

Assessment on the Usage of Insulated Concrete Forms in United Arab Emirates Construction Industry

Syed W. Ather, Saud AbdelAziz, Ibrahim A. Salloum, Abdullah N. Marzouk, and Sameh M. El-Sayegh

Department of Civil Engineering, American University of Sharjah, Sharjah, United Arab Emirates

Email: {b00045785, b00041663, b00050983, b00044358, selsayegh}@aus.edu

Abstract—Recently, the UAE government endorsed the design and implementation of green buildings to increase energy efficiency. This means that construction fraternity would need to move from the conventional construction, i.e. Concrete Masonry Unit (CMU), towards sustainable methods such as Insulated Concrete Forms (ICF). However, the cost is an issue when it comes to green buildings. Therefore, this paper looks into a green construction method, i.e. insulated concrete form, and determines problems faced by construction industry for its implementation with the help of a survey. It was found out that changes in codes and regulations are necessary to integrate and encourage the use of insulated concrete formwork. Moreover, results also depict that less proportion of people had previous experiences with insulated concrete forms. Regardless, all respondents have strongly agreed that the increase in publicity of insulated concrete formwork, and encouraging the use of green materials in the United Arab Emirates (UAE) are essential to convince construction society to adopt such methods. Future research can be done on the Life Cycle Cost Analysis of an insulated concrete formed villa to determine the overall cost. This will include factors such as initial cost, maintenance cost, and salvage value.

Index Terms—awareness, benefits, barriers, construction, insulated concrete forms

I. INTRODUCTION

Recently, the UAE government endorsed the design and implementation of green buildings to increase energy efficiency. This means that construction fraternity would need to move from the conventional construction, i.e. Concrete Masonry Unit (CMU), towards sustainable methods such as Insulated Concrete Forms (ICF). Insulated concrete form structures are a result of cast-in-place concrete walls which are sandwiched between two layers of insulation material. These structures are green, efficient and can carry significant load. Moreover, insulated concrete forms are often used for low-rise construction. Going back in time, insulated concrete formwork was initially introduced in the 1950s, but, on a large scale, manufacturing began in the 1980s [1]. Like

any other material, insulated concrete form method also faced issues pertaining to cost, adaptability, and availability of materials. However, with the passage of time, the issue of higher cost was also taken care of [2]. This paper focuses on the use of insulated concrete forms in the United Arab Emirates (UAE). One of the main points that will be discussed is: does insulated concrete form cost more than other tradition methods or lesser in the UAE? In general, insulated concrete form has low operational/maintenance costs compared to frame wall construction [3]. Similarly, insulated concrete forms also have environmental benefits. One of the environmental benefits is that it can be made from recyclable materials which in return can reduce the environmental impact of the building on the environment [4]. Some of the other benefits of insulated concrete forms are: it saves high amount of energy because of the negligible air leaks present when using it, which in its turn stops the heat loss between the inner and the outer environment, and manages the humidity inside the structure preventing molds [5]. Also, it was found to be stronger in resisting forces of nature such as tornados and hurricanes due to its high resisting ratios compared to framed walls [5]. Furthermore, the thickness provides lower rates of acoustic transmission which results in better sound absorption [5]. Insulated concrete forms can as well resist up to six hours of fire and provides better strength in resisting blasts and explosions [6]. Therefore, the purpose of this study is to determine the usage of insulated concrete forms in United Arab Emirates construction industry. The study focuses on aspects such as the awareness, benefits, and barriers to the usage of insulated concrete formwork.

II. LITERATURE REVIEW

Literature review on insulated concrete formwork showed various publications in the western part of the globe. However, negligible research was done when it comes to insulated concrete formwork in the Middle East, and comparison of insulated concrete formwork against concrete masonry unit. This can be partly due to the lack of awareness of ICF in the construction industry, and reliability on the construction methods such as concrete masonry unit and steel.

Manuscript received January 15, 2016; revised April 27, 2016.

