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Experimental Investigation on the Performance of Interlocking Concrete Hollow Block Strengthened With Steel Fibres

Sarath P[1], Pradeep P[2], Shemy S. Babu[3]
[1]P.G. Scholar, [2]Assistant Professor, Department of Civil Engineering,
Sree Buddha College of Engineering, Alappuzha, Kerala, India
[3]Assistant Director, Kerala Highway Research Institute, Thiruvananthapuram, Kerala, India

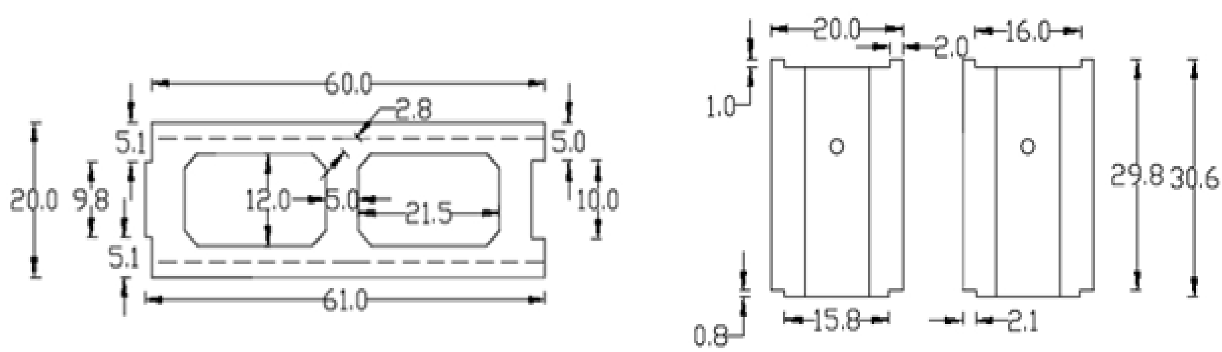
Abstract: The work aims to carry out an investigation on performance of hollow concrete block masonry strengthened with steel fibre. The geometry of the block was so arranged that the, bonding was achieved by interlocking and cement grout. The inner hollow portions considerably reduce the dead load. The side face of block was casted with good surface finish, thereby reducing the plastering cost. 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 with that of solid concrete block and concrete hollow block. The blocks were used to build masonry walls and the load bearing capacity of the walls was examined. Hollow block strengthened with steel fibre can be effectively used as load bearing wall.

***Keywords*: Interlocking, Load bearing wall, Steel fibres, Surface finish, Trial mixes**

I. INTRODUCTION

Concrete hollow blocks were used for masonry wall, because of their light weight and better insulation of sound and heat. The desire for search of safe and stable structural materials keeping in view of the economy of whole structure, has paved way for the usage of hollow concrete blocks in masonry. They are one among the modern precast materials and hence they offer the advantage of uniform quality, faster speed of construction, lower labour 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.

This work introduces a hollow concrete block in which the geometry of the block is so arranged that the bonding is achieved by interlocking and cement grout. The side face of block is casted in good finish, thereby reducing the plastering cost. The inner hollow portions considerably reduce the dead load. The hollow portion serves as a conduit for electrical and plumbing utilities. The dimension of the interlocking hollow block is 60 x 20 x 29.8 and its weight is 53 kg. Blocks for corners, intersections and lintel were geometrically designed (e.g. Fig 2). The plan and inner vertical bonding face are shown in Fig 1



Plan Vertical Bonding Face

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

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Volume 3 Issue X, October 2015
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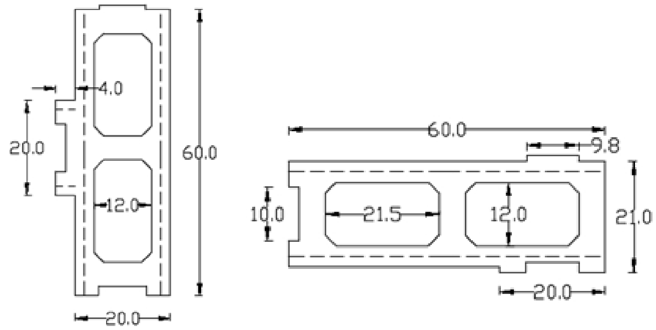
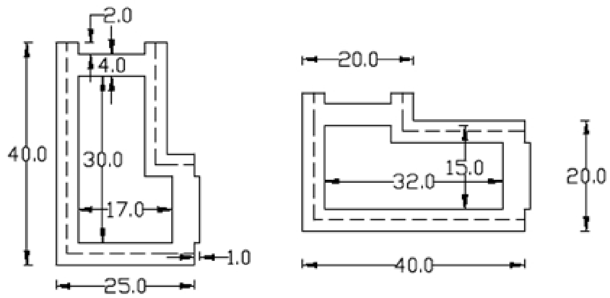
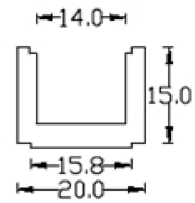


