Indian J.Sci.Res. 14 (1): 122-126, 2017
ISSN: 0976-2876 (Print)
ISSN: 2250-0138 (Online)

COMPRESSION BEHAVIOR STUDY OF INSULATED CONCRETE FORM (ICF) BLOCKS

A. ARUN SOLOMON[a1], F. RAVEEN VIRGIL[b], A. SALAMON[c] AND G. HEMALATHA[d]

[a]Assistant Professor, Department of Civil and Mechanical Engineering, Karunya University, Coimbatore, India
[bc]Undergraduate Student, Department of Civil and Mechanical Engineering, Karunya Univesity, Coimbatore, India
[d]Associate Professor, Department of Civil and Mechanical Engineering, Karunya University, Coimbatore, India

ABSTRACT

The construction industry is growing at a faster pace and the crisis in today's scenario is a shortage of materials. Insulating concrete form wall system of building construction is an emerging technique to address this issue. This technique has numerous advantages over traditional brick wall and RCC construction. It provides energy saving and energy efficient building, needs no special form works, cost effective, fastest way of construction, sound proof, less maintenance, disaster resistance, etc., Insulated Concrete Form (ICF) is an emerging construction technology using the interlocking of Expanded Polystyrene (EPS) sheet with poured in place concrete. Insulating Concrete Forms (ICFs) have been successfully used in the United States, Canada, and Europe for over twenty years. Poor in knowledge, Lack of experience and non availability of required materials are the barriers of developing this technique in countries like India. This paper presents experimental results carried out to study the behavior of ICF blocks casted with 60 mm and 100 mm thick EPS. The experimental results are compared with plain concrete and the results exhibits ductile failure rather that the common brittle failure of concrete. Among two different thick ICF specimens, it is observed ICF specimens casted with 100 mm thick EPS exhibits high ductility when compared to other specimens.

KEYWORDS: EPS Sheet, Insulated Concrete form, Load-Deflection Curve, Compressive Strength

Growth of population leads to increase in construction of residential and commercial building. India is facing problems like shortage of construction building materials. Hence the challenge faced by civil engineers is to develop new materials for the future. EPS (Expanded Polystyrene) sheets made from expandable polystyrene, which is a rigid cellular plastic containing an expansion agent. It has been tested by many researchers as an allowable light material for wall construction.

Insulating Concrete Forms (ICFs) are hollow molds with a center cavity (Figure 1) that is filled with reinforced concrete. The forms are usually made of rigid polystyrene or polyurethane insulation, and are produced as either pre-formed interlocking blocks, or as separate panels connected with plastic or steel rods and ties.

ICF structures are built by fitting together the insulating forms, adding steel reinforcing bars (rebar) for strength, and then filling the central cavity with concrete. The insulating forms, rebar, and concrete walls stay in place as a permanent part of the wall. The outer surface of the walls creates a supportive backing for most conventional finishing materials such as stucco.

Andreea-Terezia Mircea (2010) carried his research in ICF wall with parameters of ground acceleration (0.08g, 0.20g and 0.32g), the normalized axial force (0.05, 0.20 and 0.40), the quality of concrete (classes M 16/20 and M 20/25), the effective thickness of the walls (i.e., 150 mm and 200 mm), and the longitudinal reinforcing ratio at the ends of the wall (0.005, 0.020 and 0.040). The three various thickness of shear wall was casted and tested for cyclic loading to find the seismic performance. It was concluded that, ICF wall provides, energy efficient green building, high durable, increased strength, maximizes resistance to natural disasters and minimizes temperature fluctuations by absorbing and storing heat.

Figure 1: Typical ICF Block

Peter Dusicka (2010) studied the behavior of ICF wall under seismic loading. 4ft ,12 ft ICF wall and conventional wall are casted and tested under cyclic loading. It was found that failure occurred near the bottom of the wall at the point where the foundation rebar splices into the wall reinforcement. The 4ft wall exhibited ductile behavior where strength degradation did not occur until drift cycles beyond 2%. The 12ft wall showed a peak strength at 0.5% drift and significant strength degradation beyond 1% drift. It was concluded that, ICF grid wall system potential exist for the seismically active regions.