In 2001, the U.S. Department of Housing and Urban Development carried out a research where cost and benefits of insulated concrete formwork for residential construction were estimated and found out that it costs about three to five percent more than a typical new home [7]. Additionally, insulated concrete forms offered several performance benefits (safety and hazard mitigation, fire resistance, energy efficiency etc), more economical to CMU construction based on collective benefits, and exceptional structural performance, particularly in extreme wind environments [7].

Similarly, in 2004, the National Association of Home Builders collected and prepared construction data for insulated concrete form construction in residential and commercial buildings. This was done for the better understanding of construction costs associated with such system, and how costs are estimated for other common construction assemblies [8]. Furthermore, an extensive survey was also carried out with the help of experienced insulated concrete formwork builders and contractors in order to come up with average material and labor costs. In the end, it was found out that insulated concrete formwork estimates are generally higher than other common construction types, and are about double the costs of wood frame construction [8]. But, authors also argued that this might due to low number of samples, and lack of clarification from respondents in the survey [8].

In regards to insulated concrete forms, scholarly works are also published to analyze an insulated concrete formwork system. For instance, Amer-Yahia [9] conducted an experiment using Ground Penetration Radar (GPR) that helped in detecting gaps between the foam, and the concrete. These voids can be the ones that are intentionally created, or created during pouring concrete [9]. The authors also found out that small voids i.e. 0.75inch or less were not detected with this equipment, but they assert it would not affect the structural performance of the building [9]. In conclusion, the author contributed by suggesting that GPR can be used at different stages of curing to detect voids between the panels of insulated concrete formwork [9].

In addition, several associations have also endorsed the use of insulated concrete formwork for construction purposes. They claim that insulated concrete formwork system results in strong walls, energy efficiency, cost savings, easy construction (less on-site accidents), and ability to meet higher code of conducts with relative ease of construction [10], [11]. Moreover, insulated concrete formwork system can have a higher R value (thermal resistance), and save up to 4 tons of CO₂ (assuming a 20 year life cycle) if compared with a traditional wood frame home [10]. Similarly, such results were also obtained for U values (heat transfer coefficient) of ICF system. The experiment carried out across five different States in America suggested that insulated concrete formwork system exceeds minimum requirements (i.e. far better results) in terms of thermal insulation, and also showed additional savings from the reduction in the required HVAC system capacity [12].

III. METHODOLOGY

15 questions were identified from the literature, and formed the basis of survey to understand the perception of participants in regards to insulated concrete formwork. This review helped in developing a survey that contained fifteen questions to address the objectives of the study. The survey yielded a total of 30 responses. Survey respondents were requested to evaluate their level of agreement with each of the question asked according to a Likert scale from 1 to 5, where 1: strongly disagree, and 5: strongly agree.

Out of 30 respondents, 46.6% of them had less than five years of experience in the industry, while 8 respondents had 6-10 years, and the other 8 had more than 20 years of experience. Fig. 1 is a summary of the respondents' work experience. These respondents give a good sample of fresh graduates who might have heard about insulated concrete forms in their engineering curriculum and people who have worked long enough in the industry to know about insulate concrete formwork through possible experience.

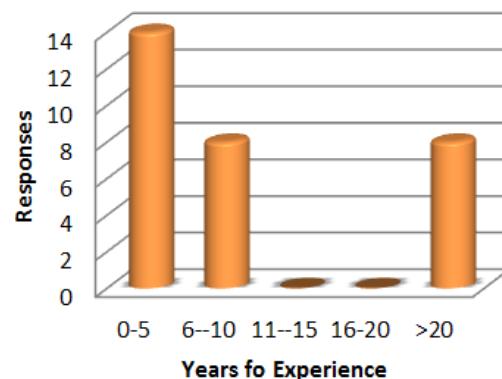


Figure 1. Respondents' experience

IV. RESULTS AND DATA ANALYSIS

The purpose of this study is to evaluate the use of insulated concrete form qualitatively through a survey to determine the level of awareness, advantages, and barriers to implementation. The research focuses on the use of insulated concrete forms because the published literature has extensively discussed the costs associated with insulated concrete forms. The scope of this research is to survey consultants, property developers, and owners and allow them to express their viewpoints on insulated concrete forms. However, one must keep in mind that insulated concrete forms are not extensively practiced in UAE construction projects. But, due to new regulations to encourage sustainable constructions this might change current trends and shift construction fraternity towards the use of green materials such as insulated concrete forms only after ensuring that it meets the UAE criteria on green construction

