Design of Interlocking Block and Replacement of Msand by Concrete Roof Tile Waste

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Abstract – *Interlocking blocks are one of the alternatives for the conventional burnt clay brick. This report deals with the design of interlocking blocks and also replacement of the m-sand by concrete roof tile waste in various percentages and finding the optimum percentage of tile waste by testing the cubes casted for compressive strength of 3 days and finally casting the blocks with that optimum percentage of tile waste. The report finally gives the results of an experimental investigation in which the compressive strength, water absorption and density were investigated by using optimum percentage of tile waste, m- sand, cement and 6mm aggregate with mix proportion of 1:2:4. The experimental results are compared with that ordinary solid block. The results indicate that these blocks are slighter lighter in weight, durable in aggressive environments and have better strength for their use in building construction.*

Key Words: **Interlocking block, Roof tile waste, Replacement, Compressive strength**

1. INTRODUCTION

The interlocking blocks are different from other normal bricks as it requires less mortar or cement for masonry work. These blocks interlocked with each other by means of positives and negative frogs on the top and bottom of the blocks which disallow the horizontal compressive stress and lateral movement of blocks. The projection of one block fits into the depression of the next so that they always align perfectly. The specifications and the characteristics of this block depend on the machine used to manufacture it. The most common size of block is 300x150x120mm. The basic raw materials are cement, fine aggregate and coarse aggregate. This is usually done with mechanized compaction and vibration.

Current process of producing the interlocking block is by using a semi mechanized stationary type machine. The other production systems are - manual mould that requires hand tamping, a mobile semi-mechanized egg-laying machine and fully mechanized system that combines compression and manual concrete filling in mould. The machine also compacts and consolidates the mix so that the blocks are uniform in size and attain desired physical properties.

The blocks are cured for a minimum period of 14 days, before they are ready to use. On an average 600-800 blocks can be made in 8 hours by 1 skilled and 6-8 semi-skilled workers. There are various types of interlocking blocks. The most commonly used cement interlocking blocks are regular shaped block, half size block and u-shaped block.

1.1 Advantages of Interlocking Blocks

Interlocking blocks offer numerous advantages to other building materials. The materials required for production are widely available so they do not have to be shipped in from long distances. Since the manufacturing process is a simple one, production facilities can be easily set up at convenient geographical locations, once again reducing the cost of transporting them to the construction site. In the case of very large construction projects, an interlocking block production facility can be set up at the construction site to provide the most cost effective supply solution.

Without the need of high waged skilled masons, by saving cement and with the speed of construction, the building costs are lower than that for standard masonry construction. When compared to convention masonry block construction, interlocking blocks, which are dry assembled, save a great deal of mortar which is normally used for vertical and horizontal joints, which produces savings in terms of both cost and time. The structural stability and durability of interlocking block construction can be far greater than the normal construction.

2. DESIGN OF INTERLOCKING BLOCKS

Each blocks have two interlocks, a projection 'tongue' part and a depression 'groove' part, this helps to resist the lateral movements and horizontal compressive stresses caused due to earthquakes.

Size of the block is chosen to be 300 X 220 X150 (in mm) and width is of 220mm, it covers the total width of two normal bricks, therefore no need of plastering. It covers an area of about more than 3 normal bricks. Slopes are provided for the ease in interlocking between the blocks so that there will not be any problem in aligning the blocks. Height of the projection is about 2.5cm, therefore less amount of mortar needed. Slope is 1 in 2, therefore front view will be of pleasing nature. As well as less amount of mortar needed, if it is to be plastered. The blocks are shaped with projecting parts, which fit exactly into depressions in the blocks placed above, such that they are automatically aligned horizontally and vertically thus block laying is possible without special masonry skills. Each block has a projection in one end of blocks side face and a depression in other end. Since the blocks can be laid dry, less mortar is required and a considerable amount of cement is saved.

