PENERBIT PRESS
UNIVERSITI TEKNOLOGI MARA

e-ISSN: 2785-924X

Available online at
https://jsst.uitm.edu.my/index.php/jsst

Journal of Smart Science and Technology 4(2) 2024, 16–26.

Journal of Smart Science and Technology

Architectural Overreach: Investigating the Absence of Structural Engineers in Building Design – A Case Study in Herat, Afghanistan

Arif Alkozay[1*], Amanollah Faqiri[1], Rahimullah Stankzai[1]

[1]*Department of Civil Engineering, Faculty of Engineering, Herat University, Herat 3001, Afghanistan*

Citation:
Alkozay, A., Faqiri, A., & Stankzai, R. (2024). Architectural overreach: Investigating the absence of structural engineering in building design – A case study in Herat, Afghanistan. Journal of Smart Science and Technology, 4(2), 16-26.

ARTICLE INFO

Article history:
Received 19 April 2024
Revised 17 May 2024
Accepted 11 June 2024
Published 30 September 2024

Keywords:
structural engineer
Herat province
building design
architect

DOI:
10.24191/jsst.v4i2.73

ABSTRACT

In the realm of architectural design and construction, collaboration between architects and structural engineers is fundamental for ensuring the safety, functionality, and aesthetic appeal of built environments. However, in regions like Afghanistan's Herat province, such collaboration is notably absent, with developers predominantly engaging solely with architects, sidelining the crucial role of structural engineers. This paper investigates the factors contributing to this lack of collaboration, focusing on developers' tendencies to exclude structural engineers from construction projects. Through a quantitative survey targeting developers and architects across Herat province, key drivers such as limited awareness, financial constraints, and seismic risk concerns were identified. The results reveal a concerning lack of awareness among respondents, with a majority indicating no prior knowledge of the role of structural engineers in building design. Additionally, a significant proportion of developers admitted to foregoing structural engineering scrutiny for most of their projects, highlighting a pervasive disregard for structural integrity. Financial considerations emerged as a predominant factor influencing developers' decisions, with cost cited as a primary reason for excluding structural engineers from construction projects. Furthermore, concerns about seismic risks, particularly earthquakes, were identified as another significant determinant. The findings underscore the urgent need for educational initiatives to enhance awareness about the importance of structural engineering and foster

[1*] Corresponding author. *E-mail address*: Arif.alko0123@gmail.com
https://doi.org/10.24191/jsst.v4i2.73

collaboration between architects and structural engineers. Addressing these factors is critical for mitigating risks associated with structural failure and ensuring the resilience of built environments in earthquake-prone regions like Herat province.

1 INTRODUCTION

Humanity's endeavor for survival and dominance in the natural world has been intricately linked with the construction of buildings, which embodies specific fundamental characteristics[1]. Over the past few decades, we have observed the erection of towering structures in some of the most vulnerable regions on the planet[2]. Architects, the creative force behind these constructions, have diligently crafted buildings to be aesthetically pleasing and spatially functional. Architectural endeavors primarily address user requirements such as aesthetics, cultural relevance, symbolism, and comfort[1]. However, while architects focus on aesthetics and spatial design, another indispensable characteristic crucial for ensuring inhabitant safety: structural integrity, a domain primarily overseen by structural engineers[3]. Divergences between architects and structural engineers are evident in their areas of responsibility, educational emphasis, cognitive approaches, and design methodologies[4]. A well-constructed building must adhere to the triad of strength, utility, and beauty[5]. Achieving these principles necessitates effective collaboration between architects and structural engineers, particularly in the early stages of the design process to integrate architectural form and structural function[6]. This collaboration involves intensive discussions to explore design possibilities within structural constraints, fostering an environment where aesthetic considerations are balanced with structural requirements[1]. Such collaboration relies on clear communication, mutual understanding, and the use of collaborative tools like Building Information Modeling (BIM) to streamline the design process and minimize conflicts. Furthermore, this collaborative effort extends beyond the design phase into construction, where architects and structural engineers work closely to ensure the accurate translation of the intended design into the built environment. Regular coordination meetings and site visits are essential to address unforeseen challenges and ensure construction progresses according to plan. Such close collaboration is widely acknowledged as critical for the success of the overall building scheme[4]. In the collaborative process of architectural design and structural engineering, various factors can either facilitate or hinder effective collaboration between architects and structural engineers. These factors include communication challenges, divergent goals and priorities, organizational dynamics, constraints in time and resources, resistance to change, and issues related to ego and ownership[7].

