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An Experimental Project of Replacing the Bricks by using Interlocking Blocks

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Abstract- The use of interlocking bricks masonry has gained rapid popularity in many foreign countries as an alternative to conventional bricks for sustainable housing. It is being always challenge for researchers to make interlocking brick light weight, low cost and improve the performance against aggressive environment. An experimental effort made in this concern. This paper gives the results of an experimental investigation in which the compressive strength, water absorption and density were investigated by using varying percentage of fly ash, stone dust, and sand with different mix proportion. A manmade fibre, glass fibre reinforce polymer (GFRP) utilize as reinforcing material to produce the interlocking blocks which gives appreciable results discuss in detail. The experimental results compared with that ordinary brunt clay brick and interlocking brick found durable in aggressive environments and have sufficient strength for their use in sustainable building construction.

Keywords:- Fly Ash, GFRP, compressive strength, water absorption, density.

I. INTRODUCTION

A very high amount of waste is being produced all around the world. The most common method of managing waste is through its disposal in landfills creating in that way huge deposits of waste. In this situation, waste recycling is gaining increasing importance [1].

At present in India, about 206 coals based thermal power plants are producing about 160 million tons of fly ash every year; the estimates prepared by Ministry of Power as well as Planning Commissions up to the year 2031-32 indicate that generation of fly ash during the year 2031-32 would be around 900 million tons per year [2-3].

Whereas the current annual production of fly ash worldwide is estimated around 600 million tones [4]. The Government of India took policies initiative for utilization and disposal of fly ash [5]. In a tropical country like India the burnt clay brick is the most basic building material for construction of houses. It is reported that the requirement of bricks for Construction activity amounts to be more than 140 billion numbers annually [6]. For fulfill such demand fly ash interlocking brick may be one of alternative for sustainable construction industry.

Much experimental research carried out for producing good quality brick with reduction ofcost using industrial waste [7]. And also for reducing price and increasing the strength many natural and manmade reinforcing material used in the production of bricks. There are a wide range of natural fibers, namely sisal, bamboo, coir (coconut fibre), jute, and many others [8].

In this research work the manmade fibre GFRP introduce as a reinforcing material. The effect of GFRP with maximum percentage of fly ash in interlocking brick is studied. This advocate the use of fly ash as the supplementary material to soil by reducing the consumption of soil in brick manufacturing towards efforts of maintaining ecological balance through sustainable development of natural resources. The dry stacked stabilized interlocking block masonry replaces the conventional burnt clay brick and mortar construction masonry. The use of interlocking bricks masonry has gained rapid popularity in many foreign countries as an alternative to conventional bricks for sustainable housing [9]. Interlocking block masonry byHydra form (or by others) is one such building system which almost full fills all such requirementsof being a sustainable masonry [10- 11].

As per IS code bricks are designated based on their average compressive strength [12-13]. Indian masonry design standard does not deal with dry interlocking block masonry, hence does not prescribe the design values for this masonry like basic compressive, tensile and shear stress. However the same code recognizes some other types of masonry and recommends that a prism test of different masonry may be done and these values may be accepted for designing the masonry [14].

Interlocking bricks in central India made with locally available raw materials have the density around 25-30 KN/m3& avg. comp. strength is 2-4 MPa [15]. Due to this high weight & low compressive strength it is not possible to use this bricks in multi storied building. Density can be reducing with increase in compressive strength through experiment which may provide the best solution for such type of bricks.

II. EXPERIMENTAL PLANS

1. Material:

For casting of interlocking bricks locally available raw materials like fly ash, stone dust, marble slurry and sand were used. Additional material GFRP was used to investigate the effect on properties of interlocking brick.

Table 1. Physical Properties of Cement.

