INDIAN JOURNAL OF SCIENCE AND TECHNOLOGY

RESEARCH ARTICLE

Value Engineering Role in Construction Sustainability During COVID-19 Pandemic in KSA

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OPEN ACCESS

Received: 07.12.2021
Accepted: 22-02-2022
Published: 25.03.2022

Citation: Al-Muaybid AI, Abdulghafour A, Mlybari EA (2022) Value Engineering Role in Construction Sustainability During COVID-19 Pandemic in KSA. Indian Journal of Science and Technology 15(12): 518-526. https://doi.org/10.17485/IJST/v15i12.2293

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Funding: Deputyship for Research & innovation, Ministry of education in Saudi Arabia for funding this research work through the project number 20-UQU-IF-P1-001

Competing Interests: None

Published By Indian Society for Education and Environment (iSee)

ISSN
Print: 0974-6846
Electronic: 0974-5645

Abstract

Objectives: The study aims to evaluate COVID-19 pandemic implications on the construction sector in the Eastern region of KSA and identify how Value Engineering strategies mitigate those implications. **Methods**: A survey questionnaire was distributed among the Eastern region's construction organizations. The samples of the study were selected randomly. The items' consistency and stability in each grouped category of the questionnaire were checked using Cronbach's Alpha value. Statistical analysis was performed using MS Excel, and the Relative Importance Index was calculated to determine the pandemic implication size on the elements of the construction projects. **Findings**: The survey's integrated results revealed that the COVID-19 pandemic negatively affected laborer productivity (ranked from the most affected element to the least affected element depending on the element's RII value), project schedule, project budget. The least affected element is the project scope respectively. The pandemic consequences were more harmful to the contractors than to the consultants, primarily due to the different nature of their work. The implications of the civil roaming ban on construction organizations were more extensive than the flight ban. 84% of the participants agreed that Value Engineering has an essential role in the construction sector's sustainability during the pandemic. The study findings agreed with the previous studies done in other countries. Since the study was conducted immediately after the Saudi government imposed civil roaming and the flight ban, its results were distinguished by exclusivity. **Novelty**: The COVID-19 pandemic implication size on the construction industry in the Eastern region of KSA was utilized in providing a statistical equation based on the induction of the participants' responses.

Keywords: Value Engineering (VE); COVID19 Pandemic; Construction Projects; Financial Losses; Sustainability

