Study on Insulated Concrete Forms Using Fibers: A Review

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Abstract - *The use of insulating concrete forms in building construction is a new strategy for dealing with the paucity of building materials and the need for speedy construction. Compared to typical brick walls and RCC construction, this method has significant benefits. It saves energy, requires no special formwork, is quicker to construct, is soundproof, requires less maintenance, and is catastrophe resistant, among other benefits. The findings of experiments and analyses conducted to investigate the behavior of ICF blocks are presented in this publication. To investigate the properties of steel fiber and natural fiber in M25 concrete in an insulated concrete form (ICF). Their primary goal is to improve the material's energy absorption capability and toughness. However, there is also an increase. There was a little improvement in ultimate strength. The inclusion of fibre considerably improved ductility.*

Key Words: **Insulated concrete forms (ICF), expanded polystyrene, natural fiber, steel fiber, Concrete, Strength, Compressive Strength**

1.INTRODUCTION

Insulating concrete formwork (ICF) is a construction method that use lightweight formwork (made of insulating material) to support concrete walls while they are being cast in place and then uses the formwork as insulation. Insulation is integrated into the walls as part of the surface in homes constructed using ICFs. These methods provide very thermally resistant walls. They are an excellent choice for places prone to wildfires, storms, and tornadoes due to their structural strength. It has excellent insulating properties. There is hardly no cutting on the jobsite, which reduces waste. This is both cost-effective and environmentally friendly. Because of the linear and simplified process from design to completion, going up is quick and efficient. One such system is insulated concrete formwork (ICF). It's very much in the area of masonry construction, and it's also very much an example of on-site building, because it employs a lot of concrete.

Brick masonry has been utilized as infill for reinforced concrete framed constructions in India, as well as load bearing walls for masonry structures. However, masonry building has caused a significant delay in the construction process. Masonry also has the problem of sustaining damage when subjected to seismic pressures if it is not adequately reinforced. In this study, insulated concrete form walls are used as an alternative wall structure to overcome these concerns. The ICF wall's structural components are a concrete core encased in EPS sheets. Steel bars are used to keep the sheets in place. [1]

Fig-1 Insulated Concrete Forms

1.1 Objective

The research's goals are to:

- To look into the current condition of insulated concrete forms and concrete fiber in the building business.
- To investigate how fiber behaves in insulated concrete forms.
- Researching the physical and mechanical characteristics of steel and natural fiber inclusion in insulated concrete forms.
- To identify existing issues with insulated concrete forms and to create an environmentally friendly and low-cost structure.

1.2 Need of Study

The needs of the following study are listed below:

- Over traditional construction methods, the use of insulated concrete formwork has been shown to have various advantages. It uses less energy, is constructed faster, is sound and heat resistant, and requires less maintenance.
- To investigate the effects of incorporating fiber into insulated concrete forms to improve structural

integrity, offer high tensile strength to concrete, increase resistance to impact loads, and minimize the number of rebar's used without sacrificing strength.

2. LITERATURE REVIEW

Benedict Egbon et al. (2021) Notches are effective in enhancing the strength and stiffness of shear connections using XPS insulation where the insulation-concrete bond is prone to break with moderate levels of slip. Notches are less effective in EPS panels because, at least in the short term, these insulating materials adhered effectively to concrete during testing. Notch efficacy increases as the insulation's tensile strength and stiffness increase, while the shear connector's strength and stiffness decrease. The rectangular notches provided a good locking mechanism, allowing the insulation to lock in place actively. It can assist structurally after the insulation-concrete bond fails. Trapezoidal notches were also effective, but their slanted surfaces allowed insulation to be punctured, lowering friction between the concrete and the insulation and resulting in a unique sort of connection failure (rupture rather than pullout). Trapezoidal notches were weaker and softer than rectangular notches, but they provided more notice of failure. Though the failure processes of connections in insulated walls are difficult to assess due to the complex stress conditions in the connectors and surrounding concrete, the insulation's role can be effectively investigated. Insulation contribution was classified using DIC into three phases during loading: first insulation-concrete bond failure, commencement of insulation tearing, and total insulation rupture. [2]

