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COMPARATIVE ANALYSIS OF STRENGTH OF ECOFRIENDLY MORTAR MADE WITH PARTIAL REPLACEMENT OF NATURAL FINE AGGREGATE WITH FLY ASH

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Abstract - *In the modern world, there is a shortage of River occurred fine aggregate (river sand), and industrialists are disposing of industrial waste inappropriately and improperly, like fly ash, which has resulted in a ban and lack of approval from the regional administrative system assembly or the state and local government in order to protect ecology and ecosystem from resource depletion and ecological/ environment pollution. A result, Fly ash is among the best sand alternatives. Fly ash has partially replaced natural sand in order to ensure the production of environmentally friendly mortar as to raise strength, we also recommended using fly ash in place of some sand. This analysis is also beneficial to the environment because it reduces pollution from industrial harmful waste disposal. Also, because to the issue of a lack of natural resources, less natural fine aggregate is being used. The use of Fly ash as partial sand in mortar, on a large scale, will be highly advantageous to the construction industries and serve to conserve ecology and its resources, this attempt to be highlighted in this study.*

Key Words: **Natural Fine Aggregate, Fly ash, Resource Scarcity, Eco-friendly**

1.INTRODUCTION

Environmentally friendly mortar production is now crucially needed in the construction industry to protect the environment and our world. Utilising a smaller amount of the limited natural aggregate, whose supplies are depleting in fast way. The infrastructure of India's is feeling the consequences of the current global environment, which is making high quality natural aggregates like river sand more and more scarce. Also, it is performed by using industrial wastes as possible, such as fly ash, which reduces the requirement for landfill space. In India, fly ash ponds are currently spread across 65000 acres of land, and by August 2022, Indian Industries had generated 270.82 million tonnes of Fly ash. Uncontrolled fly ash disposal has an effect on the local surrounding And climate due to its weightless and fine property, fly ash not only consumes acres of lands but can also go air pollution if improperly controlled. For a number of purposes, including the production of high-performance mortar and concrete mixtures, fly ash has been utilised as a substitute resource for building sector. The Fly ash is a pozzolanic substance that is added to mortar and concrete to improve properties like compressive strength.

1.1 FLY ASH

The waste, which is conveyed by the flue gases from the boiler, is a fine powder that is generated during the combustion of ground or crushed coal and is stored in electrostatic precipitate . Fly ash is a spherical particles, sizes that ranges from -0.045mm to +0.6mm.

1.2 FLYASH CLASSIFICATION

According to ASTM C-618, fly ash is divided into two general categories: Class F and Class C. The key variations between these two kinds are the amount of presence of calcium oxide, silicon dioxide, Aluminium oxide and iron.

Class F Fly ash – The category of Fly ash has a lime (CaO) percentage of 10% or less, is often produced by burning anthracite coal and old bituminous. Due of its pozzolanic properties, glassy silica and Class F Fly ash require a cementing agent.

Class C Fly ash – Fly ash from burning of Sub-bituminous coal or lignite is classified as Class "C," and it frequently contains 20% or more percentage of lime (CaO). This type of fly ash doesn't require an activator, and it frequently has higher levels of sulphate and alkali than Class "F" fly ash does.

The table, which displays the production and consumption of fly ash during the course of the last three years, from 2019–2020 to 2021–2022.

S. No.	Year.	Fly ash generation (Million ton).	Fly ash Utilization (Million ton).	% Utilization
1	2019-20	226.95	189.01	83.28
2	2020-21	232.56	214.91	92.41
3	2021-22	270.82	259.86	95.95

Source: Authority of Central Electricity

The Analysis suggests a mortar procedure for partially substituting Natural Fine Aggregate (Sand) with fly ash with conventional mortar without the use of plasticizer. As a potential improvement to the above mentioned problems of scarcity of natural resources and environment problem and pollution caused by unsuitable disposal of fly ash.

Consider that the (1:3) ratio of mortar's components are the binder (Cement), Natural Fine Aggregate (Sand), and the addition percentage Of Fly ash mixed in some % of sand greater to 20% as 22%, 24%, and 26% for experiment. One conventional mix (1:3) will also be made in addition. As part of the test procedure, the compressive strength of mortar is analysed containing varying percentages of fly ash as percentage of sand replacement and compared with a conventional mortar.

2. EXPERIMENT ANALYSIS

2.1 Materials:

2.1.1 Cement :- It acts as the binder in the mortar. As followed the IS:1489 Part 1-2015, cement of PPC grade to be used in this experiment. In a closed-circuit ball mill of very effective separator, clinker particle of cement is combined with the appropriate level of Gypsum and Flyash to produce Portland Pozzolana Cement. According to pertinent tests conducted as followed in IS:4031-1988, Portland Pozzolana Cement has the following physical qualities, which are displayed:

Table 2.1 Portland Pozzolana Cement's Physical Characteristics

S.NO.	CHARACTERISTICS	OUTCOMES
1	Specific Gravity	2.95
2	Fineness by Sieve Analysis	3.81%
3	Normal Consistency	36%
4	Initial Setting Time	38 min.

