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Success Criteria for Applying Construction Technologies in Residential Projects

Ayman Altuwaim *, Abdulelah AlTasan and Abdulmohsen Almohsen

Department of Civil Engineering, College of Engineering, King Saud University, Riyadh 4545, Saudi Arabia
* Correspondence: aaltuwaim@ksu.edu.sa

Abstract: The construction sector has seen a surge in publications over the years, indicating that construction technologies are gaining traction across all economic sectors as a result of rapid technology growth. The focus on construction technologies is evident in industrialized nations and those with high gross national product (GNP). This study was conducted to assess the success criteria of applying advanced construction technologies in residential projects. The research started with creating the evaluation criteria which were formulated by taking into account the analysis and findings of previous research and expert opinions. Then, these criteria have been evaluated according to their importance for real estate developers. To assess the contributions of construction technologies in bettering the current construction methods in residential projects, the success criteria of employing the new technologies are examined based on real estate developers in Riyadh, Saudi Arabia, who are the target customers. Research findings illustrated that the most essential criteria for utilizing construction technologies in residential projects are "Reducing cost", "Increasing the safety on-site" and "Reducing the time". Research results asserted that the effectiveness of construction technologies used in residential projects relies on their ability to improve the management of essential construction operations and provide concrete advantages to homeowners. By implementing advanced construction technologies in the residential sector, there is a possibility of transforming the way we strategize, construct, and maintain our homes, thus making them better.

Keywords: technology implementation; construction technologies; construction industry; residential projects; success criteria

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1. Introduction

The construction sector is one of the most prominent sectors of a country and is the backbone of economic activity in all countries of the world. It is a significant global industry that employs millions of people and boosts national and global economies in addition to helping countries flourish socially and economically [1]. The construction industry is predicted to spend up to USD 14 trillion in 2025, which is substantial as compared to the USD 9.5 trillion spent in 2014 [2]. In Saudi Arabia, the country with the largest and fastest-growing construction sector among the Gulf Cooperation Council (GCC) countries [3], there are numerous current and upcoming construction giga-projects, including the Red Sea, AlQiddiya, the Riyadh Metro, Neom, etc. The capital of Saudi Arabia, Riyadh, has grown from a small metropolis of 500,000 people to a city of more than seven million people over the past fifty years. Currently, Riyadh accounts for almost 29% of the kingdom's GDP [4].

The construction industry in particular has experienced significant expansion in Saudi Arabia, which also is the largest oil-exporting country in the world [5]. Hence, the need for faster, easier, and more economical construction methodology is greater. Construction technologies, which have emerged as potent instruments that may be utilized to work more productively, have been embraced by construction organizations all over the world [6]. The term "construction technology" refers to all methods, apparatus, and materials utilized in construction, from planning to dismantling [7,8]. Various construction technologies have been used in residential projects, however, the choice of technology depends on the specific needs of the residential project. In Saudi Arabia, the Ministry of Housing launched the Stimulating Building Technology Initiative, which is one of the 2030 vision programs. The construction industry is currently undergoing a transition as the more seasoned candidates are retiring and are replaced by a younger generation that significantly uses technology in their daily life [6]. Furthermore, the advances in technology provide a potential for incorporating sustainable methods in the construction industry [9]. According to Li [9], improvements in construction efficiency and the direct reduction in waste and energy consumptions are the key ways that technological progress contributes to sustainability.

Understanding the effects of these technologies can guide future studies, help develop design and construction methods, and enhance the training of aspiring professionals [10]. Industrialized construction, as opposed to traditional construction, offers a great potential for the successful adoption of developing technologies because of its factory-based characteristics [11]. Industrialized construction technologies include benefits and drawbacks that have been thoroughly studied. Reducing construction costs, increasing productivity, and cutting down on construction time are some of the benefits of industrialized construction that have been frequently highlighted [12–14]. However, construction models must be carefully examined, redesigned, and technology-driven to save time, labor costs, and material costs, resulting in a more efficient project, to attract more workers to the construction sector [15]. Previous studies have extensively explored the application of various technologies in traditional construction. Chen et al. [16] provide a landscape of technologies that have been implemented in the construction industry. They identified 26 technologies from the literature, and these can be categorized into five groups in terms of their functionality in the construction process: (1) data acquisition, (2) analytics, (3) visualization, (4) communication and (5) design and construction automation. Agenbag and Amoah [17] investigated the impact of the use of construction technology equipment on the workforce in the construction industry. The findings reveal that the use of construction equipment will have a tremendous impact on the workforce as one equipment would be able to execute work that could be performed by a sizeable number of laborers. It was also found that the productivity of construction projects in South Africa can be increased by making use of construction technology equipment.