1 Introduction

During the construction field's history, the construction organizations worldwide passed through many difficult challenges due to abnormal pandemics, such as the 1918 Spanish Flu pandemic, the HIV/AIDS pandemic, and the 2009 Swine Flu pandemic. One of the most incidents that affected the construction industry globally and significantly in KSA is the COVID-19 pandemic. Several studies have tried to recognize the impact of this pandemic on the construction industry projects and determine the linkage between applying VE strategy and the sustainability of these projects during pandemics. Gmail and Alhagar stated the impact of pandemic crises on the construction industry's survival in a study. The study statistically proved that job loss, time overrun, cost overrun, and financial impacts are the most impacting factors[(1)]. Yadeta and Pandey analyzed the global impact of the pandemic (COVID-19) on the construction industry and reached to the pandemic have created enormous uncertainty in terms of contractual implications for those involved in the construction industry. Additionally, they supposed that collaboration and good communication would be key to managing the impact and steering projects through this period of uncertainty[(2)]. Husien and others believed that the Corona pandemic might be an opportunity to change traditional policies in management, moving more toward modernity and automation, giving more attention to the issue of occupational safety and the safety factor of the workforce, and reformulating contracts and legal legislations in a way that achieves the principle of justice for all shareholders[(3)]. Another study shows the drastic impact of the global pandemic, the COVID-19 pandemic, on Oman's construction industry that slows economics[(4)]. In a different aspect, Ghandour studied the implication of the COVID-19 pandemic on construction project delivery in the UAE. The study findings revealed that the pandemic caused a lack of access to raw materials and labor, which led to a delay in projects completion[(5)]. Umar identified the impact of the pandemic on the GCC construction industry and noticed that banning construction operations has an outsized impact on the construction industry. Also, there were other impacts related to delays of construction projects, effective management of the workforce, health, and safety issues[(6)]. Shibani and others investigated the pandemic effects on the UK's construction industry and claimed that most construction organizations were exposed to the grounding of many projects, stopping many projects, financial losses, and facing financial constraints[(7)]. Choi and Staley studied the safety and health implications of COVID-19 on the United States construction industry and found that pandemic implications cause mental health issues for the workforce such as stress, fear, and anxiety[(8)]. Khair Al-Deen expressed that the efficiency of most site engineers was affected due to the precautionary measures in Jordan, while design engineers were able to work from home with reasonable efficiency[(9)]. Pamidimukkala and Kermanshachi investigated the effects of the COVID-19 epidemic on construction workers and proposed solutions. The study's findings are extremely beneficial to project managers because they make them aware of the COVID-19 problems that workers face and help them prioritize their plans[(10)]. Additionally, Biswas and others concluded that the pandemic's impacts have devastating effects on global trade, financial institutions, industrial establishments, and infrastructure companies. The construction organizations, with no exception, have been severely affected by the COVID-19 pandemic[(11)]. According to Alsharef and others, the construction business has a lot of negative repercussions. Material delivery delays, material shortages, permitting delays, decreased productivity rates, cash flow issues, project suspension, price escalation, and potential conflicts and disputes were among them[(12)]. Alketbi stated the main benefits of VE in the UAE according to a questionnaire respondent are enhancing quality in construction, improving housing affordability, reducing procurement cost, decreasing prices of materials and equipment, improving customer satisfaction, saving cost and time, and compliance with government standards and regulations of construction of housing projects[(13)]. Using a novel advanced mathematical modeling approach called the GRA approach, Ikram and colleagues investigated the effects of COVID-19 on goods and service exports, logistics performance, and ISO 14001 and 9001 certifications in the top-six highly affected Asian countries (India, Iran, Indonesia, Bangladesh, Philippines, and Pakistan). They have discovered that COVID-19 has a strong negative impact on the trade of products and logistics, ISO 9001, and ISO 14001 certificate regulations during a pandemic outbreak[(14)]. As noticed, there is no study done for the construction organizations specifically in KSA determining the pandemic consequences and providing a beneficial solution to control the progression of the projects. The proposed study focuses on identifying the detailed pandemic consequences on the construction industry in KSA. It spots the lights on a managerial solution used in the construction sector in KSA. It explains the VE strategies' contribution in passing the crises with the least losses. To our knowledge, there is no study reported by December 2021 focusing on VE's role in the sustainability of construction organizations and how it mitigates the impacts during the pandemic in the KSA's Eastern region.

2 Methodology

This study adopts one method to collect the required data, filling a questionnaire by many construction organizations in the Eastern region of KSA. The questionnaire is divided into four main categories that help recognize the consequences of the COVID-19 pandemic on construction organizations and identify how VE strategy mitigated them. After collecting the required

data, analytical processes were done, and different tables and figures were constructed to reveal the participants' demography, the implementation quality of VE strategy, the overall impact of the pandemic on the organizations, the pandemic's detailed impact on construction projects' elements, and the effectiveness of VE implementation on the sustainability of the construction industry.

Fig 1. Methodology flowchart

Figure 1 demonstrates the adopted process in the research. The introductory part focused on the literature defining and identifying the study's scope, problem, and objectives. The second phase is to collect the data by involving construction practitioners using a questionnaire survey to evaluate the crisis implications and VE applying impact in overcoming the crisis. The data of the study were analyzed using statistical analysis and MS Excel. The Relative Importance Index (RII) was calculated to rank the project elements according to their affection by the pandemic. The third phase includes representing the data analysis results in tables and charts. Also, discussions and interpretations of the results are shown in this phase. The last phase includes summarizing the study results and recommendations for the concerned organizations or individuals.