2.1.2 Fine Aggregate

(a) River Sand:- Natural Sand is a crucial ingredient in the mortar mixture because it creates the proper adhesion between cement and aggregate. Sand size in range of IS sieve of opening 4.75mm or less. As per definitions in IS:383-1963, the sand will passed from sieve with a 1.18 mm opening and retained on a 600 µm. River sand of local available is collected from river beds and utilised for the experiment of 600 µm.

Table 2.2 Natural Sand Physical Characteristics as accordance with IS:2386-1963

S.NO.	CHARACTERISTICS	OUTCOMES
1	Type	Natural
2	Size	600µm
3	Shape	Rounded
6	Specific Gravity	2.695
7	Bulk Density(Kg/m³)	1.522Kg/L
8	Fineness Modulus	3.13

(b) Fly ash:- Fly ash is used as a fine aggregate alternative for making mortar. A full understanding of the attributes, characteristics, advantages, and uses of fly ash is essential for mortar to function as it should.

Fly ash of Class C classed
Taken byproduct produced by BINA REFINERY LTD (BPCL), Bina (M.P.)
Better packaging, Pozzolonic attributes, and internal cure attributes of Fly ash makes an ideal partial alternative for sand in the construction of Enviro-friendly and green Mortar.

Table 2.3 Fly ash Engineering Characteristics

S.NO.	FLY ASH'S CHARACTERISTICS	OUTCOMES
1.	Specific Gravity	2.247
2.	Fineness	As Sand replacement Retained on 600µm

2.1.3 Water:- Water is an essential component of mortar because it facilitates chemical processes that result in cement paste, hydrates cement, and contributes to the mortar's strength after appropriate curing. Without any turbidity, alkalinity, or organic content, we used ordinary tap water.

2.2 EXPERIMENTAL WORK:

2.2.1 Mix proportion:- The following are the several mortar 1:3 proportions

Table 2.4 Proportion of Mortar that is mixed in a 1:3 with Fly ash added partially as sand replacement

Cement (kg/m³)	FINE AGGREGATE (kg/m³)			WATER (Kg/m³)
	% of Sand replaced with Fly ash	Sand (Kg/m³)	Fly ash (Kg/m³)	
468.75	0	1406.250	0	225
468.75	20	1125.000	281.250	225
468.75	22	1096.875	309.375	225
468.75	24	1068.750	337.500	225
468.75	26	1040.625	365.625	225

Table 2.5 Quantity and Percentage of Fly ash for the substitution of Partial Sand

FLYASH PERCENTAGE ADDED	QUANTITY OF FLYASH SUBSTITUTED AS A SAND WEIGHT (Kg/m³)
0	0.000
20	281.250
22	309.375
24	337.500
26	365.625

2.2.2 Batching/ Mixing :- In accordance with IS:2250-1981. Ingredients like as cement, fine aggregate (sand with Fly ash), and water are weighted. Ingredients were then mixed by hand after that. The mixing operation was continued for 5 minutes or Until the mix were gets its consistency and homogenousity. The ingredients have been thoroughly mixed but Before the Initial Setting Time begins, the mixture is initially poured into the moulds.

2.2.3 Pouring/Compaction of Fresh Mortar:- Freshly Mortar is compacted with a hand tamping rod of at a rate of 20 to 25 strokes in every layer. The mortar samples are well compressed by tamping. When pouring the cube sample mould, the proper compaction is must required to eliminate air spaces.

2.2.4 Cube Casting:- The mould is now filled, and as it has been thoroughly mixed and it is compacted with a 60 cm sized rod. Pour the remaining mortar onto the mould and compact it again, just as you did for the layer 1. Finish the top of the cube mould now by using the trowel's blade.
The 70mm x 70mm x 70mm cube-shaped mould taken.

2.2.6 Curing:- The filled mould should be kept in a clean area for complete 1 day. After the first 24 hours, demould the cube and immediately keep the moulds in fresh, clean water. The water that the cubes are maintained in needs to be replaced every week and kept at a steady 27 +-2°C temperature.

Up to the test day, the sample was properly cured in accordance with IS:456:2000.