MATERIAL DATA

The main drawback in the construction using ICF is non availability of the required thickness and density of EPS sheets in Indian scenario. The manufacturer of EPS sheets produce only, if the requirement is mass and due to this the cost is comparatively high. The figure 2 shows two

[1]Corresponding author

EPS sheets of thickness are 60 mm and 100 mm used in this project. The size of the sheet is 1000 x 500 mm. The physical properties of this material are given below

- Density : 6.37 kg/m3 for 60 mm thick EPS Sheet 11.81 kg/m3 for 100 mm thick EPS Sheet
- EPS sheets absorbed more than 80 % of water, when the sample is immersed in water for 24 hours, but it regains its property immediately after drying.
- Compressive Strength: 0.8-1.6 Kg/cm
- Cross breaking Strength: 1.4-2.0 Kg/cm
- Tensile Strength: 3-6 kg/cm
- Self ignition point: 300 C

MODELS PREPARATION

The EPS Sheets are cut into specified sizes. The specified size for the ICF model is 200 x 150 mm. Two pieces of such material is interconnected by 6 mm tor steel rods shown in figure 3. The steel was penetrated into the EPS Sheets by 40mm and gap of 60 mm was created between the two EPS sheets. In this cavity M20 grade concrete was poured. For comparison normal concrete without EPS also was prepared. The size of concrete model is 200 x 150 x 60 mm shown in figure 3.

TESTING THE MODELS

After the ICF models are casted the samples are placed for curing. Because of huge water absorption property of EPS sheets, immersed curing method is not adopted. Instead of immersed curing moist curing by gunny bags is adopted. After 7 and 28 days compressive test was conducted in the universal testing machine. The deflection curve was plotted directly in the UTM machine. The figure 4 shows the testing equipment of ICF model.

EXPERIMENTAL OBSERVATION

The figure 5 shows the typical failure of ICF models. From the figure it can be seen that even after the complete failure of concrete core part, the EPS sheets remains in an undisturbed condition. It does not exhibit any cracks or any sort of disintegration. This phenomenon implies that, the formwork does not fail during peak load is very important in the construction industry, because this type of technology may be used in the seismic prone areas and other important structures to avoid spalling of concrete.

The table 1 shows the values obtained from tests the two samples of ICF models and plain concrete model.

The graph shown in figure 7 to 10 obtained load deflection curve from digital universal testing machine explains the behavior of ICF model and plain concrete model.

Figure 2: Typical 100 mm 60 mm thick EPS sheets

Figure 3: Typical ICF model before and after casting

Figure 4: Test carried out in the UTM

Figure 5: Tested ICF blocks with 100 and 50 mm thick EPS

Table 1: Test Results

Sl. No	Description of Sample	Peak Load		Deflection at Peak Load		Maximum Deflection		Compressive Strength		Reference figure No.
		7 Days kN	28 Days kN	7 Days mm	28 Days mm	7 Days mm	28 Days mm	7 Days N/mm^2	28 Days N/mm^2	
1	Plain concrete Model	161.10	204.70	5.60	2.60	6.00	3.00	13.43	17.06	7
2	60 mm thickness of EPS sheet on both sides of concrete	198.90	215.90	7.90	2.80	9.30	9.50	16.58	17.99	8
3	100 mm thickness of EPS sheet on both sides of concrete	196.50	216.00	3.10	7.90	16.00	19.10	16.69	18.00	9
4	60 mm thickness of EPS sheet alone	3.10		9.80		9.80		0.26		10a
5	100 mm thickness of EPS sheet alone	4.70		11.30		11.30		0.24		10b

