

Effectiveness of Using Insulated Concrete Form in Residential Buildings in the Bicol Region

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Abstract—Structural development in the Philippines continues to expand in both urban and rural areas, but rural regions face major challenges due to limited resources and the country's high vulnerability to natural disasters, ranking among the top ten most disaster-prone nations in the 2020–2021 World Risk Index. These risks, particularly in regions like Bicol that are frequently affected by typhoons, floods, and earthquakes, threaten economic growth and the structural integrity of residential homes. To address this, the study explores the use of Insulated Concrete Forms (ICF) as an innovative alternative to traditional concrete masonry, focusing on its structural strength, energy efficiency, insulation properties, cost-effectiveness, and disaster resilience. Using descriptive research methods, surveys, interviews, and statistical analysis (including ANOVA), the findings show that while ICF and traditional concrete have comparable strength, ICF significantly outperforms in energy efficiency and insulation, offering long-term cost savings despite higher initial costs. Although resilience against typhoons, floods, and earthquakes showed no statistically significant difference, ICF's reinforced monolithic design provides superior protection, supported by case studies in disaster-prone regions. Despite these advantages, traditional concrete remains widely preferred for its affordability and familiarity, but the study concludes that ICF is a sustainable, disaster-resilient option for residential construction in Bicol. Recommendations include increasing awareness and training among construction professionals, introducing policy incentives, and supporting local production to lower costs, alongside further research into ICF's long-term performance and lifecycle benefits.

Keywords—Insulated Concrete Form; Expanded Polystyrene; Disaster Risk Reduction; Energy Efficiency.

I. INTRODUCTION

Structural development is rampant in the Philippines not only in urban areas, but in rural regions as well. Rural areas, however, are lacking in funds and resources. Structural development in rural areas is also dependent on local manpower and volunteers. Rural areas are mostly affected by the country's weather and climate, mostly affected by typhoons and storms. Bicol region is one of the regions averaging 20 tropical cyclones per year because it is near coastal areas and prone to tropical cyclones. Nearly 70% of

all typhoons develop during the peak of the typhoon season, which lasts from July through October. Furthermore, the Bicol region is mostly open land that is prone to strong winds and gales that average 87 to 117 kph, enough to blow the regular steel roof.

The structural wall panels known as Insulated Concrete Form (ICF) panels are composed of an interlocking expanded polystyrene (EPS) core made of poured concrete that, throughout the curing process, keeps the concrete together. ICF applications are expanded to a variety of architectural projects, such as homes, theaters, hospitals, and schools (Arun & Hemanlatha, 2020). The majority of ICF suppliers offer load tables for fending off lateral pressure and compression brought on by seismic or wind stresses, depending on the core's thickness as well as the quantity and placement of the steel reinforcement. According to FEMA 361, ICF is one of the materials that may be utilized to create a missile defense barrier against hurricanes and tornadoes, with the necessary core thicknesses based on wind speed (Oleck et al., 2012).

In this study, the researcher analyzed the location, durability, and efficiency of the design structure that will decrease the risk of collapsing houses. Focusing on structural engineers that will provide ideas and information about the design regarding the location and the possible loads that will affect the structure of the Bungalow. The study benefits the Bicol region community in terms of providing safer and more effective building materials. Once proved that ICF is more effective than concrete, less structure damage would occur. The study also benefits civil and structural engineers in terms of providing added information regarding the use of ICF as a building material. Engineers will be able to use ICF on other structures and promote its effectiveness. The study of ICF for residential use against cyclones will encourage more researchers to conduct further studies on different material substitutes aside from ICF.

II. METHODOLOGY

The researchers gathered information through a survey with target respondents coming from construction companies



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that utilize ICF as a substitute for regular concrete. Identifying the usual building components of structures damaged during natural calamities and problems that occur during these instances. After the discussion of problems that occur with the materials used, the researchers will determine why it is an issue. Additionally, the researchers will also determine the effectiveness of ICF compared to regular concrete. A survey interview will be conducted with construction companies that use ICF to improve and promote the use of ICF in disaster-prone areas.

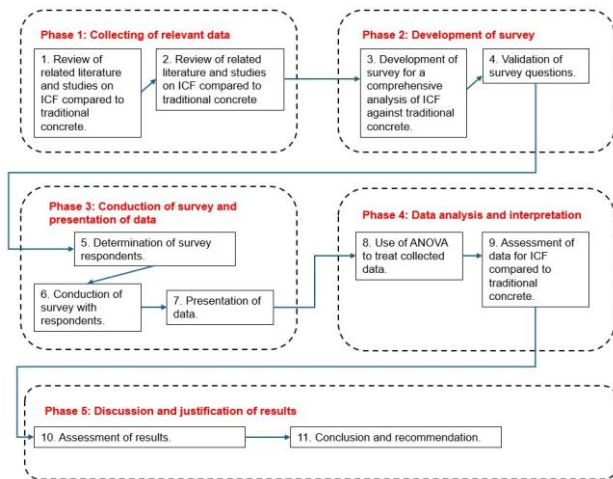


Fig. 1. Research Design.

