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Investigation on Strength Parameters of Interlocking Hollow Block Strengthened with Steel Fibres

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ABSTRACT
This work introduces a specially designed hollow block in such a way that the bonding was achieved by interlocking. The block provides facility for concealing electrical conduit, water and sewer pipes wherever so desired without causing much damage to the block. Proper surface finish was achieved by M10 mix. In order to get a finished surface several trial mixes were tested. The respective blocks were casted with and without steel fibres and the test results were compared. A comparative study of strength parameters is to be executed with respect to solid concrete block and concrete hollow block. Hollow block strengthened with steel fibre can be effectively used as load bearing wall.
***Keywords* -** Conduits, Geometry, Hollow block, Interlocking, Steel fibre

I. INTRODUCTION

Hollow concrete blocks are an excellent substitute for conventional masonry units. They are lighter than bricks, easy to place and also confer economics in foundation cost and consumption of cement. Concrete hollow blocks have an important place in modern construction industry and as such are used in all constructions viz. residential, commercial and industrial building construction. They are one among the modern precast materials and hence they offer the advantage of uniform quality, faster speed of construction, lower labor involvement and long durability. The hollow blocks, made of cement, stone chips, stone dust and sand are not only cheaper but also acted as thermal insulator because of their hollowness.

Housing is a big and complex problem in India. More attention is paid to urban housing due to the growing pressure of population. In the process, rural housing gets neglected. A great majority of Indian population lives in rural areas. The influx of population from villages to metropolis has become a burning problem of the day. Rural & small town housings may slow down an excessive country - to - town movement of people and hence the housing problems of major cities may be controlled. Residential & non - residential constructions together are capable of swinging the national economy in any direction and to any extent. According to data available, non-residential construction has a very high share in total investment for buildings. Almost 80% of total resources are invested in constructions for non-residential purposes. Studies reveal the need and scope for building construction in rural and urban areas for residential & non-residential purposes.

II. OBJECTIVES

The main goal of the work is to design a steel reinforced concrete hollow block as a load bearing wall. The objectives of the work are listed as follows

- To develop an interlocking hollow block.
- To determine a suitable mix satisfying the codal provisions (IS: 456 - 2000) by trial and error method that provides workability, strength, suitable surface finish and economy.
- To investigate compressive strength of the interlocking hollow block.
- To investigate compressive strength of the interlocking hollow block strengthened with steel fibres.
- To compare the strength of the interlocking hollow block with locally available solid and hollow block.

III. METHODOLOGY

The key points of the study are

- Fixing the dimension of the block.
- Various tests were conducted on cement, fine aggregate and coarse aggregate to determine its physical properties
  a. Test on Cement: Specific gravity, standard consistency, initial and final setting time, compressive strength of mortar cube.
  b. Test on aggregates: Specific gravity, sieve analysis.
- Mix design of M10 grade concrete by trial and error method.
- Casting of cubes, cylinders and beams with and without steel fibres.

- Compressive strength test of cubes, splitting tensile strength test of cylinders and flexural strength test of beams were conducted.
- Casting of hollow block with and without steel fibres and comparing the results with locally available hollow and solid block.

IV. INTERLOCKING HOLLOW BLOCK

The geometry of the block (Fig 1) was so arranged that the bonding was achieved by interlocking pattern and cement grout. The block was casted with proper surface finish, thereby reducing the plastering cost. The inner hollow portions considerably reduce the dead load and serves as a conduit for electrical and plumbing utilities. interlocking hollow block was designed for a dimension of 60 x 20 x 29.8 and had a weight of 53 kg. Blocks for corners, intersections and lintel were geometrically designed as shown in Fig 2

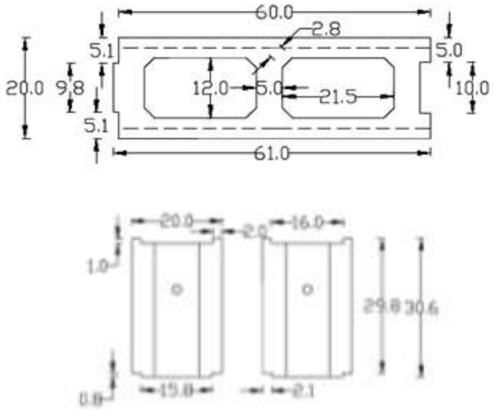
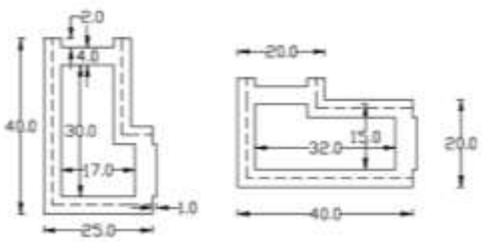
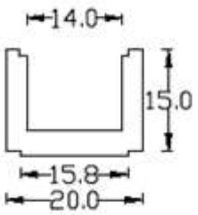