Improvements in work efficiency, health, safety, productivity, quality, and sustainability have been cited as the primary benefits of using these technologies [16]. Jadhav et al. [18] concluded that the use of technological advancements in the construction sector will increase the efficiency of the project in terms of cost, quality, and time management. Of construction technologies, building information modeling (BIM) appears to be the most commonly used technology thus far. With the development of computer technology, BIM has constantly been used in combination with other technologies/tools, such as unmanned aerial vehicles/systems (UAV/UAS), geographic information systems (GIS), light detection and ranging (LiDAR) and multidimensional modeling, to realize a specifically defined benefit [16].

However, research on applying construction technologies in residential projects have just begun in recent years. Thus, some research questions remain to be solved, such as what technologies are currently well explored, what are the significant criteria for the success of applying construction technologies in residential projects, and what research directions and future roadmaps are needed. Therefore, this research aims to identify and prioritize the success criteria for the implementation of construction technology in residential projects using a relative importance index (RII). The findings of this research can help stakeholders in the residential construction field to better understand the emerging technology and adjust their future research directions. The structure of this research paper is as follows: Section 1 gives a brief introduction to the development of construction technologies and innovations; Section 2 reviews the literature regarding the research topic; Section 3 details the research methods used; Section 4 presents the analysis and findings of the research; Section 5 discusses the findings; Section 6 sets out the conclusion and recommendation;

and finally, Section 7 highlights the limitations and suggests recommendation for future study directions.

2. Literature Review

The manufacturing services of today are significantly impacted by technological advancements, which prompt industries to re-establish production systems [19]. Due to the tremendous efforts made over the past 70 years for the development and implementation of technological and organizational advances, the construction industry had to introduce innovative procedures and technologies, such as digital fabrication, to respond to architectural design requests for flexibility, complexity, high performance, detail, personalization of material, and technology [20–22]. Olsson et al. [23] declared that the construction industry has changed from being a crafts-based sector to an industrialized and service-oriented enterprise.

The term construction technologies have a broad definition that includes everything, from a drone to computer software, making it impossible to accurately describe the state of the art in research. Consequently, construction technologies are defined as computer software or an application that provides a technological solution for construction project management practices in residential and commercial projects to achieve a goal, carry out a specific function, or address a problem [24,25].

By incorporating manufacturing design and optimization technologies to address complex difficulties in construction projects, industrialized construction is an adaptation of traditional construction [11]. Utilizing cutting-edge technology can help resolve these problems and thus help realize the full potential of residential project construction. Qi et al. [11] asserted that there are apparent differences in the utilization level of different technology types. For example, Atencio et al. [26] stated that building information modeling (BIM) is becoming more and more prevalent in construction projects and that there is mounting evidence to support its usefulness at all stages of a building's lifespan, from planning and construction to operation and maintenance. Automation in architecture [27–29] is also offered as an alternative to inefficient and wasteful production models. This model of digital architecture is expected to make a difference and a positive change in the building environment. Consequently, architectural discipline is expected to work towards fully automated production forms and processes that promote equality, sustainability, democracy, diversity, and inclusiveness.

While the construction industry is also under pressure to shift due to technological advancement [19], 3D printing technology is receiving a lot of attention as a brand-new strategic issue. The concept of 3D printing as new building technology is adopted by the construction sector. Three-dimensional printing construction is a new technology that allows making elements for buildings by additive manufacturing of the material, excluding the use of formworks, with short execution times, fewer resources, and a variety of shapes [30–33].

