Construction of Building using Fly Ash

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***Abstract*— Fly ash bricks are new material and these bricks have certain advantages over clay bricks and no information regarding strength and economy of these material in brick, mortar and concrete as partial replacement of binding material is available. Therefore, the goal of the current work is to gather information about strength and economy of fly ash in comparison to that of cement. In the current work experiment are performed to get knowledge about change in properties of sand bricks (after mixing fly ash), fly ash mortar by making mould by mixing fly ash in different percentages of binding material (by wt.) to remaining components of mortar.**

Index Terms— Brick, Compressive strength, Fly ash, Masonry, Mortar

I. INTRODUCTION

Research Significance:

As the infrastructures in our country are on the verge of development so this increases the demand of bricks and cement as this both are major construction material their demand in the market is also increasing.

Major component in brick and cement is soil (clay in bricks and both sand and clay in cement). Due to increase in production of bricks and cement, there will be decrease in quantity of soil present uppermost layer. This may lead to increased cost of materials containing soil.

Therefore to balance the cost of construction, fly ash can be employed as partial replacement which is a good Pozzolanic material and can act as a good binding material when used along with the cement.

Fly Ash: Two types of fly ash are commonly used: Class C and Class F. Class C are often high calcium fly ashes with carbon content less than 2%; whereas, Class F are generally low-calcium fly ashes with Carbon contents less than 5% but sometimes as high as 10%.

In general, Class C ashes are produced from burning sub-bituminous or lignite coals and Class F ashes bituminous or anthracite coals. Performance properties between Class C and F ashes vary depending on the chemical and physical properties of the ash.

Fly ash can be used in preparation of following construction material.

1) Fly ash bricks
2) Fly ash mortar
3) Fly ash concrete.

1) Fly Ash Bricks:

Fly Ash bricks are made of fly ash, lime, gypsum cement and sand. These can be extensively used in all building constructional activities similar to that of common burnt clay bricks.

Fly ash was mixed with the soil in varying ratios such as 0%, 10%, 20%, 30%, 40% and 50% described that the bricks cannot be manufactured with highly swelling soils without additives.

The % of fly ash giving better results generally depends upon

1) Type of coal
2) Power plant from which fly ash is made available.

Physical properties of fly ash bricks:

As compare to normal conventional clay brick, Fly ash bricks has better physical characteristics which includes,

1) Uniformity in size.
2) Uniformity in shape as machine moulded.
3) Light weight as density of fly ash is comparatively less than that of clay.

The unit volume weight of the fly ash bricks prepared with quartz sand addition was 1.15 g/cm3, whereas the unit volume weight of the bricks with river sand addition was 1.27 g/cm3. Thus, the unit volume weights of the fly ash bricks were much lower than that of the traditional clay bricks. The fly ash bricks produced were about 28% lighter than clay bricks.

Mechanical properties of fly ash bricks:

- **Compressive strength:**

Most important property for a building unit which is going to bear weight of same type of members which are set above its position.

Compressive Strength of Bricks The strength of fly ash bricks in compression varies from a minimum of 9 N/mm2 to maximum of 11.5 N/mm2, averaging about 10.25 N/mm2.

The compressive strength of ordinary bricks is found to vary in the range of 3.25 to 5.5N/mm2. Upon comparison the strength of fly ash bricks, in compression, with that of ordinary bricks it is perceived that the fly ash bricks are about 2 times stronger than the ordinary clay bricks.

- **Water absorption:**

Water absorption of fly ash brick is found between 8% to 22%. As 40% and 50% fly ash in brick gives satisfying results in almost all properties and shows a water absorption content as 11% and 9% respectively.

- **Thermal conductivity:**

The thermal conductivity of the fly ash–sand–lime bricks was found to be 0.34–0.36 W m-1 K-1 which was lower than that of the traditional clay bricks.

- **Cost of fly ash brick:**

Market price of fly ash bricks is found between ₹ 4 to ₹ 5.

- **Environment friendly:**

Using Fly ash brick not only eliminated waste disposal of fly ash and saved landfill space, it also saved much energy and eliminated all the air pollution and global warming problems caused by burning fossil fuel in kilns to manufacture clay bricks.

Fly ash bricks made from fly ash do not emit mercury into air. On the contrary, they absorbed mercury from air, making the ambient air cleaner.

Fly ash brick did not emit radon gas, but only at about 50% of that emitted from concrete. Thus, it was considered safe to use concrete or concrete products in buildings and it should be even safer to use fly ash bricks.

Leaching of pollutants from fly ash bricks caused by rain was negligible. In addition, long-term observation of the compacted fly ash bricks revealed that the long-term growth of strength of fly ash bricks was due to carbonation caused by absorption of CO2 from the atmosphere which brings relief to global warming.

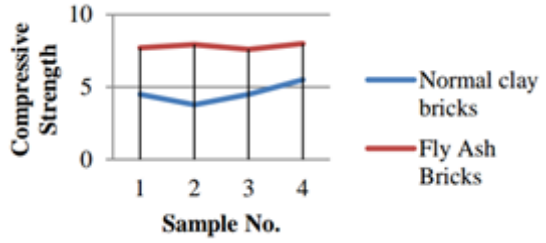

Fig. 1. Plot of compressive strength of fly ash bricks and normal bricks

Fig. 2. Compressive Strength

2) Fly Ash Mortar:

Cement was partially replaced with six percentages (10%, 20%, 30%, 40%, 50% and 60%) of class F fly ash by weight. Among the six fly ash mortars, the optimum amount of cement replacement in mortar was about 40% and 50%.

