Insulated Concrete Formwork

Harshil Chotalia[1], Gaurav Parmar[2], Amit Singh[3] and Saif Qureshi[4]
[1,2,3,4]*UG Student, Department of Civil, Shree L.r Tiwari College of Engineering*

***Abstract*—Insulating Concrete Formwork (ICF) is a robust and cost-effective building system used in Europe and North America for constructing various types of buildings. The system uses lightweight formwork made of insulating materials to support concrete walls while being cast in-situ, which is left in place as insulation. ICF provides complete thermal insulation to the walls of the finished building and a uniform surface for direct application of finishes and cladding systems. According to literature reviews, ICF is 10% more airtight and 15% more cost-efficient than conventional building systems. Additionally, ICF panel cubes have 40% more compressive strength and 10% more efficient in thermal resistance than PCC cubes, with ductile failure rather than brittle failure. The project involves casting a cube of 150mm * 150mm sandwiched between two ICF panels of varying size (50mm and 100mm) for testing compressive strength, thermal insulation, and water/moisture absorption, while also comparing the cost of conventional formwork and ICF panels.**

***Index Terms*—Awareness, Cost effectiveness, Thermal resistance, Axial Compressive Strength.**

I. INTRODUCTION

The Insulating Concrete Forms (ICF) system consists of two walls of Expandable Polystyrene (EPS) panels, separated by hard plastic ties, to hold reinforced concrete. The panels are assembled on-site to create a shuttering system that forms a hollow space where concrete is poured to create a continuous wall. The cured wall supports structural loads from floors and roofs, and the shuttering provides thermal insulation. The panels are castellated on the upper and lower surfaces, and have tongue-and-groove vertical mating surfaces that fit tightly together without the need for supporting falsework. The inner surfaces are tapered grooved vertically, with offsets on opposite faces to ensure uniform concrete thickness, and they form locks for end stops. The outer surfaces are grooved vertically at 50mm centres to aid in cutting and trimming. The system is robust and cost-effective, providing both structural support and thermal insulation. The use of ICF eliminates the need for additional insulation and reduces the amount of concrete required, making it an environmentally friendly option. The ICF system can be used in a variety of building types, from houses to commercial buildings, and offers many benefits such as high compressive strength, thermal insulation, and water/moisture resistance.

Insulated concrete formwork has advantages over traditional construction methods, as it uses less energy, is constructed faster, is sound and heat resistant, and requires less maintenance.

II. PROBLEM STATEMENT

India faces challenges in the construction industry due to socio-economic stress, chronic resource shortages, institutional weaknesses, and an inability to deal with key issues. A large segment of the population is still houseless due to constraints in taking know-how to the common man and inadequate finances. However, the government has undertaken housing projects such as Valmiki Ambedkar Awas Yojna and Indira Awas Yojna to provide shelters to the needy. Sociological issues may arise in post-disaster reconstruction projects, requiring intervention from non-governmental groups. India faces significant challenges in preserving its fragile environment, with high levels of land degradation, pollution, and inadequate waste management infrastructure. The government needs to enforce regulations on environmental performance, while market forces should demand better environmental practices from construction firms. Professional bodies should provide support services to encourage environmentally-friendly practices, while pressure groups and informed users should work to prevent environmental deterioration. India is also vulnerable to natural hazards, such as floods, earthquakes, and cyclones, leading to significant damage and financial setbacks.

III. OBJECTIVES

- To look into the current condition of insulated concrete forms in the building business.
- To investigate how concrete behaves in insulated concrete forms.
- Researching the physical and mechanical characteristics of steel and concrete inclusion in insulated concrete forms.
- To identify existing issues with insulated concrete forms and to create an environmentally friendly and low-cost structure.
- To study and analyze the functioning of approved alternate and innovative construction systems for housing in different aspects - technical details, climatic & environmental impact, durability, resilience, capital and operating costs, etc.
- To analyze the occupants' comfort in these systems through data available from the executed housing projects in India.

IV. LITERATURE REVIEW

Shruti Pulpulak & Sumedha Dua, (Feb,2022)- They had studied the feasibility which includes economy, environment, climate and fast paced construction technique between the codal provisions provided in India & abroad. They concluded that the duration of construction had been reduced significantly by 40% & whereas the procuring cost was high, while life-time cost was lower than conventional formwork. The chances of error were very less in comparison of conventional formwork.

Joel Joseph Shelton, Mohammad Izazs, Daniel Cruze & Arun Solomon, (Jan,2021)-They had compared fibre concrete sandwiched between ICF panels and normal PCC. It was found that numbers of cracks were less in Fibre Concrete Panel (FCP) & FCP shown ductile failure, while PCC shown brittle failure. The difference between the compressive strength was around 12%.