A. Respondents of the Study

The respondents of the study will be companies in the Philippines with experience using Insulated Concrete Form as a substitute for regular concrete. These companies will have extensive knowledge and understanding of the use of ICF in residential buildings and its effectiveness against calamities.

B. Data Gathering Procedure

The study is backed by studying related literature and identifying its characteristics compared to regular concrete. After a thorough review, the researchers will identify construction companies that have experience with the use of ICF. Having gathered the respondents, the researchers will formally email these construction companies requesting an interview for the study. After permission has been granted, the researchers will conduct an interview with the chosen representatives of the companies and discuss the effectiveness of ICF.

C. Data Gathering Instruments

The researchers will develop a set of questions to be asked during the interview. The interview questions are of the following categories: (a) ICF vs. traditional concrete's strength and constructability, (b) ICF and traditional concrete against natural calamities, and (c) ICF and traditional concrete's cost. See Appendix A for the interview questions.

III. RESULTS AND DISCUSSION

This section presents the findings of a survey conducted in collaboration with construction companies in the

Philippines. The survey included ten (10) respondents, and this section provides an analysis and discussion of the collected data. The findings are presented and interpreted in the order of the questions outlined in the data-gathering instrument.

A. Respondent Profile

The respondents' basic demographic information, such as age and number of years in the construction industry, was collected. The years of experience were specifically asked to assess their familiarity and level of expertise with ICF.

Fig. 2 illustrates the age distribution of the respondents. The majority of the respondents (4 out of 10) fall within the 18-24 age group. The remaining respondents were evenly distributed across the age ranges of 25-34, 35-44, and 45 and above.

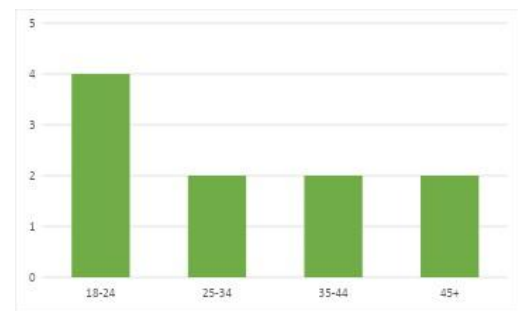


Fig. 2. Age Profile of Respondents.

B. Treatment of Data

The data gathered through the review of related literature and interviews will be processed through the ANOVA test. ANOVA, or Analysis of Variance, was developed by Ronald Fisher. One-Way Analysis of Variance determines whether there are statistical differences between the means of three or more independent groups. Analysis of variance (ANOVA) is a statistical procedure that divides observed aggregate variability within a data set into two parts: systematic and random variables. The systematic factors have a statistical impact on the supplied dataset, but the random factors do not. In regression research, analysts employ the ANOVA test to examine how independent factors impact the dependent variable.

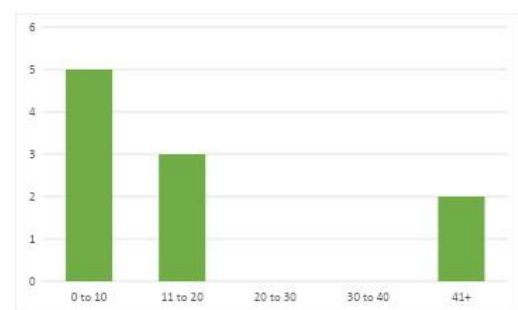


Fig. 3. Years of Work Experience of Each Respondent.

C. Familiarity with Construction Methods

As illustrated in Fig. 4, the familiarity with traditional concrete is overwhelmingly high, with most of the respondents indicating a strong understanding and experience with this material. This is evident from the significantly higher bar representing traditional concrete in the graph, which underscores its dominance in the construction industry. In contrast, familiarity with ICF is considerably lower, reflecting its relatively recent introduction and limited adoption in the industry.

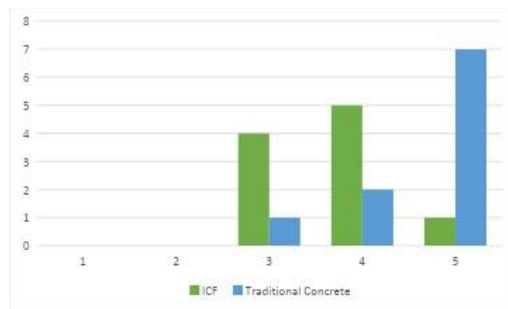


Fig. 4. Familiarity with Construction Methods.

This gap can be attributed to several factors, including the established use of traditional concrete, limited awareness of ICF benefits, and potential resistance to adopting new construction methods. The data suggest that while traditional concrete continues to dominate the industry, there is a growing opportunity to increase awareness and adoption of ICF. Educating professionals about the advantages of ICF, such as energy efficiency, durability, and faster construction times, could help bridge this gap. Additionally, targeted training programs and pilot projects could encourage more widespread use of ICF, ultimately contributing to the evolution of construction practices in the country.

