Experimental Study on the Flexural Behavior of Channel Slabs.

[1]Aditya Tubachi, [2]B. P. Annapurna, [3]Naveen P, [4]Kiran T
[1]ME Scholar, Faculty of Engineering- Civil, [2]Associate Professor, Faculty of Engineering- Civil,[3]Research Scholar, Faculty of Engineering- Civil, [4]Associate Professor, Faculty of Engineering- Civil.
Bangalore University, Bangalore, India

Abstract: In general, the slab is designed to resist vertical load. However, as people are getting more interested in residential environment recently, noise and vibration of slab are getting more important factors to consider. In addition, as the span is increased, the deflection of the slab is also increased. Therefore, the slab thickness should increase. Increasing the slab thickness makes the slabs heavier, and will increase column and foundation sizes. Thus, it makes buildings consume more materials. To reduce the quantity of materials used, slabs with lighter weight had to be introduced. Hence in the present study, we have made an attempt to analyse the precast closed channel slabs. The reinforcement for the flange of the channel slabs was provided with the welded mesh of size 2.2mm diameter with 32mm x32mm spacing whereas the reinforcement in the web was varied. The varied web reinforcement's are2.2mm diameter with 32mmX32mm spacing double layered welded mesh, vertical bars 6mm diameter HYSD bars spaced at 50mm c/c and vertical and diagonal bars of 6mm diameter bars spaced at 100mm c/c. It is found that Closed Channel Slabs perform better than Conventional Slab.

***IndexTerms* - Conventional Slab, Closed Channel Slab, Open Channel Slab, Welded Mesh, Mild Steel Frame.**

I. INTRODUCTION

In a building, slabs contribute more to the dead weight of the structure which in turn increases the size of beams, columns and footings. Thus, by introducing the Precast Channel slabs the weight of the slab is reduced and hence also there is reduction in the size of other structural members, contributing to minimum use of materials.

Also, in conventional slabs majority of the time in construction is consumed to cast the slab as it needs form work. In precast slab panels the quantity of formwork used is considerably low as number of panels can be casted in reusable moulds. Also, these precast panels can be transported and placed with relatively lesser difficulty when compared to the conventional method of slab casting.

II. PRECAST CHANNEL SLABS.

Precast Channel Unit is a full span precast RCC unit, trough shaped in section (Fig. 1). It can be used for floors and roofs supported on suitable structures like brick/stone walls and RCC beams. It does not require any intermediate temporary props or supports, since the unit will be strong enough to support the load.

In the present study, the Closed Channel slabs are studied.

Each channel panel is of size 305mm X 1525mm X 64mm casted with M_{20} grade concrete. Each Rectangle Flat panel is of size 305mm X 1525mm X 12mm.

The Closed channel slab consists of 5- single channel panels welded together in the longitudinal direction to form the bottom portion of Closed Channel slab(Fig.2) and 5- single rectangular flat panels welded together in the longitudinal direction to form the top portion of the Closed Channel Slab(Fig.3) of size 1525mm X 1525mm X 76mm as shown in Fig. 4.

