Scientific Journal of Impact Factor (SJIF): 5.71

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development
Volume 5, Issue 04, April -2018

EXPERIMENTAL INVESTIGATION ON INSULATING CONCRETE FORMS (ICF) SLABS

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Abstract —*This paper represents the study of the Insulating concrete forms (ICF) which are specifically used for the thermal insulations. It is used in residential as well as used in commercial buildings. As per past researches the ICF system gives thermal insulations but the compressive strength of the polystyrene concrete is less as compare to the normal concrete. That's why the slabs with different configuration by combining both materials as monolithic construction is casted and tested in this study. In this approach, normal concrete gives the structural strength and the polystyrene concrete gives the thermal insulation. Results of the flexure test of both specimens with are presented in this paper. This study gives the structural viability of this type of monolithic construction.*

Keywords-*Polystyrene Concrete, Normal CONCRETE, SBR Latex, ICF Walls, ICF Slabs, Flexural Test.*

I. INTRODUCTION

Insulated concrete forms (ICF) are rigid plastic forms that hold concrete in place during construction and curing and remain in place afterwards to serve as thermal insulation for concrete elements as part of a surface.

Figure 1 ICF System

(https://encrypted-tbn0.gstatic.com)

As shown in figure the ICF Walls and Slabs are connected .in the figure the cross sectional view is shows the different part of structure likewise walls slab stirrups in upper part the texture in walls and the system of casted elements. The forms are interlocking modular units that are dry-stacked and filled with concrete. The units lock together somewhat like Lego bricks and create a form for the structural walls or floors of a building.

A. Introduction to ICF System Walls

Insulated Concrete Formwork or Insulated Concrete Form (ICF) is a reinforced concrete formwork system, usually made of rigid insulation material, used as a permanent inner and outer substrate for walls, floors and roofs. These forms are interlocking module units dry-stacked (without mortar) and filled with concrete. These units are somewhat locked together like Lego bricks and create a form for the structural walls or floors of the building., ICF construction has become a common phenomenon in low-rise commercial and high-performance residential buildings.

B. Introduction to ICF System Slabs

As shown in figure, the ICF board has different materials, such as polystyrene concrete and normal concrete with reinforcement. This structure is completed in two stages. Place polystyrene concrete blocks first and then provide reinforcement after applying ordinary concrete construction.

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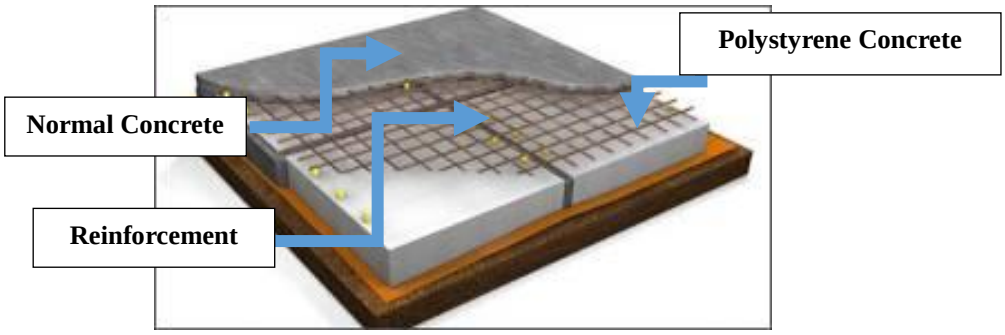

Figure 2 Cross sectional view of ICF Slab
(http://www.quadlock.com/ICF-Floors-and-Roofs)

II. MATERIALS

In this work, specific mix design is developed which replaces course aggregate with polystyrene beads which provided more benefits in terms of thermal insulation, required strength and low density. Expanded polystyrene is a stable, low-density foam. It consists of 98% air and 2% polystyrene material. It has Closed structure cannot absorb moisture. It has a good influence resistance. Polystyrene is a medical packaging material. Polystyrene is a non-biodegradable material. Polystyrene beads can be easily combined into mortar to form lightweight concrete with a wide range of concrete density. SBR Latex can be used as bonding material between normal and polystyrene concrete. Applications for polystyrene concrete include walls, cladding panels, sloping panels and laminate flooring. Polystyrene concrete for the production of load-bearing concrete walls also serve as materials for floating marine structures.

1) *Cement :-* Ordinary Portland cement , manufacture by ultratech company india.
2) *Fine aggregate :-* The zone III sand and 4.75 mm pass out material is used in the constructiom
3) *Course aggregate :-* 10mm & 20mm course aggregate are uesd .
4) *Polystyrene beads :-* The expanded polystyrene beads haven an apparent dendity of 16-27 kg/m, and diameters are ranging from 1.5 to 3.0 mm.
5) *Sbr latex :-* it is used as bonding and water proofing material, it is used as 1% of cement by weight.
6) *The proportion :-* proportion of mix design for table 1 is 1 : 1.79 : 2.58 (slump value is 35 mm & severe exposer condition)

III. METHODOLOGY

In this work the analysis is done by the casting of different types of cubes with different concrete mix. The slab is casted in two stages, first bottom layer of normal concrete is casted and the second is the upper layer of polystyrene concrete.