A questionnaire survey was done for construction organizations in the Eastern region during the pandemic to determine how it has impacted their projects' elements and how VE strategies contribute to passing this crisis with minor losses. The questionnaire was based on a Likert-type scale, a five-point scale question and these points range from strongly agree to disagree strongly and include a midpoint, which is neutral [15]. Likert-type scale responses are convertible to numerical data that can be used in analytical processes. After getting participants' responses, the collected data was transferred to numerical data; average, frequencies, percentages, standard deviation, and variation were found.

However, the sample selection for a questionnaire survey was based on random samples. At this condition, the selection of the sample is based on uniform distribution, and the broader population is provided in an accurate representation [16]. Since the suitable statistical analysis method is descriptive, regression and central tendency measures were utilized to analyze the collected data. The average is the essential central tendency measure that was used in this paper. Besides this, standard deviation and coefficient of variation were calculated to measure the variation and dispersion among each categorized question's values. Additionally, regression utilized in forming an equation can be used further. Also, the RII, a widely used index in construction research, was used to rank the project's elements according to their vulnerability [17]. According to Aibinu and Jagboro, the RII approach describes the relative importance of the specific causes and effects based on the likelihood of occurrence and effect on the project using the Likert scale of five scales [18]. Additionally, the higher value of RII is the critical cause or impact component, and it is determined by equation (1)

$$RII = \frac{\sum P_i U_i}{N(n)} \tag{1}$$

where,

RII: Relative Importance Index

P_i: respondents rating of the item

U_i: number of replies that have the same weighting/rating on the item

N: sample size

n: the highest score on the item.

To ensure the items' consistency in each grouped category of the questionnaire and check the scale stability, Cronbach's Alpha value was founded. The consistency between two values ranges between zero and one, where the closer the value of one indicates the questionnaire survey's high stability [19], and the equation (2) used to calculate the Alpha value is given as:

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum_{i=1}^{k} S_i^2}{S_t^2}\right] \quad (2)$$

where,K: number of items in a group.S_i^2: the variance associated with the item (I).S_t^2: the variance associated with the sum of all (k) item scores.

After finding the Cronbach's Alpha for each group related to the analyzed data, the average Cronbach's Alpha for the four questionnaire categories was 0.8, which shows high-scale (Good) internal consistency between the groups' items. Therefore, it ensures the reliability and validity of each grouped category in the questionnaire survey.

3 Results and Discussions

Comprehensively, 26 construction organizations were enrolled in this study. Table 1 shows the demographical data of the organizations that participated in the study. Approximately 77% of the organizations, who responded, are consultant organizations, 19% are contractor organizations, and 4% are other parties. The budgets of some projects supervised under these organizations go up to 15 million and more. They worked for private and governmental clients, and also, they have experience extending to more than 15 years in the construction field inside KSA. The detailed demographic information for the construction organizations that participated in this study is shown in Table 1.

Table 1. Participant's demography for the study

Category	Class	Frequency	Percentage (%)
Type of Organization	Consultant	20	77
	Contractor	5	19
	Client	0	0
	Other parties	1	4
Category of organization	Government	0	0
	Private	25	96
	Public	1	4

3.1 Pandemic implications' severity on contractors and consultants

As proved by the responses, the pandemic consequences were more harmful to the contractors than to the consultants, primarily due to the different nature of their work. Contractors work on a full-time basis, while consultants work flexibly and do not have to be full-time. Also, most of the contractors' work is substantially on-site; on the contrary, consultants do most of their work in the office. As an example of applying the VE strategy, consultant organizations started to hold work meetings with clients by online applications to identify the requirements and follow up on work developments instead of conducting them in the organization's offices, which was impossible. They also were sending drawings and schemes to the clients and received their notices without commuting to companies' premises. Even though contractors faced difficulties in completing tasks on the site as planned because of the sanitary precaution and the mandatory regulations, they also applied VE strategies by finding a closer residential building to the worksite, adjusting the work hours with the allowable period for roaming, and canceling the contracts of suppliers who find difficulties in delivering materials within the agreed date and concluding new contracts with suppliers can deliver them in the appropriate time. The percentage of the enrolled contractors, which were impacted by the pandemic's consequences, is more than the percentage of the enrolled consultants by 15 percent, as demonstrated in Figure 2.