In developed nations, this collaboration has yielded more resilient structures capable of withstanding natural disasters such as earthquakes, floods, and high winds[8]. Structures in these regions are so robust that residents are often advised to remain indoors during earthquakes, as the risk of structural failure is minimal compared to the risk of injury from falling objects[8]. However, in some cases, particularly in developing countries like Afghanistan, collaboration between architects and structural engineers is lacking, resulting in designs primarily driven by architects. This disconnection leads to unfavorable consequences, including uncertainty regarding the strength and stability of structures. Although such occurrences are less frequent in developing nations, they are more pronounced in Afghanistan, where over 70% of buildings are erected without adherence to established standards[9]. Consequently, when earthquakes strike, poorly constructed buildings collapse, resulting in significant loss of life. In contrast, earthquakes with similar magnitudes in developed countries result in fewer casualties and less economic damage due to the collaborative efforts of architects and structural engineers[10].

In Afghanistan, particularly in Herat province, there is a notable absence of collaboration between developers, architects, and structural engineers[11]. Local developers, who undertake the construction and sale of buildings or construct for personal use, occasionally referred to as homeowners due to their predominant involvement in over 80% of construction endeavors, frequently collaborate with architects but often overlook engagement with structural engineers. This trend is more pronounced in Herat, where

https://doi.org/10.24191/jsst.v4i2.73

developers operate independently without consulting governmental authorities. The underlying reasons behind this preference for exclusive collaboration with architects remain unclear, but it has marginalized the role of structural engineers in society. Consequently, there is widespread skepticism regarding the structural safety of buildings among residents. An illustrative example of this uncertainty is the October 7, 2023, earthquake in Herat, where panicked residents fled buildings without regard for falling objects[12]. Their lack of confidence in the structural integrity of buildings resulted in tragic outcomes, with many individuals sustaining injuries or perishing while attempting to escape through windows or from rooftops[12]. This underscores the heightened risk of structural failure compared to other hazards. This demonstrates that the risk of structural failure surpasses that of remaining at home, emphasizing the imperative for proper structural design to mitigate inhabitant risk[12]. Effective collaboration between architects and structural engineers is indispensable in ensuring such design integrity.

This research aims to identify the factors contributing to the lack of collaboration between developers, architects, and structural engineers in Herat province and why developers predominantly engage solely with architects. The primary hypothesis posits that developers may be unfamiliar with the role of structural engineers, perceiving architects as capable of fulfilling all engineering aspects. This study fills a critical gap in the literature by addressing these factors, potentially paving the way for measures to enhance structural stability in Herat province.

2 METHODOLOGY

This research adopted a quantitative approach to thoroughly examine the factors and incentives influencing developers' decisions not to collaborate with structural engineers while exclusively collaborating with architects. The survey targeted approximately 120 developers and 30 architects across all 15 districts of Herat province, with each district featuring eight developers and two architects. To ensure internal consistency and reliability of the data, a pilot survey was undertaken before the main survey to validate the survey instrument and refine the data collection process. The pilot survey involved a smaller sample size comprising eight participants. Participants were asked to provide feedback on the clarity and relevance of the survey questions, as well as the overall length and format of the questionnaire. Additionally, open-ended questions were included to gather qualitative feedback on any perceived challenges or ambiguities in the survey instrument. Participant selection among developers was randomized from a population of between 6,000 to 8,000 individuals. Initially, 190 individuals were randomly selected over two weeks, followed by a final selection of 120 participants through chance selection. Subsequently, a scheduling system was established to survey four developers and two architects daily.