2.3 MORTAR HARDENED CHARACTERISTICS

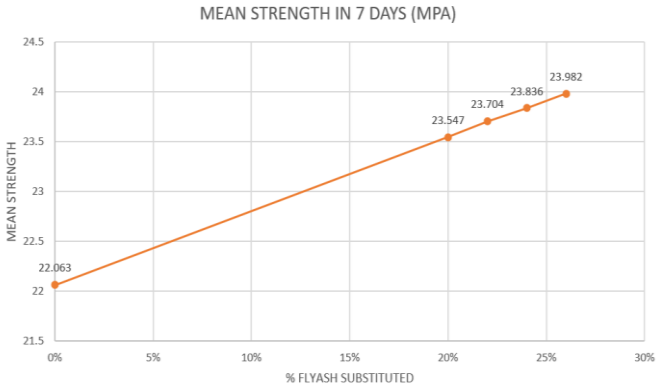
Compressive Strength:- The ability of a structure to withstand loads or pressures applied to its surface without splitting, deflecting, or degrading is known as its compressive strength. The mortar be pour into mould in layered manner to ensure proper Compaction that there are no voids in the mixture. These cubes undergo compressive test after 7 and 28 days of curing. In order to ensure that the load should be applied at gradual rate of 35N/mm2 per minute till specimen fails. The Mortar's compressive strength is then calculated by dividing the load at the point of failure of cubes by the cross-sectional area of specimen.

3. RESULT AND OBSERVATION

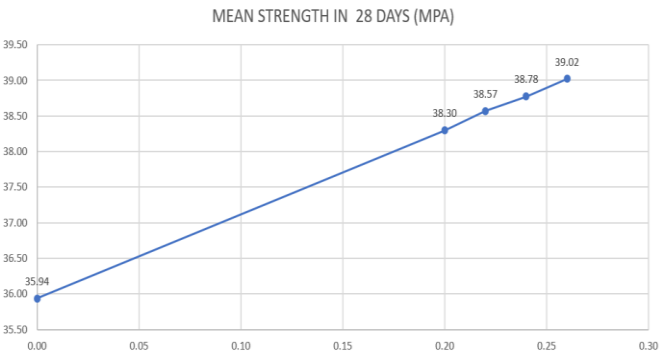
Compressive Strength:- Fly ash was replaced for natural sand in varied amounts (0%, 20%, 22%, 24%, 26%) when casting of 30 cubes of natural sand. Each sample underwent a 7 and 28-day cure period as per test conducted day. In the current investigation, replacing varying percentages of fly ash with sand results in a increase in the mean compressive strength of mortar.

Table 3.1 Compressive Strength with Utilizing Natural sand with Partially Substituted Sand by Fly ash

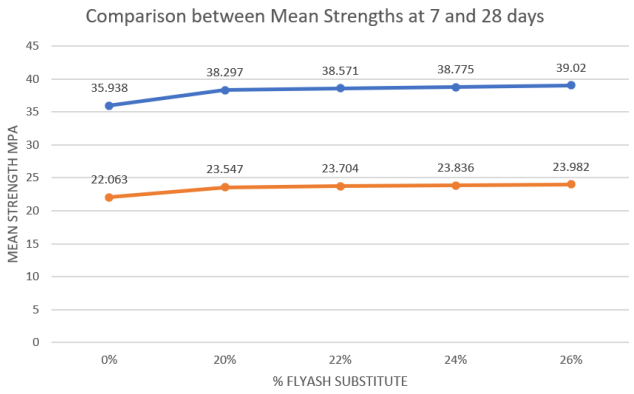
MORTAR MIX OF RATIO 1:3 WITH VARIOUS REPLACEMENT OF SAND WITH FLY ASH	COMPRESSIVE STRENGTH (MPa) For 7 Days	For 28 Days
Only Sand (100%) Natural (0% Fly ash)	22.063	35.939
80% Sand with 20% Fly ash	23.547	38.297
78% Sand with 22% Fly ash	23.704	38.571
76% Sand with 24% Fly ash	23.836	38.775
74% Sand with 26% Fly ash	23.982	39.020



Graph 3.1 Mean Compressive Strength of Mortar Cubes with Natural sand and with various percentage level substitution of Sand by Fly ash at 7 days



Graph 3.2 Mean Compressive Strength of Mortar Cubes with Natural sand and with various percentage level substitution of Sand by Fly ash at 28 days



Graph 3.3 Comparison Line Chart of Mean Compressive Strength of Mortar Cubes with Natural sand and with various % level substitution of Sand by Fly ash at 7 and 28 days

4. CONCLUSIONS

The concluded results of an experiment on the effects of using fly ash as a partially alternate for natural sand on compressive strength of mortar are as follows:-

- When fly ash is added to mortar as a partial substitute for some percent of the natural sand, the strength of the mortar increases by around 6.5% when Fly ash added to 20% of natural sand as compared to mortar made with 100% natural aggregate. Causes the compressive strength in mortar to steadily grow. Moreover, a +2% interval increase in fly ash content, for 22%, 24%, and 26% replacement levels, causes a progressive increase in the compressive strength of mortar.

- The partially prepared fly ash mortar is effective for load-bearing masonry constructions as well as for regular masonry brickworks and stone works, masonry for reinforced brickworks, and all plaster projects during moist climate.

- Using Fly ash as a some percentage for natural sand helps the environment by minimising pollution Caused by improper disposal of flyash by industrial house.

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