

EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF CEMENT AND SAND BY USING METAKAOLIN AND ECO SAND IN CONCRETE

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Abstract— The Concrete is a fused development material assumes an essential job in the development of the country's framework. One of the critical elements of regular cement is normal sand or stream sand. The issue of ecological debasement and costly nature of the stream sand do us to change on to the elective sources. Its smaller scale filling impact diminishes pores in cements and gives better dampness resistivity. Eco sand are terribly fine particles, by-product from cement manufacture which might be accustomed will increase potency in concrete. Its micro filling result reduces pores in concrete and provides higher wet impedance. The raw material in the manufacture of china clay is metakaolin. It is fine, white, clay mineral that has been historically used in the manufactures of ceramic ware. The exploratory work fuses blend structure for M30 grade concrete with steady rate of eco sand 15% and various rate of metakaolin 5% 10% 15% 20% & 25% in plain concrete. The exploratory work generally centers with split tensile strength and compressive strength and comparing it with control concrete and finding the optimized quantity.

Keywords— *Eco sand, Metakaolin, Compressive strength, Split tensile strength, Flexural strength*

I. INTRODUCTION

Concrete is a well-known composite construction material comprised mostly of aggregates, cement, and water. There are countless details that provide various qualities. The aggregate is often coarse gravel or crushed rock, such as limestone or stone, combined with a fine total, such as sand. The cement is usually Portland cement, while various cementitious materials, such as metakaolin, serve as aggregate binders. Various chemical admixtures are also used to get the desired qualities. This dehydrated composite is then mixed with water, allowing it to be moulded (regularly poured) and then set and hardened into hard strength through a chemical process known as hydration. Water reacts with cement, causing adhesiveness to alternate segments in the long run, resulting in a strong stone-like material. Concrete has a moderate compressive strength but a far lower tensile strength. As a result, high-tension materials are commonly used to reinforce it (regularly steel). Concrete can be affected by a variety of processes, such as trapped water solidifying.

A Metakaolin is a not a by-product. It's made by calcining pure or refined Kaolinite mud at temperatures ranging from 650° C to 850° C, then smashing it to a fineness of 700-900 m²/kg. It is a better pozzolanic substance that is used with cement to increase the cement's durability. It will fill the vacant space between cement particles when employed in concrete, resulting in an inexorably impenetrable concrete. Metakaolin molecules are smaller than cement particles.

B. Eco sand are extremely fine particles that are produced as a by-product of the cement manufacturing process and can be used to boost the strength of concrete. Its micro-filling effect reduces concrete pores, resulting in increased wet electrical resistance and sturdiness. It takes a lot more constant grading than extracting many aggregates. Cement is made from limestone, bauxite ore, and iron ore, among other materials. Because all of these chemicals contain silica, the silica content of cement may increase. As a result, excess silicon oxide is removed using processes such as Froth Floatation and released as Eco sand. The floatation rejects are extremely small particles. As a result, it can be blended with sand at an optimal level to improve aggregate grading. Floatation rejects, which are leftover materials in the cement manufacturing process, can be used to improve concrete efficiency. Direct replacement of M sand in traditional laboratory mix designs yielded better results. It has been used as a substitute percentage. Literature Review

Magudeaswaran, Eswaramoorthi, and kumar this paper aims at creating and finding out the various properties of inexperienced high performance concrete victimization this oxide fume, ash and therefore the alternative ingredients, that is domestically offered eco sand and coarse aggregates. An experimental investigation was distributed to judge the physical and mechanical properties of inexperienced high performance concretes containing cementitious materials by the replacement of cement with silica fume (7.5-15%) and coal ash (15-30%) and replacement of sand with eco-sand, a by-product of cement as filler material. Super plasticiser is additional to fifteen to enhance the workability of the concrete.

Sri Ranjani .R (2015) An experimental study has been done to achieve high strength concrete exploitation created mineral silica (Eco sand) from manufacture of cement as a result of the partial replacement of a natural sand (up to 50%) in concrete and studied its mechanical properties. Eco sand being industrial by product may be used as partial replacement of fine combination in concrete. The combined grading of fine combination confirms higher packing pattern. The compressive strength of cube, split durability of cylinder, prism flexural strength obtained by victimization the mix of fine combination and Eco sand offers a better price up to fiftieth.