3.1. Normal Concrete

After doing all the preliminary test on sand, aggregates and cement, mix design for grade M25 is done. Total six cubes of standard sized 15 cm x 15 cm x 15 cm are casted in laboratory of Marwadi Education Foundation, Rajkot. Results of preliminary test of fine and coarse aggregates are mentioned in Table 1. Final proportion derived for mix design is mentioned in Table 2. Test results observed for all the cubes after curing period of 7 and 28 days are mentioned in Table

Table 1: Properties of C.A & F.A

Property	Coarse Aggregate	Fine Aggregate
Specific Gravity	2.5	2.7
Bulk Density (kg/m^3)	1409	-
Loose Bulk Density (kg/m^3)	1250	-
Water Absorption (%)	0.93	2.12
Impact Value	8.95	-
Crushing Value	38	-
Fineness Modulus	6.5	3.55

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Table 2: Mix Design For M25 Normal Concrete for Cubes

Sr. No.	Material	Quantity (kg/m^3)
1	Cement	14.76
2	Sand	26.43
3	20 mm C.A	22.96
4	10 mm C.A	15.31
5	Water	6.92 liters
6	Proprtions	1:1.79:2.58

Table 3: Results of Normal Concrete Cubes

Specimen Name	Curing Period	Weight (kg)	Ultimate Load (kN)	Ultimate Stress (MPa)	Average Strength (MPa)
S1	7 Days	8.70	989.5	43.97	38.73
S2		8.75	797	35.11	
S3		8.99	835	37.11	
S4	28 Days	8.84	872.9	38.78	37.6
S5		8.90	830	37.65	
S6		8.60	802	36.37	

3.2. Polystyrene Concrete

For polystyrene concrete also six cubes are casted and tested in laboratory. Mix proportion considered for the polystyrene concrete is mentioned in Table 4. It is important to use SBR Latex as binder material to develop bond between EPS beads and fine aggregates. Properties of the SBR Latex used are given in Table 5. EPS beads are totally replaced by coarse aggregates by volume in the mix. Test results observed for all the cubes are mentioned in Table 6.

Table 4: Mix Proportion of Polystyrene Concrete

Sr. No.	Material	Quantity (kg/m^3)
1	Cement	11.072
2	Sand	19.81
3	Water	5.19
4	SBR latex (1% of Cement)	0.036
5	Polystyrene Beads	0.360
6	Proprtions	1:1.79:2.58

Table 5: SBR Properties

Properties	Results
Vision	Free flowing liquid
Color	White
Bond Strength (N/mm^2)	5
Ph value	7-9
Stableness, %	42-45
Specific Gravity	1.04
Resistant of Freezing	Very Good
Resistant to Chemical	Alkalis & Mild acid resistant

Table 6: Results of Polystyrene Concrete Cubes

Specimen Name	Curing Period	Weight (kg)	Ultimate Load (kN)	Ultimate Stress (MPa)	Average Strength (MPa)
P1	7 Days	4.150	85.2	3.78	3.89
P2		4.190	88.3	3.92	
P3		3.970	89.6	3.98	
P4	28 Days	4.150	101.6	4.51	4.5
P5		4.210	112.8	5.01	
P6		4.420	92.0	4.08	

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3.3. ICF Slabs

Total two ICF slabs having variation in width and reinforcement are casted in this study. The slab having size 1.8 m x 1.8 m is named as MSA and another slab with size 0.9 m x 1.8 m is named as MSB. Detail descriptions of both the slabs are given in subsequent subsections.

3.3.1 ICF Slab: MSA

Overall size of the slab MSA is 1.8 m x 1.8 m x 0.23 m. This slab is made from normal and polystyrene concrete details regarding layers and reinforcement of MSA slab is shown in Figure 3.