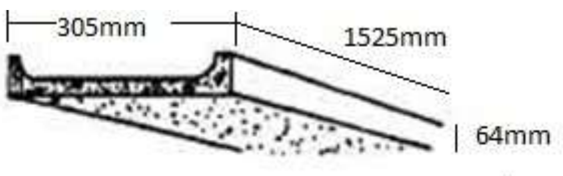


Fig 1 Cross section of C-channel

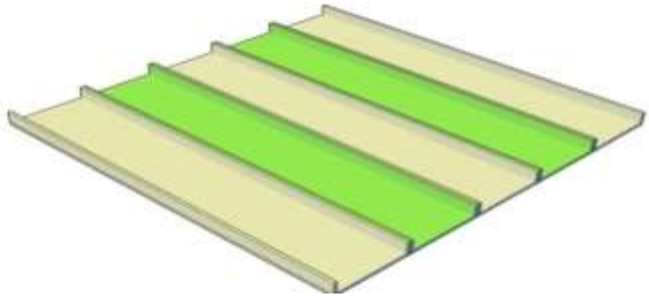


Fig.2 Bottom Portion of Closed Channel Slab

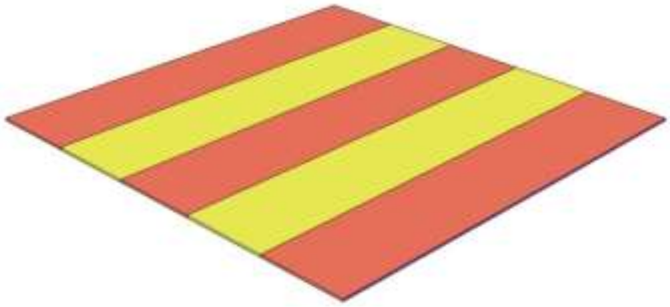


Fig.3 Top Portion of Closed Channel Slab

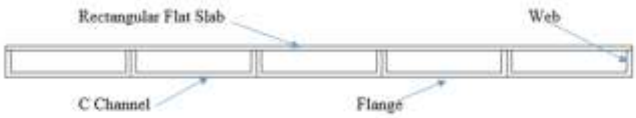


Fig.4 Cross section of Closed Channel Slabs.

The behaviour of Closed Channel Slabs is compared with the Conventional slab of size 1525mm X 1525mm X 76mm, Grade of concrete-M_{20}, Reinforcement- HYSD bars of 6mm diameter at 200mm c/c.

The Web Reinforcement in the closed channel slab is varied in this study.

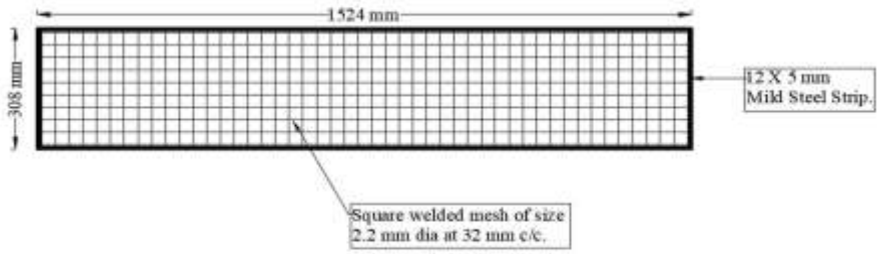
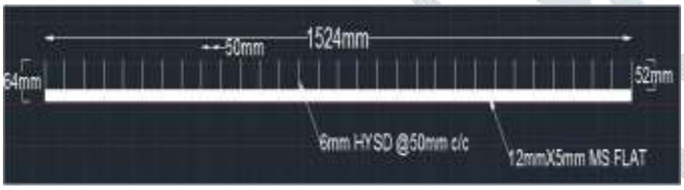


Fig. 5 Flange Reinforcement in C-Channel & Rectangle Slabs

(a) S_{1P}



(b) S_{2P}

(c) S_{3P}

Fig.6 Web Reinforcements in C-Channel Panels

Fig. 7 Typical Closed Channel Slab

The Slabs are Designated as follows.

S_0:Conventional Slab of size 1524X1524X76mm.

S_{1P}:Individual Closed Channel panel of size 305X1524X76mm consisting of two layers of welded mesh in web of C-Channel. (Fig 6(a))

S_{2P}:Individual Closed Channel panel of size 305X1524X76mm consisting of vertical bars of 6mm diameter in web of C-Channel. [Fig.6(b)]

S_{3P}:Individual Closed Channel panel of size 305X1524X76mm consisting of vertical and diagonal bars of 6mm diameter in web of C-Channel.[Fig.6(c)]

S_1:Closed Channel Slab which consist of five individual closed channel panels of S_{1P},welded together.

S_2:Closed Channel Slab which consist of five individual closed channel panels of S_{2P},welded together.

