Experimental Investigation on Strength Properties of Concrete by Using Fly ash and M-Sand for Partial Replacement of Cement and Natural Sand

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Abstract- *Concrete is the most widely used construction material in civil engineering industry because of its high structural strength and stability. Cement industry has majorly contributed in the emission of CO2 to the atmosphere. The global consumption of natural sand is too high due to its extensive use in concrete. The demand for natural sand is quite high in developing countries which results in the supply scarcity. To overcome this crisis, new alternatives for the conventional river sand are being discovered with the available resources. Cement can be partially replaced with a pozzolonic characteristic material like fly ash, which is a by-product obtained from Thermal Power Plants. One of the alternative materials for replacing natural river sand came in to light which was later named as M-Sand or Manufactured sand. M-Sand is the product obtained from Vertical Shaft Impactors in crushers. The present experimental investigation carried out aims at determining the amount of fly ash in intervals of 0%, 5%, 10%, 15%, 20%, 25% and 30% which can replace the cement in concrete along with M-sand by 20%, 43%, 60%, 80% and 100% to replace conventional natural sand. The sample mixes are casted, cured and are tested for compression and split tensile strengths. The obtained results from various combinations of mixes are then compared with conventional concrete mix.*

Keywords- Concrete, CO_2, Cement, Natural Sand, Fly ash, M-Sand.

I. INTRODUCTION

The primary need of Civil Engineering stream is concrete. It is being used in various fields of construction industry Concrete is a heterogeneous mix element which mainly Consists of fine aggregate, coarse aggregate and water which are embedded in a hardened matrix of material called cement, which fills up the voids among aggregates and adheres them strongly. The most important component of a concrete is cement. The manufacturing process of cement has lead to various environmental and social consequences which are harmful. Cement manufacturing process requires lots of energy and simultaneously it emits huge amount of carbon dioxide (CO2) to the atmosphere. This has increased global warming which is a threat to the environmental balance. Various attempts have been made to reduce the carbon dioxide emission relating to concrete from both industrial and academic sectors by substituting of conventional clinkers with industrial wastes such as fly ash, GGBS, metakaolin, alcofine, rise husk ash etc. without any reduction on its desired strength.

Fly Ash is one of the pozzolanic materials produced by burning coal in Thermal Power plants. Instead of disposing this huge amount of fly ash in land, it can be effectively used partially as a replacement component for cement in concrete. Now days, almost all the thermal plants are e utilising Electro Static Precipitators (ESP) from which fly ash is being collected in separate chambers according to their grain size. Hence un-diversified graded particles of fly ash are being collected from the thermal plants.

Natural River sand is used as a major construction material globally, especially in production of concrete, cement blocks and in cement and sand mortar. Various Government, Non-Governmental associations and Research Institutions are striv¬ing to find a substitute for replacing natural sand. To control further environmental hazards, Government has banned the digging the sand from river beds. This has resulted in scarcity and remarkable increase in the price of natural sand. So it became necessary to find alternatives for naturally available sand.

Artificially manufactured sand by specifically designed machines can be a better alternative to natural river sand. The sand should be of particular gradation and it should have lesser voids and should be of reasonable price. River sand is not properly graded and contains uncontrollable silt contents and organic impurities which can adversely affect the durability of concrete; on the other hand manufactured sand doesn't have silt content and organic impurities. So, for now the long term effective replacement element for natural sand

has been discovered and it is called Crushed stone Sand which is also as called Manufactured Sand (M-Sand).

II. MATERIALS AND METHODOLGY

1. Cement:

Ultra-Tech Ordinary Portland cement of 43 grade is used for all the concrete mixes according to IS: 8112-1989.

Table 1. Physical properties of cement

Sl No	Parameter	Value
1	Specific Gravity	3.1
2	Initial Setting Time	50 min
3	Final Setting Time	240 min
4	Fineness	6.22%
5	Compressive strength (28 days)	42.32MPa

2. Fly ash:

For the experimental work, Class- F Fly Ash from Shakthi Nagar Thermal Power Plant, Raichur (district), Karnataka is considered as cement substituting material. Fly ash properties confirm to IS: 3812-1981.