Vishnumanohar.A This research includes tests to find out the chemical and physical properties of finely graded silica and also replacing this finely graded silica with fine aggregate partially (15%,30%,45% & 60%) . A mix of M25 and M40 concrete is selected for the replacement. For the compression testing cubes of size 150x150x150mm prepared and they were tested at 3,7,28 and 90 days. From the obtained results we tend to determined that the most strength is achieved by fifteen percentage of fine combination replacement with eco sand in concrete. While increasing the amount of eco sand the cube compressive strength value is getting decreased. From the SEM analysis, at a fifteen percentage replacement the combination remains homogenized because the small pores are stuffed and therefore the transition zone is densified.

S.Wild et al. studied the mechanism of increasing the strength due to addition of metakaolin contents (0– 30%) for different curing periods of 1 to 90 days . The observed results establish that there is an optimum OPC replacement level of 20 wt% MK and that the contribution which MK makes to strength is restricted beyond 14 days.

Dhinakaran (2012) studied the strength increases by MK concrete is effective only at the early age of concrete and in the long term the strength increase is only marginal. The increase in compressive strength for MK concrete was greater especially at higher water cement ratios (i.e., 0.4 and 0.5) and hence more suitable for higher w/cm ratios. From the studies an optimum percentage of MK was found to be 10% for all w/cm ratios except for 0.32 and for 0.32 it was 15%. MK concrete higher increase in strength at early ages beyond 28 days it was found to be less than 10%. The maximum compressive strength of 59.25 N/mm² was observed at 0.4 w/cm with 10% MK. Addition of MK reduced the pH values, but the reduction is insignificant, since the pH values are still above 11.5, which will be helpful for maintaining the steel in a passive state itself. The depth of penetration of chloride ions for MK concrete is much lesser than control concrete. The minimum rate of reduction of chloride penetration depth for MK admixed concrete were arrived as 78%, 38%, 25% and 25% for w/cm ratios 0.32, 0.35, 0.40 and 0.50 respectively. The maximum rate of reduction was observed as 95% for 0.32 and 0.3 ratios.

II. MATERIAL PROPERTIES

A. Collection of Eco Sand

Eco sand is bought from Associated Cement Company (ACC) cement factory madukarai, Coimbatore. It is a by-product from the process of cement manufacturing.



Fig.1 ECO SAND

TABLE 1 CHEMICAL PROPERTIES OF ECO SAND

Chemical	Percentage%
Silica	58-60
Alumina	2-3
Iron	1-3
Calcium oxide	20-25
Magnesium oxide	0.4-1

TABLE 2 PHYSICAL PROPERTIES OF ECO SAND

Properties	Result
Fineness modulus	0.029
Specific gravity	2.43

B. Collection of Metakaolin

Metakaolin is brought from ASTRRA CHEMICALS Chennai. Metakaolin is a calcined form of clay mineral.



Fig.2 METAKAOLIN

TABLE 3 CHEMICAL PROPERTIES OF METAKAOLIN

Chemicals	Results
SiO ₂	52
Al ₂ O ₃	46
Fe ₂ O ₃	0.60
TiO ₂	0.65
K ₂ O	0.03
CaO	0.09
Na ₂ O	0.10
MgO	0.03

TABLE 4 PHYSICAL PROPERTIES OF METAKAOLIN

Properties	Result
Specific gravity	2.6
Bulk density	0.4-0.5
Appearance	OFF-WHITE

C. Cement

It is defined as materials with adhesives and cohesive effects which make it capable of binding materials fragment into compact mass. Cement is obtained by burning chalky and clayey materials by partial fusion at high temperature of concerning 1450°C. The OPC is commonly characterized into three evaluations, they are 33, 43 and 53 grades. In this examination OPC 53 grade has been utilized. Its physical properties shown in table 5

TABLE 5 PROPERTIES OF CEMENT

Properties	Result
Specific gravity	3.13
Initial setting time	35 mins

D. Fine Aggregate

The fine aggregates utilized in this investigation was M sand pass through 4.75 metric linear unit sieve with specific gravity of 2.64. The percentage of passing is within the limits as Indian Standard Specifications.