S_3:Closed Channel Slab which consist of five individual closed channel panels of S_{3P},welded together. (Fig. 7)

III. CASTING PROCEDURE

First the MS metal strip of 12mm X 5mm is Welded to form a Metal Frame of 305mm X 1525mm X 12mm. Next the welded mesh of size 2.2mm dia and 32mm X 32mm spacing is welded to the mild steel frame to form the rectangular flat panels.

Later to form the C-channel panels the welded mesh was cut to a height of 52mm and length of 1515mm and welded vertically to the Metal frame along the length with the vertical height of 52mm to form rectangular channel panels. Similarly, the skeletal frames for five C-channel and five Rectangular flat panels were prepared.

After preparing these skeletal frames, they are placed on the flat surface with polythene membrane and wooden planks are placed in between each frame to form the formwork for the web of C-Channel panels.

Then, concrete is poured on the flat part of the C-Channel slab and compacted using the custom made tamping rod which has the surface dimension of 100mm X 100mm. Once the concrete is poured in flat part of the C-Channel panel, the two more wooden planks are placed either side of C-Channel Panel in order to form the 20mm thick web of the C-Channel panel. The Rectangular flat panels are also casted in the same manner as the flat part of the C-Channel panel.

After 24 hours the form work of the C-Channel panels are striped and membrane cured for another 24 hours after which the panel are carefully lifted and placed in water tank for 28 days to cure.

After curing five C-Channel Panels are kept side by side and welded together to form a single member of size 1525mm X 1525mm X 64mm. Five Rectangular flat panels are welded in the same manner to form a member of size 1525mm X1525mmX12mm.

The above procedure is repeated for other two parameters of different web reinforcements.

IV. TESTING PROCEDURE

After the specimens(slabs) were ready for testing, the specimens were coated with white wash so that the cracks will be clearly visible.

Once the white wash is dried, the centre of the slab on the bottom surface and on the web portion of C-Channel (centre panel) in the longitudinal direction are marked to fix the strain gauge. Before fixing the strain gauge, the surface is polished with the emery paper to obtain a smooth finish. After polishing the surface, the Strain Gauges were fixed with the help of adhesive. The electrodes are then soldered with the wire which is later connected to Strain Indicators.

The Specimens are placed on the open square frame of dimension 1650mm X 1650mm which acts as Simply Supported. The specimen is placed on the open square frame for testing and the dial gauge is placed at the centre of the bottom portion of slab to measure the deflection.

The slab is tested for uniformly distributed load, so the loading is done by placing 2' X 2' slabs in layers. Each layer consists of 4 slabs placed one beside the other to form a square platform of 4'X4'. Each layer consists of four slabs weighing 200kg±10kg. Six layers of these slabs were placed one above the other. It was observed that there was no yielding of slabs after placing six layers of slabs, further placing of slabs was found to be difficult.

Fig 8 Testing Arrangement

Hence over these slabs a box shaped channel section of dimension 1m X 1m is placed at the top of the sixth layer of slab. Above this box type channel section, a steel beam of 200mm depth is placed diagonally. The hollow section between steel beam and the box shaped channel section, sand bags were placed to transfer the load uniformly onto the slab.

On the Steel beam a hydraulic jack and load cell of weight 50kg is placed. The loading is carried out and the readings of Dial gauge and strain gauge were noted down at regular intervals of loading. (Fig 8)

V. RESULTS AND DISCUSSIONS

Result of Closed Channel Slabs is discussed by comparing with Conventional slab in terms of Load-Deflection Behaviour, Stress- Strain Behaviour, Performance Evaluation Factor (PEF) of Load vs Deflection and Ductility.

Ductility is defined as the ratio of ultimate deflection to deflection at yield.