The manufacturing of the elements is usually executed by depositing a fluid mixture that hardens quickly (mostly cement-based), with a nozzle controlled by robotic arms or automated motors on displacement rails, through a printing path sent from a digital design. Three-dimensional printed construction has emerged in recent years, with different equipment and materials, demonstrating its ability to make some construction components and full little buildings, mostly one-story [34–36] (Figure 1).

This technology has important advantages, such as the reduction in construction deadlines; a decrease in waste, transportation, and work accidents; industrialization and specialization of the workforce; design versatility; and performance optimization of buildings [37,38]. However, these procedures are not yet consolidated, nor are construction systems massified.

Figure 1. Example of one-story 3D printed construction (Source: [39]).

Without the use of tools, dies, or fixtures, 3D printing is a method of layering materials and uniting them to create complex geometric patterns and a variety of structures [40–42]. From a digital file, 3D printed construction creates 3D objects through an additive, layer-by-layer manufacturing process [43,44]. It is an interdisciplinary activity that combines the fields of software engineering, architecture, structural, mechanical, and materials science [45]. Even though this technology has been around for more than 25 years, its rapid development began only recently. A lot of sectors of late have become interested in 3D printing as a result of its expanded applications and benefits [46]. Three-dimensional printing (3DP) is viewed as an innovation that improves design, efficiency, and greenness while also promoting automating civil engineering [47].

The extensive customization options are one factor that encourages the use of technologies in construction [30]. Waste reduction [48] and reduced carbon impact [49] are two other intriguing options. Cost efficiency is also a possibility due to the increasing automation and the need for less labor. Automation might lessen the dangers to workers in challenging conditions [50]. Furthermore, construction technologies can be quickly deployed [51]. The use of technologies in the construction industry is progressing, but it seems the pace is slow. Numerous studies have examined various factors that influence the adoption of technologies in several industries, yet these factors can occasionally be overwhelming and lead to misunderstanding among decision-makers. For instance, a recent study by Tsai and Yeh [52] found that a total of 12 different factors, including the employee's age, education, position, and experience, are important. In light of the organization's standard operating procedures, this is misleading in some ways. The employee's experience increases together with his or her age. Similar to this, experience gives workers the chance to advance within an organization. Employee position, experience, and age are closely related to one another and can be seen as a single unit. The cost of technologies is another crucial aspect that would further draw the decision-makers. Materials, equipment, software, hardware, operation, and maintenance would all add to the cost of technologies [53,54]. Thus, these cost variables might theoretically be separated into six attributes; however, for a decision-maker, cost is only considered to be one component. Similar findings were highlighted in another study by Attaran [55] on construction technologies, which found that technology, materials, and pricing are the key obstacles in the wider adoption of the technology. The scale of the created goods, governmental laws and regulations, and financial restrictions all have an impact on how well construction technologies are adopted. Additionally, similar to other technologies, many experts come to the conclusion that costs have a significant impact on the adoption of technologies [56,57]. Weller et al. [57] discussed the technological and financial aspects affecting manufacturing firms as they implemented technologies.

Project success is an elusive topic and goes beyond project management success and traditional criteria [58]. The success criteria for implementing construction technologies in the construction sector have been studied in general and include enhancing critical construction operations and delivering tangible benefits. However, there is a knowledge gap in analyzing and prioritizing success criteria in the residential sector particularly and in understanding the long-term impact and sustainability of these technologies.

3. Methodology

In order to build a questionnaire survey for data collection that is necessary to achieve the research objectives, this study utilized a content analysis of academic literature on the criteria for the successful application of construction technologies in residential projects. Content analysis is a thorough and methodical analysis of the contents of a certain body of literature [59]. As a starting point, extensive searches were conducted on scholastic databases including Google Scholar, Science Direct, Scopus, and Web of Science, where these databases cover more quality distributions than others [60]. The keywords for the search process were Construction Industry; Construction Technologies; Residential Projects; Technology Innovation. Keywords serve as descriptors of papers' contents, and they represent the basic subjects covered in the research paper [61]. The primary outcome of the content analysis is the success criteria of using construction technologies in residential projects. Eighteen success criteria were proposed after an intensive literature review. An amendment process was necessary to develop the final questionnaire that surveyed the target sample, the amendment process including face validity and pilot study. Figure 2 shows the questionnaire development stages.