Block for Intersections



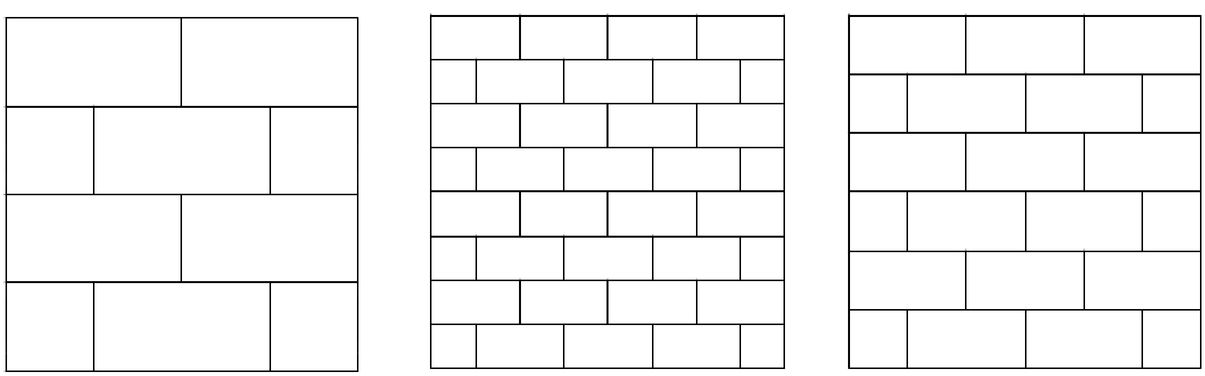


Block for Corners

Block for Lintel

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.



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

II. MATERIALS USED

Cement, fine aggregate and coarse aggregate were tested as per IS specification. The material properties are enlisted in Table 1

Volume 3 Issue X, October 2015
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International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Table 1. Material Properties

Cement	Brand: Shankar Cement; 43 grade Portland Pozzolana Cement
	Standard Consistency: 32%
	Initial Setting Time: 190 min
	Final Setting Time: 365 min
	Specific Gravity: 2.965
	Mortar Cube Strength: 43 N/mm^2
Fine Aggregate	Fineness Modulus: 4.129
	Zone: 1
	Specific Gravity: 2.697
	Water Absorption: 0.2%
Coarse Aggregate	Fineness Modulus: 3.21
	Nominal Size: 12 mm
	Specific Gravity: 2.748
	Water absorption: 0.15%
Steel Fibre	Brand: Duraflex^{TM} Hook End Steel Fiber
	Product Code: HKL 50/30
	Material: Low Carbon Drawn Wire
	Aspect Ratio: 50
	Length: 30 mm
	Diameter: 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

III. CONTROL MIX

A trial and error method was adopted to confirm a workable M10 mix. The mix proportioning was as per IS 456 – 2000 (e.g. [5]) and IS: 2185 (Part 1) – 1992 (e.g. [6]).

Table 2 Mix Proportion – Control Mix

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

IV. EXPERIMENTAL INVESTIGATIONS

Cubes, cylinders and beams and hollow blocks were casted for both the control mix (CM) and mix with steel fibres (SF) respectively. SF contained 0.2% steel fibre (by volume).

Table 3 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	37

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

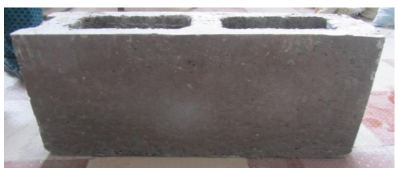
Table 4 Block Designation and Dimension

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


Cubes, Cylinders and Beams


HB


SB


Designed Interlocking Hollow Block


Interlocking ends of Designed Hollow Block

Fig 4 Casted Specimens and Blocks

Walls of 90 cm width and 90 cm height were built with SB, HB and SHB respectively inorder to determine the load carrying capacity of the walls. Cement mortar having a mix proportion of 1:5 were used.