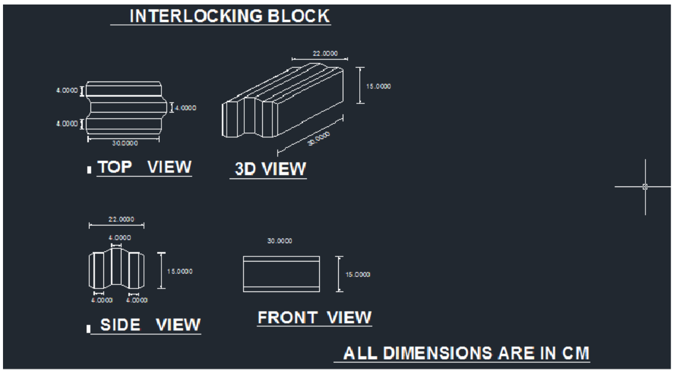

Fig -1: CAD Drawing

Fig -2: Parts of mould

3. METHODODLOGY

In this methodology, the materials used were:-Cement (53 grade), M-Sand, Concrete roof tile waste (collected from "PIONEEER ROOFING TILES" company), Coarse aggregate (6mm).

3.1. Trial Casting

In trial 1, mix design was done and the ratio obtained was 1:1.54:2.51.Since this ratio cannot be adopted according to clause 7.1.1 IS 2185 (Part 1):2005.Also we analyzed that the water content was not sufficient for providing workable mix. In trial 2, 4 cubes of size 15cm x 15cm were cast in the mix proportions of 1:2:4 and 1:3:6 using 53 grade cement, 6 mm coarse aggregate and M-sand. The cubes were tested for compression and the results obtained were:-
Compressive strength of M15 mix cube =15 MPa
Compressive strength of M10 mix cube =9 MPa
The ratio of M15 mix cube was adopted and decided to add Master Glenium Sky 8233 for better finishing as well as for increasing workability.

Fig -3: Cubes of M10 and M15 mix

Slump test was done in the fixed ratio of 1:2:4 for finding the water-cement ratio and thus obtained the value as 0.45.
In trial 3, 14 cubes of size 10cm x 10cm were cast in the ratio of 1:2:4 with the replacement of M-sand by roof tile wastes as 0%, 5%, 10%, 15%, 20%, 25% and 30%.The cubes were tested for compressive strength test.

Fig -4: Cast cubes by replacement of M sand by roof tile waste in 0,5,10,15,20,25 and 30%

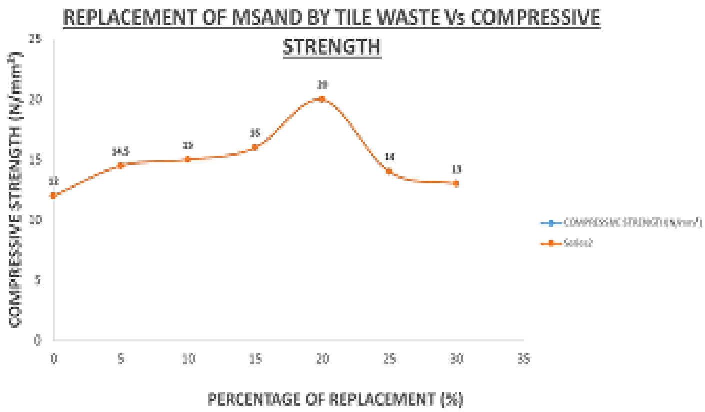

Chart 1: Compressive strength of cubes and optimum value fixation

Since 20% replacement was the optimum value, concluded to cast the interlocking block with this ratio.

3.2. Casting of interlocking blocks

The blocks were cast in the ratio 1:2:4 by using 53 grade cement, Msand replaced by 20% of roof tile waste, 6mm aggregate. All the materials were mixed in the mould and compacted using vibratory compaction machine. 11 cubes were casted and were tested for compressive strength, water absorption, and block density.