Material	Physical Properties	Value
Cement	Specific gravity	3.18
	Specific surface	2250 cm^2/gm
	Soundness	1 mm
	Initial setting time	35 min
	Final setting time	380 min.
	Compressive Strength (1:3 cement sand mortar)	19.2 Mpa (3 days) 28.5 Mpa (7 days)

1.1 Cement: Ordinary Portland cement were used satisfying all the IS requirements was used in making the bricks [16]. The physical properties of cement listed in Table no.1.

1.2 Fly Ash: The fly ash which is shown in figure.1 was collected in dry state from the Paras Thermal power station and the chemical characteristics of the fly ash are given in Table 2. Zone-III as per IS: 383-1970 [17] and its physical properties are enlisted in Table 2.

Table 2. Physical Properties of Fly ash.

Material	Chemical Constituents	Percentage
Fly ash	Silica (SiO_2)	64.23 %
	Alumina (Al_2O_3)	25.82 %
	Iron (Fe_2O_3)	4.06 %
	Sodium (Na_2O)	0.40 %
	Sulphur Trioxide (SO_3)	0.27 %
	Magnesium Oxide (MgO)	0.78 %
	Loss of Ignition(as I.OI)	0.39 %

1.3 Stone Dust: Powder form stone dust which is shown in figure.2 was available locally used in moderate quantity for preparing the bricks. Its fine size make possible to retain proper shape of the bricks particularly maintaining the edges and corners.

2.1.4 GFRP: GFRP used as reinforcing material, the physical properties are listed in Table 3.

Table 3. Physical Properties of Sand, Stone dust and GFRP.

Material	Properties	Value Obtained
Sand	Specific Gravity	2.48
	Water Absorption	1.05
	Bulking of Sand	26.84%
	Free Moisture	1.00%
	Bulk Density	1500 kg/m^3
Stone dust	Specific Gravity	2.68
	Water Absorption	0.32%
	Fineness Modulus	2.89
	Silt Content	2.1%
GFRP	Nominal dia.	0.09 mm
	Tensile strength	25 N/mm
	Type of wave	Plane

Fig 1. Fly Ash.

Fig 2. Stone Dust.

Fig 3. GFRP.

2.1.5 Fine Aggregate: Sand i.e., fine aggregate obtained locally from nearest river passing through 4.75 IS sieve having fineness modulus (F.M)-2.61 and confirming to Table 3.

Fig 4. Interlocking Brick (Ridge).

Fig 5. Interlocking Brick (Bed).

2.1.6 Water: Ordinary tap water was used for both mixing the constituents of the bricks as well as for the curing of bricks.

2. Process Operation:

2.1 Casting of Interlocking Bricks: For casting the Cement and other constituents were used randomly in varying proportions of 1:10, 1:11 and 1:12. In order to establish the feasibility of producing a binder that can impart adequate strength, three specimen bricks were casted for each mix proportions given in Table 4.

A pan mixer and hydraulic machine used for casting the bricks. Before casting the bricks, mixer was properly cleaned. Cement and stone dust were added in dry state, mixed thoroughly and then clean potable water was added to get a mix of desired work ability. The mix so prepared for the bricks was then poured in hydraulic machine and bricks were then taken out of it and kept over level surface under the shed for drying purpose.

The blocks have geometric size of 230 mm x 100 mm x 75 mm. This machine produces solid blocks of laterite composition mainly and stabilized with cement material.

2.2 Curing: The green bricks were allowed for surface dry for one day and cured normally for 28 days by spraying water four to five times in one day. After gaining sufficient strength they were submerged in water and sulphate solution at normal room temperature of 27+2oC for different ages. Sulphate solution having sulphate (SO4) concentration equal to 10000 ppm was prepared in laboratory by mixing 14.79 gm NaSO4 in one liter of water.

3. Testing:

The casted bricks were taken out from water one day prior to the testing and were tested for compressive strength after 14, 28 and 90 days and water absorption test as per IS 1077-1957 Code.

3.1 Compressive Strength Test Procedure: Compressive strength test should be done in compression testing machine. Blocks should be placed between the jaws and load should be applied gradually. Precaution should be taken such that load should be applied to the flanged portion of the blocks. For this cement mortar ofproportion1:3 are placed on top flange as well as at bed and gradual load is applied over the complete area till the failure occurs and not the maximum load at failure.