Primary data collection utilized a meticulously designed questionnaire comprising 12 questions, with eight tailored for developers, two for architects, and two common questions. The questionnaire encompassed both closed-ended and open-ended inquiries, with participants encouraged to respond to open-ended questions if preferred. For illiterate participants, questions were read aloud to facilitate their participation. Among the questions posed to developers, the first query investigated their familiarity with the role of structural engineers in building design and construction. Participants unfamiliar with the term "structural engineer" were provided detailed explanations before proceeding to subsequent questions. Conversely, participants acquainted with the term responded without interruption. Common questions shared between architects and developers focused on the October 7, 2023, earthquake in Herat, aiming to gauge the community's perception of the importance of structural engineers. Completion of closed-ended questions required approximately six minutes, while responses to open-ended questions necessitated around 10 minutes. Data analysis was conducted using Excel for closed-ended questions, while responses to open-ended questions were interpreted. The processes involved in this methodology are illustrated in the flowchart shown in Fig. 1.

https://doi.org/10.24191/jsst.v4i2.73

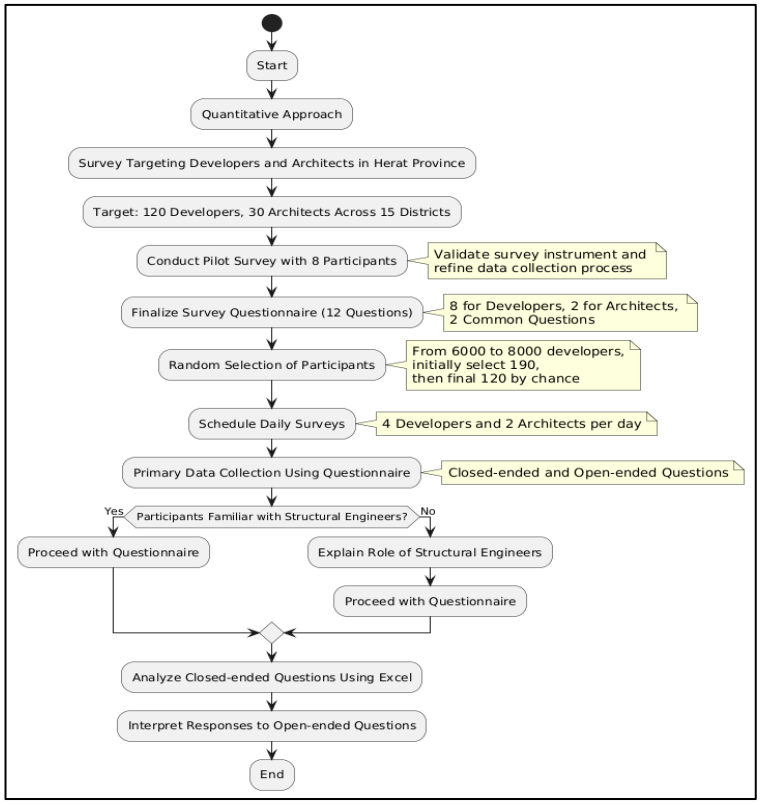

Fig. 1. Flowchart illustrating the methodology for investigating the absence of structural engineers in building design in Herat province.

3 RESULTS AND DISCUSSION

The findings presented in Fig. 2 depict the responses obtained regarding familiarity with the rule of structural engineering among developers. Notably, 86.6% of respondents indicated that they had never heard of this rule in the context of building design, while only 13.3% reported having some awareness of it. Among these respondents, demographic data reveals that 65% were male architects, while 35% were female architects, all aged between 26 to 60. The lower representation of female architects is consistent with the broader gender disparity in engineering professions within Herat province. Additionally, all developers surveyed were male, given the absence of female developers in Herat province. Most of these developers fell within the age range of 30 to 70, reflecting the demographics of the profession in the region. This disparity underscores a significant lack of familiarity with the role of structural engineers among developers. Moreover, it is reasonable to infer that this unfamiliarity would likely be even more pronounced among the general populace. Thus, these results underscore the rarity of public awareness regarding the role and responsibilities of structural engineers.

Subsequently, researchers inquired about the primary overseers of structural aspects in building projects within the community. Fig. 3 illustrates the outcomes of this inquiry, revealing a predominant reliance on architects in overseeing construction endeavors in Herat province. Specifically, architects were reported to oversee approximately 65% of projects, whereas structural engineers were involved in only 22% of cases. A mere 6% of developers indicated joint involvement of both professionals. Notably, drawing from their accumulated experience across numerous projects, some homeowners (developers) assumed complete responsibility for construction projects, often in the absence of engineering expertise. This

https://doi.org/10.24191/jsst.v4i2.73

phenomenon is underscored by the data, with Fig. 3 indicating that 8% of homeowners undertake construction projects independently.