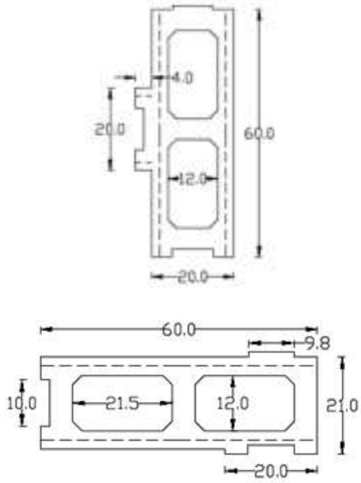
Fig 1 Plan and Inner Vertical Bonding Face of Interlocking Hollow Block



Block for Corners



Block for Lintel

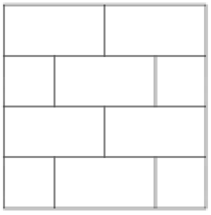


Block for Intersections

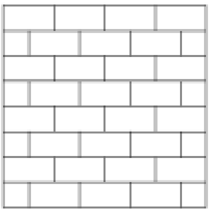
Fig 2 Interlocking Hollow Block for Corner, Intersections and Lintels

For covering an area of 60 x 30 cm, one steel fibre reinforced concrete hollow block is sufficient and it weighs about 53 kg. To cover the same area, 4 solid blocks of standard dimension 30 x 20 x 15 cm and 3 hollow blocks of standard dimension 40 x 20 x 20 cm are required. The required solid block and hollow block weighs about 74 kg and 60.75 kg respectively. Thus the steel fibre reinforced concrete hollow block reduces the dead load by 21 kg with respect to solid block. The area of 120 cm x 120 cm, that can be covered by different types of blocks is visualized in the Fig 3. Advantages of steel fibre reinforced concrete hollow blocks are

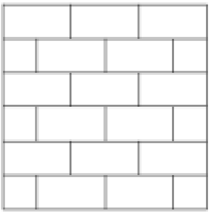
- Larger size reduces the joints, and increase load carrying capacity and decrease mortar volume.
- The face shells are in a good finish which helps in avoiding plastering and thus save the cost of plastering.
- The large width hollow portions concealed the plumbing and electrical pipes and hence wall chasing cost can be avoided
- Improve architectural aesthetics because of fewer joints.
- Faster construction practice due to interlocking pattern.
- Dead load reduction.
- Thermal insulation (having dual character of keeping building cool in summer and warm in winter).
- Sound insulation (to decrease disturbance due to external noise).



Hollow Block having Interlocking Ends



Locally Available Solid Block



Locally Available Hollow Block

Fig 3 Wall with Hollow Block having Interlocking Ends, Locally Available Solid and Hollow Block

V. MATERIALS USED

Material testing were conducted as per IS specifications.

5.1 Cement

Cement was tested as per IS: 1489 (Part 1) – 1991 (i.e. [7]).

Table 1 Properties of Cement

Brand	Shankar Cement; Portland Pozzolana Cement - 43 grade
Standard Consistency	32%
Initial Setting Time	190 min
Final Setting Time	365 min
Specific Gravity	2.965
Mortar Cube Strength	43 N/mm^2

5.2 Fine Aggregate

Fine aggregate was tested as per IS: 2386 (Part 1 and 3) - 1963 (i.e.[8]) and IS: 383 - 1970 (i.e.[9]).

Table 2 Properties of Fine Aggregate

Fineness Modulus	4.129
Zone	I
Specific Gravity	2.697
Water Absorption	0.2 %

5.2 Coarse Aggregate

Coarse aggregate was tested as per IS: 2386 (Part 1and 3) – 1963 (i.e.[8]) and IS: 383 – 1970 (i.e.[9]).