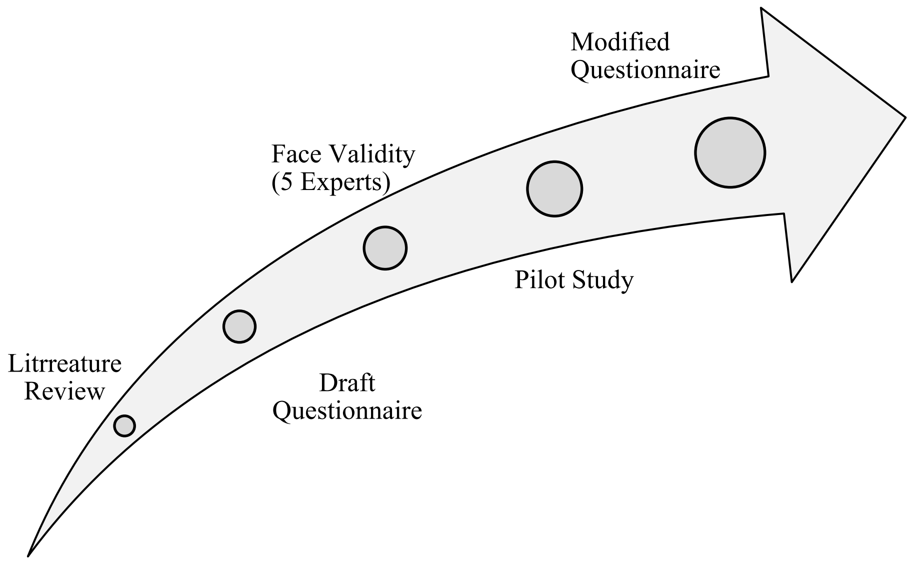

Figure 2. Questionnaire design and development process.

Checking the questionnaire's face validity simply means verifying that the questionnaire is adequate for measuring what it is supposed to measure [62]. To check the face validity of the questionnaire used in this research, five experts were asked to revise the draft questionnaire and suggest any modifications necessary. Table 1 presents the profiles of experts.

Table 1. Expert Profiles.

Interviewee	Scope	Experience (Years)
Expert 1	Master's degree in Statistics	5
Expert 2	Ph.D. in Construction Management	12
Expert 3	Real estate developer	15
Expert 4	Consultant	7
Expert 5	Contractor	10

Prior to distributing the questionnaire, a pilot study was conducted with ten (10) engineers. This ensured that the questionnaire is well constructed and that there are no ambiguities. During the pretest, respondents took about 6–7 min to fill out the questionnaire.

The questionnaire has been modified based on their feedback. The main comments in the pilot study were about the ambiguity in the meaning of some questions. To avoid misunderstanding the questions and to be confident that the question is understood correctly, the researcher met all the respondents face-to-face, either individually or in groups, and explained the questions to them. Table 2 shows the modified list of success criteria and their sources.

Table 2. List of success criteria with their sources.

#	Criteria	Sources
A	Reducing the time	[34,39,40,63–66]
B	Reducing the cost	[34,39,40,63–66]
C	Reducing manpower	[34,39,63,65]
D	Capability to build a complex design	[34,39,64–67]
E	Capability and ease of changing the design during and after construction	Lessons learned from Dubai Future Foundation (DFF)
F	Reducing the lifecycle cost	[34,39,66]
G	Capability to install heat and sound isolation	Brainstorming
H	Increasing customization to fit customer needs	[34,39,40,63,65,66]
I	Increasing precision and reducing rework	[39,63,64]
J	Facilitation of integration of services and the structure	[63,65]
K	Reducing reliance on skilled labor	[39,63,64]
L	Increasing safety on site.	[39,65,66]
M	Increasing the benefit of visualization and communication	[63]
N	Capability to build a multi-story building	Brainstorming, interviews
O	Capability to apply different types of exterior design (glass facade, stone facade, brick, etc.)	Brainstorming, interviews
P	Avoiding mobilization of building components and installing them on site	Lessons learned from Dubai Future Foundation (DFF)
Q	Reduce the need for a storage area for materials and equipment on site	Brainstorming, interviews
R	Capacity of equipment to withstand climatic conditions	Interviews