In Herat province, a prevalent misconception exists among the populace regarding the role and specialization of engineers. Many individuals perceive engineers as versatile professionals capable of undertaking diverse tasks without recognizing the specialized nature of engineering disciplines. This perception emerged prominently in the responses to a question probing developers' awareness of different types of engineers and their respective areas of expertise. The majority of respondents expressed unfamiliarity with this concept, erroneously equating engineering solely with architecture, expecting architects to provide structural drawings and fulfill other project requirements. Only a minority of respondents demonstrated awareness of the various engineering fields currently being taught at the Faculty of Engineering in Herat province. This observation highlights a significant deficit in public understanding of the roles and significance of engineers within the community. Moreover, the findings reveal a notable lack of awareness regarding the sequential process of building design and development. Specifically, when asked about the necessity for structural engineering design following the provision of architectural drawings, only 16% of developers demonstrated awareness of this essential step. Conversely, a substantial majority, comprising 84% of respondents, remained unaware of this crucial aspect of the construction process, as illustrated in Fig. 4. This lack of awareness underscores the need for enhanced education and dissemination of information regarding the collaborative roles of architects and structural engineers in ensuring safety and structural resilience.

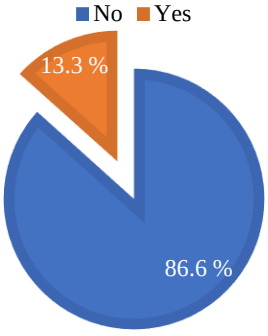

Fig. 2. Displays participant awareness regarding the role of structural engineers in construction.

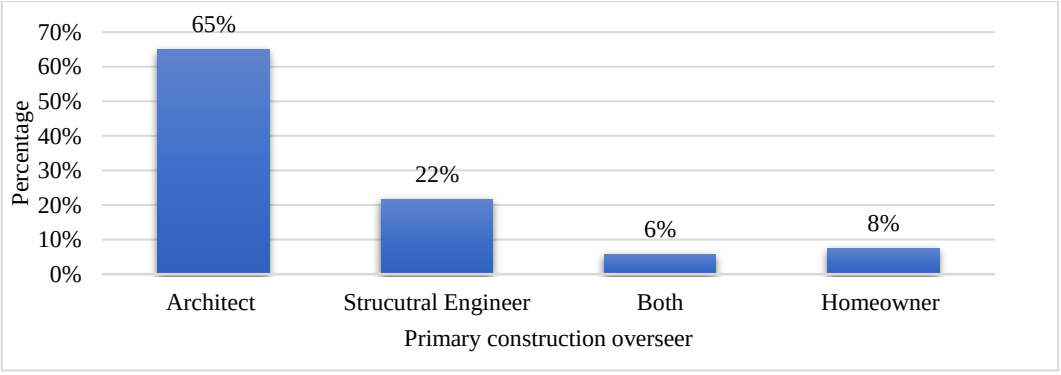

Fig. 3. Participants response regarding overseer of structural aspects in building projects.

https://doi.org/10.24191/jsst.v4i2.73

Respondents who initially lacked familiarity with the rule of structural engineers in building design and construction were provided with detailed explanations regarding the role and significance of structural engineers in these processes, including the potential ramifications of omitting their involvement. Subsequently, participants were queried regarding their inclination to engage a structural engineer for the design of their buildings in future construction endeavors. The data, depicted in Fig. 5, illustrates a varied spectrum of responses. Notably, 38% of respondents indicated a reluctance to hire a structural engineer for their next construction project. Conversely, 27% expressed a firm intention to enlist the services of a structural engineer for design purposes. A further 21% of respondents conveyed their intention to engage an architect exclusively, with the expectation of receiving well-crafted architectural drawings for their building projects. Interestingly, 15% of participants expressed a self-reliant stance, asserting their capability to undertake the engineering aspects of building design themselves, effectively assuming the role of engineers. These findings underscore the diverse perspectives and decision-making factors among developers regarding the involvement of structural engineers in their construction projects. They also highlighted the need for further education and awareness initiatives to elucidate the indispensable contributions of structural engineers in ensuring the safety, durability, and functionality of built environments.

