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RESEARCH ARTICLE

Experimental Investigation on Behaviour of Folded Plate

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ABSTRACT

Persistence of research was towards the behaviour of folded plate. In this project, we used GGBS blended ferrocement concrete to cover a folded plate 600 mm x 1800 mm x 150 mm. Ferro cement is a building material that is emerging as an alternative for traditional RCC. According to prior research, folded plates are the most cost-effective and visually acceptable option for longer span roofs. First, we built the folded plate model in ANSYS and investigated its behaviour in terms of load versus deflection. Later, for experimental purposes, we cast a folded plate coated with GGBS mixed ferrocement concrete. The results of the experimental inquiry demonstrate that there was an improvement in flexural behaviour when compared to the traditional model. The same was verified using ANSYS findings. ANSYS analysis aids in comparing and summarising experimental data. Both the analytical and experimental inquiry results show that ferro cement structures are a good alternative to RCC since they are less costly and lighter. Because folded plates retain their effectiveness for a longer length of time when Ferro cement is utilised. Ferro cement has made the components smaller to support the load because ferro cement parts are high in stress when reinforcement is spread.

Keywords: flexural behaviour, folded plates, ferro-cement applicability in folded plates.

1 Introduction

By extension, the phrase "Ferro cement" has been used to different composite materials, even ones with no cement or ferocious component. Folded ferrocement and plain reinforcement panels (length of roughly 3 m, depth of 2.7 m, and thickness of 0.03 m) were casted, and analysis revealed that utilising ferrocement panels increased flexural strength [1]–[3]. TCFST columns can obtain a first-level fire-resistance rating by using an appropriate thickness of the fire protection layer [4], [5]. Experimental verifications that test the specimens into extremely nonlinear areas show that element model analysis may properly forecast the buckling consequences [6], [7]. As the number of steel strips grows, so does the restraining effect of steel strips, the energy dissipation capacity, and the plastic deformation performance of specimens [8], [9]. Increased self-tapping screw diameter and lowered self-tapping screw spacing enhanced the mechanical behaviour of MCJR substantially [10], [11]. Welded stiffeners on the surface of the steel plate can help to reduce local buckling [12], [13]. The shape of the border components has a considerable impact on the structure's quasi-static behaviour [14]. Fatigue crack initiation is correctly accounted for at the top surface of the bottom tubular flange, where longitudinal stress accumulates at the welded toes towards the end of the inclined fold adjoining longitudinal fold of the corrugation [15], [16]. Very stiff springs are used to mimic the geometric limitations of the folded plates, such as the conditions at the ends and intermediate supports [17]–[22]. Previous research has shown that ferrocement panels improve an element's flexural behaviour. The primary goal of this research is to obtain high strength mortar as well as bending response of folded plate coated with ferrocement under UDL. Also, towards the conclusion, we compared empirical values with ANSYS Analysis for both conventional and ferrocement coated folded plates.

2 Research Methodology

In this study, we began with mortar mix design and then chose components to manufacture ferrocement concrete, most likely cement, fine aggregate, and water. The cement employed in this investigation had a specific gravity of 3.15. It corresponds to IS: 12269-2013 [23]. Table 1 shows the cement properties. This work made use of GGBS with a specific gravity of 1.24.

Table 1: *Properties of Cement*

S.No	Property	Test Result
1	Normal consistency	33%
2	Initial and Final setting time	55 min & 295 min
3	Specific Gravity	3.17
4	Soundness (Le-Chatlier Exp)	1.00 mm

Steel is an iron-carbon alloy that contains less than 2% carbon, 1% manganese, and trace amounts of silicon, phosphorus, sulphur, and oxygen. Steel is the world's most significant engineering and construction commodity. It is employed in every aspect of our existence, including automobiles and construction materials, refrigerators and washing machines, cargo ships, and medical scalpels. The maximum hexagonal mesh strength is 270 N/mm^2. Figure 1 shows the square mesh utilised for the investigation. The specific gravity of the sand was 2.62. It complies with IS 2386:1963 [24]. Table 2 shows the fine aggregate properties. This study made use of ordinary water with a pH of 7.40.

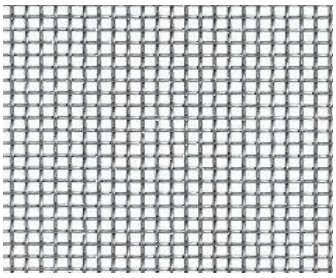

Fig 1: *Square Mesh*

Table 2: *Properties of Fine Aggregate*

S. No	Fine aggregate properties	result
1	Specific Gravity	2.60
2	Bulk density	1750
3	Fineness Modulus	2.77

3 Analysis of Folded Plate Element

In this study, we used ANSYS software to perform independent analyses on the flexural behaviour of folded plates coated with normal concrete and ferrocement concrete. Numerical analysis is critical for comparing results to experimental study outcomes. In this paper, we use Ansys Software to analyse folded plates with conventional and ferrocement models. Maximum deformation and ultimate load numerical findings were compared to experimentally tested results. Table 3 shows the different sorts of components employed in this study model. The Solid65 factor was utilised to simulate the concrete. Beam 188 is a two-node linear three-dimensional beam element having six degrees of freedom at each node. Shell 181 is an excellent choice for studying thin to moderately thick shell structures. The folded plate is modelled in ANSYS in volume arbitrary utilising key points. Figure 2 to figure 4 depicts a folded plate model with a boundary condition. Figure 3 shows a folded plate after meshing.