To accomplish the stated objective, the following research questions are addressed and are divided in 3 sections namely awareness, benefits, and barriers in implementation. Table I contains the questions asked in the survey. These questions were prepared after several

similar published surveys were reviewed [7], [8], [11], [13], [14].

TABLE I. QUESTIONS BASED ON SECTIONS

Awareness
ICF is not very popular in the Middle East and North Africa region
ICF is more costly than traditional methods
Currently, there is less involvement of green projects in United Arab Emirates
Increase in publicity of green buildings will help in creating awareness for green construction
Incorporating ICF into an engineering curriculum can help in creating awareness of ICF
Within a short amount of time, United Arab Emirates' citizens will prefer to live in ICF built villas
Benefits
ICF has proven to be environmentally friendly
The use of ICF will contribute in lowering electricity bills
ICF's thermal and sound resistance will encourage the use of ICF?
Customers are willing to pay more for a green building in comparison to traditional villas.
Barriers
ICF/Green construction methods can replace traditional building methods in the near future
If I were buying a new home, I would pay more for an 'eco' house
ICF will be able to withstand extreme weather conditions in UAE
Change in codes, regulations, and ordinance are necessary for integrating green construction
The inadequacy of green materials in the construction market is the reason why ICF and other sustainable materials are not used

Fig. 2 shows that insulated concrete formwork is not very popular in the United Arab Emirates as only 40% of the participants had previous experience with insulated concrete formwork. Respondents who answered yes were familiar with benefits of insulated concrete formwork compared to participants who answered "No". This was obvious from their response in the survey to the "benefits" questions.

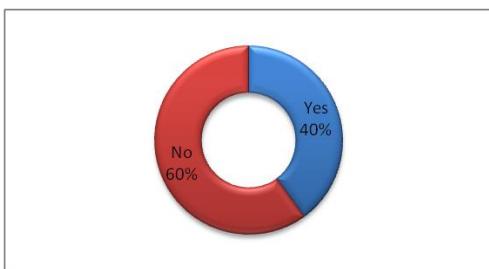


Figure 2. Previous experience with insulated concrete formwork

As mentioned earlier, the survey was divided to target three main concerns of why insulated concrete forms are barely used in United Arab Emirates. Those concerns are level of awareness, benefits of ICF, and barriers of implementation. After collecting the data and running a statistical analysis of the responses the following results were achieved in regards to insulated concrete formwork (Fig. 3). In addition, the questions were ranked within each category to identify the question where the majority of respondents agreed against the questions they disagreed. Fig. 3 shows the results for the awareness section.

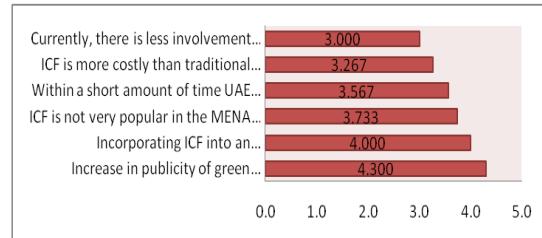


Figure 3. Ranking for awareness

In the awareness section of the general survey, the questions "Increase in publicity of green buildings will help in creating awareness for green construction" and "Incorporating ICF into an engineering curriculum can help in creating awareness of ICF" were both above four indicating that respondents strongly agreed that for owners, contractors, and designers to start implementing insulated concrete formwork in the United Arab Emirates it should be publicized and taught at universities so that future engineers get acquainted with the benefits and methods of construction of insulated concrete formwork. On the other hand, respondents were neutral about the involvement of green projects in United Arab Emirates, meaning that green projects are somehow a major part of construction in the United Arab Emirates. However, insulated concrete formworks are not as popular as the other environmentally friendly method and this is the reason for insulated concrete formwork not being used.