D. Perception regarding ICF vs. Traditional Concrete

The effectiveness of ICF vs. traditional concrete is differentiated across several key parameters: cost-effectiveness, ease of construction/design flexibility, insulation properties, energy efficiency, and structural strength. Fig. 5 illustrates the respondents' perceptions of these attributes based on their experience with both materials. Traditional concrete is identified as more cost-effective, likely due to its lower initial costs and widespread use.

However, ICF outperforms in insulation and energy efficiency, reflecting its thermal performance and long-term energy savings. Both materials are rated similarly for structural strength, indicating equal confidence in their durability.

E. Structural Strength

The ANOVA results in Table 4.1 reveal no statistically significant difference in structural strength between traditional concrete and ICF ($F(1, 18) = 0.130$, $p = 0.722$). While traditional concrete had a slightly higher mean strength ($M = 4.0$, $SD = 0.47$) compared to ICF ($M = 3.9$, $SD = 0.74$), the difference was not significant. The low F-

statistic (0.130) and high p-value ($0.722 > 0.05$) confirm that both materials exhibit comparable structural strength.

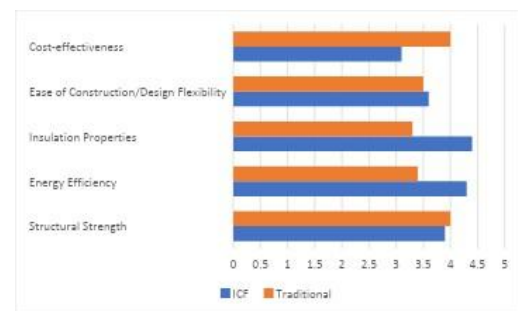


Fig. 5. Comparison of Perceptions between ICF vs. Traditional Concrete.

Table 1. ANOVA results for Structural Strength.

ANOVA						
Source of Variation	SS	df	MS	F	P-value	Fcrit
Between Groups	0.05	1	0.05	0.130435	0.722186	4.413873
Within Groups	6.9	18	0.383333			
Total	6.95	19				

The comparable strength of ICF suggests it can match traditional concrete in load-bearing capacity, making it a possible alternative for structural applications. Additionally, this similarity in strength, combined with ICF's advantages in insulation and energy efficiency, positions it as an option for sustainable construction.

F. Energy Efficiency

The ANOVA results in Table 2 show a statistically significant difference in energy efficiency between ICF and traditional concrete ($F(1, 18) = 8.712$, $p = 0.009$). The mean energy efficiency score for ICF ($M = 4.3$, $SD = 0.82$) was significantly higher than that of traditional concrete ($M = 3.4$, $SD = 0.52$). The large F-statistic (8.712) and low p-value ($0.009 < 0.05$) confirm that ICF outperforms traditional concrete in energy efficiency.

Table 2. ANOVA results for Energy Efficiency.

ANOVA						
Source of Variation	SS	df	MS	F	P-value	Fcrit
Between Groups	6.05	1	6.05	8.712	0.008537	4.413873
Within Groups	12.5	18	0.694444			
Total	18.55	19				

This highlights ICF's superior thermal performance, which is attributed to its insulation properties. The higher energy efficiency of ICF can lead to reduced heating and cooling costs, making it a more sustainable and cost-effective option in the long term. These results emphasize the potential of ICF to contribute to energy-efficient construction practices, aligning with global efforts to reduce energy consumption and promote environmental sustainability.

G. Insulation Properties

The ANOVA results in Table 3 indicate a statistically significant difference in insulation properties between ICF and traditional concrete ($F(1, 18) = 8.712$, $p = 0.009$). The

mean insulation score for ICF ($M = 4.4$, $SD = 0.97$) was significantly higher than that of traditional concrete ($M = 3.3$, $SD = 0.67$).

Table 3. ANOVA results for Insulation Properties.

ANOVA						
Source of Variation	SS	df	MS	F	P-value	Fcrit
Between Groups	6.05	1	6.05	8.712	0.008537	4.413873
Within Groups	12.5	18	0.694444			
Total	18.55	19				

The large F-statistic (8.712) and low p-value ($0.009 < 0.05$) confirm that ICF provides superior insulation compared to traditional concrete. This supports ICF's design, which integrates insulation into the building structure, enhancing thermal performance. These results further support the adoption of ICF in construction projects aiming at sustainability and energy efficiency.

H. Ease of Construction/Design Flexibility

The ANOVA results in Table 4 reveal no statistically significant difference in ease of construction or design flexibility between ICF and traditional concrete ($F(1, 18) = 0.070$, $p = 0.795$). The p-value ($0.795 > 0.05$) and the low F-statistic (0.070) indicate that both materials are perceived similarly in terms of construction ease and design adaptability.

Table 4. ANOVA results for Ease of Construction/Design Flexibility.