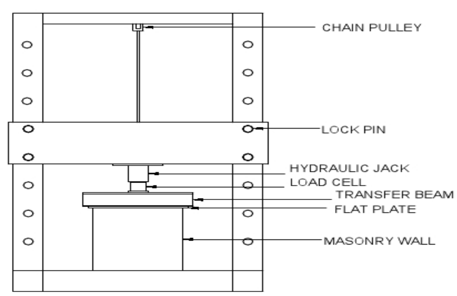


Fig 5 Schematic Diagram for Test Setup


SB


SHB


HB

Fig 5 Masonry Wall

Volume 3 Issue X, October 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Table 8 Total Number of Blocks Required for Casting Respective Wall

Specimen	Total Number
SB	18
SHB	5
HB	10

V. TEST RESULTS

A. Compressive Strength Of Concrete

Compressive strength of SF increased by 21% when compared to that of CM (e.g. Fig 6) due to the better bonding of the concrete achieved by hooked end anchorage of steel fibre.

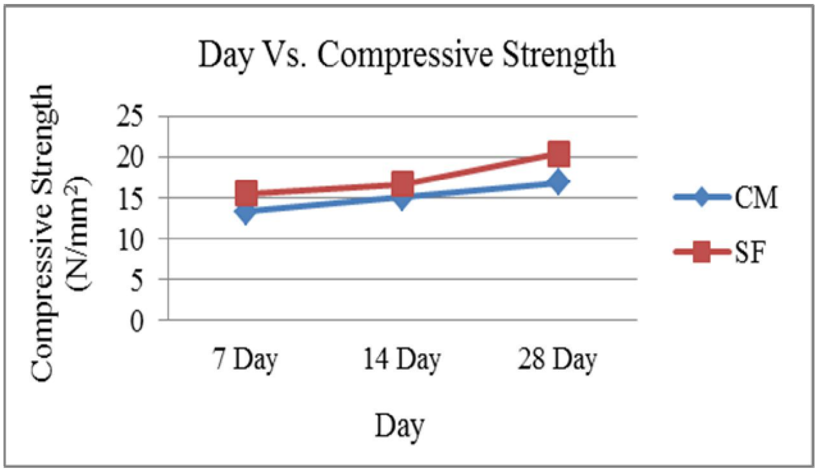


Fig 6 Variation in Compressive Strength of Concrete

B. Splitting Tensile Strength Of Concrete

Split tensile strength of SF increased due to increase in tensile strength of concrete which was achieved by addition of steel fibres (e.g. Fig 7).

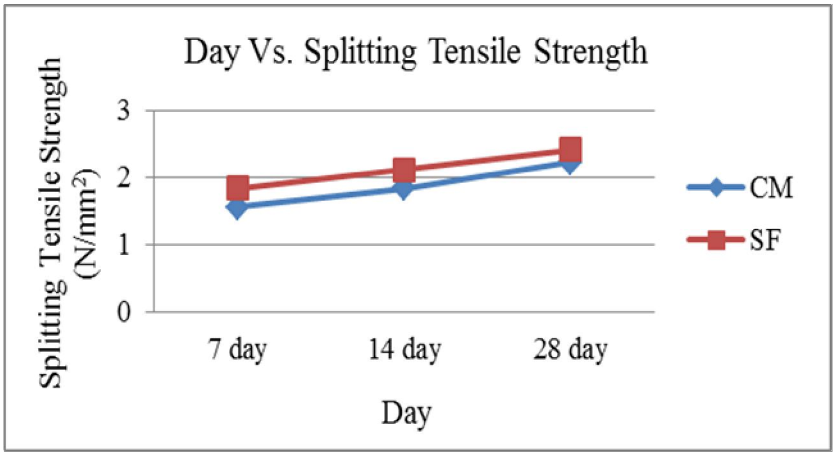


Fig 7 Variation in Splitting Tensile Strength of Concrete

C. Flexural Strength Of Concrete

The flexural strength improved by 5% due to addition of steel fibre (e.g. Fig 8)