Table 3 Properties of Coarse Aggregate

Fineness Modulus	3.21
Nominal Size	12 mm
Specific Gravity	2.748
Water Absorption	0.15

5.4 Steel Fibres

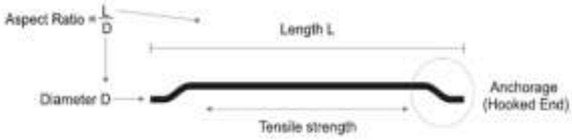


Fig 4 Hooked End Steel Fibres

Table 4 Details of Steel Fibre

Brand	Duraflex™ Hook End Steel Fiber
Product code	HKL 50/30
Material	Low Carbon Drawn Wire
Aspect ratio	50
Length (mm)	30 mm
Diameter (mm)	0.60 mm
Tensile strength	Greater than 1100 MPa
Appearance	Clear, Bright, Loose unglued with hook end anchorage
Conforms to	EN 14889-1,ASTH A820 M04 Standards

5.5 Water

Water used for mixing and curing was clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that are deleterious to concrete or steel.

VI. CONTROL MIX

M10 mix was considered as per IS: 456 – 2000. Since surface finish of steel fibre reinforced hollow block was an important factor, a trial and error method was adopted to arrive at a workable mix (TABLE 5).

Table 5 Mix Proportion

Material	Cement	Fine Aggregate	Coarse Aggregate	Water
Weight (kg/m^3)	280	914.403	1143	190.4
Ratio	1	3.26	4.08	0.68

VII. CASTING OF SPECIMENS

Specimens such as cubes, cylinders and beams were casted for the control mix (CM). Similarly specimens such as cubes, cylinders and beams were casted for the CM with steel fibre (SF). Hollow blocks were also casted with and without steel fibres.

Previous studies showed that on application of load a hollow block fails due to the detaching of web from the face shell due to poor tensile strength of the block. Hence to improve flexural strength steel fibres were added to hollow blocks with interlocking ends.

Previous studies also states that 1% of steel fibre in concrete mix can enhance early as well as long term compressive and splitting tensile strength of concrete. Also mode of failure changes from brittle to ductile. Considering economical factor this study utilizes 0.2% (by volume) of steel fibre. Total numbers of specimens casted for the study are given in TABLE 7. Blocks are designated as

Table 6 Block Designation and Dimension

Block	**Designation**	**Dimension (mm)**
Locally available solid block	SB	300 x 200 x 150
Locally available hollow block	HB	400 x 200 x 200
Hollow block with interlocking pattern for CM	CHB	600 x 200 x 300
Steel fibre reinforced hollow block with interlocking pattern	SHB	600 x 200 x 300

Table 7 Total Number of Specimens Casted

Specimen	**Dimension**	**Total No.**
Cube	150 mm x 150 mm x 150 mm	18
Cylinder	150 mm diameter, 300 mm height	18
Beam	100 mm x 100 mm x 500 mm	18
CHB	600 mm x 200 mm x 300 mm	24
SHB	600 mm x 200 mm x 300 mm	24

Fig 5 Casted Specimens

Fig 6 Interlocking Ends of the Block

VIII. TEST RESULTS AND DISCUSSIONS

8.1 Mix – M10

As per IS: 2185 (Part 2) – 1992 (i.e.[13]), the average minimum compressive strength of load bearing hollow block should vary from 4 N/mm^2 to 5 N/mm^2. On account of this, the block was casted for M10 mix. Surface finish was the prime consideration. Hence the mix was confirmed by trial and error method.

8.2 Compressive Strength of Concrete

Compressive strength of concrete cube increased by 21% on addition of steel fibres when compared to that of CM (Fig 7). This is due to the better bonding of the concrete achieved by hooked end anchorage of steel fibre. It was noticed that there is less crack in the cube during failure and the crack width was comparatively smaller.

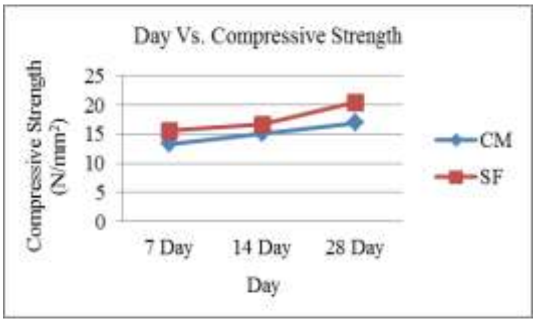


Fig 7 Variation in Compressive Strength of Concrete

8.3 Splitting Tensile Strength of Concrete

Split tensile strength of SFCy increased due to increase in tensile strength of concrete which was achieved by addition of steel fibres (Fig 8). Tensile strength increased by 8% when compared to CM.

