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An Experimental Study on Fly Ash based Interlocking Hollow Concrete Blocks for Walls

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Abstract— ***The interlocking hollow concrete blocks have many benefits over simple bricks since they have very high compressive strength, easy and feasible construction, reduces use of mortar and are also cheaper as compared to simple bricks. The fly ash obtained by combustion of coal was used as partial replacement for cement owing to its pozzolanic nature, which provides strength to cement. The huge quantity of fly ash being accumulated over the years is likely to pose a serious threat for its disposal and cause environmental problems. Its influence or effect on the compressive strength and properties of fresh concrete has been carried out in this project. Fly ash was used to replace 30%, 40% and 50% of cement by weight for the designed interlocking hollow concrete block. The results showed that strength of interlocking hollow concrete block decreases rapidly as we increase the percentage of fly ash.***

Keywords— interlocking, hollow concrete blocks, fly ash, partial replacement, pozzolanic.

INTRODUCTION

With the increase in material costs in the construction industry, there is a need to find more cost saving alternatives so as to maintain the cost of constructing houses at prices affordable to clients. So interlocking bricks were introduced and that results in cheaper building costs due to faster completion time, less skilled workers and less wastages. Hollow concrete bricks are 60% less weighted than concrete solid block. Studies show that hollow bricks or blocks have greater advantages than the solid bricks. Both clay hollow bricks and concrete hollow bricks have enough proven benefits but the former having much more than the later. Fig. 1 and Fig. 2 shows the top and side view of the interlocking hollow concrete block (* patent filed).

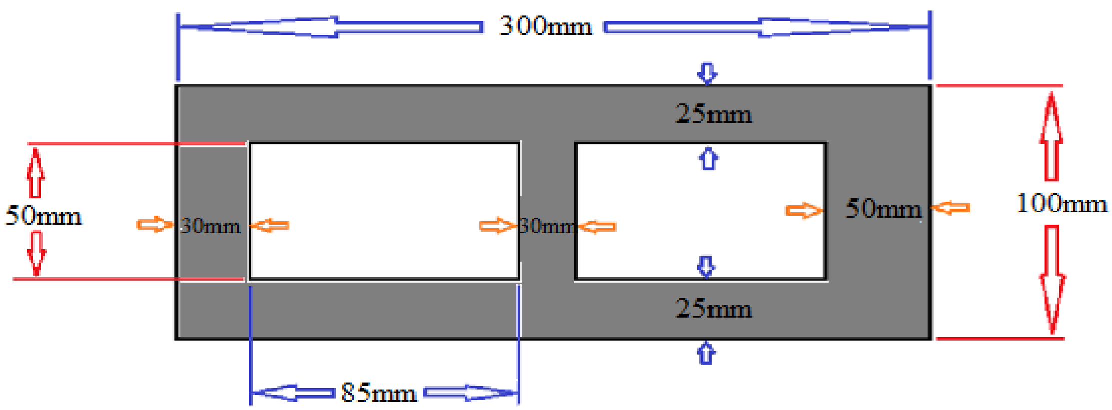

Fig. 1 Top view of the hollow concrete block

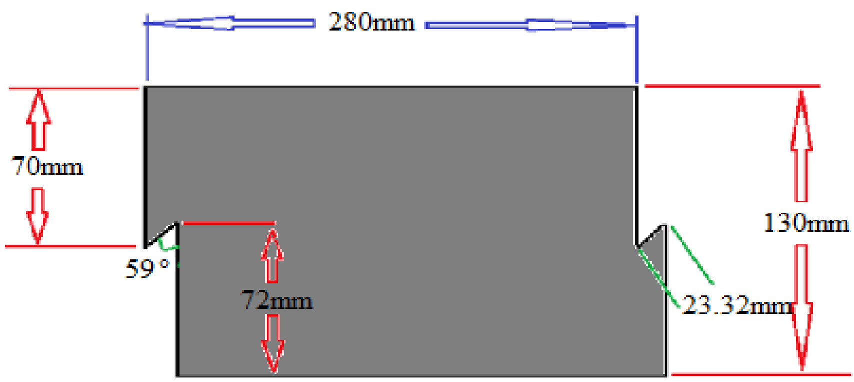

Fig. 2 Side view of the hollow concrete block

Hollow bricks can be used to build load bearing as well as non-load bearing walls depending upon the compressive strength of the material used. Hollow concrete blocks/ bricks can be proven eco-friendly since they are manufactured by using recycled/waste material/natural substitutes like coal ash, rice husk, granite slurry, fly ash, etc.