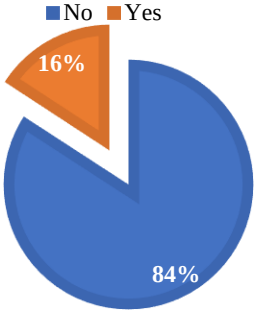

Fig. 4. Awareness among developers regarding structural engineering design following architectural drawings.

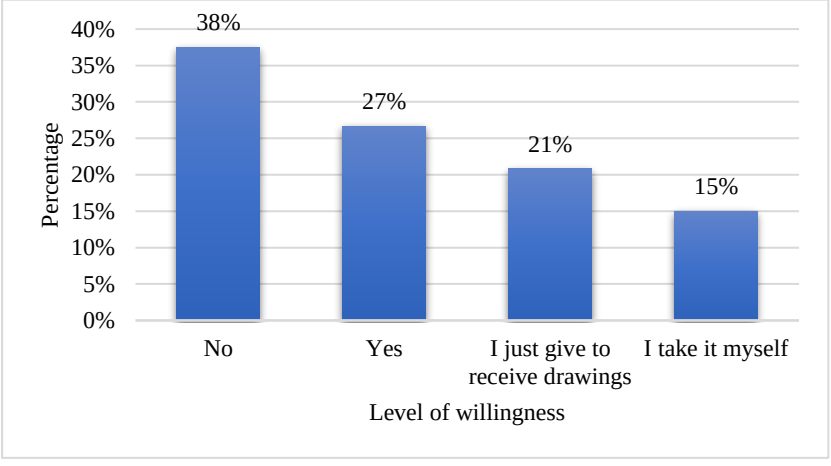

Fig. 5. Willingness to engage a structural engineer for subsequent building projects.

https://doi.org/10.24191/jsst.v4i2.73

A significant proportion of developers disclosed that a substantial majority of the buildings they have been involved in constructing—amounting to 88%—were not subjected to structural engineering scrutiny after the completion of architectural work, as illustrated in Fig. 6. A minority of respondents, constituting 8%, indicated that between 1 to 5 of the buildings they had been involved in were handed over for structural engineering design, while 3% reported involvement in projects where 5 to 10 buildings underwent such scrutiny. Merely 2% of developers stated that more than 10 of the buildings they had participated in constructing were subjected to structural engineering design. These findings align closely with a report by Tolo News, Afghanistan's leading television news network, which highlighted that over 70% of buildings across the nation fail to meet standard construction criteria. Such alignment underscores the critical need for enhanced awareness and regulatory measures to ensure compliance with structural engineering standards in construction practices, thereby safeguarding the safety and integrity of built environments.

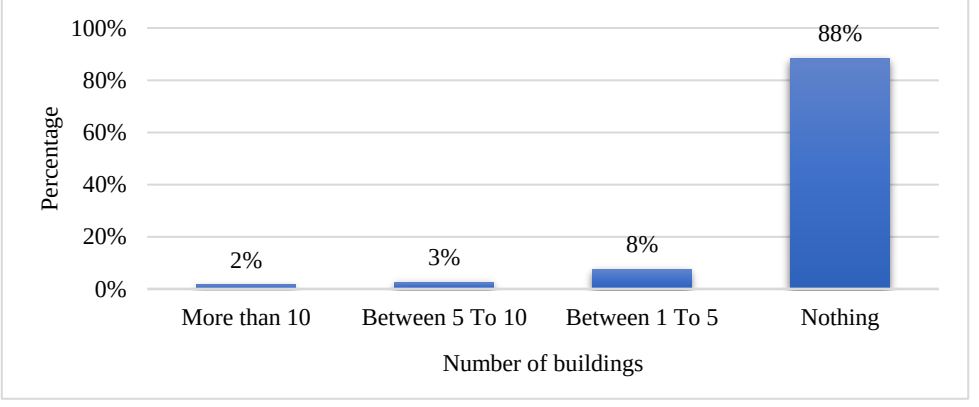

Fig. 6. Number of buildings transferred to structural engineers' post-completion of architectural work in participant involvement.