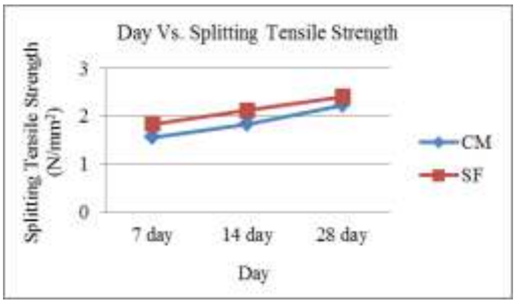


Fig 8. Variation in Splitting Tensile Strength of Concrete

8.4 Flexural Strength of Concrete

The flexural strength improved by 5% due to addition of steel fibre. Spalling of beam containing steel fibres was comparatively less.

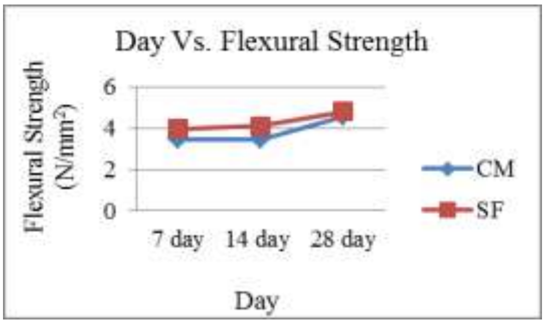


Fig 9. Variation in Flexural Strength of Concrete

8.5 Compressive Strength of Blocks


SB


HB


SHB

Fig 10. Blocks

Compressive strength tests were conducted on SB, HB, CHB and SHB (Fig 10).

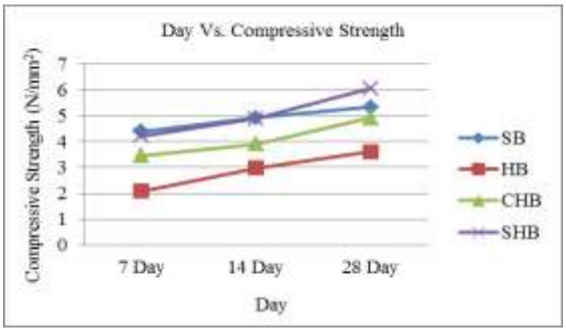


Fig 11. Variation in Compressive Strength of Blocks

28 day compressive strength of SHB was comparatively greater than that of SB, HB and CHB (Fig 11). This increase in strength was due to the dimension of the web and face shells, mix for casting, and influence of steel fibre.

Fig 12. Failure Pattern of SB

Fig 13. Failure Pattern of HB

Fig 14. Failure Pattern of CHB

Fig 15. Failure Pattern of SHB

IX. CONCLUSION

A study of hollow block strengthened with steel fibre was performed in this present work. The study showed that the block with an interlocking ends and sufficient surface finish provides considerable strength and reduces the cost of construction. The extra cost of steel fibers can be compensated by saving time of construction, avoiding plastering of walls and minimizing the quantity of bonding mortar. The block also provides provisions for concealing plumbing and electrical conduits. The conclusions derived from this work are listed below:

- 28 day compressive strength of steel fibre reinforced hollow block was 6.05 N/mm^2 which is 14% and 68% greater than that obtained for locally available solid and hollow blocks, respectively.
- The interlocking pattern helps in proper alignment and faster construction.
- Hollow blocks (HB) failed due to splitting of webs whereas in the case of interlocking blocks cracks and failure were developed through face shells.
- Failure of solid block was due to the crushing and in most of the cases cracks developed through the centre of the block.
- Steel fibre reinforced hollow block reduces the dead load by 28% and 11% compared to locally available solid and hollow block.

Acknowledgment

Apart from the efforts of me, the success of any project depends largely on the encouragement and guidelines of many others. I take this opportunity to express my gratitude to the people who have been instrumental in the successful completion of this project. The guidance and support received from all the members who contributed and who are contributing to this project, was vital for the success of the project. I am grateful for their constant support and help

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