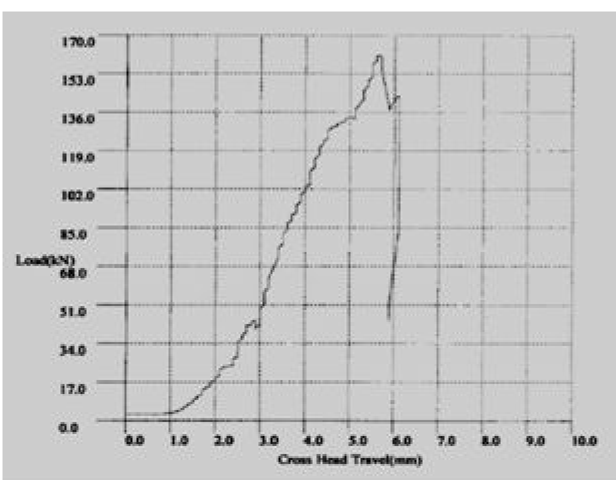

Figure 7a: 7 Days Load – Deflection curve for Plain concrete model

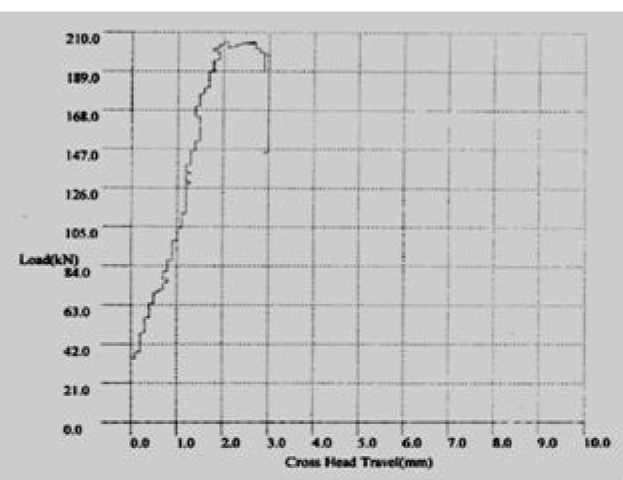

Figure 7b: 28 days Load-Deflection Curve for Plain concrete model

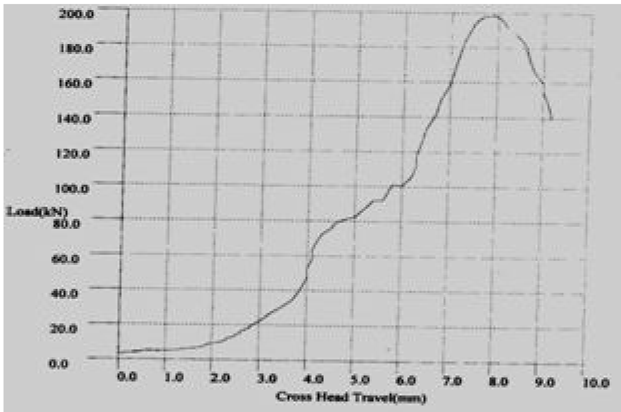

Figure 8a: 7 days Load-Deflection curve for 60mm thick EPS sheet on both sides

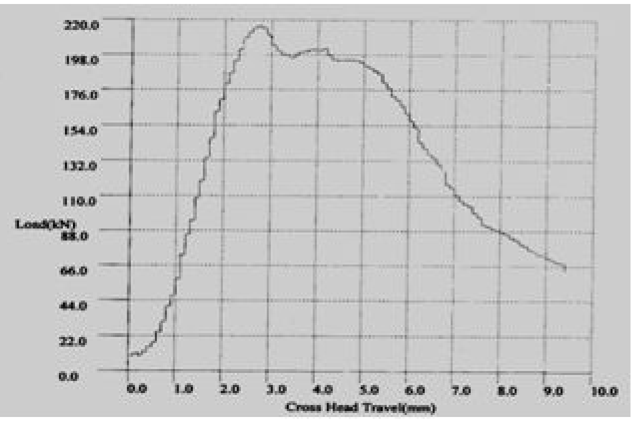

Figure 8b: 28 days Load-Deflection curve for 60mm thick EPS sheet on both sides

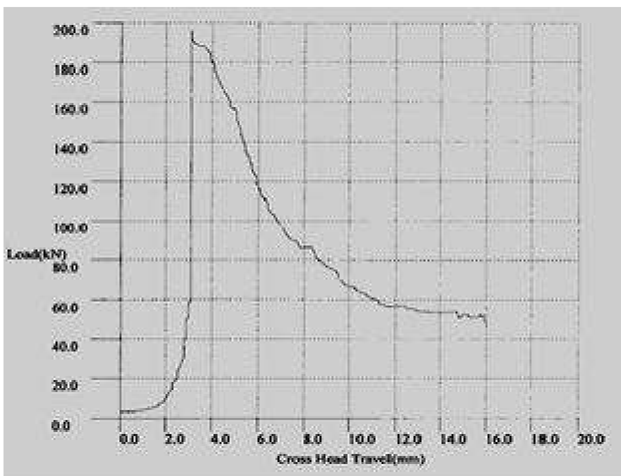

Figure 9a: 7 days Load-Deflection curve for 100mm thick EPS sheet on both sides

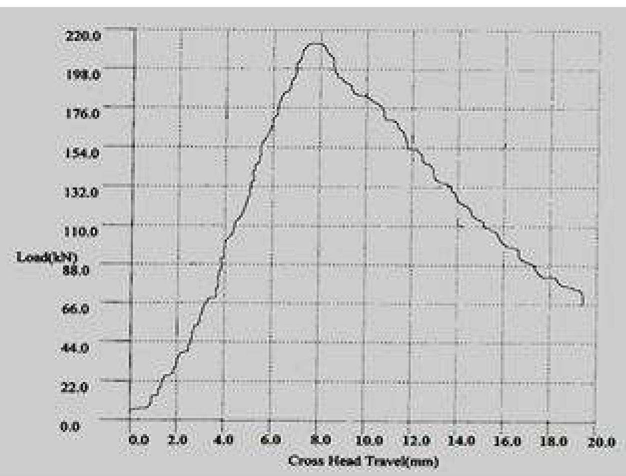

Figure9b: 28 days Load-Deflection curve for 100mm thick EPS sheet on both sides

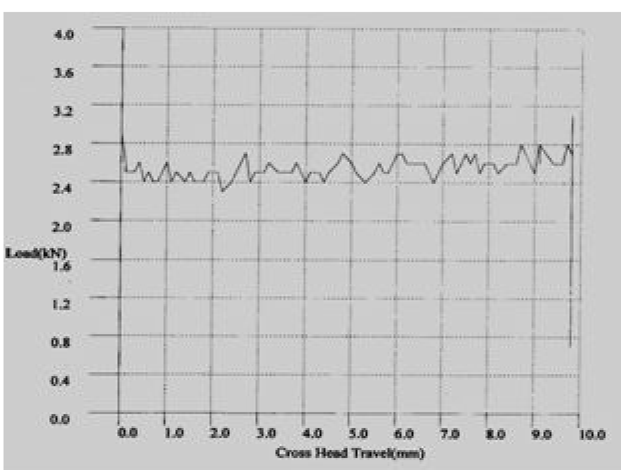

Figure10a: Load-Deflection curve for 60mm thick EPS sheet of size 200 x 150 x 60

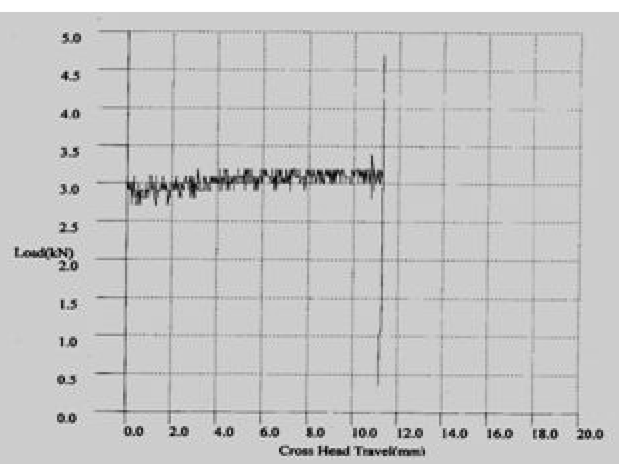

Figure10b: Load-Def. curve for 100mm thick EPS sheet of size 200 x 150 x 100

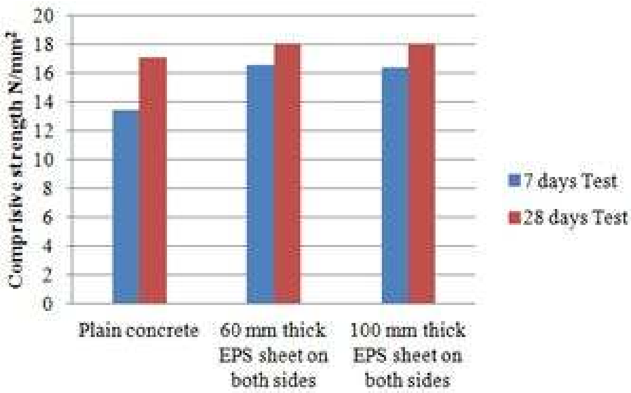

Figure 11: Compressive strength comparison chart