ANOVA						
Source of Variation	SS	df	MS	F	P-value	Fcrit
Between Groups	0.05	1	0.05	0.069767	0.794676	4.413873
Within Groups	12.9	18	0.716667			
Total	12.95	19				

This suggests that, while ICF is often praised for its modular design and potential for faster assembly, respondents in this study did not perceive it as significantly easier to work with compared to traditional concrete. However, the comparable scores highlight that ICF does not introduce additional complexity, making it a viable alternative without compromising construction efficiency.

I. Cost-effectiveness

The ANOVA results in Table 5 reveal a statistically significant difference in cost-effectiveness between traditional concrete and ICF ($F(1, 18) = 10.57$, $p = 0.004$).

Table 5. ANOVA results for Cost-effectiveness.

ANOVA						
Source of Variation	SS	df	MS	F	P-value	Fcrit
Between Groups	4.05	1	4.05	10.56522	0.004441	4.413873
Within Groups	6.9	18	0.383333			
Total	10.95	19				

Traditional concrete is perceived as more cost-effective, likely due to its widespread availability, lower initial costs, and the local workforce's familiarity with its use. In contrast, ICF, often imported and less familiar to workers, is viewed as less cost-effective in the short term.

However, while traditional concrete may have lower upfront costs, ICF's long-term benefits—such as energy efficiency, reduced maintenance, and faster construction—could offset initial expenses over time. These findings highlight the importance of considering both immediate and long-term costs when evaluating construction materials.

J. Perceived Resilience Against Natural Calamities

Fig. 6 compares the resilience of ICF and traditional concrete against natural disasters, including fires, floods, typhoons, and earthquakes. The results indicate that ICF outperforms traditional concrete across all hazards, with the most significant advantage in fire resistance. This is likely due to ICF's insulating properties, which provide better protection against high temperatures. ICF also shows improved resilience against floods, typhoons, and earthquakes, though the margins are smaller. Its monolithic structure and flexibility contribute to better performance under seismic and wind loads, while its moisture-resistant properties enhance durability during floods. These findings suggest that ICF offers superior structural protection against a range of natural disasters, making it a more resilient construction material. This resilience, combined with its energy efficiency and insulation benefits, positions ICF as a compelling choice for disaster-prone areas.

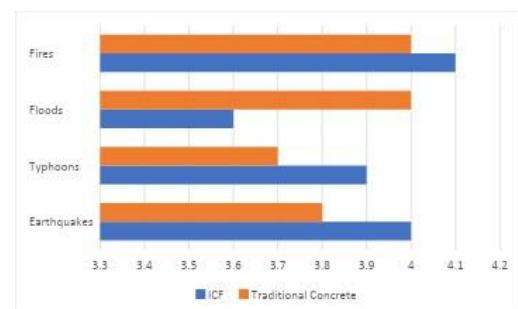


Fig. 6. Comparison of Resilience between ICF vs. Traditional Concrete.

K. Earthquakes

The ANOVA results in Table 6 reveal no statistically significant difference in earthquake resilience between ICF and traditional concrete ($F(1, 18) = 0.474$, $p = 0.500$).

Table 6. ANOVA Results for Resilience against Earthquakes

ANOVA						
Source of Variation	SS	df	MS	F	P-value	Fcrit
Between Groups	0.2	1	0.2	0.473684	0.500072	4.413873
Within Groups	7.6	18	0.422222			
Total	7.8	19				

The p-value ($0.500 > 0.05$) and low F-statistic (0.474) indicate that both materials perform similarly under seismic conditions. This suggests that ICF, despite its modular and flexible design, does not significantly outperform traditional concrete in earthquake resilience within the scope of this study. However, it is important to note that both materials demonstrate comparable performance,

reinforcing the viability of ICF as a reliable alternative in seismic zones. Further research with larger sample sizes and varied seismic conditions could provide deeper insights into the long-term performance of ICF during earthquakes.

L. Typhoons

The ANOVA results in Table 7 show no statistically significant difference in typhoon resilience between ICF and traditional concrete ($F(1, 18) = 0.400$, $p = 0.535$).

Table 7. ANOVA Results for Resilience against Typhoons

ANOVA						
Source of Variation	SS	df	MS	F	P-value	Fcrit
Between Groups	0.2	1	0.2	0.4	0.535041	4.413873
Within Groups	9	18	0.5			
Total	9.2	19				

The p-value ($0.535 > 0.05$) and low F-statistic (0.400) indicate that both materials perform similarly under typhoon conditions. This implies that ICF, despite its monolithic and flexible design, does not significantly outperform traditional concrete in withstanding typhoon forces within the scope of this study. However, the comparable performance of both materials reinforces ICF's viability as a reliable alternative in typhoon-prone areas.

M. Floods

The ANOVA results in Table 8 indicate no statistically significant difference in flood resilience between ICF and traditional concrete ($F(1, 18) = 1.714$, $p = 0.207$).