Coal based thermal power stations generate electricity on one hand which is essential for our development and growth, on the other hand, these power stations also produce massive quantities of coal ash which could pose serious environmental and other related problems. Ash that falls in the bottom of the boiler is called bottom ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide, aluminum oxide and calcium oxide (CaO).

Due to the presence of pozzolanic activities, which is responsible for setting of concrete and provide concrete with more protection from wet conditions and chemical attack, fly ash can be used as a partial replacement for cement. Moreover, cement industry is the major contributor of pollution by releasing carbon dioxide. 1 ton of cement produces approximately 1 ton of carbon dioxide. So by partially replacing cement with pozzolanic material such as fly ash, the cement industry can serve both the purposes of meeting the demands of construction industry and at the same time producing green and clean environment. Fly ash is of two types, class F and C. Class F fly ash is produced by burning of harder, older anthracite and bituminous coals. This fly ash is pozzolanic in nature and contains less than 7% lime (CaO). However, class C fly ash is produced by burning of younger lignite sub-bituminous coal. It possesses pozzolanic as well as self-cementing properties. In the presence of water, class C fly ash hardens and gets stronger over time. It generally contains more than 20% lime (CaO).

In many civil engineering structures tensile forces can lead to cracks and these can occur relatively soon after the structure is built. Repair of conventional concrete structures usually involves applying a concrete mortar which is bonded to the damaged surface. Sometimes, the mortar needs to be keyed into the existing structure with metal pins to ensure that it does not fall away. Repairs can be particularly time consuming and expensive because it is often very difficult to gain access to the structure to make repairs, especially if they are underground or at a great height.

LITERATURE REVIEW

The present study aims to study the effect of fly ash on the designed hollow concrete block by partial replacement of cement with 30%, 40%, and 50% of fly ash. Various research works have already been conducted to study the effect of fly ash on various properties of the designed hollow concrete block at different ages and for different grades of concrete. Some research works were reviewed and are presented in this paper.

R. Ahmad *et al* [1] concluded that the economy and stability are the prime requisites of any structure. Best designer is one who comes out with a design which gives the stable and economic structure. In this paper an investigation on hollow concrete block masonry was carried out and a comparative study was executed with respect to brick masonry construction and strength parameter, economy, light weight character and insulation property were studied and compared.

T. Sama *et al* [2] studied the effect of strength of concrete by partial replacement of cement with fly ash and addition of steel fibres. The grade of concrete used was M40 with mix proportion of 1:1.62:2.83 and w/c ratio of 0.45. It was observed that the optimum percentage of adding fly ash and steel fibres was determined to be 40% and 2% which showed the maximum improvement in tensile and flexural strength.

A. Jatale *et al* [3] studied the effects on compressive strength when cement is partially replaced by fly ash and observed that the use of fly ash slightly retards the setting time of concrete. It was also found that the rate of strength development at various ages is related to the w/c ratio and percentages of fly ash in the concrete mix. Moreover, the modulus of elasticity of fly ash concrete also reduced with the increase in fly ash percentage for a given w/c ratio.

R. Bansal *et al* [4] studied the effect on compressive strength on concrete by partial replacement of cement with fly ash and found that on 10% replacement of cement by fly ash, 20% and 50% decrease in compressive strength was observed at the age of 7 and 28 days respectively. Similarly on 20% replacement, 7% and 11% increase in compressive strength was observed at the age of 7 and 28 days respectively and on 30% replacement, 23% and 25% increase in compressive strength was observed at the age of 7 and 28 days respectively. It was also observed that with the increase in age, the compressive strength increased for fly ash replaced concrete.

C. Marthong and T.P. Agrawal [5] studied the effect of fly ash additive on concrete properties and found that the normal consistency increases with increase in the grade of cement and fly ash content. It was also concluded that the use of fly ash improves the workability of concrete. Moreover, it was also observed that the compressive strength of concrete increases with the grade of cement. As the fly ash content increases in all grades of OPC there is reduction in the strength of concrete. The reduction is more at earlier ages as compared to later ages. Fly ash concrete was also found to be more durable as compared to normal OPC concrete.

MATERIALS USED

The physical properties of cement, fine aggregates, coarse aggregates, fly ash and water used for mix design of M20 grade of concrete were tested in laboratory and are mentioned below.

Cement

The cement used was OPC53. All properties of cement were in accordance with IS269:1976. The physical properties of the cement used are as listed below in Table 1.