In the benefits section of the general survey i.e. Fig. 4; three out of four questions were skewed toward agreeing on the benefits associated with insulated concrete formwork. Respondents agreed the insulated concrete formwork is proven to be environmentally friendly by providing high thermal and sound insulation leading to reduction in electricity consumption. This also shows that respondents are well aware of benefits associated with insulated concrete formwork. Nonetheless, participants do not think that customers are willing to pay more initial cost (if needed) to live in a green building with all the benefits it has on the environment.

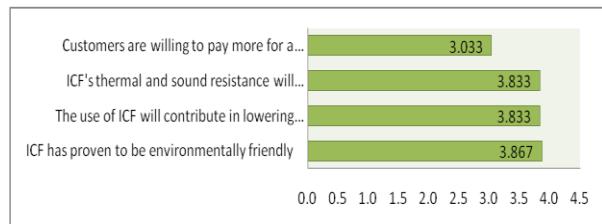


Figure 4. Ranking for benefits

In the barriers part of the survey (Fig. 5), it was clear that respondents strongly agreed that changes in codes and regulations in the construction industry is the number one barrier for implementing green construction. Also, when asked if people are willing to pay more to live in green sustainable building participants were neutral, but when asked if they are willing to pay more they responded with a 3.467 showing that they are willing to pay more because they are aware of the benefits to the environment green buildings provide.

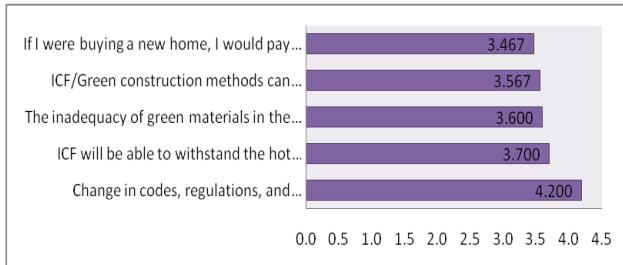


Figure 5. Ranking for barriers

V. CONCLUSION

Insulated concrete formwork wall system of building construction is a well-known technique to address the issue of building materials and faster construction. 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. The research presents analytical results carried out to study the assessment of using insulated concrete formwork blocks in United Arab Emirates. The research's main objective is to assess the use of insulated concrete formwork and that was done by providing a literature review on the benefits of insulated concrete formwork and analyzing the results achieved from the survey created to the address its use in the United Arab Emirates.

The surveys were used to demonstrate the level of awareness of insulated concrete formwork in United Arab Emirates, the benefits of insulated concrete formwork and the number of barriers that insulated concrete formwork face in United Arab Emirates and the Middle East and North Africa region. The analysis showed that most of the participants agreed that the level of awareness of insulated concrete formwork among the United Arab Emirates professionals is low. This was also evident as only 40% of the participants had past experience with insulated concrete formwork. In addition, participants agreed that the inadequacy of green materials in the United Arab Emirates construction market and changes in codes, regulations, and ordinance are necessary to integrate and encourage the use of Insulated concrete formwork.

VI. SUGGESTIONS FOR FUTURE RESEARCH

Future research can be done on the life cycle cost analysis of an insulated concrete form villa in United Arab Emirates where all the factors are taken into consideration i.e. initial construction cost, salvage value, annual maintenance costs etc. These costs can then be compared with a typical concrete masonry unit villa in United Arab Emirates.

ACKNOWLEDGMENT

Special thanks to the companies Adnan Safarrini, and Royal City Contracting for helping us out in this research.