Table 8. ANOVA Results for Resilience to Floods

ANOVA						
Source of Variation	SS	df	MS	F	P-value	Fcrit
Between Groups	0.8	1	0.8	1.714286	0.206898	4.413873
Within Groups	8.4	18	0.466667			
Total	9.2	19				

Although traditional concrete had a slightly higher mean resilience score ($M = 4.0$, $SD = 0.66$) compared to ICF ($M = 3.6$, $SD = 0.70$), the difference was not significant. The p-value ($0.207 > 0.05$) and F-statistic (1.714) confirm that both materials perform similarly under flood conditions. This then suggests that ICF, despite its moisture-resistant properties, does not significantly outperform traditional concrete in flood resilience within the scope of this study. However, the comparable performance of both materials highlights ICF's potential as a viable alternative in flood-prone areas.

N. Fires

The ANOVA results in Table 9 reveal no statistically significant difference in fire resilience between ICF and traditional concrete ($F(1, 18) = 0.101$, $p = 0.754$).

Table 9. ANOVA Results for Resilience to Fires.

ANOVA						
Source of Variation	SS	df	MS	F	P-value	Fcrit
Between Groups	0.05	1	0.05	0.101124	0.754145	4.413873
Within Groups	8.9	18	0.494444			
Total	8.95	19				

Although ICF had a slightly higher mean resilience score ($M = 4.1$, $SD = 0.74$) compared to traditional concrete ($M = 4.0$, $SD = 0.66$), the difference was not significant. The low

F-statistic (0.101) and high p-value ($0.754 > 0.05$) confirm that both materials perform similarly under fire conditions. This suggests that ICF, despite its insulating properties, does not significantly outperform traditional concrete in fire resilience within the scope of this study. However, the comparable performance of both materials reinforces ICF's viability as a reliable alternative, particularly given its additional benefits in energy efficiency and insulation.

IV. PROPERTIES AGAINST NATURAL CALAMITIES

Fig. 7 compares Insulated Concrete Forms (ICF) and traditional concrete across six key properties relevant to natural disaster resilience: structural strength, durability, insulation performance, water resistance, fire resistance, and impact resistance.

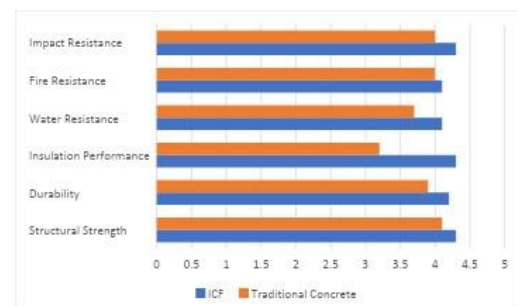


Fig. 7. Comparison of ICF vs. Traditional Concrete on Properties Against Natural Calamities.

The results show that ICF outperforms traditional concrete in insulation, water resistance, fire resistance, and impact resistance, highlighting its superior performance in these areas. Both materials exhibit similar scores in structural strength and durability, though ICF maintains a slight edge. These suggest that ICF offers significant advantages in disaster resilience, particularly in insulation, which enhances energy efficiency during extreme weather, and in water, fire, and impact resistance, which improve its ability to withstand natural calamities. While both materials are structurally sound and durable, the added benefits of ICF make it a compelling choice for construction in disaster-prone regions.

A. Structural Strength

The ANOVA results in Table 10 indicate no statistically significant difference in structural strength between ICF and traditional concrete ($F(1, 18) = 0.514$, $p = 0.482$).

Table 10. ANOVA results for structural strength against natural calamities.

ANOVA						
Source of Variation	SS	df	MS	F	P-value	Fcrit
Between Groups	0.2	1	0.2	0.514286	0.482493	4.413873
Within Groups	7	18	0.388889			
Total	7.2	19				

Although traditional concrete had a slightly higher mean strength score ($M = 4.0$, $SD = 0.66$) compared to ICF ($M = 3.8$, $SD = 0.83$), the difference was not significant. The p-value ($0.482 > 0.05$) and low F-statistic (0.514) confirm that both materials exhibit comparable structural strength under natural calamities. This suggests that ICF, despite its innovative design, matches traditional concrete in structural integrity, reinforcing its viability as a reliable alternative in

disaster-prone areas. The comparable performance of both materials highlights ICF's potential to meet structural demands while offering additional benefits such as insulation and energy efficiency.

B. Durability

The ANOVA results in Table 4.11 indicate no statistically significant difference in durability between ICF and traditional concrete ($F(1, 18) = 1.246$, $p = 0.279$).

Table 11. ANOVA results for durability against natural calamities

ANOVA						
Source of Variation	SS	df	MS	F	P-value	Fcrit
Between Groups	0.45	1	0.45	1.246154	0.278969	4.413873
Within Groups	6.5	18	0.361111			
Total	6.95	19				

Although ICF had a slightly higher mean durability score ($M = 4.2$, $SD = 0.42$) compared to traditional concrete ($M = 3.9$, $SD = 0.56$), the difference was not significant. The p-value ($0.279 > 0.05$) and low F-statistic (1.246) confirm that both materials exhibit comparable durability under natural calamities. This suggests that ICF, despite its innovative design, matches traditional concrete in long-term durability, reinforcing its viability as a reliable alternative in disaster-prone areas. The comparable performance of both materials highlights ICF's potential to meet durability demands while offering additional benefits such as insulation and energy efficiency.