Fig 6. Curing.

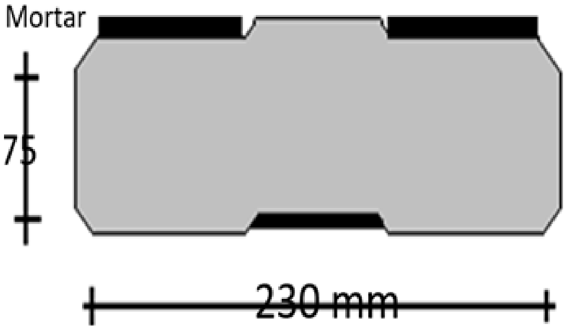

Fig 7. Interlocking Brick.

Fig 8. CTM Testing.

The load at failure shall be the maximum load at which the specimen fails to produces any further increase is the indicator reading on compression testing machine. The compressive strength of any individual block shall not fall below the minimum average compressive strength by more than 20% as per IS 1725-1982 [18].

Compressive strength = Maximum load at failure/ Average area at bed face.

3.2 Water Absorption Test: Bricks have pores in them. Due to porosity, the dry bricks when come into contact with water absorb water through these pores. Smaller the porosity; lesser is the absorption. Formula to calculate water absorbed by the bricks, using following formula: [(W2- W1) / W1] x100.

3.2 Density: After 90 days of casting, these bricks were dried to a constant mass in an oven at 105°. They were cooled to room temperature and their density was obtained by dividing the mass of a brick by its overall volume. The shrinkage of the bricks was not measured. It may be relevant to mention that the cracks were not visible on these bricks with naked eye after 90 days of casting.

Table 4. Mixing Ratio.

Ratio	Mix Designation	Constituent Materials (Percentage)			
		Fly Ash	Stone dust	Sand	GFRP
1:10	M1	45	35	20	--
	M2	55	25	20	--
	M3	60	20	20	--
	G1	60	20	20	0.10
	G2	65	15	20	0.10
	G3	70	10	20	0.10
1:11	M4	50	40	20	--
	M5	55	35	20	--
	M6	60	30	20	--
1:12	M7	60	45	20	--
	M8	65	40	20	--
	M9	70	35	20	--

III. EXPERIMENTAL RESULTS AND DISCUSSION

The experimental results are presented in Figs. 1 to 5 Figs. 1 to 3 show the compressive strength for mix ratio 1:10, 1:11, and 1:12 of bricks with increasing percentage of Fly ash and a constant sand content of 20 respectively. Fig 4 and Fig 5 shows the percentage of water absorption for mix proportions and density respectively for all mix proportion.

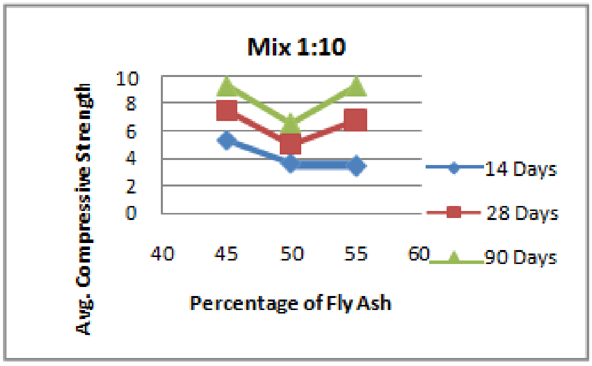

Fig 9. Compressive Strength for Mix 1:10.

