flyash which is a byproduct material obtained from coal combustion in thermal power plants. It is a very fine particle substance which can be replaced in the production of Portland cements. Due to the property of pozzalon, flyash can be utilized in a large amount of percentage in all over the world. Most of the flyash are disposed in landfills, ponds,etc., In India, high percentage of flyash is used in the concrete. Due to the property of fine particle, it is replaced with cement in manufacturing of concrete in about 30-60%.

C. Ecosand:

Eco sand is manufactured sand and it's a substitute of river sand for construction purposes, ecosand are produced from hard granite stone by crushing process. The eco sand is in a cubical shape with grounded edges, washed and graded to as a construction material. It is manufactured from cement industry through wet process. It is a very fine particle, which fills the micro pores in the concrete and provides better moisture resistivity and thus durability. Different test has been conducted for eco sand to find the better replacement for fine aggregate.

II. METHODOLOGY

M30 and M40 grades of concrete are taken for study. cement with flyash like 0% and 30% and sand with eco sand like 30%,40%,50% and 60%. The specimens are casted to test the various hardened properties and workability properties of concrete. The cement, fine aggregate, coarse aggregate are tested for properties testing and are tabulated.

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I. MATERIALS AND METHODS:

The material used for this experimental work is cement, sand, water, flyash, and Ecosand.

A. Cement:

Ordinary Portland cement purchased from local store has been commonly used for concrete in preparing specimens where there is no special durability requirement (such as exposure to sulphate attack) are not required. In the study OPC of 53 grade was used.

Table A. Properties of Ordinary Portland cement

Physical properties	Values	Permissible range
Specific gravity	3.14	3.10-3.15
Normal consistency	31	30-35
Initial setting time(min)	37 min	30 minimum
Final setting time(min)	570 min	600 maximum

B. Fine Aggregates:

Mostly river sand passing through 4.75mm sieve is accepted as fine aggregate and it is used. Various Physical properties of fine aggregates are determined per IS 2386-1968 and the results are given in table B

Table B. Properties of river sand

Properties	Values
Specific gravity	2.58
Fineness modulus	2.87

C. Coarse Aggregates:

Coarse Aggregate passing through 20mm sieve and retained in 10mm sieve. The results are given in the table C

Table C. Physical properties of coarse aggregates

Physical properties	Values
Specific gravity	3.09
Fineness modulus	6.4

D. Flyash:

Flyash which is a byproduct material obtained from coal combustion in thermal power plants available in a plenty. It is a very fine particle substance which can be replaced in the production of Portland cements. Mineral admixture used here is flyash which has been collected from nearby thermal plants. From the test results, the specific gravity and specific area of the fly ashes are 2.10 and 380(m^2/kg) respectively.

The chemical properties of FA obtained from thermal power plant are given in the table D.

Table D. Chemical properties of Flyash:

Chemical properties min% by mass	**IS:3812-1981**
$SiO_2+Al_2O_3+Fe_2O_3$,	70
SiO_2	35
CaO	5
SO_3	2.75
Na_2O	1.5
L.O.I	12
MgO	5

G. Mix Design

E. Ecosand:

Eco sand has been collected from ACC Cement, Madukarai, Coimbatore and it has been tested in the laboratory, the results are obtained for the clay particles present in the material and limits of deleterious materials are found. Dry and wet samples are tested and found that silica particles are found in the sample. The main component of the eco sand is crystalline silica. It is crystalline white in color.

Table E.1. Physical properties of Eco sand

Property	Eco sand
Specific gravity	2.35
Loose density	1460Kg/m3
Compacted density	1610Kg/m 3
Fine modulus	2.2
Grading zone	IV

Table E.2. Chemical Composition of Eco sand

Constituent	Composition (%)
Silica(SiO2)	58-60
Alumina(AL2O3)	2-3
Iron content	1-3
Magnesium oxide(MgO)	0.4-1
Calcium oxide(CaO)	20-25

F. Water:

Water used for this experimental study is tap water available in the college and having an pH value of range from 6.8-7.2 and conforming to the specifications of IS456-2000 is used for concreting as well as curing of the specimens.