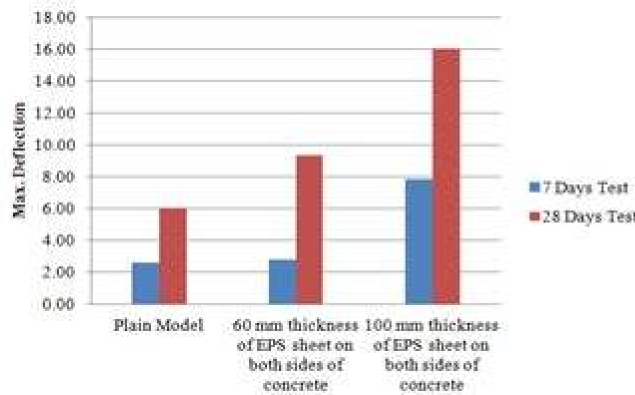

Figure 12: Maximum Deflection comparison chart

RESULTS AND DISCUSSION

The figure 11 shows, the comparison of compressive strength between plain concrete and with EPS sheets. It indicates, increase in compressive strength for specimen with the EPS sheet on both sides of concrete. It also shows that, the difference of compressive strength of three models is not increasing significantly, but as the load increases plain concrete fails and it was observed that, the EPS sheets have not failed and in position. No single crack was observed in the sheets, indicates a ductile behavior.

The figure 12 plotted between maximum deflection and respective concrete model explains that at ultimate load for plain concrete behavior was brittle whereas the specimen with EPS sheets shows prolonged yielding without failure.

CONCLUSION

- Concrete specimen with EPS sheets exhibit, no cracking or zero disintegration of EPS sheets even after complete failure of concrete core. This means if walls are constructed with this method, the walls stands and deflect largely even though the load carrying concrete has failed.
- When compared to normal plain concrete and ICF model there is no much change in the load carrying capacity, but after attaining peak load sudden failure occur in the normal plain concrete but ICF shows ductile failure.
- Because of usage of EPS sheets, formwork is not necessary during construction; hence project time schedule will reduced. And it requires minimum skilled labors, leading to reduction in labor cost.
- Curing process is not required, since the concrete is covered by EPS sheets.
- Initial cost of ICF building is high for the reason that, non availability of required EPS sheets and concrete corer is the entire wall. But the building requires lesser amenities for heating and cooling, which may reduce the electric bill and it requires low maintenance
- Due to the ductile behavior its use may protect the structure from natural disasters like earthquake.

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