Ductility of Slab =Ultimate Deflection / Yield Deflection

PEF for any quantity = Load or Deflection of Channel Slab / Load or Deflection of Conventional Slab

5.2 Load Vs Deflection.

- Fig 9 presents the variation of load vs deflection of the closed channel slabs S_1, S_2 and $S_3$and the conventional slab S_0.
- From table 1 and fig. 9 The Closed Channel Slab S_3 has the highest load Carrying Capacity than the Conventional Slab S_0 and Closed Channel Slab S_1 & S_2.
- The performance of the Closed Channel Slab S_3 with respect to load is 16% higher compared to the Conventional Slab S_0.
- The performance of the Closed Channel Slab S_1 with respect to load is 4% higher compared to the Conventional Slab S_0.
- The performance of the Closed Channel Slab S_2 with respect to load is 36% less compared to the Conventional Slab S_0.
- Area under the Load vs Deflection Graph shows the Stiffness of the Slab. From Fig.9,it is evident that the area under Closed Channel Slab $S_3$is more which indicates closed channel slab S_3 is Stiffer compared to other closed channel slabs and also conventional slab.
- With respect to the ultimate deflection all the three slabs i.e. S_1, S_2 and S_3, the PEF is 19%, 25% and 23% more compared to Conventional Slab S_0.[Table 1].

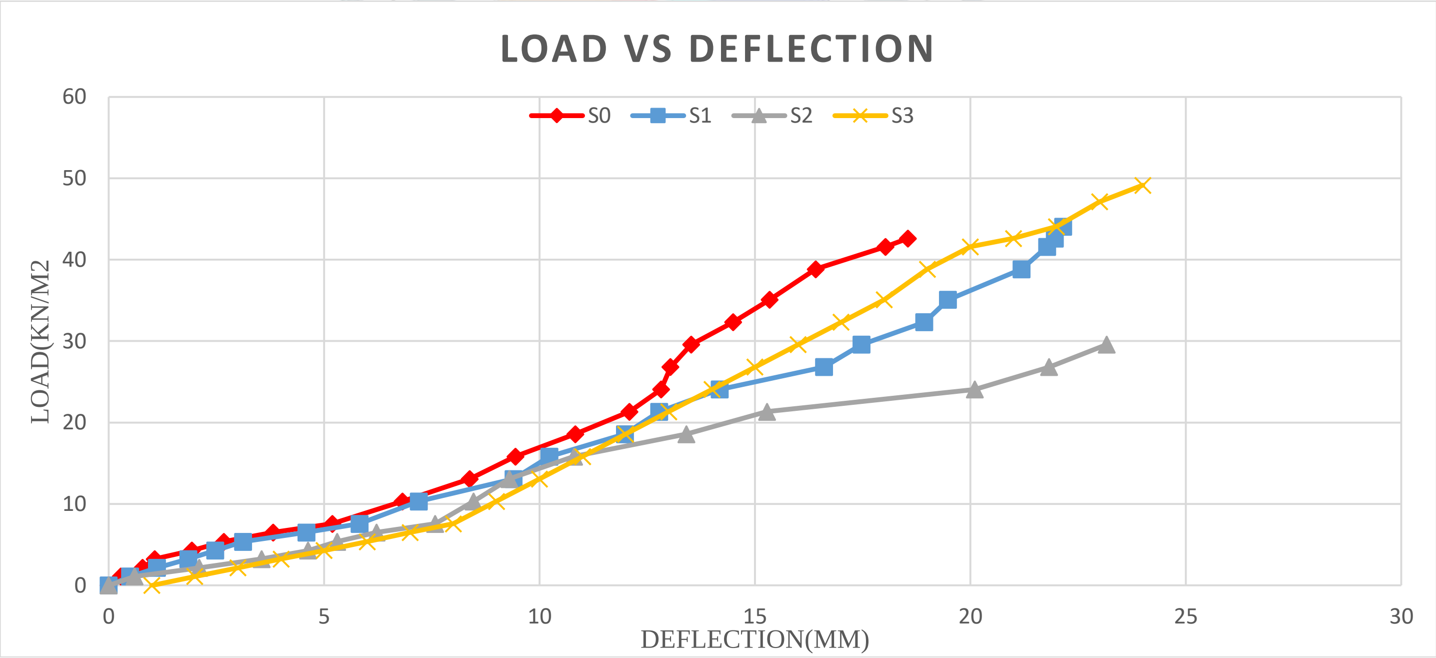


Fig 9 Load vs Deflection Curve.