- **Compressive strength:**

The maximum compressive strength occurred with 50% fly ash content at all ages. It was 40.0 MPa at 28 days, 51.4 MPa at 91 days, and 54.8 MPa at 365 days. It was suggested that class F fly ash could be very conveniently used in structural mortar. Which provides 14% higher compressive strength and 8% higher tensile strength as compared to ordinary Portland cement mortar.

TABLE I
COST ESTIMATION OF FLY ASH MORTAR

S.No.	Particulars	Quantity	Rate	Unit	Cost
1	Materials				
	Cement	6 bags	₹ 320	Per bag	₹ 1920
	Fly ash	160 kg	₹ .55	Per Kg	₹ 88
	Sand	1.2 cu.m.	₹ 1750	Per cu.m.	₹2100
2	Labor				
	Supervisor	1	₹ 300	Per person per day	₹ 300
	Coolie	3	₹ 200	Per person per day	₹ 600
				Total	₹ 4108
				5% Contingencies	₹ 206
				10% Contractor profit	₹ 410
				Total cost / cu.m.	₹ 4724

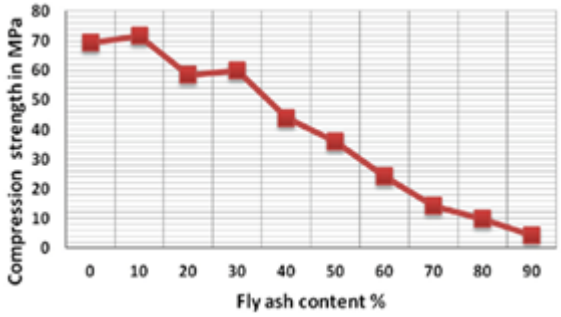

Fig. 2. Plot of compressive strength of fly ash mortar

The rate of gain in strength of fly ash mortar specimens was observed to be lower than the corresponding ordinary Portland cement mortar. Fly ash mortar provides satisfactory or higher strength as compared with ordinary Portland cement mortar. Use of high volume fly ash in any construction work as a replacement of cement, provides lower impact on environment (reduce CO2 emission) and judicious use of resources (energy conservation, use of by-product). Use of fly ash reduced the amount of cement content as well as heat of hydration in a mortar mix. Thus, the construction work with fly ash concrete became environmentally safe and also economical.

3) Fly Ash Masonry:

In can be said that fly ash masonry is results of two sub components:
a) Fly ash brick
b) Fly ash mortar

So it can be also said that strength of fly ash brick masonry will also provide satisfying results as the basic raw material of the component is same. From the studies following points can be concluded that,

- It is found that Fly ash brick masonry has average comparative strength is about 8.13 N/mm², which is approximately 1.3 times the strength of conventional brick masonry and these bricks are environmental friendly alternative to burnt clay bricks which are generally used for construction in India. Therefore, use of this masonry system is strongly recommended over conventional burnt clay and other brick masonry.
- It can also be inferred that the strength of masonry is about 40 to 45 % of the strength of brick units.
- Very little variation is observed in compressive strength of various piers indicate that brick used were of uniform strength hence lower factor of safety may use.

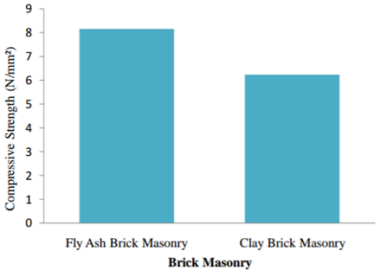

Fig. 4. Comparison of compressive strength of fly ash bricks and clay brick masonry

TABLE I
COST ESTIMATION OF FLY ASH BRICK MASONRY

S.No.	Particulars	Quantity	Rate	Unit	Cost
1.	Materials				
	Bricks	500	₹ 4	Per brick	₹ 2000
	Sand	.224	₹1750	Cu. m.	₹392
	Fly ash	50 kg	₹.55	Per kg	27.5
	Cement	1 bags	₹320	Bag	₹320
2.	Labor			Material cost A	₹ 2740
	Mason	1	400	Per person per day	₹400
	Male coolie	2	200	Per person per day	₹400
				Labor cost B	₹800
				A+B	3540
				10% Contractor pro.	354
				5% contingencies	177
				Total rate per sq.m.	4071

(NOTE: The prepared estimate is according to the rates of material in Indore, M.P., India on 10/04/2018)

- The Stress versus H/T ratio curve shows an increase in stress taken by the pier specimen, with increasing H/T ratio, attaining a peak value at the H/T ratio 3. Later on stress falls gradually with the increasing H/T ratio. This behavior is found to be peculiar when compared to the ordinary brick masonry.
- Failure of masonry in compressive stress is mainly governed by failure of bond. Therefore, strength may be increased by improving bond strength either by mixing some adhesive material in mortar or by making corrugation on brick surfaces.

II. Conclusion

Fly ash mortar provides 14% higher compressive strength and 8% higher tensile strength as compared to ordinary Portland cement mortar. Fly ash brick masonry is approximately 1.3 times the strength of conventional brick masonry. Estimated cost is found 10% to 13% of the cost estimated without using fly ash as partial replacement of cement.

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