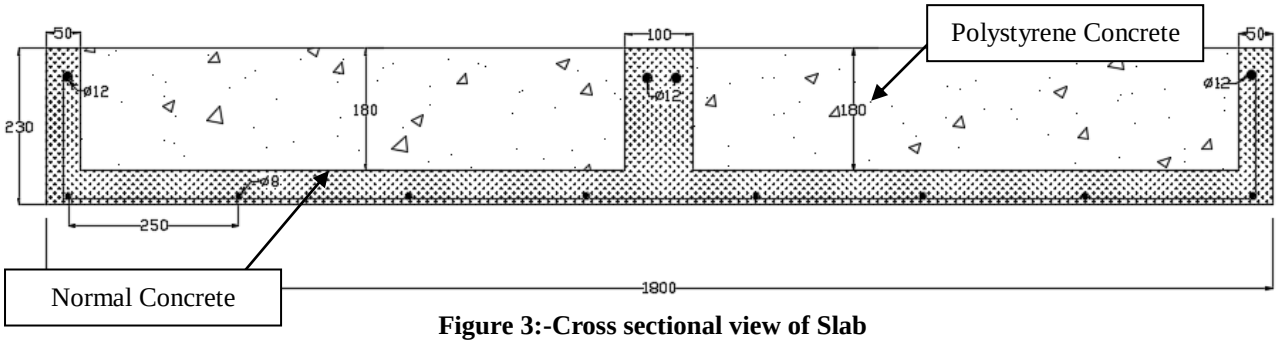

Figure 3:-Cross sectional view of Slab

As shown in Figure 4, MSA slab formwork and reinforcement are arranged as per dimensions. Subsequently, first layer of normal concrete with rib beams are casted. Rib beams are provided to support polystyrene concrete as well as to help in flexural capacity of the slab. The casting stage of normal concrete is shown in Figure 5. In the last stage of casting polystyrene concrete is placed in the place and final finish is given to the slab. Figure 6 shows the final casted MSA.

Figure 4 :- Form work of Slab

Figure 5 :- Complete casting Normal Concrete for (MSA)Slab

Figure 6 :- Complete casting polystyrene Concrete for (MSA) slab

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3.3.2 ICF Slab: MSB

Overall size of the slab MSB is 0.9 m x 1.8 m x 0.23 m. This slab is made from normal and polystyrene concrete details regarding layers and reinforcement of MSA slab is shown in Figure 3.

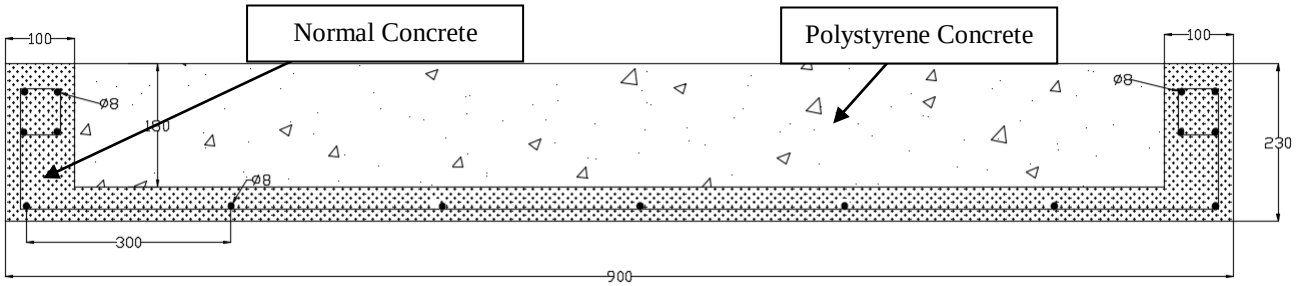

Figure 7:- Cross Sectional View of (MSB) Slab

As shown in Figure 8, MSB slab formwork and reinforcement are arranged as per dimensions. Subsequently, first layer of normal concrete with rib beams are casted. Rib beams are provided to support polystyrene concrete as well as to help in flexural capacity of the slab. The casting stage of normal concrete is shown in Figure 9. In the last stage of casting polystyrene concrete is placed in the place and final finish is given to the slab. Figure 10 shows the final casted MSB.

Figure 8 :- Form work of (MSB) Slab

Figure 9 :- Complete casting of normal concrete in (MSB) Slab

Figure 10:-Complete casting (MSB) Slab

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III. RESULTS

4.1 Testing of MSA Slab

The flexure test is performed for MSA slab. Figure 11 shows the two-point load system which is used in the flexure test. As per figure 12 the shear cracks are generated at the one end support of slab at 90.48 kN load and the deflection is 4.005mm. The shear cracks are developed at 80 cm from the Right end of the slab. Table 7 shows the load vs deflection values for the slab.

Figure 11 :- Flexure test of (MSA) Slab

Figure 12:- Creck after test in (MSA) Slab

Table 7: Results of Slab (MSA)

Sr. No.	Load (kN)	Deflection (mm)
1	6.96	0.030
2	13.92	0.049
3	20.88	0.081
4	27.84	1.000
5	34.8	1.017
6	41.76	1.046
7	48.72	1.060
8	55.68	1.084
9	62.64	2.017
10	69.6	2.035
11	76.56	2.097
12	83.52	3.071
13	90.48	4.005
14	83.52	5.005
15	76.56	5.030
16	69.6	5.084