Rajan Rawal, Dr Sameer Maithel, (June,2020)- had mentioned that thermal resistance of ICFs were greater than other materials. Not only that, but it was cheapest among the wall technology.

Hemalatha.G, (May,2018)- The objective of this work was to investigate the compressive behaviour of ICF blocks with various thickness of EPS sheet and polypropylene sheet (PP sheet) as a face sheet. Two different thickness of ICF are cast with 25 mm and 75 mm thick EPS with and without PP sheet as a face sheet. In addition to that two plain concrete samples are cast in order to compare the experimental results with ICF. Experiment was carried out in 100T capacity computerized Universal Testing Machine. Experimental results proved improved behaviour of ICF blocks than plain concrete in terms of strength and nature of failure. Load-deflection, ductility ratio and variation of load and deflection are analysed and presented.

Syed W. Ather, Saud Abdelaziz, (Feb,2017)- In this study properties of EPS was determined by the standard procedure as per IS 4671:1984, compression behaviour of ICF and bondage between EPS and concrete were analysed using ICF specimens casted using M25 grade concrete. Two types of ICF specimens were casted with corrugated EPS and Plain EPS and using different densities of 4,8,12 kg/m 3 and varying thickness of 50 mm and 100 mm EPS. The results show that the compressive strength of ICF blocks casted with plain EPS was higher than the samples casted with corrugated EPS as well as results show that good bondage exist between EPS and concrete for plain and corrugated EPS without adding any bonding agent while casting and when compared to plain concrete all the ICF blocks exhibit tremendous ductile nature of failure.

V. EXPERIMENTAL PROGRAM

5.1 Materials

5.1.1 Expanded Polystyrene

Expanded Polystyrene (EPS) is a widely used material due to its excellent insulating properties, light weight, and low cost. According to the Indian Standard (IS) 4671:1984, self-extinguishing type EPS must have a density not less than 25kg/m3.

Flammability of EPS as per DIN 4102 test is B2,
Water vapour permeability as per ASTM E96 is
0.0037 mg/hmpa, Thermal conductivity at 20 C
Is 0.028 as per IS 3346. Cross breaking strength: 1.4-2.0 Kg/cm. Tensile Strength: 3-6 Kg/cm.

5.1.2 Cement

In this case, for M25 grade concrete, the cement content is determined as 438.13 kg/m³, which falls within the permissible range. The appropriate cement content ensures that the concrete has the required

workability, strength, and resistance to environmental conditions, making it suitable for various construction applications. Specific of Gravity of cement is 3.15. Grade of cement is OPC 53.

5.1.3 Aggregate

According to Table 3 of IS-10262:2009, for M25 grade concrete with zone I fine aggregate and a maximum coarse aggregate size of 20 mm, the volume of coarse aggregate per unit volume of total aggregate should be 0.60.the shape of the particle is angular. specific gravity of aggregate is 2.74 and water absorption is 0.5 %.

5.2 Preparation of model

For experimental investigation sheets of size 25mm thickness has been used. The concrete has been be sandwiched between the EPS of thickness of 25 mm. The EPS Sheets were cut into specified sizes. The specified size for the ICF model is 210 X 160 X 150 MM. four pieces of rod of 8mm tor was used as tie to connect EPS sheets. the space between two EPS sheet was about 100mm which was filled with concrete.in this space 1 set was casted with M20 grade of concrete and another set was casted with M25 grade.

5.3 Curing of Concrete

Insulated Concrete Forms blocks are made of EPS sheets. Therefore, it is essential to ensure proper curing to achieve the desired strength and durability of the ICF blocks. In this case moist curing by gunny bags was adopted. This involves covering the ICF blocks with moist gunny bags to keep them hydrated and prevent the evaporation of moisture. This method ensures that the blocks remain moist during the curing period, allowing the cement to fully hydrate and form strong bonds with the EPS sheets. After 7 days of moist curing, compressive testing was conducted in a compressive testing machine to determine the compressive strength of the ICF blocks.

VI. RESULTS AND DISCUSSIONS

A. Compressive Strength

The compressive strength after 7 days of curing was done and the following results were obtained and were presented in table no 1.

Table 1: compressive strength of ICF for M20 & M25

Sr. No	Grade of Concrete (N/mm2)	Size of Cubes (mm)	Weight of Cubes (Kg)	Compressive Load (KN)	Compressive Strength (N/mm2)	Mean Strength (N/mm2)
1	M20	210*150*160	8.42	500	15.873	15.873
2		210*150*160	8.42	490	15.556	
3		210*150*160	8.42	510	16.190	
4	M25	210*150*160	8.42	600	19.048	19.365
5		210*150*160	8.42	620	19.683	
6		210*150*160	8.42	610	19.365	