Table 1 Ultimate load, Deflection and PEF of Slab Specimens

Sl No.	Specimen	Slab Designation	Ultimate load	Deflection @ Ultimate Load	Performance Evaluation Factor (PEF)	
			kN/m^2	mm	Load	Deflection
1	Conventional Slab	S_0	42.62	18.55	1.00	1.00
2	Closed Channel Slab	S_1	44.07 **(3.40%)**	22.12 **(19.25%)**	1.04	1.19
3	Closed Channel Slab	S_2	29.58 **(-36.5%)**	23.20 **(25.06%)**	0.64	1.25
4	Closed Channel Slab	S_3	49.14 **(15.30%)**	22.78 **(22.80%)**	1.16	1.23

Table 2 PEF with respect to Ductility

Sl No.	Specimen	Slab Designation	Yield Deflection	Ultimate Deflection	Ductility	Performance Evaluation Factor
			mm	mm		
1	Conventional Slab	S_0	12.82	18.55	1.25	1.00
2	Closed Channel Slab	S_1	16.70	22.12	1.32	1.06
3	Closed Channel Slab	S_2	14.90	23.20	1.56	1.25
4	Closed Channel Slab	S_3	17.72	22.78	1.30	1.05

5.3 Stress Vs Strain:

Fig. 10 presents the stress vs strain variation at the bottom of slabs S_0, S_1, S_2 and S_3.
From the Fig.10, the strain of $S_3$is higher than the conventional slab S_0.

- The Strain at the bottom surfaces of the Closed Channel Slab S_1 and conventional slab S_0 are 592 X 10^{-6} and 516 X 10^{-6} respectively.
- The Strain in the Closed Channel SlabS_2 and conventional slab S_0 at bottom surfaces are 568 X 10^{-6} and 516 X 10^{-6} respectively.
- The Strain in the Closed Channel slab S_3 and conventional slab S_0 at bottom surfaces are 738 X 10^{-6} and 516 X 10^{-6} respectively.
- Strain in bottom portion of S_3 is higher by 43%, 25% and 30% when compared to the strain in bottom portion of S_0, S_1 and S_2 respectively.
- Area under the Stress vs Strain Graph denotes the Toughness of the slab. So it is seen that the Closed Channel Slab is tougher compared to all other closed channel slabs and also conventional slab.

Fig 10,11 and 12 RepresentStress vs strain variation in the web and at the bottom of Closed Channel Slabs S_1,S_2 and S_3respectively.

- Strain in bottom portion of $S_1$is higher by 33% compared to the strain in web portion of S_1.(Fig.10)
- Strain in bottom portion of $S_2$is higher by 27% compared to the strain in web portion of S_2.(Fig.11)
- Strain in bottom portion of $S_3$is higher by 32% compared to the strain in web portion of S_3.(Fig.12)
- Area under the Stress vs Strain Graph denotes the Toughness of the slab. So it is seen that area under the stress vs strain at bottom portion of S1 is more than area under the stress vs strain in web portion which indicates that bottom portion of Closed Channel Slab S_1 is tougher compared to web portion of S_1.