TABLE 6 PROPERTIES OF FINE AGGREGATES

Properties	Results
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Specific gravity	2.64
Fineness	2.53

E. Coarse Aggregate

Machine shattered stone angular in form was used as coarse aggregates. The physical properties of coarse aggregate like specific gravity ,bulk density, fineness modulus ,impact test and crushing strength test were performed as per IS: 383-1978, IS: 2386 (part iii)-1963.

TABLE 7 PROPERTIES OF COARSE AGGREGATE

Properties	Result
Specific gravity	2.84
Water absorption	0.5%

III. Mix Ratio

The usually utilized strategy for mix design is the Indian standard method. Different mix ratio were acquired, for example, NM, EMK1, EMK2, EMK3, EMK4 and EMK5.

TABLE 8 PERCENTAGE OF REPLACEMENT OF EMK

MIX	CEMENT (%)	META KAOLIN (%)	M SAND (%)	ECO SAND (%)
NM	-			
EMK1	95	5	85	15
EMK2	90	10	85	15
EMK3	85	15	85	15
EMK4	80	20	85	15
EMK5	75	25	85	15

IV. RESULT AND DISCUSSION

A. Compressive Test

Compressive strength is defined as the capacity of material to withstand axially directed pushing forces. For compressive strength test the cubes are casted with dimensions of 150mm x 150mmx 150mm. The casted specimens are tested after curing 7, 28 and 56 days in compression testing machine as shown in Fig 7.4 and the applying load is noted. Then the compressive strength is calculated by following formula.

$$\text{Compressive strength} = \frac{P}{A}$$

P – maximum compressive load

A – Cross sectional area

TABLE 9 COMPRESSIVE STRENGTH TEST RESULTS

MIX	7 DAYS	28 DAYS
NM	23.7	39.4
EMK1	22.96	37.4
EMK2	25.03	40.54
EMK3	29.9	47.7
EMK4	27.8	43.1
EMK5	26.2	41.48



Fig.3 Compressive strength

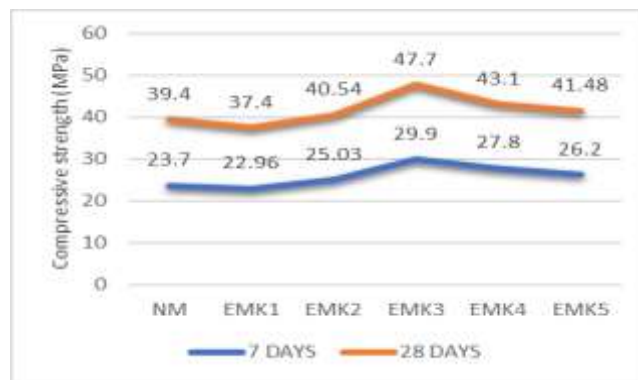


Fig.4 Effect of volume of EMK on compressive strength

From the comparative analysis of compression strength of M30 mix cubes, it is shown that at a replacement of 15% the cubes are getting a higher strength than the conventional mix. All other replacements are achieved a low strength compared to the 15% replacement mix.

B. Split Tensile Strength

This test 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. The split tensile test is a method of determining the tensile strength of concrete. The test is carried out according to IS:5816-1970. The experiment consists of casing and testing of cylinder, 100mm diameter and 300mm height as shown in Fig 7.5. Specimens were cured for 28 days under water prior to testing. Compression testing machine having capacity 2000kN is used for loading. Load at a constant stroke rate, is applied through two hardwood strips of 25mm wide, 3mm thick and 300mm long.