C. Insulation Performance

The ANOVA results reveal a statistically significant difference in insulation performance between ICF and traditional concrete ($F(1, 18) = 9.308$, $p = 0.007$). ICF demonstrated significantly higher mean insulation performance ($M = 4.3$, $SD = 0.68$) compared to traditional concrete ($M = 3.2$, $SD = 0.82$). The low p-value ($0.007 < 0.05$) and high F-statistic (9.308) confirm that ICF provides superior insulation. This highlights ICF's inherent advantage in thermal performance, which is critical for maintaining energy efficiency and indoor comfort during extreme weather conditions. The superior insulation properties of ICF not only enhance its resilience against natural calamities but also contribute to long-term energy savings. These results underscore ICF's potential as a preferred material for sustainable and disaster-resilient construction. Further research could explore the long-term insulation performance of ICF under varying climatic conditions to validate these findings.

D. Water Resistance

The ANOVA results indicate no statistically significant difference in water resistance between ICF and traditional concrete ($F(1, 18) = 2.057$, $p = 0.169$). Although ICF had a slightly higher mean water resistance score ($M = 4.1$, $SD = 0.56$) compared to traditional concrete ($M = 3.7$, $SD = 0.67$), the difference was not significant. The p-value ($0.169 > 0.05$) and F-statistic (2.057) confirm that both materials perform similarly in terms of water resistance. This suggests that ICF, despite its moisture-resistant properties, does not significantly outperform traditional concrete in water resistance within the scope of this study. However,

the comparable performance of both materials highlights ICF's potential as a viable alternative in flood-prone areas.

E. Fire Resistance

The ANOVA results indicate no statistically significant difference in fire resistance between ICF and traditional concrete ($F(1, 18) = 0.130$, $p = 0.722$). Although ICF had a slightly higher mean fire resistance score ($M = 4.1$, $SD = 0.74$) compared to traditional concrete ($M = 4.0$, $SD = 0.47$), the difference was not significant. The p-value ($0.722 > 0.05$) and low F-statistic (0.130) confirm that both materials perform similarly under fire conditions. This suggests that ICF, despite its insulating properties, does not significantly outperform traditional concrete in fire resistance within the scope of this study. However, the comparable performance of both materials reinforces ICF's viability as a reliable alternative, particularly given its additional benefits in energy efficiency and insulation.

F. Impact Resistance

The ANOVA results in Table 4.15 indicate no statistically significant difference in impact resistance between ICF and traditional concrete ($F(1, 18) = 0.669$, $p = 0.424$). Although ICF had a slightly higher mean impact resistance score ($M = 4.3$, $SD = 0.98$) compared to traditional concrete ($M = 4.0$, $SD = 0.66$), the difference was not significant. The p-value ($0.424 > 0.05$) and low F-statistic (0.669) confirm that both materials perform similarly under impact conditions. This finding suggests that ICF, despite its innovative design, does not significantly outperform traditional concrete in impact resistance within the scope of this study. However, the comparable performance of both materials highlights ICF's potential as a reliable alternative, particularly given its additional benefits in insulation and energy efficiency.

V. PERCEPTION ON COST

This section shows the data obtained from the survey on the perception of the respondents on the cost of ICF compared to Traditional Concrete.

A. Initial Construction Cost

Fig. 8. illustrates respondents' perceptions of the initial construction costs for ICF and traditional concrete. A majority (50%) viewed traditional concrete as significantly cheaper, while 20% found it slightly cheaper. In contrast, 20% believed ICF was either slightly cheaper or equally priced, and only 10% considered ICF significantly cheaper. These results indicate a strong perception that traditional concrete is more cost-effective for initial construction compared to ICF. This perception likely stems from traditional concrete's widespread availability, lower material costs, and the local workforce's familiarity with its use. However, while ICF may have higher upfront costs, its long-term benefits—such as energy efficiency, reduced maintenance, and faster construction—could offset these initial expenses. To encourage ICF adoption, stakeholders could focus on educating professionals about its lifecycle cost advantages and exploring ways to reduce initial costs through local production or subsidies.