Table G.1. Mix proportions for M_{30} mixes

Mix	Water Kg/m ^{3}	W/C Ratio	Cement Kg/m^3	Fly Ash Kg/m^3	Eco sand Kg/m^3	Fine Aggregate Kg/m ^{3}	Coarse Aggregate Kg/m^3
F0 ,E0	197	0.40	438	0	0	663	1256
F30,E30	197	0.40	306.6	131.1	198.9	464.4	1256
F30,E40	197	0.40	306.6	131.1	265.2	397.8	1256
F30,E50	197	0.40	306.6	131.1	331.5	331.5	1256
F30,E60	197	0.40	306.6	131.1	397.5	265.2	1256

Table G.2. Mix proportions for M40 mixes

Mix	Water Kg/m 3	W/C Ratio	Cement Kg/m 3	Fly Ash Kg/m3	Eco sand Kg/m3	Fine Aggregate Kg/m 3	Coarse Aggregate Kg/m3
F0,E0	197	0.40	280	0	0	812	1120
F30,E30	197	0.40	196	84	243.6	568.5	1120
F30,E40	197	0.40	196	84	324.9	487.2	1120
F30,E50	197	0.40	196	84	406	406	1120
F30,E60	197	0.40	196	84	568.5	243.6	1120

III. TESTING METHODS:

A. Preparation of the specimen:

Moulds for casting specimen for strength study are cast iron. The oil is applied on the inner surface of the moulds of cubes and cylinders. Concrete was mixed in a concrete mixer. Each beam together with cubes and cylinders were cast from the same batch of concrete .The specimens for strength study like cubes, cylinder and prism are compacted using table vibrator. The test specimens were cured for 7days, 14days, 28 days, in curing tanks.

Table A. Types of Tests and Specimen Sizes

S.NO	Properties studied	Specimen	Specimen size (mm)
1	Compressive strength	Cube	150 x 150 x 150
2	Split tensile strength	Cylinder	150 x 300 ht
3	Flexural strength of concrete	Prism	100 x 100 x 500

B. Compressive strength:

Casting: The concrete prepared was filled into the mould in layers approximately 5cm deep and each layer was compacted by using table vibrator after the top layer was smoothly finished by using a trowel. The cast specimens are shown from fig B.1 to B.3

Curing: The casted specimens were demoulded after 24 hours and cured for 7, 14, and 28 days in curing tank. After curing period, the specimens were kept for drying and tested.

Testing: specimens were placed in the 2000kN capacity of compression testing machine and the load was applied to the opposite side of the cubes as cast, that was not at the top and bottom, the axis of the specimen was carefully aligned of the testing machine. The load was applied gradually until the specimens cracked and break down. The maximum load applied to the specimens was recorded and appearances of the cracks are noted. Mostly compressive strength results are compared with other strength properties.

Fig B. Casting of cube specimens

Fig B.1: Curing of Cube specimens

Fig B.2: Testing of Cube in UTM Machine

Fig B.3. Reading from UTM Machine

C. Split tensile strength:

The split tensile strength of concrete is determined by casting, curing and testing cylinder at the age of 28days. For the studies on split tensile strength, cylinders are tested with flyash replacements of 0% and 30% & ecosand replacement with 30%, 40%, 50%and 60% of fine aggregate. For each replacements three cylinders are casted and tested.

Casting: The concrete was filled into the mould in layers and each layer was compacted by using table vibrator after the top layer was smoothly finished by using a trowel.

Curing: The casted specimens were demoulded after 24 hours and placed under cured for 28,days in curing tank. After curing period, the specimens were kept for drying and then tested using CTM 2000kN capacity.

Testing: The test was carried out by placing a 150mmX 300 mm size cylindrical specimen placed horizontally between the top plate and bottom plate on the loading surfaces of a compression testing machine. The load was applied on the cylinder specimen until it failures i.e., getting splitted along the vertical diameter. The experimental set up of split tensile strength test is shown fig C.1.