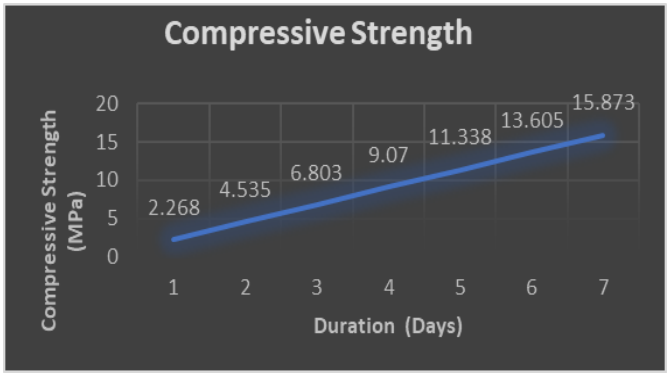

Fig.1.Graphical Representation of Compressive strength of ICF for M20

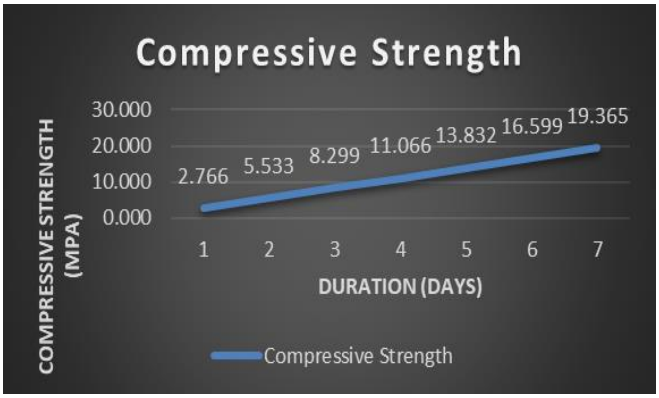

Fig.2.Graphical Representation of Compressive strength of ICF for M25

B. Cost Analysis

For comparing conventional formwork and insulated concrete formwork we have considered G+1 Bungalow having Built up area 6477 sft and the cost are as follows:

Table no 2: Cost Comparison Between Conventional Construction & ICF

Construction Form	Cost per Square Foot
Conventional	2980
ICF	1775
Cost Difference	1207

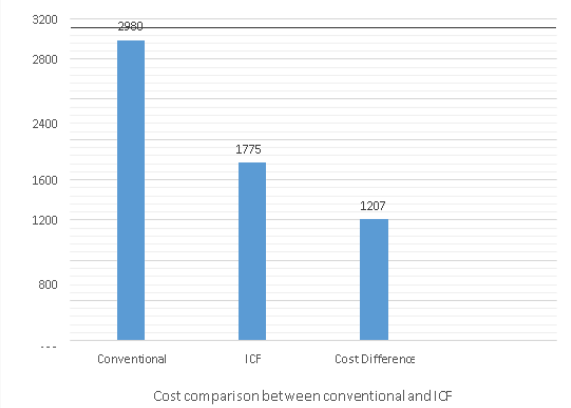

Fig.3.Graphical Representation of cost comparison

VII. CONCLUSIONS

- While normal plain concrete fails suddenly and catastrophically after reaching peak load, ICFs and EPS sheets exhibit ductile failure, allowing them to absorb and distribute loads more evenly. This improves safety and longevity.
- Due to the ductile behavior its use may protect the structure from natural disasters like earthquake.
- 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 the walls stands and deflect largely even though the load carrying concrete has failed.
- In conclusion, insulated concrete formwork was proven to have numerous advantages over traditional construction methods. It provides higher energy savings, faster construction, excellent sound and thermal resistance, and less maintenance cost.

REFRENCES

[1] Andreea-Terezia Mircea and Ruxandra Crutescu (2010), Research Contributions to the Seismic Performance of ICF Technology Wall Systems, pp 1240-1250.

[2] AfshinHatami and George Morcous (2011), Job-Built Insulated Concrete Forms (ICF) for Building Construction, 47th ASC Annual International Conference Proceedings.

[3] Dr. Richard Boser, Mr. Tory Ragsdale, (2002), Recycled Foam and Cement Composites in Insulating Concrete Forms, Journal of Industrial Technology, 18 pp 1-5.

[4] Peter Dusicka, Thomas Kay, (2010), Seismic Evaluation of Green Building Structural System: IStar Laboratory infrastructure Testing and Applied Research.

[5] Peter Dusicka(2009), Seismic Evaluation of a Green Building Structural System American Society of Civil Engineers, Structures Congress pp. 1-7.

[6] R. Oleck, A. Habel, and D. Herrit, "Insulated Concrete Forms (ICF) as blast-resistantbarriers," in Proc. Structures Congress, 2012, pp. 35-45.

[7] Amer-Yahia and T. Majidzadeh, "Inspection of insulated concrete form with ground penetrating radar," Construction and Building Materials, vol. 26, no. 1, pp. 448-458, 2012.