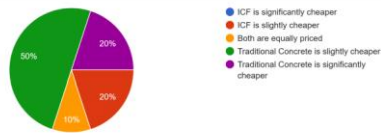


Fig. 8. Initial Construction Cost of ICF vs. Traditional Concrete

B. Long-Term Maintenance Cost

Fig. 9 highlights respondents' perceptions of long-term maintenance costs for ICF and traditional concrete. A significant portion of respondents favored ICF, with 40% viewing it as slightly cheaper and 30% considering it significantly cheaper. In contrast, 20% found traditional concrete slightly cheaper, and only 10% perceived it as significantly cheaper. Additionally, 10% of respondents believed both materials were equally priced. These results suggest that ICF is perceived as more cost-effective in the long term, likely due to its durability, energy efficiency, and lower maintenance requirements. This perception aligns with ICF's inherent properties, such as superior insulation and resistance to environmental factors, which reduce ongoing costs. The findings underscore ICF's potential as a sustainable and economical choice for long-term construction projects. To further promote ICF adoption, stakeholders could emphasize its lifecycle cost benefits and provide case studies demonstrating its long-term savings.



Fig. 9. Long-Term Maintenance Cost of ICF vs. Traditional Concrete.

C. Labor Costs

Fig. 10 illustrates respondents' perceptions of labor costs for ICF and traditional concrete. A plurality (40%) viewed traditional concrete as slightly cheaper for labor, while 30% believed ICF was slightly cheaper, and 10% considered it significantly cheaper. Respondents were evenly split (20% each) on whether ICF was significantly cheaper or equally priced compared to traditional concrete. These mixed perceptions suggest a slight leaning toward traditional concrete being more cost-effective for labor, likely due to the workforce's familiarity with its use. However, the notable proportion of respondents who viewed ICF as cheaper highlights its potential to reduce labor costs, possibly due to its modular design and faster construction process. To enhance ICF's appeal, stakeholders could focus on training programs to improve workforce proficiency with ICF, thereby reducing labor costs and increasing adoption rates.

D. Long-Term Living Costs

Fig. 11 highlights respondents' perceptions of long-term living costs for ICF and traditional concrete. A significant portion of respondents favored ICF, with 30% viewing it as

significantly cheaper and 20% considering it slightly cheaper.



Fig. 10. Labor Costs of ICF vs. Traditional Concrete

In contrast, 20% believed traditional concrete was slightly cheaper, and another 20% found it significantly cheaper. Only 10% of respondents considered both materials equally priced. These results indicate a strong perception that ICF is more economical for long-term living costs, likely due to its superior energy efficiency, insulation properties, and reduced maintenance requirements. This aligns with ICF's ability to lower heating and cooling expenses over time, making it a cost-effective choice for homeowners. The findings underscore ICF's potential as a sustainable and economical option for long-term residential construction. To further promote ICF adoption, stakeholders could emphasize its lifecycle cost benefits and provide real-world examples of energy savings achieved with ICF.



Fig. 11. Long-Term Living Costs of ICF vs. Traditional Concrete.

The findings reveal a nuanced cost comparison between ICF and traditional concrete. Traditional concrete is perceived as more cost-effective in the initial construction phase, likely due to its lower material costs and the workforce's familiarity with its use. However, ICF is viewed as potentially more economical in the long term, with respondents favoring it for lower maintenance and living costs.

This is attributed to ICF's superior energy efficiency, insulation properties, and durability, which reduce ongoing expenses such as heating, cooling, and repairs. Labor costs present a mixed picture, with a slight leaning toward traditional concrete being cheaper, though a notable portion of respondents believe ICF could offer significant labor cost savings. This suggests that while traditional methods are currently more familiar, ICF's modular design and faster construction process could reduce labor expenses with increased workforce training and experience. These results highlight the importance of considering both short-term and long-term costs when evaluating construction materials. While traditional concrete may have an initial cost advantage, ICF's long-term benefits—such as energy savings, reduced maintenance, and improved resilience—make it a compelling option for sustainable and cost-effective construction.

E. Personal Experience and Perception

Fig. 12 illustrates respondents' experience with ICF and traditional concrete. The majority of respondents (50%)

reported having used both materials, indicating a level of familiarity with their respective applications. However, 40% of respondents have only used traditional concrete, reflecting its widespread adoption and dominance in the construction industry. In contrast, only 10% have exclusively used ICF, highlighting its relatively limited penetration in the market.

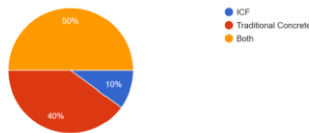


Fig. 12. Experience in the use of ICF and Traditional Concrete.

Fig. 13 reveals an evenly split preference between ICF and traditional concrete, with each chosen by 40% of respondents. A smaller proportion (20%) expressed no preference. This equal preference suggests a lack of clear consensus among respondents regarding the superior construction method for residential applications. The results indicate that respondents recognize the merits of both materials. Traditional concrete is likely favored for its familiarity, lower initial costs, and established practices, while ICF is appreciated for its energy efficiency, insulation properties, and potential long-term savings.

Based on your experience and perception, which construction method do you believe is best suited for residential homes?
10 responses

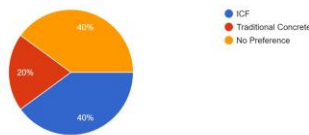


Figure 4.13. Construction method best suited for residential homes.