Fig C.1: Split tensile strength test

Flexural strength:

The prism is casted to find the flexural strength of concrete and initial cracks are observed and noted. The prism is casted and tested after 28 days curing. Here replacement of 30%, 40%, 50%and 60% of mass of fine aggregate with Eco sand are used for the experimental work. And for each replacement three prisms are casted and tested. The results obtained are tabulated

Casting: The concrete was filled into the mould in layers and each layer was compacted by using table vibrator after the top layer was smoothly finished by using a trowel. The cast of prism specimens are shown fig D.1.

Curing: The casted specimens were demoulded after 24 hours and cured for 28days in curing tank. After curing period, the specimens were kept for drying and tested.

Testing: The flexural test was carried out on 100mm X 100mm X 500mm size prism. Basically flexural test will conducted in larger size on beams, but smaller beams like prism can be conducted for finding out flexural property. The flexural test was conducted out on a UTM, based on two point load. The loose particles present in the rollers are wiped out and the specimen is placed over there. The flexural strength gives flexibility about the specimen and it shows that load carrying capacity of the specimen. The load applied on the specimen and it was gradually increased so that a initial cracks appear on the surface of the specimen and further increasing the specimen fails. A crack developed on the specimen is measured for further study. The experimental set up is shown fig D.2

Fig D.1: Casting of Prism Specimens

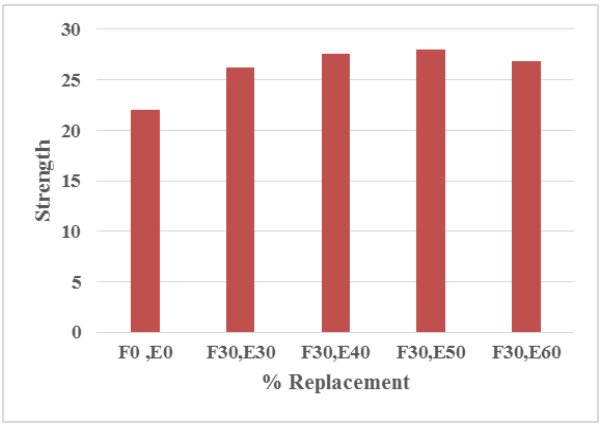
Fig D.2: Test setup for Prism

IV. RESULTS AND DISCUSSION

To determine the hardened properties of concrete standard tests like compression test on cubes for compressive strength, split tensile test on cylinders for tensile strength and flexural test on beams for flexural strength of concrete were carried out at 28days of curing. The test results are compared with M30 and M40 grade concrete and results are shown in table.

A. Compressive strength:

For compressive strength test, cube specimens of dimensions 150 x 150 x 150 mm were cast for M30 and M40 grade of concrete and test results are shown that replacement gives better results.