The ranking of success criteria according to importance is the second outcome. The survey research is targeting employees in real estate development companies with the following conditions:

- The real estate company has to be in the city of Riyadh, Saudi Arabia.
- The real estate company has to have previous experience in residential projects with the Ministry of Housing to ensure high qualifications for participating residential real estate companies in this survey.
- The participant has to be an engineer.

Since there are some difficulties in finding information on the survey population of falling under the aforementioned conditions, the population of the study cannot be found, and the sample size cannot be calculated. The researcher tried to reach all the targeted respondents by asking well-known real estate companies, searching the internet, and visiting the projects of the Ministry of Housing. Moreover, the researcher visited some courses provided by the Real Estate Institute and distributed the survey to attendants. Some of them are not from the targeted group but their answers could be used to compare different answers from different resources. The researcher explained the questionnaire to every respondent face to face either individually or in groups.

This survey has been designed as hard copy and soft copy (electronically) using the Survey Monkey website in both Arabic and English languages. A pilot study was carried out before the survey was distributed. The pilot study confirms the feasibility of the main study and replicates all its processes [68]. The survey involves enquiring about demographic information and evaluating success factors. The demographic section has six questions. These questions are related to the academic background of the respondents, their years of experience, their experience in housing projects, experience in research on modern construction techniques, etc. These questions aim to facilitate the filtration process before data analysis. There are 18 success factors for using construction technology in residential projects. The participants have been asked to evaluate the mentioned factors according to their importance using the Likert scale. The results of the survey are examined using the Relative Importance Index (RII). Rooshdi [69] declared that the relative importance index analysis is a very helpful and well-known approach that enables measuring the value of the criterion based on participant responses. It is utilized in this study because it is very pertinent to the subject, simple for survey respondents to grasp, and provides accurate results for comparing the relative relevance of various criteria. As a result of RII, the most important criteria could be found with their quantitative importance. The RII equation is shown in following equation:

$$\mathrm{RII} = \frac{\sum \mathrm{W}}{(\mathrm{A} \times \mathrm{N})} \tag{1}$$

where:

RII = The Relative Importance Index.

W = Weightage given to each criterion by the respondents.

A = Highest weight (i.e., 4 in this case).

N = The total number of respondents.

The RII value varies from (0) to (1). The higher the value of RII the more important the factor. Therefore, these criteria can be ranked from top priority to low priority.

4. Findings and Analysis

4.1. Demographic Information

The overall number of survey respondents is 80. After removal of the incomplete responses, a total of the 71 responses remained. Most of the survey respondents are engineers (88%) and the respondents have 5+ years of experience (70%). The general overview of all survey respondents is shown in Table 3.

The survey respondents have been classified into two groups: the targeted group (real estate developer) and the non-targeted group, called group A and group B, respectively. There are 38 respondents from group A (real estate developer) and 33 respondents from group B (non-real estate. The general overview of group A and group B is shown in Table 4.

Table 3. Overview of all survey respondents.

	Classification	Percentage %
Number of respondents as per their major	Civil/Architectural engineering	74%
	Electrical/Mechanical/Industrial engineering	14%
	BA/Finance/Accountant	7%
	Others	5%
Number of respondents as per their years of experience	0~5 years	30%
	5~10 years	33%
	above 10 years	37%
Number of respondents who worked previously in modern construction techniques	Yes	43%
	No	57%
The number of respondents who worked previously on housing projects with 50 units and more.	Yes	56%
	No	44%
Number of respondents as per the activity of their companies	Real estate company	54%
	Engineering consulting company	10%
	Contracting company	15%
	Others	21%

Table 4. Overview of the respondent from the targeted companies (group A) and non-targeted companies (group B).