Muhammad Asim et al. (2020) when fiber concentrations were altered from 2.5 percent to 10 percent, the findings revealed that the Coconut and Basalt fibers RC samples showed the greatest increase in thermal insulation, ranging from 6.5 percent to 17.4 percent and 5.8 percent to 17.1 percent, respectively. As the fraction of natural fibers rises, the thermal conductivity falls linearly. When coconut fiber is used as a 2.5 percent reinforcement in concrete, it improves thermal insulation by 6.5 percent and increases final compressive strength by 3.7 percent when compared to plain concrete .[3]

Irfan Ahmad Wani et al. (2020) Sheep wool fiber had a 21.1 percent increase in flexural strength, a 28.7% rise in split tensile strength, and a 12 percent increase in compressive strength. It was successfully tried to employ environmentally friendly concrete combined with sheep wool fiber in this experimental inquiry. In comparison to regular concrete without sheep wool fiber, the heat conductivity of concrete with sheep wool fiber was good, resulting in insulation. Concrete with less than 5% sheep wool fiber content had lower capillary absorption, greater workability, and other mechanical qualities than concrete with more than 9% fiber content. It may be utilized as a fake ceiling tile as well as non-load bearing wall dividers due to its light weight and high performance. When sheep wool is used as an additive and dipped in salt water, it has higher compressive and flexural strength than standard Portland cement concrete. Because sheep wool is eco-friendly, the results of these trials show that using it as a fiber reinforcement in concrete can remove the greenhouse impact produced by other reinforcements.[4]

J. Daniel Ronald Joseph et al. (2019) This study presents and discusses the experimental work done to evaluate the flexural behavior of precast light-weight concrete sandwich panels. Wires in the form of continuous truss-shape shear connections were found to be successful in achieving 100% composite action of concrete sandwich panels in experimental research. Experiments also show that panel thickness affects load bearing capacity and wire mesh size affects panel deformability. The decrease in panel stiffness as the amount of the load increases is mostly due to material (concrete) strength limitations..[5]

Arun Solomon A et al. (2019) Compression and flexure studies were carried out to understand more about the mechanical properties of EPS and how they affect the mechanical and thermal performance of the ICF system. Three different densities of EPS were used in the experiment, namely 4, 8, and 12 kg/m3, with varying thicknesses of 50 and 100 mm. According to the results of the compression tests, 100 mm thick EPS outperforms 50 mm thick EPS in terms of plastic deformation, energy absorption, and returning to its original shape when the load has been removed. Brittle failure was discovered in the early phases of loading in the flexure test of EPS; nonetheless, the deflection of 100 mm thick EPS was greater. The flexural strength of EPS smaller than 50 mm thick ranges from 0.24 to 0.98 MPa, whereas the flexure modulus of elasticity ranges from 0.013 to 0.029 MPa. The modulus of elasticity of EPS during compression is roughly 350 times that of EPS during the flexure test. Because of its superior thermal insulation and structural strength, the ICF technology is suggested for sustainable building construction.[6]

Arun Solomon et al. (2018) Experiments were used to look at the quasi-static cyclic load behaviour of ICF wall panels. ICF 12100 denotes wall panels cast with 60 mm thick core concrete and both sides of concrete wall affixed with 100 mm thickness EPS having density 12 and 20 kg/m3. ICF 20100 denotes wall panels cast with 60 mm thick core concrete and both sides of concrete wall affixed with 100 mm thickness EPS having density 12 and 20 kg/m3. The experiment was carried out in a loading frame with a capacity of 100 tonnes. The wall panel was subjected to cyclic loads in increments of 1 kN up to the failure load. On each load scale, three load cycles were applied. The wall specimens were found to resist up to eighteen cycles. On the basis of force-displacement data acquired from the system, hysteresis loops were built. The hysteresis loops were used to generate load versus displacement graphs for study. The highest peak load for ICF 12100 is 7.2 kN, whereas ICF 20100 is 7.4 kN, according to the graph. ICF12100 has a maximum displacement of 42 mm, whereas ICF 20100 has a maximum displacement of 48 mm. ICF12100 dissipates 341.65 kN.mm of energy, while ICF 20100 dissipates 340.2 kN.mm. ICF4100 dissipates 3055.162 kN.mm of cumulative energy, while ICF 20100 dissipates 2971.368 kN.mm. The ICF wall panels were shown to be resistant to lateral stresses in this pilot study.[7]