Cost emerges as a predominant factor influencing the decision of homeowners (developers) to involve structural engineers in construction projects, with 44% of respondents attributing their choice to financial considerations, as depicted in Fig. 7. However, it is noteworthy that this perception may not always align with reality, as evidenced by instances where buildings handed over solely to architects may incur unnecessary expenses due to overdesign, which could be mitigated by engaging structural engineers. Engaging structural engineers not only offers potential cost savings in some projects but also instills confidence and certainty in project outcomes. Moreover, the fear of natural disasters, particularly earthquakes, emerges as another significant determinant, with 28% of participants citing this concern. This increase in apprehension can be attributed, in part, to the October 7, 2023, earthquake in Herat, which prompted heightened awareness among individuals regarding the importance of constructing buildings capable of withstanding seismic events. Additionally, the nature and scope of the project itself exert influence over the decision to involve structural engineers, as noted by 26% of participants. The complexity and scale of a project often dictate the necessity for specialized engineering input to ensure its successful execution and structural integrity. These findings underscore the multifaceted considerations that inform the decision-making process of homeowners in engaging structural engineers for construction projects, highlighting the interplay between cost, safety concerns, and project requirements.

In many instances, even when homeowners opt to engage in the design process themselves or wish to undertake construction independently, they frequently seek guidance from professionals, including architects and structural engineers. As depicted in Fig. 8, a significant majority of participants, approximately 93%, indicated a propensity to seek advice from professionals when initiating construction projects. At this initial stage, even when homeowners do not necessarily commission formal design work,

https://doi.org/10.24191/jsst.v4i2.73

engineers often find themselves called upon to offer recommendations and guidance. Engineers recognize the critical importance of providing prompt and informed advice to homeowners during this phase. They acknowledge that failure to do so may result in homeowners seeking guidance elsewhere and potentially undermining their perception of the engineer's expertise and credibility. Consequently, engineers strive to offer comprehensive and timely recommendations to homeowners, understanding that this proactive approach not only fosters trust and confidence but also reinforces the perception of their professional competence. This practice underscores the dynamic and collaborative nature of the relationship between homeowners and engineers, wherein the exchange of expertise and advice plays a crucial role in guiding decision-making and ensuring the successful realization of construction projects.

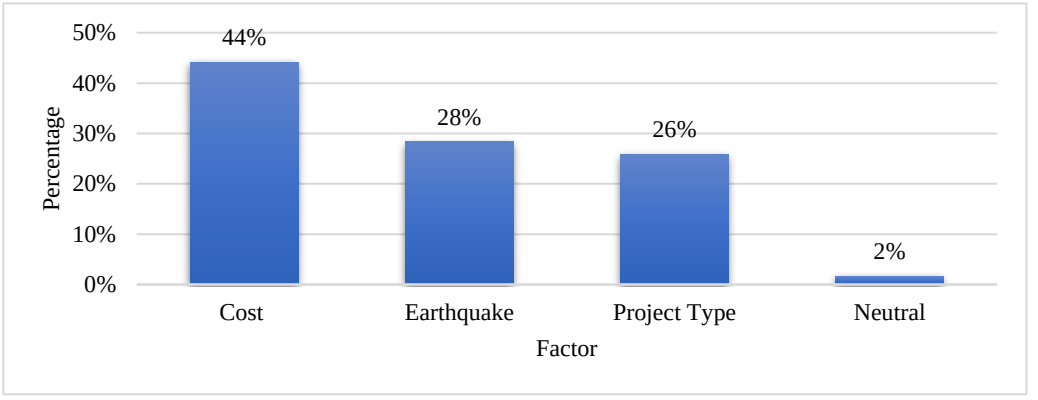

Fig. 7. Factors influencing the decision to engage a structural engineer in construction projects.

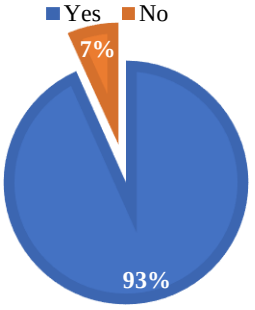

Fig. 8. Engagement of professional advice or recommendations during project planning stages.