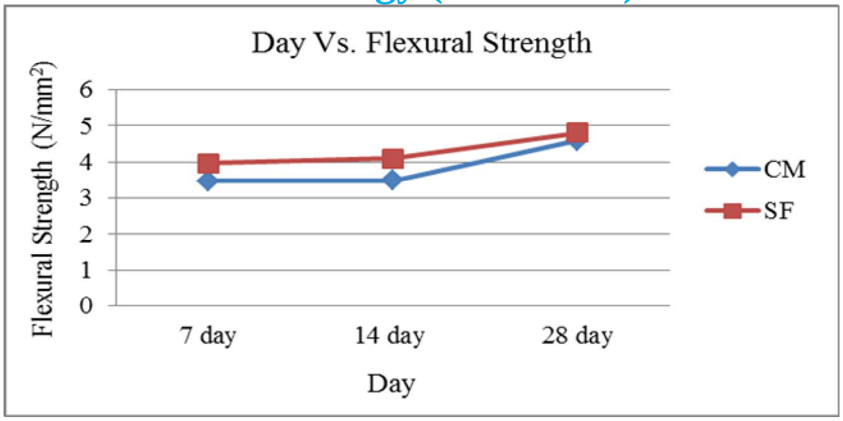


Fig 8 Variation in Flexural Strength of Concrete

D. Compressive Strength Of Blocks

28 day compressive strength of SHB was comparatively greater than that of SB, HB and CHB (e.g. Fig 9). This increase in strength was due to the dimension of the web and face shells, mix for casting, and influence of steel fibre.

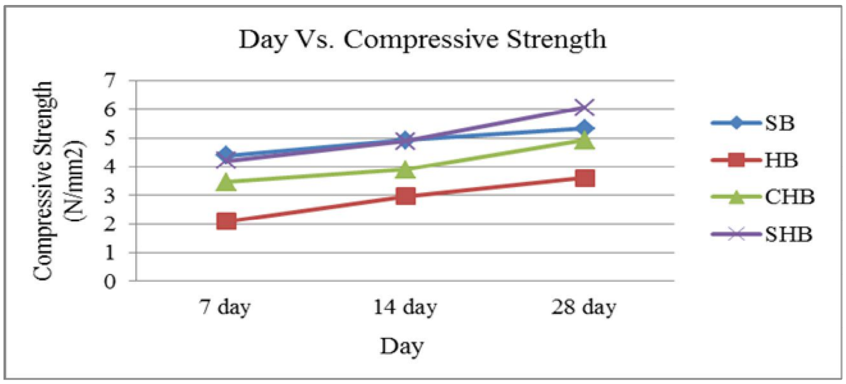


Fig 9 Variation in Compressive Strength of Blocks

E. Ultimate Load Carrying Capacity Of Wall

The SHB had a better load carrying capacity compared to other two blocks (e.g. Fig 10).

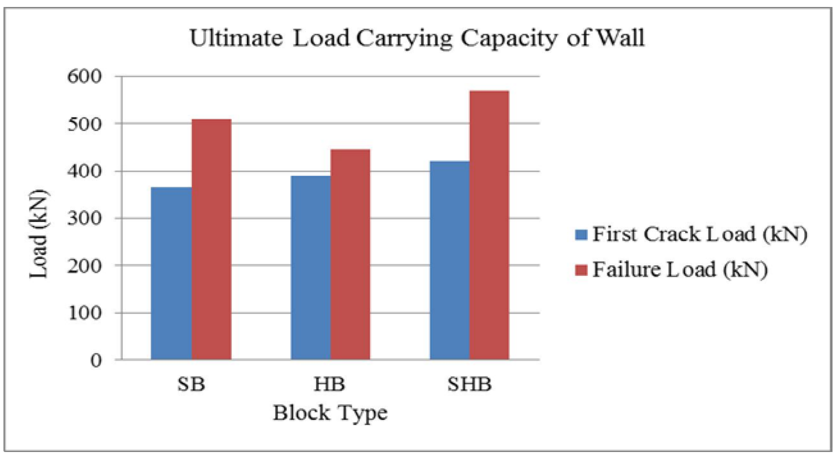


Fig 10 Variation in Ultimate Load Carrying Capacity of Masonry Walls

Volume 3 Issue X, October 2015
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International Journal for Research in Applied Science & Engineering Technology (IJRASET)

VI. CONCLUSIONS

A study of hollow block strengthened with steel fibre was performed in the work. The experimental investigations lead to the following conclusions:

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.
The load carrying capacity of masonry wall with steel fibre reinforced hollow block was greater than that with locally available solid and hollow block by 12% and 22% respectively.
The failure of solid block masonry wall developed from the joints.
Hollow block masonry wall failed due to the detaching of face shells.
Cracks were developed only at the top layer in the case of hollow blocks strengthened with steel fibres. Also the face shells were not detached as seen in the case of hollow block.
Steel fibre reinforced hollow block reduces the dead load by 28% and 11% compared to locally available solid and hollow block.

VII. ACKNOWLEDGMENT

Apart from the efforts made by me, the success of this work 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 work. The guidance and support received from all the members who contributed to this work, was vital for the success of the project. I am grateful for their constant support and help.