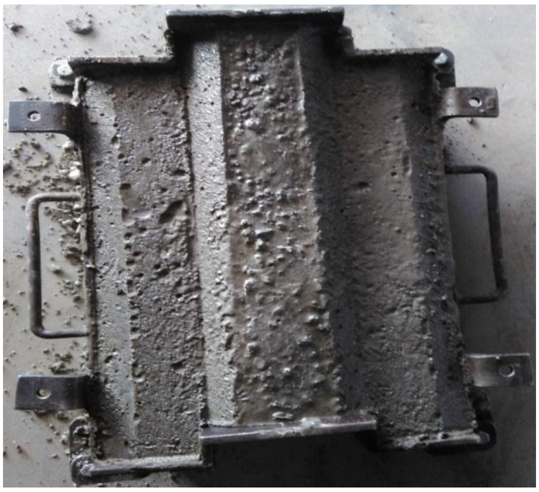

Fig -5: Interlocking block with mould

Fig -6: Interlocking blocks cast

4. TESTS AND RESULTS

4.1. Material Tests

Tests were conducted on the aggregates used and following results were obtained
Specific gravity of cement =2.92
Specific gravity of tile waste = 2.262
Specific gravity of Msand = 2.26
Normal consistency of cement = 33%
Fineness of cement = 4.6%
Sieve analysis of Msand and tile wastes were done

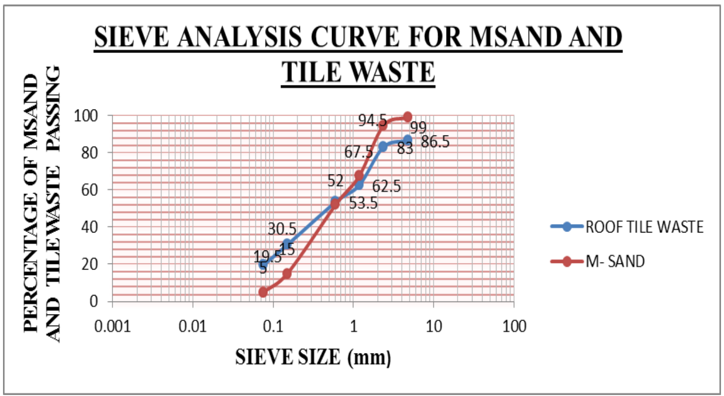

Chart 2: Particle size distribution for Msand and roof tile waste

4.2. Interlocking block tests

4.2.1. Water absorption

Table 1: Water absorption

WATER ABSORPTION		
	Wet mass (kg)	Dry mass (kg)
Specimen 1	18.820	18.500
Specimen 2	18.980	18.600
Concordant value	18.840	18.550

After 28 days continuous curing,

Water absorption = (18.84-18.55) / (18.55) x 100

=1.563.

It should not be more than 10 percent by mass.

10% by mass = 0.1 x 18.21 = 1.821; 1.563 < 1.821.

It was safe as per code IS 2185 (PART 1): 2005.

4.2.2. Compressive strength

Specimen shall be tested only after the curing period of 28 days. The bearing surface of the testing shall be wiped clean and any loose material removed from the surface. Place the specimen in the compressive testing machine and keep the steel plates on the top and bottom of the specimen. Fill the gaps the between the specimen and the steel plates using sand. The load shall be applied slowly without shock and increased continuously until the resistance of the specimen to the increased load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded.

Table 2: Compressive strength

COMPRESSIVE STERNGTH		
	Crack load (kN)	Collapse load (kN)
Specimen 1	195	350
Specimen 2	205	350
Concordant value	200	350

Crack load value=200 kN
Collapse load value=350 kN
Compressive strength of crack load =Load/Area
= $(200x10^3)/(660x10^2)$ = 3.03MPa
Compressive strength of collapse load =Load/Area
= $(350x10^3)/(660x10^2)$ = 5.30MPa