When specifically queried about their collaboration with structural engineers on-site, the responses from architects revealed a notable discrepancy, with 63% indicating that they had never collaborated with a structural engineer, while only 37% reported having done so, as illustrated in Fig. 9. Moreover, a significant majority of architects conveyed instances where they assumed the responsibilities typically assigned to structural engineers. This trend emerged due to various factors, primarily stemming from homeowners' reluctance to engage structural engineers due to perceived cost implications. Architects recounted numerous occasions where they found themselves compelled to accept structural engineering responsibilities, despite advocating for the involvement of specialized professionals. Homeowners' resistance often stemmed from concerns regarding additional expenditure. Consequently, architects frequently found themselves in the position of making structural decisions, albeit lacking the specialized

https://doi.org/10.24191/jsst.v4i2.73

training and expertise required for such tasks. In some cases, homeowners were amenable to accepting simplified structural solutions based solely on the architect's construction experience, foregoing formal engineering design. Moreover, architects highlighted the regulatory constraints they encountered, wherein compliance with building permit requirements necessitated adherence to homeowners' preferences, even when contrary to professional recommendations. This scenario further underscored the challenges architects faced in advocating for comprehensive structural engineering involvement in construction projects. These revelations shed light on the intricate dynamics at play within the construction industry, emphasizing the need for greater awareness and cooperation among stakeholders to ensure the safety and integrity of built environments.

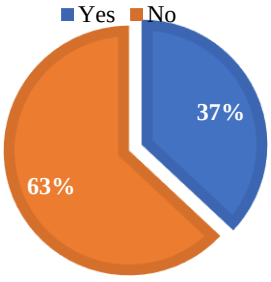

Fig. 9. Architect's collaboration experience with structural engineers on construction projects.

When inquiring both architects and homeowners about the primary reasons prompting individuals to evacuate their homes while shouting in panic during the October 7, 2023, earthquake in Herat province, responses predominantly emphasized concerns surrounding structural uncertainty and the potential for structural failure. A notable portion of respondents also cited the unfamiliarity with earthquake experiences as a contributing factor, alongside apprehensions regarding structural integrity. The prevailing sentiment among participants underscored the pervasive uncertainty regarding the ability of structures to withstand seismic events. Despite acknowledging the possibility of overdesign in some instances, respondents expressed a pervasive lack of confidence in the structural resilience of buildings, prompting hasty evacuations during earthquakes. Fig. 10 illustrates that 59% of participants firmly believed that had the building they were in been appropriately designed to withstand seismic forces, they would have remained inside and not evacuated, highlighting the paramount importance of structural integrity in ensuring occupant safety during seismic events. These insights emphasize the critical role of structural engineering in mitigating risks and instilling confidence in the built environment's ability to withstand natural disasters. They underscore the imperative for robust structural design and engineering practices to ensure the safety and well-being of occupants in seismic-prone regions.

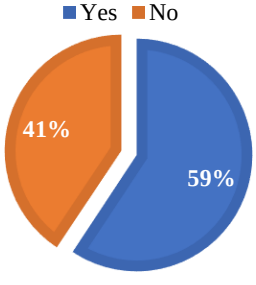

Fig. 10. Participant response to remaining in or evacuating a building designed by a structural engineer in the event of an earthquake.

https://doi.org/10.24191/jsst.v4i2.73

4 CONCLUSION

Addressing the absence of collaboration between architects and structural engineers in building design, this study investigates the factors contributing to this phenomenon, focusing on developers' tendencies to exclude structural engineers from construction projects in Herat province, Afghanistan. Through a quantitative survey targeting developers and architects, key drivers were identified, some of which are listed below

(i) Awareness emerges as a critical factor contributing to the absence of structural engineers in building design. A significant portion of the population lacks awareness of the role and importance of structural engineers, often equating them with architects solely focused on aesthetics. To address this, government initiatives such as workshops should be organized to educate the public about the distinct roles of structural engineers and architects in building design, emphasizing the essential role of structural engineers in ensuring structural integrity.

(ii) Cost considerations represent another significant barrier to the involvement of structural engineers in building design. Despite architects advocating for their necessity, many individuals are unwilling to incur the additional expenses associated with hiring structural engineers. Efforts to increase awareness regarding the long-term benefits of structural engineering involvement and potential cost savings through improved structural integrity are essential in addressing this barrier.

(iii) The type of project also influences the absence of structural engineers, with private projects often lacking involvement compared to government or NGO projects. Enhanced government supervision of private projects could lead to greater participation of structural engineers, ensuring higher construction and safety standards across all projects.

(iv) Architectural practices, driven by concerns of losing projects to structural engineers, may downplay the necessity of structural engineering involvement to homeowners. This widespread acceptance of architectural oversight may further perpetuate the absence of structural engineers in building design. Efforts to promote collaboration between architects and structural engineers, emphasizing the complementary nature of their roles, are essential in addressing this issue.