		Classification	Group A	Group B
1.	Number of respondents as per their major	Civil/Architectural engineering	71%	85%
		Electrical/Mechanical/Industrial engineering	11%	15%
		BA/Finance/Accountant	11%	3%
		others	7%	0%
2.	Number of respondents as per their years of experience	0~5 years	24%	35%
		5~10 years	39%	30%
		above 10 years	37%	35%
3.	Number of respondents who worked previously in modern construction techniques	Yes	53%	54%
		No	47%	46%
4.	The number of respondents who worked previously on housing projects with 50 units and more.	Yes	79%	39%
		No	21%	61%

4.2. Success Factors Criteria of Applying Construction Technology in Residential Projects

The procedure used to analyze the data aims to find the relative importance index of all the criteria. Two steps have been used to analyze the data: calculating the relative importance index and, ranking each criterion based on its relative importance index. The RII calculated from the survey result shows the importance of each criterion. The RII value varies from (0) to (1). The higher the value of RII the more important the factor. Therefore, these criteria can be ranked from top priority to low priority. Table 5 shows the 18 factors with their RII from group A and group B. After that, a comparison between the ranked criteria from the two groups' perspectives has been conducted (group A and group B).

In general, there are some similarities in the opinions of group A and group B. The top five criteria and the bottom five criteria from group A and group B perspectives are shown in Table 6. Figure 3 shows the bar chart that compares the relative importance index between the two groups for the whole criteria.

Table 5. RII for success criteria of applying construction technology in residential projects.

Success Criteria		Group A		Group B	
		RII	Ranking	RII	Ranking
B	Reducing Cost	0.907	1	0.875	2
L	Increasing the safety on site	0.895	2	0.89	1
A	Reducing time	0.888	3	0.809	8
J	Facilitation of integration of the services and the structure	0.855	4	0.846	5
G	Capability to install heat and sound isolation	0.849	5	0.860	3
O	Capability to apply different types of exterior design (glass facade, stone façade, brick, etc.)	0.842	6	0.735	13
N	Capability to build a multi-story building	0.829	7	0.824	7
F	Reducing the lifecycle cost	0.809	8	0.75	11
I	Increasing precision and reducing rework	0.796	9	0.860	4
R	Capacity of equipment to withstand climatic conditions	0.783	10	0.765	9
H	Increasing the customization to fit the customer's needs	0.776	11	0.831	6
E	Capability and ease of changing the design during and after construction	0.77	12	0.743	12
M	Increasing the benefit of visualization and communication	0.743	13	0.75	11
C	Reducing manpower	0.697	14	0.647	16
D	Capability to build a complex design	0.691	15	0.669	15
Q	Reducing the need for storage area for materials and equipment on site	0.684	16	0.64	18
K	Reducing the reliance on skilled labor	0.678	17	0.699	14
P	Avoiding mobilization of the building components and installing them on site	0.658	18	0.64	17