REFERENCES

- [1] Insulated Concrete Forms. [Online]. Available: <http://www.cement.org/think-harder-concrete-/homes/building-systems/insulated-concrete-forms>.
- [2] LEED | U.S. Green Building Council. (2015). [Online]. Available: <http://www.usgbc.org/DisplayPage.aspx?CMSPageID=147>
- [3] I. R. Labs. Greening the Mainstream. [Online]. Available: <http://www.toolbase.org/Technology-Inventory/walls/Insulating-Concrete-Forms>
- [4] A. Maino and G. Keclik, Lessons Learned for Exterior Insulation Finish Systems, AEI 2008, pp. 1-10.
- [5] P. Dusicka and T. Kay, "Seismic evaluation of a green building structural system: ICF grid walls," in *Proc. Structures Congress*, 2009, pp. 1-7.
- [6] R. Oleck, A. Habel, and D. Herrit, "Insulated Concrete Forms (ICF) as blast-resistant barriers," in *Proc. Structures Congress*, 2012, pp. 35-45.
- [7] U.S. Department of Housing and Development, Cost and Benefits of Insulating Concrete Forms for Residential Construction, PATH, Washington, D.C., 2001.
- [8] National Association of Home Builders Research Center, Inc., Insulated Concrete Forms Construction Cost Analysis, Portland Cement Association, 2004.
- [9] C. Amer-Yahia and T. Majidzadeh, "Inspection of insulated concrete form walls with ground penetrating radar," *Construction and Building Materials*, vol. 26, no. 1, pp. 448-458, 2012.
- [10] C. Davis, K. Marchand, and J. Keith, "Blast analysis of integrated framing assemblies at openings in insulated concrete form wall construction," in *Proc. Structures Congress*, 2012, pp. 1-11.
- [11] The Developer and ICF. [Online]. Available: <http://www.icfa.org.uk/icf-benefits/the-developer-and-icf/>.
- [12] Portland Cement Association, Energy Use in Residential Housing: A Comparison of Insulating Concrete Form and Wood Frame Walls, Portland Cement Association, Illinois, 2000.
- [13] National Association of House Builders, Green Multifamily and Single Family Homes: Growth in a Recovering Market, McGraw Hill Construction, Bedford, 209.
- [14] US Department of Housing and Urban Development, Insulating Concrete Forms for Residential Construction: Demonstration Homes, NAHB Research Center, Inc., Maryland, 1997.



Syed W. Ather is a graduate from American University of Sharjah, Sharjah, United Arab Emirates. Syed Waqas was born on 6th of Feb, 1992, Dubai, United Arab Emirates. He obtained his Bachelors of Science in Civil Engineering with minors in Engineering Management, and Environmental and Water Engineering from American Universityof Sharjah in 2016. His research interests are green construction, project partnering, and integration of sustainability parameters.



Saud AbdelAziz is a graduate from American University of Sharjah, Sharjah, United Arab Emirates. Saud was born on 6th of March, 1993, Sharjah, United Arab Emirates. He is currently employed in Dubai Electricity and Water Authority as a planning engineer.Saud obtained his Bachelors of Science in Civil Engineering from American University of Sharjah in 2016. His research interests are green construction, project partnering, and integration of sustainability parameters.



Abdullah N. Marzouk is a graduate from American University of Sharjah, Sharjah, United Arab Emirates. Abdullah was born on 10th of October, 1993, Abu Dhabi, United Arab Emirates. Abdullah obtained his Bachelors of Science in Civil Engineering from American University of Sharjah in 2016. His research interests are float ownership, design of steel structures, and supply & procurement.



Sameh M. El-Sayegh is an Associate Professor of Civil Engineering at the American University of Sharjah, UAE. He has Ph.D. and MS from Texas A&M University. He is a certified Project Management Professional (PMP). He published over thirty research papers in international reputed project management journals and conferences. His research interests include project scheduling and construction contracting.



Ibrahim A. Salloum is a graduate from American University of Sharjah, Sharjah, United Arab Emirates. Ibrahim was born on 2nd of September, 1992, Hama, Syria. He is currently working for Arabtec Construction as a planning engineer. Ibrahim obtained his Bachelors of Science in Civil Engineering from American University of Sharjah in 2015. His research interests are planning and management of infrastructure projects, self power generating structures, and insulated concrete formwork