Fig. 14 reveals an evenly split preference between ICF and traditional concrete for residential homes in disaster-prone areas, with 40% favoring each method. The remaining 20% expressed no preference. This equal distribution suggests a lack of clear consensus on which construction method offers superior protection against natural calamities. The results indicate that respondents recognize the strengths of both materials.

Based on your experience and perception, which construction method do you believe is best suited for residential homes against natural calamities?
10 responses

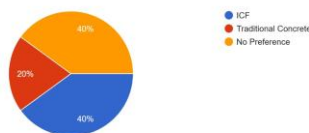


Fig. 14. Preference against Natural Calamities between ICF and Traditional Concrete.

Traditional concrete is likely favored for its proven durability and familiarity, while ICF is appreciated for its insulation properties, energy efficiency, and potential resilience in extreme conditions.

Based on your experience and perception, which construction method do you believe is more cost-effective?
10 responses

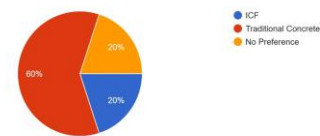


Fig. 15. Cost-Effectiveness between ICF and Traditional Concrete.

Fig. 16 reveals that a large majority (90%) of respondents recommend using ICF for projects where cost is a significant factor, while only 10% do not. This strong endorsement suggests that most respondents perceive ICF's long-term benefits—such as energy efficiency, durability, and reduced maintenance—as outweighing its higher initial costs. The overwhelming support for ICF indicates a growing recognition of its lifecycle cost-effectiveness, even in budget-conscious projects. This shift in perception highlights ICF's potential to deliver significant savings over time, particularly in energy and maintenance expenses. To further encourage adoption, stakeholders could focus on educating decision-makers about ICF's long-term economic advantages and providing real-world examples of cost savings. Additionally, exploring strategies to reduce upfront costs, such as local production or financial incentives, could make ICF more accessible for cost-sensitive projects.

Would you recommend the use of ICF for projects where cost is a significant factor?
10 responses

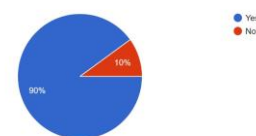


Fig. 16. Recommendation of ICF use.

VI. CONCLUSIONS

A. Structural Performance and Constructability

ICF and traditional concrete exhibit comparable structural strength and ease of construction, with no statistically significant differences ($p > 0.05$). This suggests that ICF is a viable alternative without compromising structural integrity or construction efficiency.

B. Energy Efficiency and Insulation

ICF demonstrated significantly higher energy efficiency ($F(1, 18) = 8.576, p = 0.009$) and insulation properties ($F(1, 18) = 8.712, p = 0.009$) compared to traditional concrete, highlighting its potential to reduce heating and cooling costs.

C. Cost-Effectiveness

Traditional concrete was perceived as more cost-effective for initial construction ($F(1,18) = 10.57, p = 0.0044$), but ICF was viewed as offering long-term savings in maintenance and living expenses. Labor cost perceptions were mixed.

D. Resilience Against Natural Calamities

While ICF was perceived to offer better resilience against fires, floods, typhoons, and earthquakes, no statistically significant differences were found ($p > 0.05$). However, ICF showed higher performance in insulation, water resistance, fire resistance, and impact resistance.

E. Properties Against Natural Calamities

ICF generally showed higher performance in insulation, water resistance, fire resistance, and impact resistance compared to traditional concrete. However, like the findings on overall resilience, the statistical analysis did not show significant differences between ICF and traditional concrete.

F. Perception and Preferences

Respondents were evenly split on preferences for ICF and traditional concrete for residential and disaster-resilient construction. However, traditional concrete was strongly preferred for cost-effectiveness. Despite this, 90% of respondents recommended ICF, recognizing its long-term benefits.

VII. RECOMMENDATIONS

To promote the adoption of Insulated Concrete Forms (ICF) in the Bicol region and beyond, several recommendations are proposed for engineers, construction professionals, policymakers, homeowners, and researchers. Engineers and construction professionals should stay informed about ICF technology and consider incorporating it into their projects, particularly in regions prone to natural disasters. Further training and education on ICF construction techniques are essential to improve proficiency and confidence in using this innovative material. Policymakers can play a crucial role by promoting ICF adoption through incentives, subsidies, or awareness campaigns that highlight its long-term benefits. Additionally, supporting local production of ICF materials could reduce costs and improve accessibility, making it a more viable option for residential construction.

Homeowners are encouraged to consider ICF for its long-term advantages, such as energy efficiency, durability, and disaster resilience. While the initial costs may be higher, the potential savings in energy bills, maintenance, and insurance premiums over the building's lifecycle make ICF a cost-effective choice in the long run. Finally, researchers should conduct larger-scale studies to further investigate ICF's resilience against natural calamities, quantify its long-term cost benefits, and assess its environmental impact in the Bicol region. Exploring the availability and affordability of ICF materials in the Philippines is also critical to addressing barriers to adoption. By addressing these areas, stakeholders can work together to make ICF a more accessible and attractive option for sustainable and disaster-resilient construction.

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