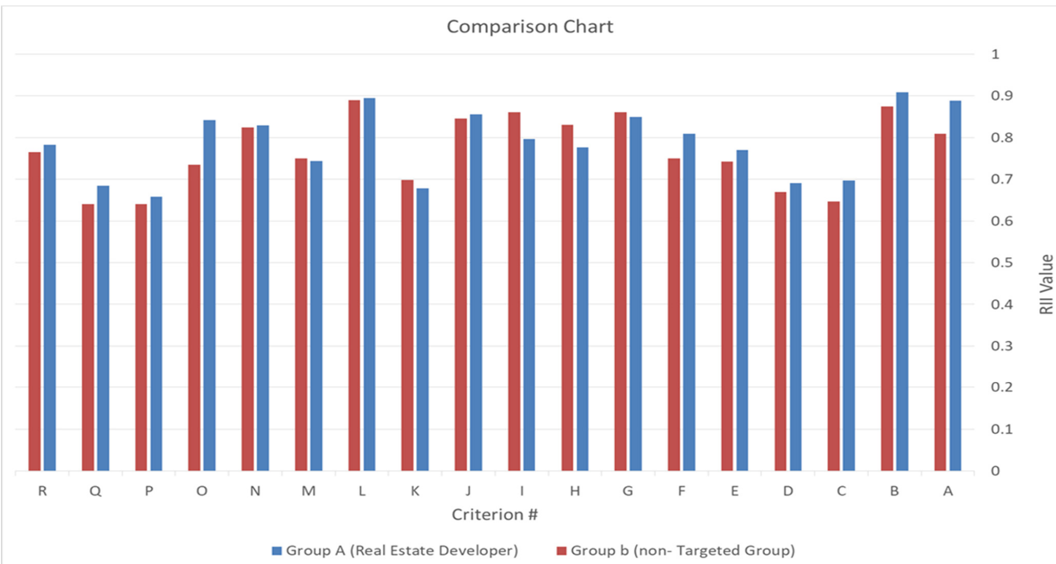

Figure 3. Comparison of RII (group A vs. group B).

Table 6. Top five and bottom five success criteria from group A and group B perspectives.

	Importance	Group A	Group B
Top Five	1	Reducing the cost	Increasing safety on site
	2	Increasing safety on site	Reducing the cost
	3	Reducing time	Capability to install heat and sound isolation
	4	Facilitation of integration of the services and the structure	Increasing the precision and reducing rework
	5	Capability to install heat and sound isolation	Facilitation of integration of the services and the structure
Bottom Five	14	Reducing manpower	Reducing the reliance on skilled labor
	15	Capability to build complex designs	Capability to build complex designs
	16	Reduce the need for storage area for materials and equipment on site	Reducing manpower
	17	Reducing the reliance on skilled labor	Avoiding mobilization of building components and installing them on site
	18	Avoiding mobilization of building components and installing them on site	Reduce the need for storage area for materials and equipment on site

In Table 5, there are some similarities in opinions. Both groups (group A and group B) agree on four common criteria that make it to the top five criteria list. While reducing time is the third important criterion in group A, it is the eighth criterion in group B. On the other hand, increasing precision and reducing rework is the fourth important criterion in group B and it is the ninth important criterion in group A. The comparison between the top five lists of criteria from both groups of respondents is shown in Table 6. Moreover, the bottom five criteria are almost the same in both groups, but with some differences in the ranking (see Table 6).

Since this research is concerned with the opinion of real estate developers, the discussion is limited to the group A results. The criteria in Table 5 are ranked as per the RII values which show the relative importance of each criterion. The RII value varies from (0) to (1) and the closer the number is to (1) the more important is the criterion. The highest important criteria in Table 6 from group A perspective is as follows:

- Reducing the cost.
- Increasing safety on site.
- Reducing time.
- Facilitation of integration of the services and the structure.
- Capability to install heat and sound isolation.

On the contrary, there are some less important criteria as per the RII method. These criteria are:

- Reducing manpower.
- Capability to build complex designs.
- Reducing the need for storage areas for materials and equipment on site.
- Reducing reliance on skilled labor.
- Avoiding mobilization of building components and installing them on site.

5. Discussion

The tendency to utilize new technologies has increased due to the rapid growth of population and the growing demand for housing as well as due to the ineffectiveness of traditional construction systems [70]. According to Aleksandrova [71], technology adoption can hasten decision-making and improve administration of key construction processes.

Tam [72] contrasts the costs of building using traditional and low-cost housing technologies. His investigation makes use of Indian case studies and discovered that, in comparison to conventional construction methods, between 22.68% to 26.11% of the construction cost may be reduced by employing low-cost housing technologies. This agrees with our research results and demonstrates that the housing sector may cut construction costs by utilizing low-cost housing technologies.

According to Aleksandrova [71], the construction process can be greatly enhanced by integrating numerous technical tools, such as BIM, high-performance IT systems, cloud platforms, IoT solutions, specialized mobile apps, robots, autonomous vehicles, additive technologies, Big Data, and blockchain. The usage of construction technology allows for more precise planning and execution of construction projects besides leading to improved quality in the finished product. Moreover, construction technologies significantly impact the construction project times; this result agreed with Saeedi's [70] study, which tried to investigate the effects of new construction technologies from the perspective of construction management on time, cost and quality of construction projects. They found that these methods will accelerate the project's time by about 50%. Additionally, construction costs have increased by about 30% in most individual projects and decreased in mass projects.