Table 2. Principal chemical composition of fly ash

Constituents	Value
Silica	25-60%
Alumina	10-30%
Ferric oxide	5-25%

Table 3. Physical properties of fly ash

Sl No	Parameter	Value
1	Appearance	Very fine powder
2	colour	Grey
3	Specific gravity	2.16
4	Particle Size	0.1μm-150μm

3. Fine aggregate:

The fine aggregate which is considered in they present work is ordinary natural sand. Sand passing through 4.75 mm size sieve is considered for the preparation of mix specimens. It confirms for Zone-II according to IS: 383-1970.

Table 4. physical properties of natural river sand

Sl No	Parameter	Value
1	Specific Gravity	2.59
2	Water Absorption	0.8%
3	Grading zone	Zone- II
4	Fineness modulus	2.66

4. Coarse aggregate:

The considered coarse aggregate in the study is 20 mm down size crushed granite stone which is obtained from the locally available quarry. Properties of the material are according to IS: 383-1970.

Table 5. Physical properties of coarse aggregate

Sl.No	Parameter	Value
1	Specific gravity	2.68
2	Fineness Modulus	5.82
4	Water Absorption	0.34 %

5. M-Sand:

M-Sand is used as partial replacement material for fine aggregate. For the present experimental work, M-Sand is obtained from locally available crusher.

Table 6. Physical properties of M-Sand

Sl No	Parameters	value
1	Maximum size	4.75mm
2	Specific gravity	2.78
3	water absorption	1.35%
4	Fineness modulus	2.64
5	Grade Zone	II

Methodology:

- Materials like cement, fly ash, natural sand, M-Sand and coarse aggregate are tested to find out their physical properties.
- Using the obtained results, the mix design is prepared with the required W/C ratio for M25 grade of concrete.
- Cement is replaced by 0%, 5%, 10%, 15%, 20%, 25%, and 30% of fly ash and natural sand is replaced by M-Sand in the intervals of 0%, 20%, 40%, 60%, 80% and 100%.
- Concrete cubes and cylinders were casted and were cured for time duration of 7 and 28 days. The specimens were then tested for compression and split tensile strength.
- The obtained results were compared with the controlled concrete specimens.
- Mix design: M25 grade of concrete is considered for the experimental work. The mix design is worked to as per IS 10262-2009. Water cement ratio of 0.45 is adopted for the mix design.

Cement : Fine aggregate : Coarse aggregate
1 : 1.74 : 3.08

III. RESULTS AND DISCUSSIONS

Compression strength and split tensile strength tests for 7 and 28 days were conducted on the concrete cubes and cylinder specimens respectively for various mixes. The maximum compression strength is obtained for the specimen of 20% fly ash and 60% M-Sand. Similarly the maximum split tensile strength is obtained for 20% fly ash and 80% M-Sand specimen. The increased strength is due to additional formation of C-S-H gel which aids for the enhancement of the strength and also because of the properties of M-Sand like better shape, size, proper and specified gradation of particles and due to absence of silt content which in turn increases the strength properties of concrete.