TABLE I

PHYSICAL PROPERTIES OF ORDINARY PORTLAND CEMENT

S. No.	Properties	Test Values
1.	Specific Gravity	3.15
2.	Normal Consistency	30%
3.	Initial setting time	60 min.
4.	Final setting time	260 min.

Fine Aggregates

The sand which was locally available and passing through 4.75mm IS sieve size was used as fine aggregate. The physical properties of the fine aggregates are as listed in table below in Table 2.

Table II

PHYSICAL PROPERTIES OF FINE AGGREGATES

S. No.	Properties	Test Values
1.	Specific Gravity	2.60
2.	Water Absorption	1%
3.	Fineness Modulus	2.5

Coarse Aggregates

The coarse aggregates with nominal maximum size of aggregates as 20mm (60%) and 10mm (40%) as per Indian standard were used. The physical properties of the coarse aggregates are listed below in Table 3.

Table III

PHYSICAL PROPERTIES OF COARSE AGGREGATES

S. No.	Properties	CA-20	CA-10
1.	Type	Crushed	Crushed
2.	Specific Gravity	2.65	2.70
3.	Water Absorption	0.50%	0.50%
4.	Fineness Modulus	6.8	6.5

Fly Ash

The fly ash used was of class F with specific gravity of 2.10.

Water

The water used for experiments was potable water.

I. RESULTS & DISCUSSIONS

Each set of 3 cubes of M15, M20 and M25 grade of hollow concrete blocks were tested in Compression Testing Machine with 0%, 30%, 40% and 50% replacement of cement with fly ash to determine the compressive strength after 7, 28 and 90 days of curing. It was observed that with increase in percentage of fly ash, there was significant decrease in the compressive strength of interlocking concrete blocks. For M15 grade of concrete, the decrease in compressive strength at the age of 28 days was found to be 3.00%, 10.60% and 23.87% for 30%, 40% and 50% replacement of cement with fly ash.

The results for compressive strength of interlocking hollow concrete blocks for M15 grade of concrete after 7, 28 and 90 days of curing is tabulated in Table 4 and represented through line chart in Fig. 3.

Table IV

COMPRESSIVE STRENGTH OF HOLLOW CONCRETE BLOCK (M15 GRADE) FOR DIFFERENT PERCENTAGES OF FLY ASH

Type of Concrete	Compressive strength in N/mm^2		
	7 days	28 days	90 days
Normal Concrete	8.03	11.98	12.34
Concrete with 30% fly ash	7.24	11.62	11.89
Concrete with 40% fly ash	5.84	10.71	10.90
Concrete with 50% fly ash	5.14	9.12	9.72

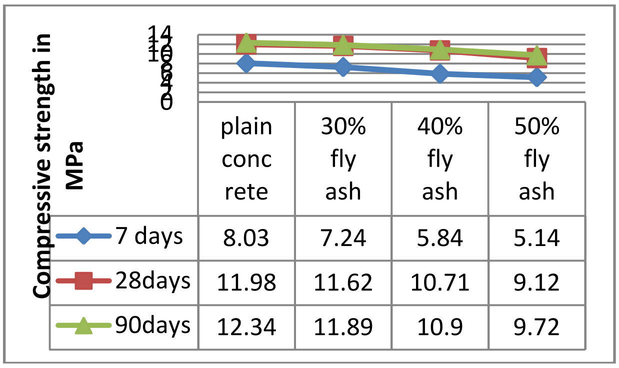

Fig. 3 Compressive strength of interlocking hollow concrete block (M15 grade) for different percentages of fly ash

Similarly, for M20 grade of concrete, the decrease in characteristic compressive strength was found to be 22.20%, 36.41% and 46.98% for 30%, 40% and 50% replacement of cement with fly ash. The results for compressive strength of interlocking hollow concrete blocks for M20 grade of concrete after 7, 28 and 90 days of curing is tabulated in Table 5 and represented in Fig. 4.