FigA.1: 7days strength, M30 Grade

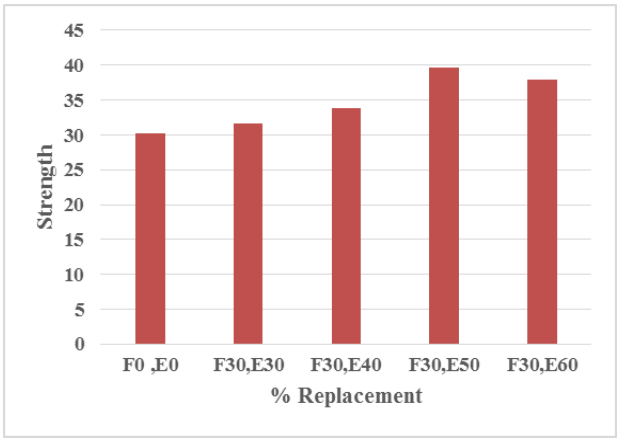


Fig A.2: 28 days compressive strength, M30 Grade

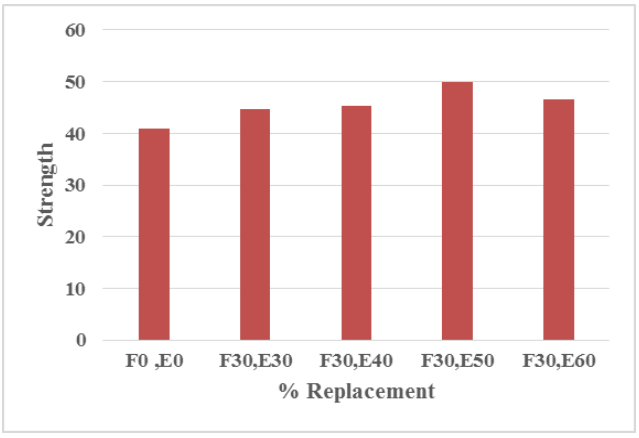


Fig A.3: 28 days compressive strength, M40Grade

Table A.1 Compressive strength-cube M30 mix (MPa)

Specimen	Replacement % (Flyash)	Replacement % (Ecosand)	7 days Mpa	14 days Mpa	28 days Mpa
F0 ,E0	0	0	22.07	26.67	30.22
F30,E30	30	30	26.18	28.70	31.65
F30,E40	30	40	27.53	28.98	33.89
F30,E50	30	50	27.98	29.08	39.64
F30,E60	30	60	26.80	28.77	37.84

Table A.2 Compressive strength-cube M40 mix (MPa)

Specimen	Replacement %(Flyash)	Replacement %(Ecosand)	7 days Mpa	14 days Mpa	28 days Mpa
F0 ,E0	0	0	31.58	36.8	40.87
F30,E30	30	30	35.9	37.47	44.74
F30,E40	30	40	36.01	39.52	45.32
F30,E50	30	50	38.6	39.96	49.98
F30,E60	30	60	37.67	38.32	46.63

B. Split tensile strength:

The split tensile strength test on cylinders showed that 30% flyash replacement with cement and 50% eco sand replacement with fine aggregate gives better results when compared to conventional concrete specimens.

Table B.1: Split Tensile Strength (cylinder)

Specimens	Replacement % (Flyash)	Replacement % (Ecosand)	28 days Mpa (M_{30})	28 days Mpa (M_{40})
F0 ,E0	0	0	5.28	5.99
F30,E30	30	30	5.35	6.09
F30,E40	30	40	5.49	6.43
F30,E50	30	50	5.98	6.92
F30,E60	30	60	5.56	6.14

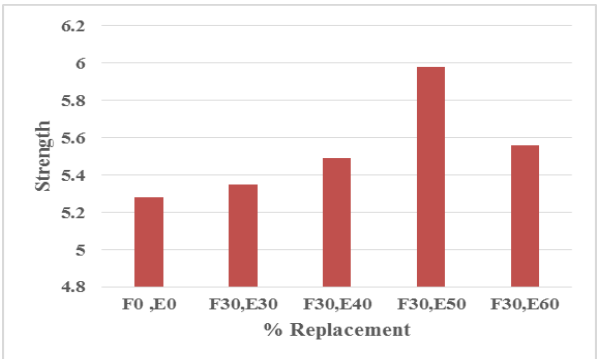


Fig B.1: 28 days split tensile strength, M30 Grade

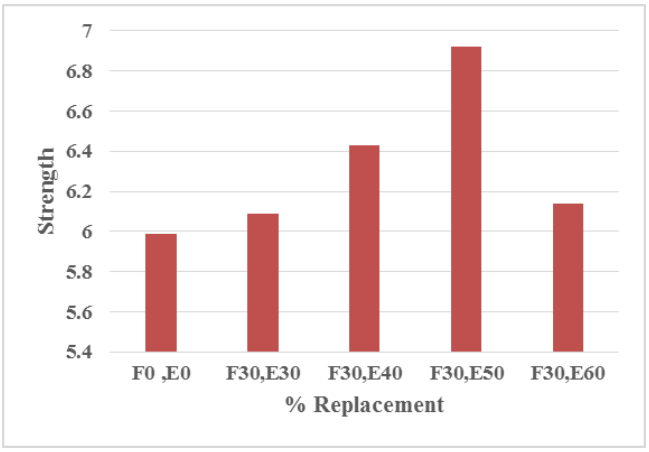


Fig .B.2: 28 days split tensile strength, M40 Grade

C. Flexural strength:

The flexure performance of is also showed that 30% flyash and 50% eco sand replacement gives better strength when compared to Conventional concrete.