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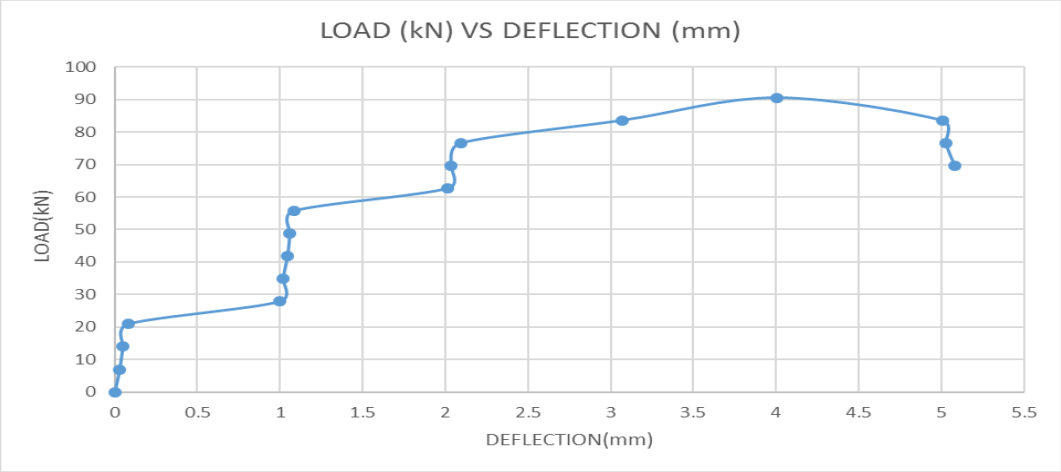

Figure 13:-Graph of Load VS Deflection

4.2 Testing of MSB Slab

The flexure test is performed for MSA slab. Figure 13 shows the two-point load system which is used in the flexure test. As per figure 14 the shear cracks are generated at the one end support of slab at 104.44 kN load and the deflection is 10.95 mm. The shear cracks are developed at 60 cm from the Right end of the slab. Table 8 shows the load vs deflection values for the slab.

Figure 14:-Testig of the MSB Slab

Figure 15 :- Shear Crack after test

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Table 8: Results of the Deflection

Sr. No.	Load (kN)	Deflection (mm)
1	6.96	0.055
2	13.92	1.065
3	20.88	2.065
4	27.84	3.004
5	34.8	3.092
6	41.76	4.008
7	48.72	4.096
8	55.68	5.076
9	62.64	6.072
10	69.6	7.005
11	76.56	9.035
12	83.52	10.039
13	90.48	10.089
14	97.44	10.09
15	104.4	10.95

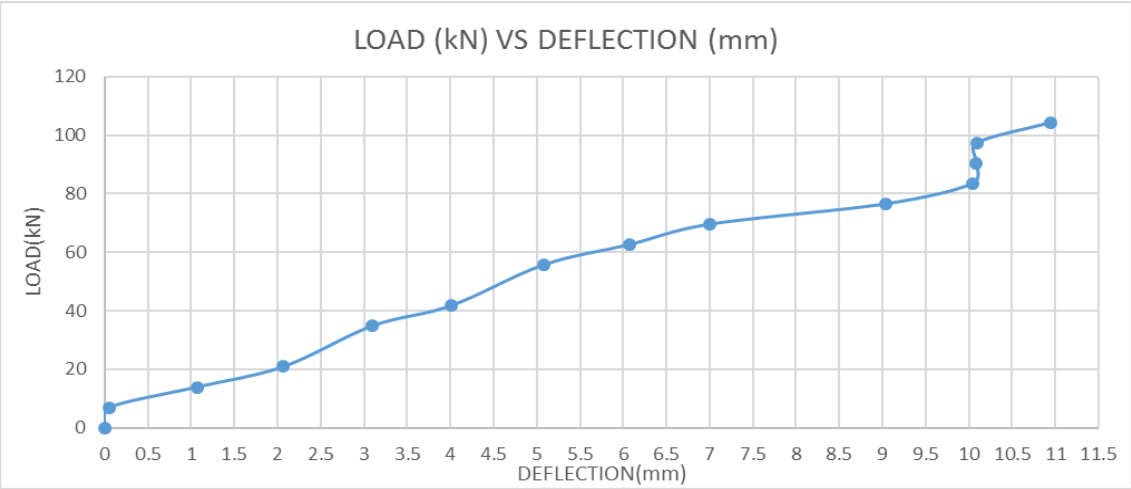

Figure 16 Load VS Deflection Graph for MSB Slab

V – CONCLUSIONS

It can be concluded from this experiment that the objective of investigating structural viability is achieved. Both the slab elements have bared the design load. Even, polystyrene concrete and normal concrete have performed monolithically up to failure. Use of SBR latex as binder material has played vital role in development of bond between normal and polystyrene concrete. This assembly gives the thermal insulation and also structural strength. Deflection produced up to design load also remained well within the limits.

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