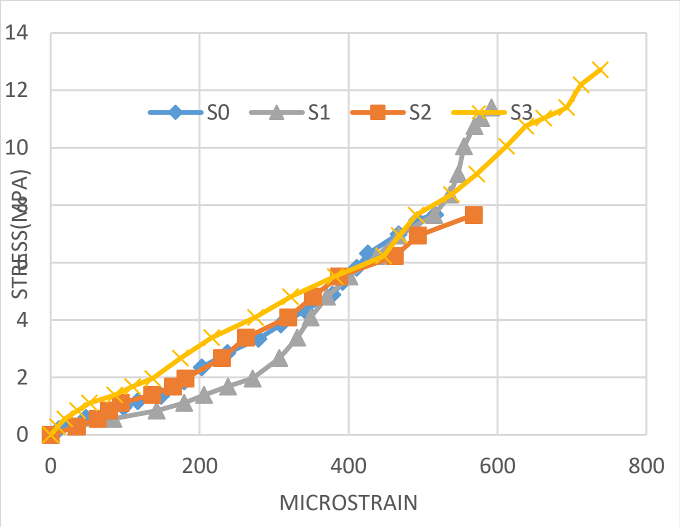


Fig 9 Stress vs Strain at Bottom of Slabs

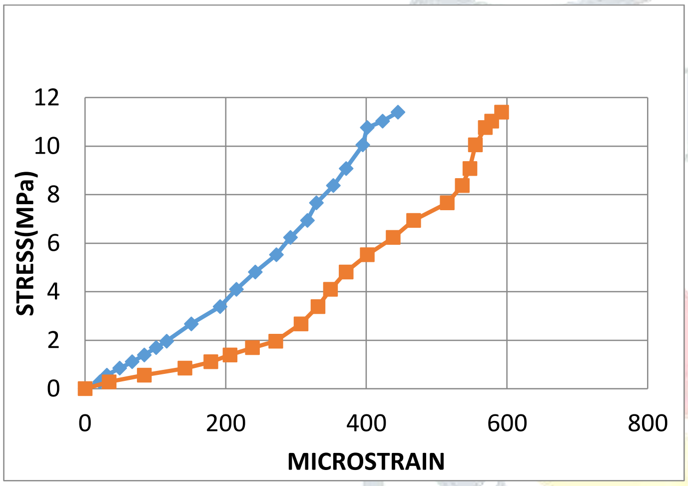


Fig 10 Stress vs Strain variation in S_1

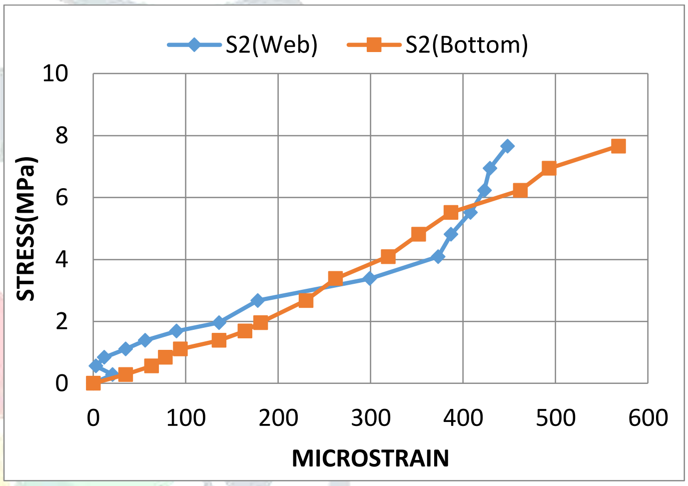


Fig 11 Stress vs Strain variation in S_2

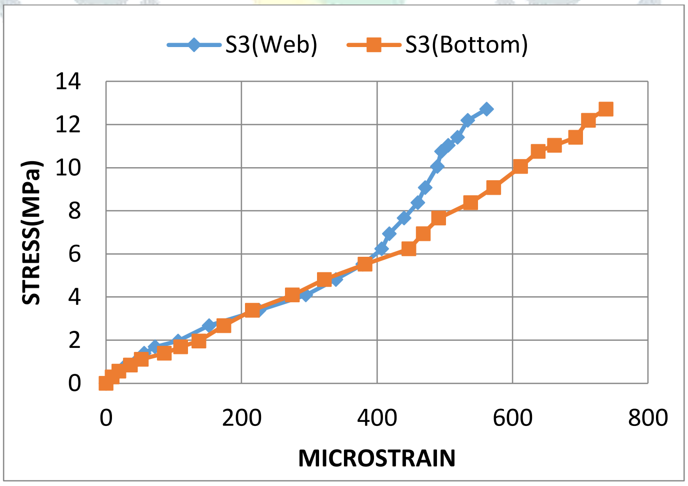


Fig 12 Stress vs Strain variation in S_3

5.4 Crack Pattern:

5.4.1 Slab S_1

- In the Closed Channel Slab S_1, vertical cracks were seen on the web portion of the C-Channel.
- In the middle panels of the C-channel Slabs the cracks were prominent in the web.
- There were no cracks developed on the Bottom of the channel slab nor on the top rectangle flat slab.
- Crushing of web portion was not observed in this slab.
- The cracks observed on the web portion were few in number (fig 13).

Fig. 13 Crack pattern on Web of Closed Channel Slab S_1

Fig.14Crack pattern on Web of Closed Channel Slab S_2

Fig.15Crack pattern on Web of Closed Channel Slab S_3.

Fig. 16 Crack Pattern on Conventional Slab at the Center Span.

5.4.2 Slab S_2

- In the Closed Channel Slab S_2, vertical cracks were seen on the web portion of the C-Channel and there were cracks observed at the junction of the web and the bottom slab.
- There were no cracks formed at the bottom of the C-Channel closed slab nor on the top rectangle flat slab.
- The number cracks on the web portion were more on slab S_2 compared to S_1.(fig 14)

5.4.3 Slab S_3

- In the Closed Channel Slab S_3, vertical cracks and also diagonal cracks were seen on the web portion of the C-Channel.
- No cracks were observed on the bottom of the channel slab nor on the top rectangle flat slab.
- Crushing of web portion in central panel was observed.
- In the middle panels of the C-channel Slabs the cracks were prominent. (fig 15)
- On the conventional slab S_0, cracks were developed at the bottom surface, extended from the centre to edges (diagonal cracks). (fig. 16)

6 CONCLUSION