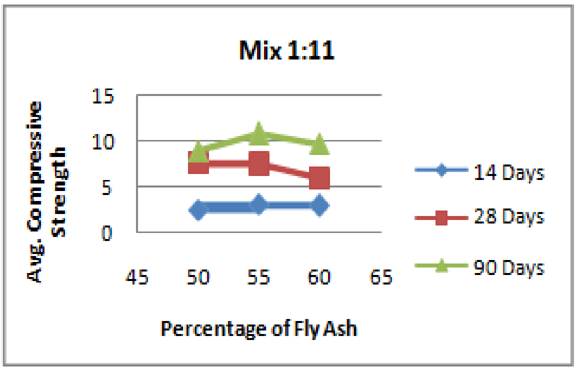

Fig 10. Compressive Strength for Mix 1:11.

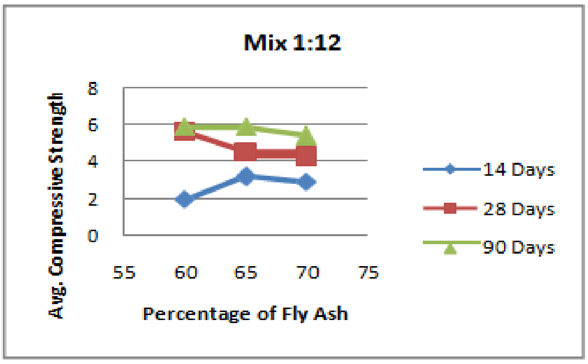

Fig 11. Compressive Strength for Mix 1:12.

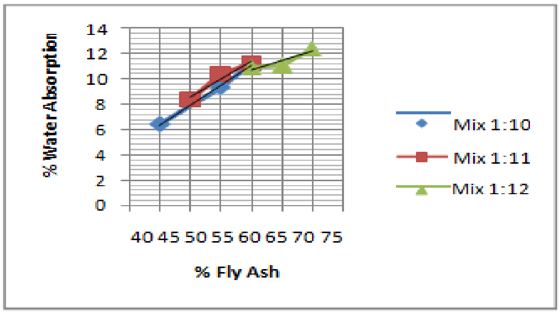

Fig 12. %Water absorption of interlocking bricks.

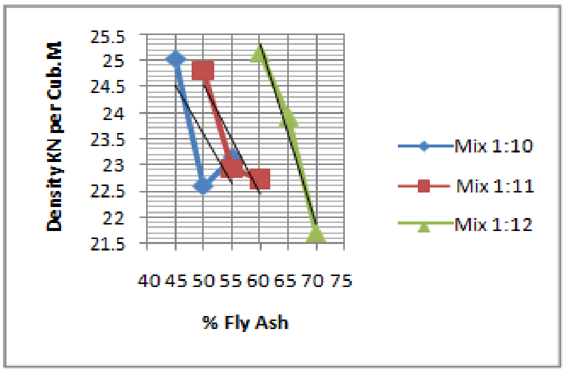

Fig 13. Density of interlocking brick.

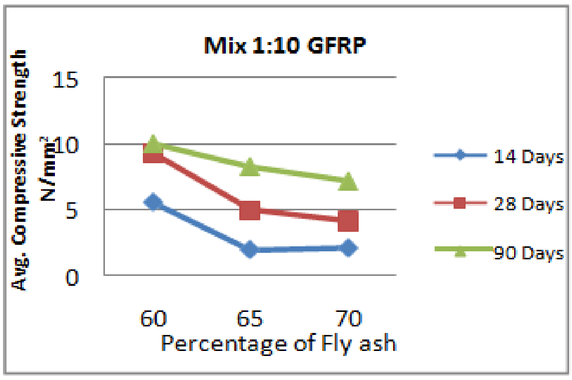

Fig 14. Compressive Strength for Mix 1:10 GFRP.

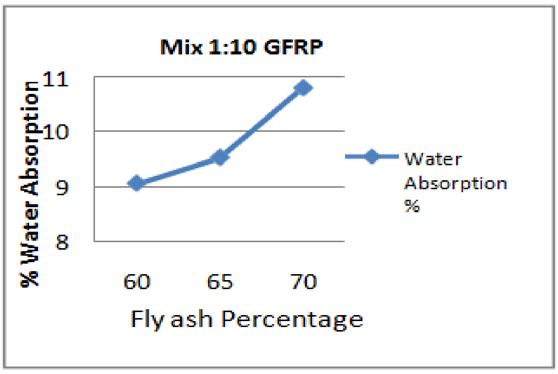

Fig 15. % Water absorption of Mix 1:10 GFRP.