3.2 The impacts' assessment of pandemic on construction projects

Aggressively, the pandemic impacted the project elements on different levels. These impacted levels are listed in table 2 for further analysis by using statistical approaches. Descriptive analysis was performed to evaluate the degree of impact

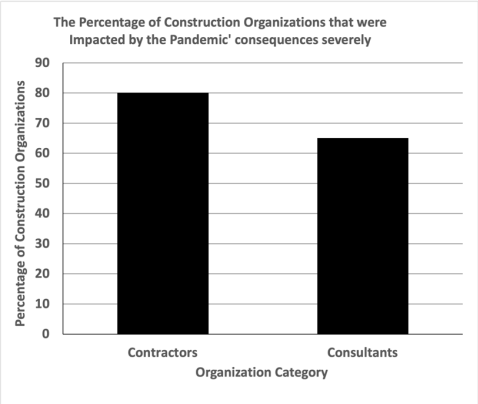

Fig 2. The Percentage of Construction Organizations that were Impacted by the Pandemic' consequences severely

by calculating the RII to rank the project elements according to their vulnerability. Table 2 shows the collected data and demonstrates the assessment of the impacts based on the level of effect using Likert's type scale. The frequency of the impacts was calculated, and the RII was found. The RII shows the degree of the impact according to the number of scales. It is revealed that the project's laborer is the most affected element by the pandemic with a 0.83 RII, which is justified due to the organizations' need to compensate their financial losses to survive by confining the work on the essential laborers. Laborers have been exposed to immense psychological pressure by working under these hazardous conditions to their health. The second most affected element is the project schedule, which is constrained by the government's time limitations to control the spread of the infectious pandemic. The third impacted element is the project budget due to VAT amount increase and the unforeseen rising of material prices. The fourth is the project scope, caused by the client's desire to finish the project within the agreed date and specifications regardless of the abnormal condition that they are passing. As noticed, every element of the construction project was affected by the pandemic undoubtedly, but the impaction degree was disparate, as shown in Table 2.

Table 2. The Impacts' Assessment of Pandemic on construction Projects

Identified Impacts from Survey	Frequency of the Level of Impact					RII	Rank
	Not impacted (1)	Slightly impacted (2)	Neutral (3)	Very impacted (4)	Extremely impacted (5)		
Project Scope	3	6	4	10	3	0.63	4
Laborer	0	0	2	18	6	0.83	1
Project Schedule	1	1	0	16	8	0.82	2
Project Budget	1	4	3	12	6	0.74	3

3.2.1 Roaming and flight ban implications on construction projects

During the COVID-19 pandemic, flights ban and civil roaming ban had significant implications on the progress process of construction projects. These two factors caused difficulties in materials delivery, lack of laborers, increasing materials prices, reducing labor productivity, delaying the project schedule, and others. To identify the influence of each factor, a comparison between the percentage of construction organizations affected by the flight ban to the percentage of construction organizations affected by the civil roaming ban was made, as shown in Figure 3. The civil roaming ban obviously affected the procedures and performance of the construction projects more extensively than the flight ban. The civil roaming ban causes an obstacle for laborers, especially those living far away from the project site, to reach the site in the required time. Also, since most of the construction organizations in KSA depend on national products, the civil roaming ban caused a delay in delivering the product materials through the national transportation means.