Table C: Flexural Strength (Prism)

Specimens	Replacement % (Flyash)	Replacement % (Ecosand)	28 days Mpa (M_{30})	28 days Mpa (M_{40})
F0 ,E0	0	0	5.17	5.8
F30,E30	30	30	5.25	5.97
F30,E40	30	40	5.89	6.23
F30,E50	30	50	5.9	6.67
F30,E60	30	60	5.6	6.39

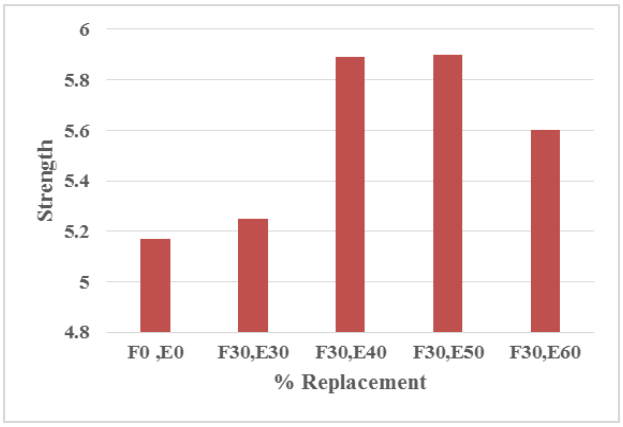


Fig C.1: 28 days flexural strength, M30 Grade

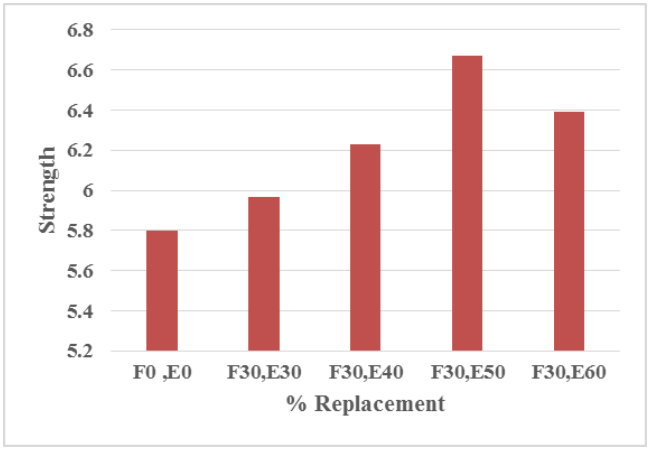


Fig C.1: 28 days flexural strength, M40 Grade

V.CONCLUSION:

By this experimental study, results have found that it shows that flyash and ecosand are better replacement of cement and fine aggregate by certain amount. The results against hardened properties of the replaced concrete are compared with normal concrete. Both M30 and M40 grade concrete shows better results and other properties of the concrete are also satisfied. The usage of waste materials gives solution to disposal problem of waste materials. It was also found that increase in replacement level of Eco sand above 50% decreases the workability of concrete. Eco sand was behaving as normal sand when in its maximum replacement ie.50%.When cement and fine aggregate replacement was at minimum level concrete was in a good compacted mode and workability conditions are also suited, but when the replacement percentage is increased there will be water absorption in the concrete which reduces the workability factors. Finally by the result it shown that optimum percentage was found to be 50%. When using these optimum percentages together, gives much more results compared with the conventional concrete and also gives economical consideration in saving materials upto 40%.

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