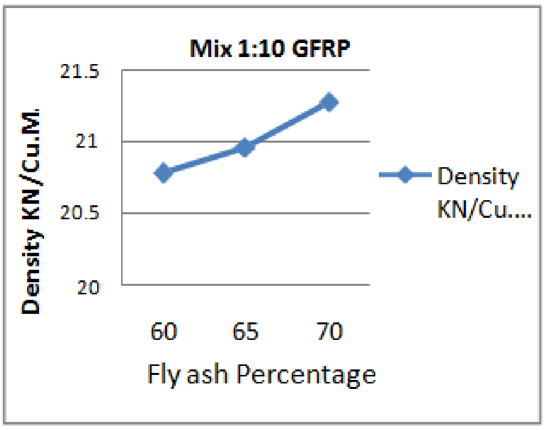

Fig 16. Density of Mix 1:10 GFRP.

Figs. 9, 10 shows that the compressive strength of interlocking brick initially increases with the increase in fly ash content but fig.11 after attaining a maximum value it start decreasing with the further addition of fly ash. Fig 12 shows the water absorption of interlocking bricks.

It is observed that in general, the water absorption of bricks increases with the increase in fly ash content replacing stone dust. On comparing interlocking bricks with ordinary burnt clay bricks it is observed that water absorption of interlocking bricks in the present investigation was obtained in between 6.42 to 12.4 percent whereas the water absorption of ordinary bricks shall not be more than 20 percent by weight.

Density of interlocking bricks is shown in Fig. 13. It is observed that the water absorption and density are closely related to each other. The density of inter locking bricks was found to be 7.5 to 25 percent higher than that of the ordinary burnt clay bricks.

GFRP a reinforcing material plays vital role with increase in percentage of fly ash. Its influence make increase in compressive strength, lesser water absorption and density reduce up to 20 percent comparing with initial density of interlocking brick.

IV. CONCLUSION

Based on the experimental investigation reported in this paper, following conclusions are drawn: Strength of interlocking bricks with increasing fly ash increases with the age. All mix proportions gives satisfactory higher values of compressive strength. At some with out GFRP mix ratio 1:11 gives the higher compressive strength greater than 10 N/mm2.

Interlocking bricks with economically available fly ash in large proportion have sufficient strength for their use in low cost housing, non-load bearing construction and in regions where good quality burnt clay bricks are not available.

Water absorption of interlocking bricks without GFRP is found to be in the range of6.42 to 12.4 percent, whereas the water absorption for ordinary burnt clay bricks should not be more than 20 percent. The water absorption of interlocking bricks increases with the increased fly ash content.

The density of interlocking bricks was found to be 7.5 to 25 percent higher than that of the ordinary burnt clay bricks. Interlocking brick with reinforcing agent GFRP increases the compressive strength at maximum utilization of fly ash with the age. The water absorption and density increase with increase in fly ash in GFRP interlocking brick.

As density concern the difference between ordinary clay brick and interlocking brick should be minimize with reinforcing agent.

Interlocking bricks require no skilled labour and can be molded in any shape and size depending on the requirements. These bricks have better tolerances and no efflorescence as compared to conventional bricks. A number of other benefits also be ascribed for the prospect of interlocking bricks which includes no consumption of mortars, better efficiency in laying and low cost of finishing.

It is further needed to develop the awareness among users, professionals and financial supporters for using these waste materials for solving the housing problems in addition to balance economy and achieve energy conservation. For reducing the density of bricks more experimentation requires with different wasted material with natural reinforcing fibre for considering economy and use for multi storied building.

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