G. Hemalatha et al. (2018) To better understand the behaviour of Insulated Concrete Forms (ICF) under axial compression, ICF wall panels were cast. To compare the experimental findings, two specimens were cast with 20 kg/m3 density EPS sheet with various thicknesses of 50 and 100 mm, and two specimens were cast with 40 kg/m3 dense EPS sheet with varying thicknesses of 50 and 100 mm. All ICF wall panels have a failure pattern that is comparable to a plain concrete wall panel, but with a higher elastic range and a more desirable plastic range. Despite the fact that the internal concrete core has completely collapsed, there are only a few visible cracks in the ICF after the trial. Plain concrete, on the other hand, had numerous fissures and eventually cracked when the maximum weight was reached.[8]

Pradeep reddy et al. (2016) Steel fibers reduce workability; therefore, using superplastic improves workability. Workability declines when the amount of steel fibers grows from 0.5 percent to 1.5 percent, resulting in slump loss. When the amount of steel fibers in concrete is increased from 0.5 percent to 1 percent, the compressive strength of the concrete improves significantly, and the increase is practically identical to all the grades of regular concrete, which are M20, M25, M30, and M40. Similar to the grade of concrete, the tensile strength improves dramatically as the amount of steel fibers increases. Concrete's shear strength improves as the amount of fibers increases. FRC has significantly higher reserve and ultimate strength than traditional concrete, as well as significantly higher tensile strength. .[9]

Navid Ekrami et al. (2015) According to preliminary thermal measurements of the ICF walls, integration as a TES with system is a viable option. The study also aids designers in determining the thermal capabilities of each embedded unit metre pipe within the concrete walls. If the beginning condition differs from the stated boundary conditions, the system's performance changes. That is, provided the temperature-velocity parameters are near to those seen in the real world. The temperature distribution is uniform when the distance from the intake is more than half a meter. The variation in heat transfer rate with time has also been investigated for many temperature-velocity setups. Because the water-polyethylene Glycol solution is a component of the piping system, it's a good idea to look into it as a working fluid. [10]

E.Arunraj et al. (2014) even after total collapse of the concrete core, concrete specimens the EPS sheets exhibit no signs of cracking or disintegration. This means that if walls are constructed, they will be able to stand and deflect attacks. to a significant extent even if the load-bearing concrete has collapsed. There is no significant difference in load bearing capability between typical plain concrete and the ICF model, however after reaching peak load, plain concrete has rapid failure, but the ICF exhibits ductile failure. Because formwork is not required during construction due to the use of EPS sheets, the project time schedule will be lowered. It also necessitates the use of minimally skilled employees, lowering labor costs. Because the concrete is covered by EPS sheets, no curing is necessary. Because of its ductile nature. [1]

Clay Naito et al. (2014) Empirical equations were utilized to forecast the spall and breach on the insulated wall panels by assuming that the outside Wythe was not present and increasing the standoff distance. The intricate behavior that occurs as the shockwave travels through the various panel materials and the outer Wythe debris collides with the internal Wythe was demonstrated to be incorrect. Numerical simulations were used to predict the spall and breach occurrences for insulated panels subjected to close-in detonations; the breach diameters on the rear face of the interior Wythe were found to be slightly conservative for small foam thicknesses but bound the response at larger thicknesses. According to density and numerical simulations.[11]

George Morcous et al. (2014) Despite the numerous advantages of ICF for both homeowners and builders, problems can occur during construction due to poor concrete consolidation and the creation of air voids around plastic connections, reinforcing bars, and form corners. They have the potential to affect the system's long-term viability, safety, and thermal efficiency. This research looked into the use of GPR as a non-destructive instrument for ensuring the quality of ICF walls. A laboratory specimen was built using predetermined objects such as reinforcing bars, air voids, and utility pipes to test the accuracy of GPR scans in recognizing and finding preset items such as reinforcing bars, air spaces, and utility pipes. The results of the lab experiment were applied to a case study involving the post-construction survey of a three-story ICF building.[9]