The conclusions pertaining to the comparison of Flexural behaviour of Channel Slabs are listed below.

- Closed Channel Slabs have shown considerable reduction in dead load. The Dead load of Closed Channel slab is about 52% less when compared with the Conventional slab.

- The performance of Closed Channel slab $S_3$with respect to Load carrying capacity is highest among Closed Channel Slabs by 15.30% when compared to Conventional Slab S_0.
- The performance of Closed Channel slab S_2 with respect to Load carrying capacity is least among Closed Channel Slabs by 36.50% when compared to Conventional Slab S_0.
- Closed Channel Slabs are found to be more ductile compared to Conventional Slab.
- The Closed Channel Slabs are safer compared to Conventional slab as the bottom slab of Closed Channel Slabs does not crack even at the ultimate failure of web portion as web of Closed Channel Slab is stiffer compared to bottom portion of closed channel slab.

REFERENCES

1. A.Dhasarathan, Dr. R. Thenmozhi, et al. “Experimental Study On The Ductile Characteristics Of Hybrid Ferrocement Slabs”, International Journal of Engineering Sciences and Research Technology.
2. M.Amala, Dr.M.Neelamegam, “Experimental Study of Flexure and Impact on Ferrocement Slabs”, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), e-ISSN: 2278-1684, p-ISSN: 2320-334X. PP 62-66
3. Randhir J. Phalke, Darshan G. Gaidhankar, “Flexural Behaviour of Ferrocement Slab Panels Using Welded Square Mesh by Incorporating Steel Fibers”, IJRET: International Journal of Research in Engineering and Technology, eISSN: 2319-1163 | pISSN: 2321-7305
4. Yu T. Chou, M. ASCE, “Stress Analysis Of Small Concrete Slabs On Grade”, Journal of Transportation Engineering, ASCE
5. Dr.T.Ch.Madhavi, ShanmukhaKavya .V, et al., “Composite Action Of Ferro-Cement Slabs Under Static And Cyclic Loading”, International Journal of Civil Engineering and Technology (IJCET),Volume 4, Issue 3, May - June (2013), pp. 57-62.