Table 3: *Types of Elements in ANSYS*

Cement mortar	Solid 65
Steel reinforcement	Beam 188
Mesh	Shell 181

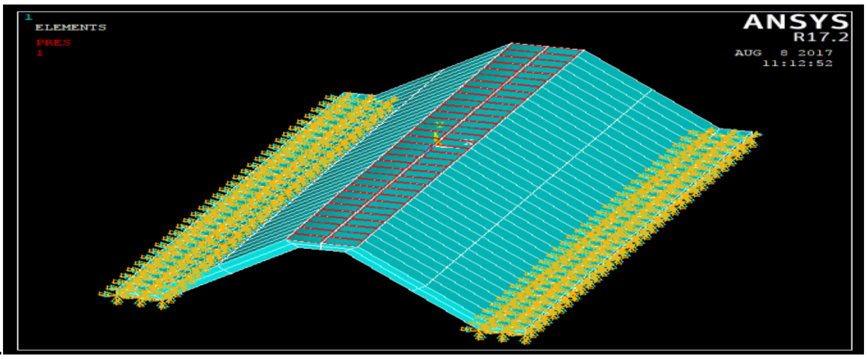

Figure 2: *Boundary Conditions*

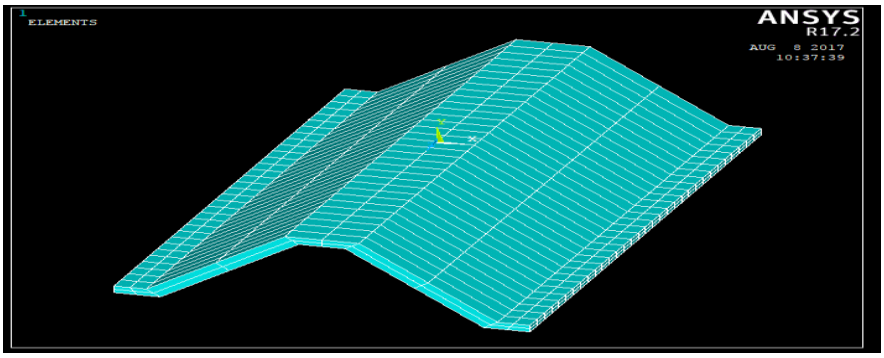

Figure 3. *Meshing of Folded Plate in ANSYS*

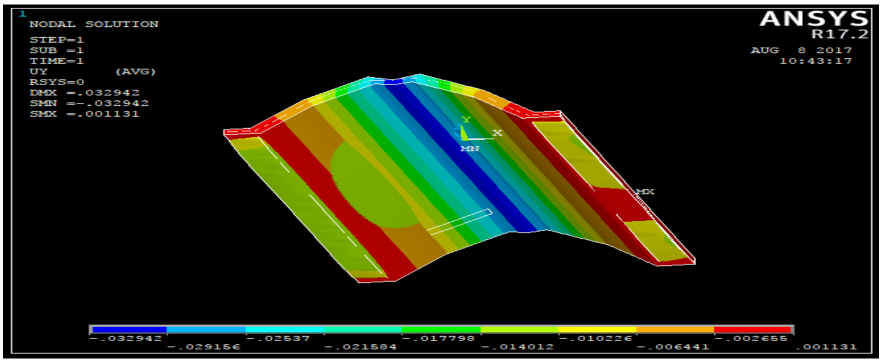

Figure 4: *Nodal Deformation*

4 Experimental Investigation

The goal of the project is to cast and test folded plate examples made of ferro cement. The compressive strength of Ferro cement is investigated using a mix proportion of 1:3 and a water-cement ratio of 0.35 in specimens. The folded plate size of 600 mm x 1800 mm x 15 mm was selected. Theoretical predictions of RCC folded plates are compared to Ferro cement folded plates in deflection under flexure using slab – beam theory. The load ratio between the initial crack load and the ultimate load was also evaluated. Because ferro cement is a composite material, all experimental work is done. The compressive strength of the Mortar casted ratio was determined by taking the average strength of three cubes. The mortar cubes used for this purpose are (70.6 x 70.6 x 70.6) mm in size. Table 4 displays the compressive strength data. Mortar cubes with a 10% GGBS substitution yielded strong compressive strengths when compared to others. As a result, in our experimental work, we used 10% GGBS as a cement alternative.