ACKNOWLEDGEMENTS/ FUNDING

The authors declare that they have no known competing financial interests or funding to declare.

CONFLICT OF INTEREST

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

AUTHORS' CONTRIBUTIONS

Conceptualization: A. Alkozay
Data curation: A. Alkozay
Methodology: A. Alkozay & A. Faqiri
Formal analysis: A. Alkozay & R. Stankzai
Visualization: A. Alkozay & A. Faqiri
Software: A. Alkozay
Writing (original draft): A. Alkozay
Writing (review and editing): A. Alkozay & A. Faqiri
Validation: R. Stankzai & A. Faqiri

https://doi.org/10.24191/jsst.v4i2.73

Supervision: A. Faqiri
Funding acquisition: Not applicable
Project administration: A. Alkozay

REFERENCES

1. Kirci, N. (2015). Unifying or sharing of power between the architect and the structural engineer. *European Journal of Scientific Research, 132*(3), 269-280. https://www.academia.edu/download/38376886/EJSR-132-3_05

2. Gifford, R. (2007). The consequences of living in high-rise buildings. *Architectural Science Review*, *50*(1), 2-17. https://doi.org/10.3763/asre.2007.5002

3. Chen, P. H., Cui, L., Wan, C., Yang, Q., Ting, S. K., & Tiong, R. L. (2005). Implementation of IFC-based web server for collaborative building design between architects and structural engineers. *Automation in Construction*, *14*(1), 115-128. https://doi.org/10.1016/j.autcon.2004.08.013

4. Hofmann, H., & Rinke, M. (2018, July). On the nature of early design collaboration of architect and structural engineer: Development of a socio-cognitive framework. In *Proceedings of IASS Annual Symposia*. International Association for Shell and Spatial Structures Symposium: Creativity in Structural Design (IASS 2018), Boston, MA, USA (pp. 1-8). International Association for Shell and Spatial Structures (IASS). https://doi.org/10.3929/ethz-b-000318569

5. Beghini, L. L., Beghini, A., Katz, N., Baker, W. F., & Paulino, G. H. (2014). Connecting architecture and engineering through structural topology optimization. *Engineering Structures*, *59*, 716-726. https://doi.org/10.1016/j.engstruct.2013.10.032

6. Lin, C. Y., & Xu, N. (2022). Extended TAM model to explore the factors that affect intention to use AI robotic architects for architectural design. *Technology Analysis & Strategic Management*, *34*(3), 349-362. https://doi.org/10.1080/09537325.2021.1900808

7. Doloi, H., Sawhney, A., Iyer, K. C., & Rentala, S. (2012). Analysing factors affecting delays in Indian construction projects. *International Journal of Project Management*, *30*(4), 479-489. https://doi.org/10.1016/j.ijproman.2011.10.004

8. Esteva, L., Díaz-López, O., & García-Pérez, J. (2001). Reliability functions for earthquake resistant design. *Reliability Engineering & System Safety*, *73*(3), 239-262. https://doi.org/10.1016/S0951-8320(01)00045-X

9. TOLOnews. (2011, August 1). *Afghanistan lacks construction code*. https://tolonews.com/business/afghanistan-lacks-construction-code-0

10. Fernandez, R. H. F. (2014). *Strategies to reduce the risk of building collapse in developing countries* [Unpublished doctoral dissertation]. Carnegie Mellon University. https://doi.org/10.1184/R1/6723218.v1

11. Sawruk, T. (2013). Reconstructing Afghanistan: An architecture curriculum for a 'New Way of Life'. *International Journal of Islamic Architecture*, *2*(2), 371-395. https://doi.org/10.1386/ijia.2.2.371_1

12. Alkozay, A., Usefi, A., Ahmadi, K. A., Salehi, M., Amini, Z., Rahmani, T., Ayoubi, F., Alko, M., & Homayouni, S. (2023). Public awareness and perception of earthquake hazard: A case study in Herat Province. *International Journal of Multidisciplinary Research and Publications*, *6*(6), 95-102. https://ijmrap.com/wp-content/uploads/2023/12/IJMRAP-V6N6P73Y23.pdf

https://doi.org/10.24191/jsst.v4i2.73