Table V

COMPRESSIVE STRENGTH OF HOLLOW CONCRETE BLOCK (M20 GRADE) FOR DIFFERENT PERCENTAGES OF FLY ASH

Type of Concrete	**Compressive strength in N/mm^2**		
	7 days	**28 days**	**90 days**
Normal Concrete	11.47	17.88	18.60
Concrete with 30% fly ash	11.38	13.91	15.60
Concrete with 40% fly ash	9.77	11.37	13.04
Concrete with 50% fly ash	8.63	9.48	11.25

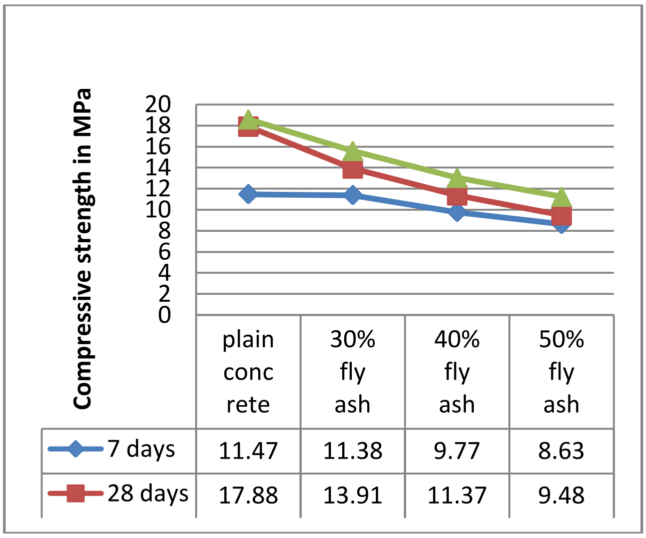

Fig. 4 Compressive strength of interlocking hollow concrete block (M20 grade) for different percentages of fly ash

Moreover for M25 grade of concrete, the decrease in characteristic compressive strength was found to be 17.68%, 26.03% and 34.43% for 30%, 40% and 50% replacement of cement with fly ash. The results for compressive strength of interlocking hollow concrete blocks for M25 grade of concrete after 7, 28 and 90 days of curing is tabulated in Table 6 and represented through line chart in Fig. 5.

Table VI

COMPRESSIVE STRENGTH OF HOLLOW CONCRETE BLOCK (M25 GRADE) FOR DIFFERENT PERCENTAGES OF FLY ASH

Type of Concrete	**Compressive strength in N/mm^2**		
	7 days	**28 days**	**90 days**
Normal Concrete	17.10	21.55	22.70
Concrete with 30% fly ash	14.71	17.74	21.39
Concrete with 40% fly ash	13.67	15.94	18.50
Concrete with 50% fly ash	11.45	14.13	15.13

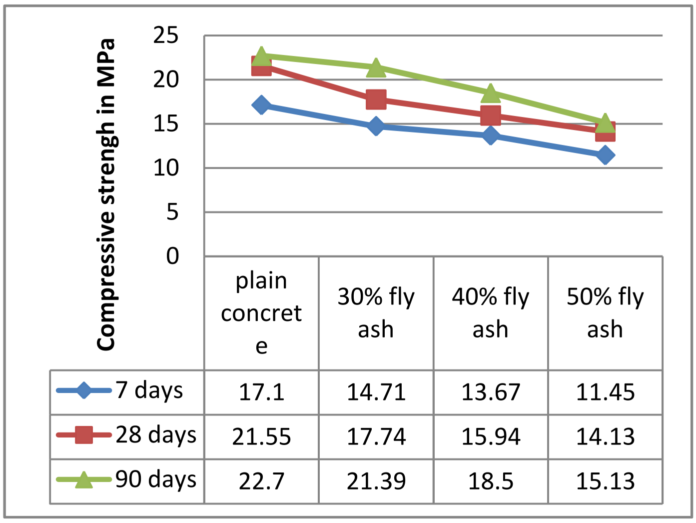

Fig. 5 Compressive strength of interlocking hollow concrete block (M25 grade) for different percentages of fly ash

II. CONCLUSIONS

The present research provides experimental data on the compressive strength of normal concrete and fly ash mixed concrete used in the design of interlocking hollow concrete block, without using super plasticizer, at different grades of concrete.

The following conclusion can be made from the study:

1. The interlocking hollow concrete blocks/units have very high compressive strength as compared to ordinary bricks.
2. The load bearing capacity of these units/blocks is very high as compared to normal bricks.
3. The compressive strength of hollow concrete blocks decreases with increase in fly ash content. The reduction in the compressive strength at the age of 28 days was found to be 22.20%, 36.41% and 46.98% for 30%, 40% and 50% replacement of cement with fly ash for M20 grade of concrete.
4. M15 grade concrete blocks are more suitable for infill walls as compared to M20 and M25 grade fly ash mixed concrete. The reason being the strength required is not as high as gained in M20 and M25 grade of concrete and it also leads to the wastage of material and makes the section uneconomical.
5. The decrease in the compressive strength of hollow concrete blocks with the rise in fly ash content increases for higher grade of concrete.

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