Table 4: *28 day's Compressive Strength of Mortar Cubes*

S.No	GGBS replacement	Compressive strength (MPa)
1	10 %	61
2	20 %	55
3	30%	57

Specimens are confirmed with sizes of 600 mm x 1820 mm x 15 mm, thicknesses of 0.25 m, and 0.06 m milder toughen bars as skeleton fortification with arrangement of 0.15 centre to centre remoteness and a stainless-steel mesh with a spacing of 2 mm put together the skeleton meshing with shelter of 0.90 cm. Fig 5.0 shows a sample of folded plate reinforcement utilised in the work. mortar remained poured with frame within short time of a complete fraternization, the concrete were compacted in the frame using manual compaction. Since the chicken mesh is put during the casting of the specimen, a mortar with trough force should be used to ensure correct compaction of the material. Steel troughs were later used to complete the surface. The specimen is demolished after 24 hours in the mortar. After the formwork was destroyed, the specimen was protected using gunny sacks to prevent water evaporation. specimens were healed by proper healing prior to date of research on gunny bags. During test, the samplings stayed painted with the snowy emerald water resolution to make fractures visible. On the bottom of the specimens, the positions of the deflection gauge were indicated. Figure 5 and figure 6 shows the replacement of ferrocement with casting of a specimen coated with GGBS.

Fig 5: *Reinforcement in Folded Plate*

Fig 6: *Casting of Specimen Coved Ferrocement*

The load was assessed by a test ring with a capacity of 10 tonnes. The weight was transferred from the jack to the specimen via an 8 cm diameter cylindrical steel plate. An electrical crane with a capacity of 100 tonnes was used to lift the test model onto the loading frame. For simply assisted edge condition, the specimens rest on top of the test frame. Placing of folded plate in loading frame given in figure 7. Ferrocement folded plate during testing shown in figure 8. Location of dial gauge shown in figure 9.

Figure7: *Placing of Specimen on Loading Frame*

Figure 8: *During Testing of Ferrocement Folded Plate*

Figure 9: *Shows the View of Location of Deflection*

A test ring was detected after a zero reading of the dial gauges. The weight has been recorded. The weight was then gradually increased to the manual jack, and load values from the test ring were collected. The deflection values were recorded after each loading. The operation was repeated until cracks appeared and load at were crashes happening stood recorded. The crack propagation was then sped up by adding more loading. This phase be situated followed by extreme bends, as evidently showed by incessant spin of dial devices, let down consignment stayed registered. Load and Deflection results of specimen 1 and 2 are given in Table 5 and Table 6.

Table 5: *Load Deflection Behavior for Specimen 1*

S.No	LOAD ‘kN’	Deflection ‘mm’	Remarks
1	0	0	-
2	1.33	2.8	-
3	2.66	4.95	-
4	4	5.64	-
5	5.33	9.08	-
6	6.66	9.73	First crack load
7	8	11.72	-
8	9.33	13.2	-
9	10.66	15.8	-

Table 6: *Load Deflection Behavior for Specimen 2*

S.No	Load kN	Deflection ‘mm’	Remarks
1	0	0	-
2	1.33	1.22	-
3	2.66	2.03	-
4	4	4.03	-
5	5.33	4.18	-
6	6.66	5.00	-
7	8	6.08	First crack
8	9.33	6.67	-
9	10.66	7.32	-
10	12	9.05	-
11	13.33	-	-
12	14.66	-	-
13	16	-	Ultimate load

5 Result Discussion

Both folded plate coated with ferrocement, and regular plates were examined in this study. The results showed that when folded plate is coated with ferrocement concrete, the flexural strength improves significantly. Because the moment carrying capacity of RCC trough type folding plates is lower in longitudinal than transverse directions, cracks in the transverse section at the stress zone on the bottom side of the plate are more common. Because Ferro cement is a flexible element, the trough type folded plate crack begins at the bottom in transverse section, similar to the RCC folded plate, but then progresses to the longitudinal section with larger deflection when compared to the RCC folded plate. The initial fracture load for the two specimens examined was 8 kN/m and 6.6 kN/m, respectively, while the ultimate load was 16 kN & 14.4 kN, respectively. Figure 10 shows the longitudinal crack pattern of specimens one and two. In addition, we discovered that the ultimate load bearing capability of the folded plate element increased by roughly 25% in the experiment. Also, according to our experimental findings, when using ferrocement to cover folded plates, the first fracture will appear solely in the tension zone. Figure 10 shows that longitudinal crack pattern of folded plate element.

Specimen 1

Specimen 2

Figure 10: *Longitudinal Crack Pattern*

6 Conclusion

We concluded from our experimental and analytical studies that Ferro cement systems have a high ductile structure that fails only via swift, non through abrupt disaster, unfluctuating at greater loads. Because folded plates are effective for a longer amount of time, Ferro cement is used in folded plates. Because ferro cement elements are high on stress when reinforcement is spread, they have made the components smaller for supporting the weight. The average initial fracture load for the two specimens examined is 8 kN/m and the ultimate load is 16 kN/m, respectively. The analytical values are closer to the experimental values than the experimental values. In experimental observation, the eventual load is twenty-five percentage higher than initial crash load. tension zone is where the fractures in the folded plate of ferrocement begin.

7 Declaration

7.1 Competing Interests

Authors involved in this study declared that they have no conflict of interest.

7.2 Publisher's Note

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