According to Saeedi [70], the greatest impact of modern technologies on construction operations is ensuring the integrity and stability of the structure; the long-term quality of the structure; accelerating construction time; promoting better resistance to natural and environmental hazards, such as earthquakes; reducing the costs of massive construction scales; less harmful effects on the environment, more efficiency in installations and optimizing energy consumption.

Real-time monitoring of people, tools, and materials using wearables and sensors can help to uncover possible hazards and risks on construction sites; and construction technology can play this critical role of enhancing safety. Using all of this knowledge will enable one to put safety procedures into place and reduce risks. Therefore, utilizing technology is seen as an efficient method to enhance the health and safety conditions of site workers and ensure safe construction management. According to [73], multiple types of technology and measures have been put in place for the protection of construction sites, including Virtual Reality (VR), online databases, Geographic Information Systems (GIS), Building Information Modelling (BIM), Unmanned Aerial Vehicle (UAV), 4D Computer-Aided Design (4D CAD), wearable robotics, laser scanning, photogrammetry, and sensor-based technologies.

Customer satisfaction is critical to the success of any residential project; therefore, the use of construction technologies should result in a final product that meets or surpasses customer expectations. According to [74], the advancement of powerful sound sources in homes and the growing awareness of noise pollution in society have played a part in the creation of sound insulation design. Moreover, smart building automation systems can be employed to regulate HVAC systems, manage consistent temperatures, and decrease heat transfer between spaces.

6. Conclusions and Recommendations

The application of technology in construction has led to a significant evolution in construction techniques over the last and present centuries. These advances will accelerate production, improve quality, increase safety, and occasionally cut costs. Construction technologies have significantly contributed to the quality and efficiency of residential projects, resulting in homes that are safer, more sustainable, durable, and comfortable for the occupants. However, the success of construction technologies depends on their ability to provide tangible benefits to the construction industry and their ability to overcome any barriers to adoption.

Evaluation of the application of construction technology in residential projects is vital. Indicators, such as reduced costs, shortened project timelines, higher quality standards, and increased sustainability can help with this. Frequent assessment and evaluation can assist in pinpointing areas that need improvement and in streamlining procedures for the next initiatives. However, success criteria for applying construction technologies in residential projects can vary depending on various factors, such as project size, budget, timeline, the specific technologies being used that best suit the project's goals and requirements, effective implementation, and regular evaluation of their performance. The results indicate that reducing cost, increasing safety, and reducing time are among the highly significant criteria.

However, for construction technologies to be taken seriously as long-term construction techniques, they must be cost-competitive with traditional techniques, and be valuable to and usable by the end users. Decision-makers will have to weigh the trade-offs between construction technologies and conventional methods as well as the potential effects of their choice on the society and the economy as construction technologies become more competitive. The numerous applications, proof of concept, and research developments over the past ten years show that although construction technologies are still in their infancy, there is potential for the future. Therefore, with encouraging investment in construction technologies and continuing funding for research and development, construction technologies could become a practical and widely accepted method of construction with the potential to revolutionize the way the industry handles materials, design, scheduling, labor, logistics, and costs in far-flung, remote, and expeditionary environments.

7. Limitations, and Future Suggested Research

While there have been many advancements in construction technology, not all of them may be suitable or effective for the residential building sector, which has its unique challenges and requirements.

Some potential research questions that could address this limitation include:

- What are the specific challenges faced by the residential building sector that may impact the adoption and effectiveness of construction technologies?
- How can construction technologies be adapted or customized to better suit the needs of the residential building sector?
- What are the most promising construction technologies for residential building projects based on their effectiveness, cost, and ease of adoption?
- How can the benefits of construction technologies be quantified and compared for residential building projects, and what metrics should be used to evaluate their success?

By addressing these questions and other related issues, future research can provide a more comprehensive understanding of the capabilities and limitations of construction technologies in the residential building sector and help inform better decision-making and technology adoption strategies.

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