$$\text{Split tensile strength} = \frac{2P}{\pi LD}$$

- P- Maximum load
- L- Length of cylinder
- D-Diameter of cylinder

TABLE 10 SPLIT TENSILE STRENGTH TEST RESULTS

MIX	7 DAYS	28 DAYS
NM	3.11	4.02
EMK1	3.28	4.27
EMK2	3.43	4.48

EMK3	3.88	4.64
EMK4	3.70	4.21
EMK5	3.58	4.16



Fig.5 Split tensile strength

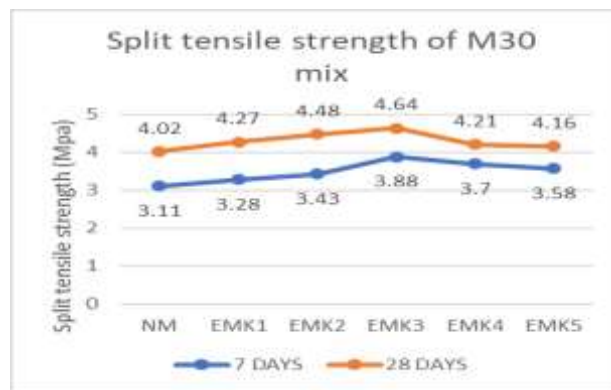


Fig.6 Effect of volume of EMK on split tensile strength

From the comparative analysis of split tensile strength of M30 mix cubes, it is shown that at a replacement of 15% the cubes are getting a higher strength than the conventional mix. All other replacements are achieved a low strength compared to the 15% replacement mix.

C. Flexural Strength

Beams of size (500x100x100mm) casted and the specimen were subjected to central loading as shown in Fig 7.6. The specimen is 50mm marking both ends and as well as 133.3mm marking from where 50mm marking is done. The failure load is noted based on the following formula flexural strength is calculated.

$$\text{Flexural strength} = \frac{3PL}{bd^2}$$

- P – Failure load
- L – Effective span
- b – Breadth of the beam
- d – Depth of the beam

TABLE 11 FLEXURAL STRENGTH TEST RESULTS

MIX	28 DAYS
NM	5.11
EMK1	5.41

EMK2	5.78
EMK3	5.82
EMK4	5.58
EMK5	5.46



Fig.7 Flexural strength

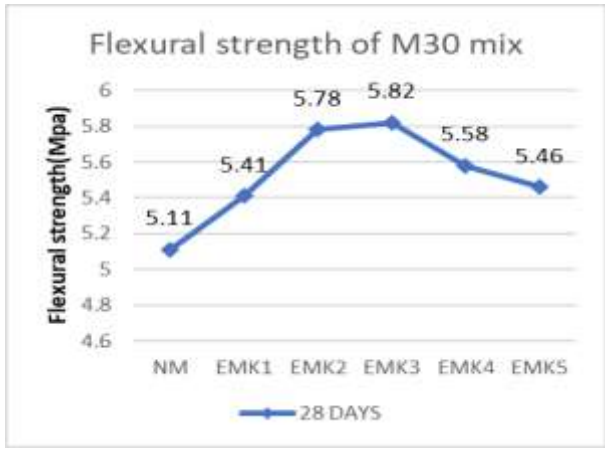


Fig.8 Effect of volume of EMK on flexural strength

From the comparative analysis of flexural strength of M30 mix cubes, it is appeared at a substitution of 15% the cubes are getting a higher strength than the conventional mix. All other replacements are achieved a low strength compared to the 15% replacement mix.

V. CONCLUSION

- Material properties of metakaolin and eco sand showed that, metakaolin is high fibrous and contained considerable amount of silica and hence can be replaced for OPC.
- Regarding waste eco sand, it is sub-angular material and contains high amount of silica and hence can be replaced for natural river sand.
- Fresh concrete properties showed that addition of metakaolin decreases workability due to high water absorption capacity.
- The slump value decreased drastically in EMK3 mix when compared with NM mix.
- On addition of eco sand, the slump value decreased gradually
- Strength properties showed that optimum mix was taken as EMK3, since it showed around 15% increase in compressive strength when compared to conventional concrete. Similarly split tensile strength and flexural strength showed increased values in optimum mix.

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