A.M. Shende et al. (2012) When compared to 0%, 1%, and 2% fibres, 3 percent fibres have better compressive strength, split tensile strength, and flexural strength. When comparing aspect ratios of 50 to 60 and 67, all of the strength attributes are found to be on the higher side. When steel fibres are employed, compressive strength is boosted by 11 to 24 percent. When steel fibres are added, flexural strength rises by 12 to 49%. When steel fibres are added, split tensile strength improves by 3 to 41%...[12]

N. Banthia et al. (2007) It is possible to improve the flexural toughness of fiber reinforced concrete utilizing large diameter crimped steel fibers by hybridizing them with smaller diameter crimped steel fibers of the same length. Deflection-hardening may occur in such hybrids, which is uncommon in composites formed entirely of large diameter fibers. Despite the fact that hybrid FRCs with a combination of large and small diameter crimped fibers appear to be a promising notion, hybrid FRCs with a combination of large and small diameter crimped fibers were unable to match the toughness of FRCs with small diameter fibers alone. In hybrid composites with tiny and large diameter fibers, there does not appear to be a universally applicable additive rule. In other words, just substituting a smaller diameter fiber for a bigger fraction of the large diameter fiber may not necessarily result in a superior result.[13]

S J-M Dudek et al. (2007) the thermal performance of a standard thermal block structure has been shown to be influenced by the bridging of the insulating layer. When this layer is bridged by a mortar joint, the thermal transmittance increases substantially beyond the one-dimensional and area-weighted approximation. The insulating thickness for composite concrete blocks would have to be 80mm rather than 30mm to comply with the 1985 Building Regulations. A thickness of 120mm of insulation is required if the new 1990 Building Regulations are implemented. The insulation should not be bridged with mortar, as should be clear. if these concrete blocks are to be used properly. Responsible block manufacturers should give clear, unambiguous instructions on how to use their goods to builders the building industry has a considerably larger burden to bear and is in a position to contribute significantly. [14]

O.C. Choi et al. (2002) During flexural testing on the cracked surface of the RSFRC, the yielding and rupturing of ring-type steel fibers, cone type fracture of the matrix concrete surrounding the embedded ring-type steel fibers, and concrete separation around the ring-type steel fibers were discovered. The failure processes of ring-type steel fiber-reinforced concrete RSFRC do not involve a pullout mechanism, unlike standard steel fiber-reinforced concrete SFRC with straight steel fibers. There were no significant differences in magnitude between RSFRC and SHSFRC, and the starting fracture loads were slightly higher than plain concrete's. When RSFRC is compared to straight hooked-end steel fibers SHSFRC, RSFRC surpasses SHSFRC by 45 percent on average..[15]

3. MATERIAL USED IN INSULATED CONCRETE FORM (ICF)

Insulating concrete forms are manufactured from any of the following materials:

- Polystyrene foam (most usually expanded or extruded)
- Polyurethane foam (most commonly expanded or extruded)
- Wood fiber bound to cement
- Polystyrene beads bonded to cement
- Concrete with a cellular structure.

3.1 Expanded Polystyrene (EPS)

EPS stands for Expanded Polystyrene and is a white foam plastic made up of solid polystyrene beads. Packaging, insulation, and other related applications are popular uses. It's a hard, closed-cell foam with a cellular structure made of Styrene and a blowing agent made of Pentane. Styrene and pentane are hydrocarbon chemicals that are produced from leftover petroleum and natural gas. EPS is a lightweight material with strong cushioning qualities, low heat conductivity, and minimal moisture absorption. The relatively low maximum working temperature of 80°C is one of the most severe limitations of polystyrene foam. Its physical qualities do not change after long-term temperature exposure within its service temperature range (i.e. up to 167°F/75°C). Its chemical resistance is approximately identical to that of the polystyrene on which it is based.

3.2 Process of Expanded Polystyrene (EPS)

Three phases are involved in the conversion of expandable polystyrene to expanded polystyrene: Molding, maturation/stabilization, and pre-expansion Styrene, a crude oil refinery product, is used to make polystyrene. The foaming agent pentane is injected into polystyrene beads to create expanded polystyrene. At temperatures exceeding 90°C, polystyrene granulate is pre-foamed. The foamy element evaporates at this temperature, expanding the thermoplastic base material to 20-50 times its original size. The beads are then stored for 6 to 12 hours to establish balance. The beads are then fed into a mould, which produces proper forms for the job.