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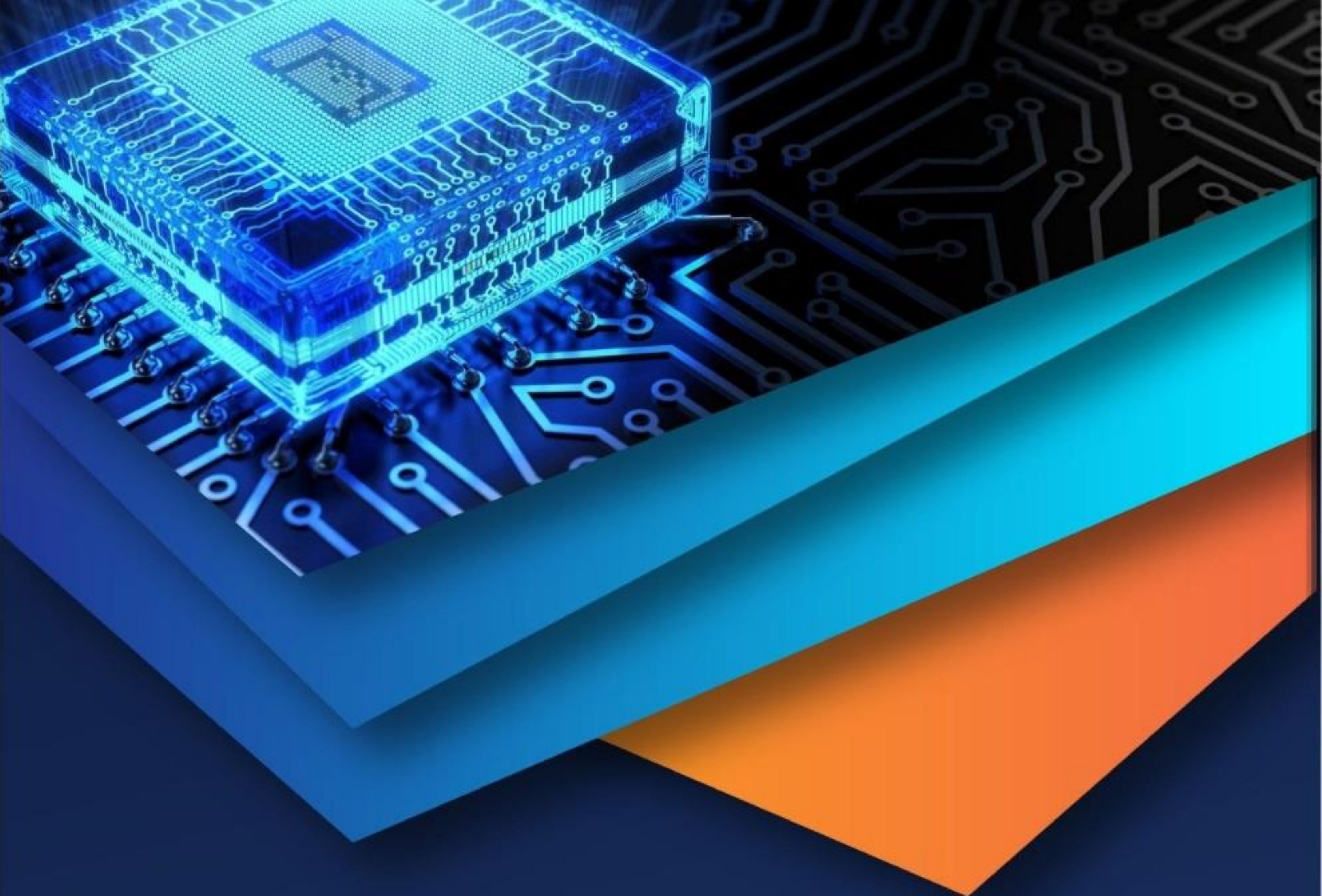
AUTHORS PROFILE

Sarath P, is specialising in Structural Engineering from Sree Buddha College of Engineering, Kerala, India. He served Confident Projects Pvt. Ltd. for 2 years as Site Engineer after completing his B.Tech degree in Civil Engineering from Caarmel Engineering College in 2010.

Email: er.sarathaml@gmail.com

Pradeep P, has 25 years of working experience in industries as well as in the field of teaching. He was graduated in 1989 (Civil Engineering) and completed M.S in 1997. At present, he is an Assistant Professor at the Department of Civil Engineering, Sree Buddha College of Engineering, Kerala, India.

Shemy S. Babu, completed her B.Tech degree in Civil Engineering during 1997 – 2000. After working as a lecturer for two years, she specialized in Structural Engineering. She presently works for the Kerala Highway Research Institute, Kerala, India as the Assistant Director. She joined the institute in 2008.



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