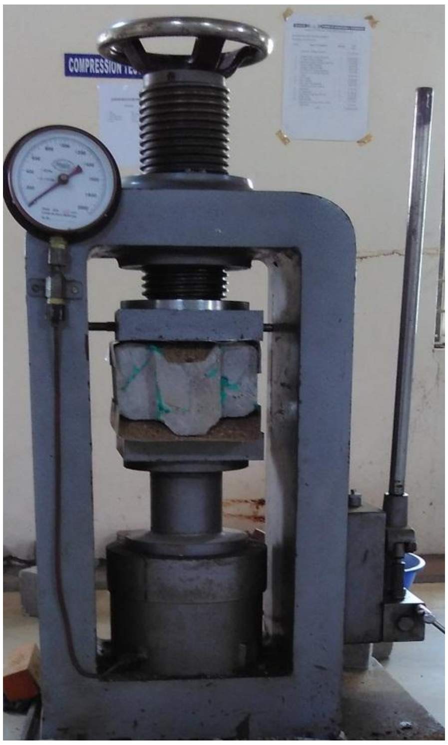

Fig-7: Compressive strength set up

Fig-8: Compressive strength value

Compressive strength of solid block = 2.05MPa.
Therefore, when compared with solid block interlocking block is found to have greater compressive strength.

4.2.3. Block density

Table 3: Block density

BLOCK DENSITY		
	Mass (kg)	
	Before drying	After oven drying
Specimen 1	18.190	17.980
Specimen 2	18.230	17.960
Concordant value	18.210	17.980

Volume of the block=9900 cm^3
Density of block before drying = $(18.210/9900)x\ 10^6\ kg/m^3$
$=1839\ kg/m^3$
Density of block after oven drying = $(17.980/9900)x\ 10^6\ kg/m^3 = 1816.1\ kg/m^3$
It was safe as per code IS 2185 (PART 1): 2005.

5. ESTIMATION

Comparison of cost estimation of Interlocking block with solid block

5.1. Cost Estimation of solid block ($1m^3$)

5.1.1. Cost of 100 blocks

Cost of cement = Rs 1788.8
Cost of Msand = Rs 536

Cost of coarse aggregate = Rs 2817.57
Total cost of solid block required for 1m^3 wall =
Rs 5142.434

5.1.2. Mortar

Cost of mortar = Rs 338.638 (including plastering charge of 60%)

5.1.3. Labour cost

10% of the total cost.
Therefore, Total cost = Rs 6029.22

5.2. Cost estimation of interlocking blocks (1m^3)

5.2.1 .Cost of 100 blocks

Cost of cement = Rs 2400
Cost of M-Sand = Rs 384
Cost of coarse aggregate = Rs 2520
Total cost of solid block required for 1m3 wall = Rs 5304

5.2.2. Mortar

Cost of mortar = Rs 16
1.5% of the total cost for architectural works
Therefore, Total cost = Rs 5406.10

5.2.3. Labour cost

When 10% of the total cost is considered, total cost = Rs 5946.71.
Since the amount of mortar required for construction is less as well as the aligning of interlocking block requires only a fair time, it requires half of the labour cost when considered with solid block. Therefore, assuming labour cost as 5% of total cost.
Total cost = Rs 5676.405
Percentage of saving = 5.85%
Thus, it can make a large variation in the cost estimation of a building

6. CONCLUSIONS

Depending upon certain considerations, a suitable interlocking block has been designed. Interlocking blocks were cast successfully as per the code 2185:2005 (part 1) in the mould made of mild steel.
1. Optimum value of Msand by tile waste replacement was found as 20% through trials. Block density and water absorption tests were satisfactory.

2. Compressive strength of interlocking block was found greater than that of ordinary solid block of approximately same size and components. Compressive strength of interlocking block and solid block obtained were 5.45MPa and 2.05MPa respectively.

3. Comparison of cost analysis of interlocking block with solid block resulted in an economic construction. Rate of construction for 1m3 using solid block and interlocking block were obtained as Rs 6029.22 and Rs 5676.40 respectively.

4. Because of the pattern of interlock, it provides better matrix strengthening, wall stability, disallows movements and reduces mortar.

Therefore, the interlocking block masonry can be adopted as a suitable substitute for traditional masonry. And in conclusion, interlocking masonry can be recommended for housing projects as an alternative method that is cheaper than the conventional.

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