Fig-2 Producing Expanded Polystyrene Sheets and Molds

In the final stage, the stabilized beads are molded into large blocks (Block Molding Process) or bespoke shapes (Shape Molding Process). Additives such as flame retardants can be added to EPS to improve its fire behavior even more.

3.3 Steel Fiber

Steel fiber reinforced concrete is a composite material that incorporates fibers that are dispersed uniformly at random in small percentages in ordinary concrete, ranging from 0.3

to 2.5 percent by volume. To create SFRC goods, steel fibers are mixed with the concrete materials in the mixer, and the green concrete is poured into moulds. The product is then crushed and cured using traditional methods. Segregation or balling is a problem that arises while merging and compacting SFRC. If you want your fibers to be evenly dispersed, you should avoid this. Mixing, transporting, putting, and finishing SFRC takes a little more exertion.

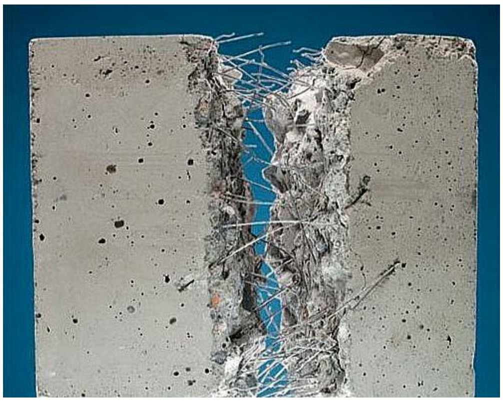

Fig-3 Steel Fiber Reinforced Concrete

The usage of steel fibers can considerably improve the following properties:

- Flexural Strength: When flexural bending strength is compared to conventional concrete, it can be boosted by up to three times.
- Fatigue Resistance: Increased fatigue resistance by more than 1.5 times.
- Impact Resistance: Increased damage resistance in the event of a significant collision.
- Permeability: The material has a lower permeability.
- Abrasion Resistance: The composition is abrasion and spalling resistant.
- Shrinkage Cracks: Shrinkage cracks can be avoided.
- Corrosion: Corrosion will affect the material, but only in limited areas.

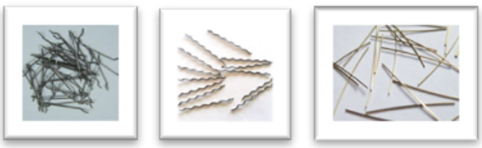

Fig-4 Type of Steel Fibers (end hook, crimped and straight steel fiber)

3.4 Natural Fiber

Natural fiber like cotton, wool, jute, coir and other natural fiber can be used to make concrete. The natural materials are more durable than standard concrete. However, as cost become a deciding factor in construction, these natural material were eventually supplanted by concrete.

Fig-5 Type of Natural Fiber (sheep wool, coir, jute)

4. ADVANTAGES

Following are advantages of insulated concrete forms (ICF)

- Strong walls
- Disaster Resistance and Safety
- Fire Resistance
- Energy Efficiency
- Thermal Insulation
- Built faster and Easier = More time savings and profits
- Flexibility
- Ability to fulfil greater energy code demands with less complicated design
- Lightweight for easy shipment and setup

5. ADVANTAGE OF ADDING FIBER IN CONCRETE

- • Fiber-reinforced concrete has a higher tensile strength than non-reinforced concrete, and it has a longer lifespan.
- • It slows the spread of cracks and improves impact resistance.
- • Fiber-reinforced concrete improves freezing and thawing resistance.
- • Fiber reinforcement of concrete improves fatigue resistance.

6. CONCLUSION

Based on previous research into the mechanical properties of fibre in concrete, insulated concrete forms were developed (ICF).Fatigue strength, durability tensile strength and resistance against freezing and thawing is increased through adding fibre in concrete. Fibre reinforced concrete may theoretically be utilised in insulated concrete forms in place of concrete. The fibre possesses all of the required mechanical and structural properties, making it a great building material. In insulated concrete forms, The strength and durability of fibre reinforced concrete have been studied, and it has been found that fibre reinforced concrete in insulated concrete formworks is stable and durable (ICF).

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