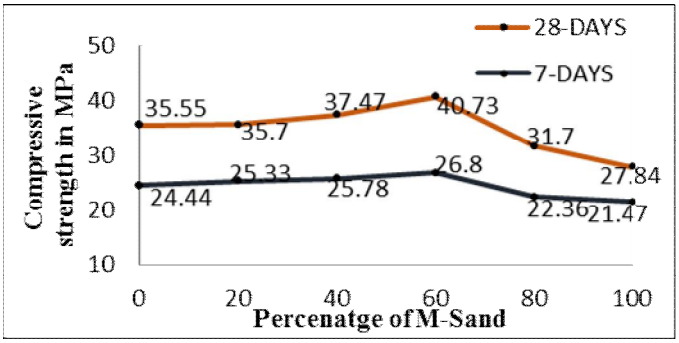

Figure 1. Compressive strength for 20% fly ash and varying percentage of M-Sand

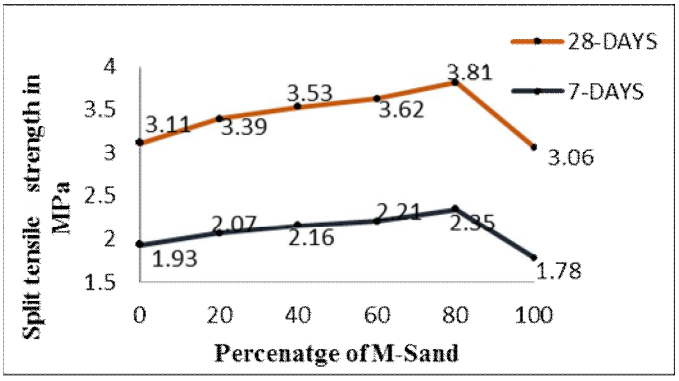

Figure 2. Split tensile strength for 20% fly ash and varying percentage of M-Sand

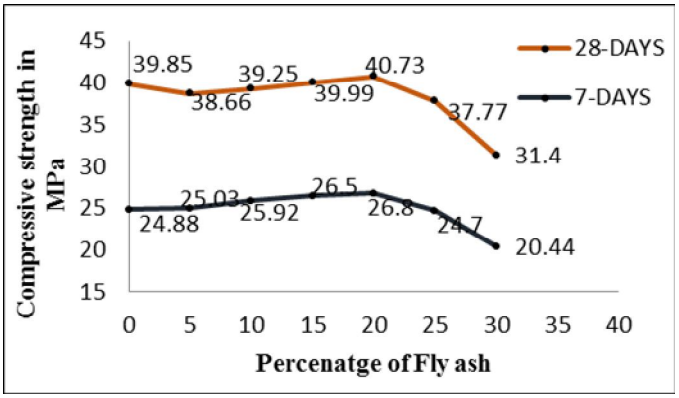

Figure 3. Compressive strength for 60% M-Sand and varying percentage of fly ash

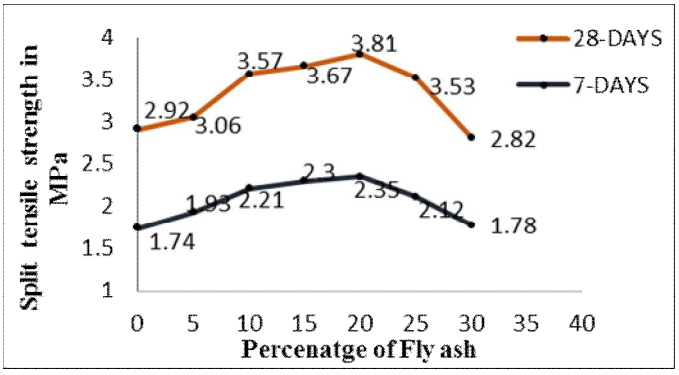

Figure4. Split tensile strength for 80% M-Sand and varying percentage of fly ash

IV. CONCLUSIONS

The experimental work carried out mainly deals with the utilization of pozzolonic cementitious material fly ash which is a by-product obtained from the Thermal Power Plants. The study also deals with the effective adoption of M-Sand or Crushed stone sand as fine aggregate in the cement concrete mix.

With respect to the experimental work carried out, following conclusions are drawn;

- The maximum compressive strength of the concrete mix is obtained when the natural river sand and cement is replaced by 60% of M-Sand and 20% of fly ash respectively.
- Maximum split tensile strength is achieved when natural sand is replaced by 80% of M-Sand and cement is replaced by 20% of fly ash.
- As the percentage of M-Sand increased the compressive strength of concrete increased up to 60% of M-Sand. Further increase in percentage of M-Sand resulted in the depletion of strength.
- As the percentage of M-sand increased, the split tensile strength also increased up to 80% utilisation of M-Sand. Further utilisation lead to the decreased tensile strength of concrete.
- When the percentage of fly ash increased by 0%, 5%, 10%, 15%, 20%, 25% and 30%, the maximum compressive and split tensile strength is achieved when 20% of fly ash is used. When 25% and 30% of fly ash is used strength of concrete decreased.

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