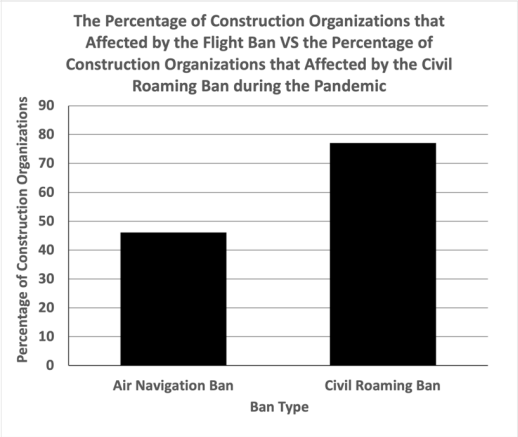

Fig 3. The Percentage of Construction Organizations that Affected by theFlight Ban VS the Percentage of Construction Organizations that Affected by the Civil Roaming Ban during the Pandemic

3.3 Required credentials for the VE team members

To recognize the VE team's proficiency level for the participated construction organizations, the organizations were asked about the organization's VE team members' required credentials. The results reveal that experience and professionalism are the essential credentials VE team members must characterize, as demonstrated in Figure 4.

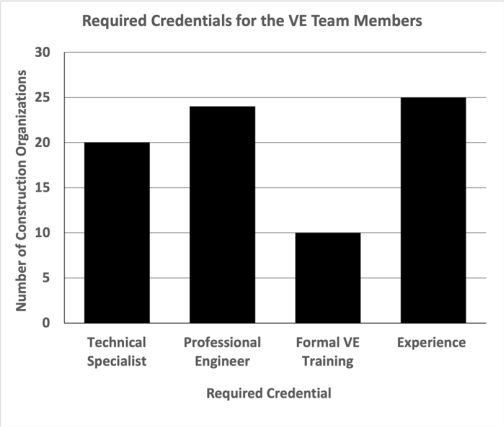

Fig 4. Required Credentials for the VE Team Members

3.4 VE feasibility in the construction industry during COVID-19 pandemic

84% of the enrolled organizations agreed that VE has a vital role in the sustainability of construction organizations. The aim of applying VE strategies differs from one organization to another. Some have financial purposes, some have quality maintaining purposes, and others have targeted financial and quality maintaining purposes. Regarding VE's feasibility in the construction industry during the pandemic of COVID-19, 42% of the construction organizations acknowledged that the VE mitigated the predicted size of the financial losses. On the other hand, 15% of the organizations find that VE contributed to project quality maintenance. Moreover, 27% discovered that it enhanced the project quantitatively and qualitatively, as shown in Figure 5.

3.5 Pandemic impaction percentage (PIP) on the construction industry in KSA

To measure the size of the COVID-19 pandemic impact on the construction industry in the Eastern region of KSA, a statistical equation was provided based on the induction of the participants' responses, as shown in Figure 6. The model represents the

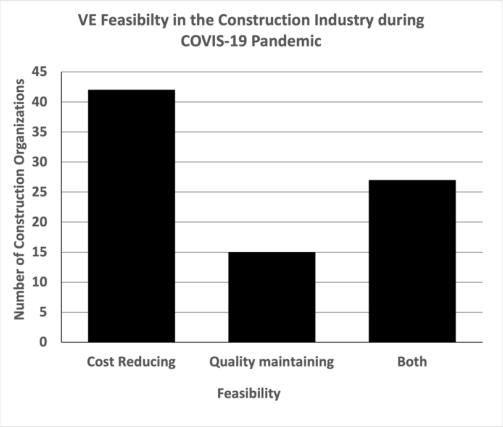

Fig 5. VE Feasibility in the Construction Industry during COVID-19 Pandemic

impact of the pandemic, which was 64% of the total number of samples, which equals 26, on the construction industry in KSA for eight months (March till November 2020). A linear curve appeared on the graph after representing the data on a graph and displaying the trend line using Excel. The regression equation of the linear curve was used to calculate the PIP by substituting Y by PIP and X by the number of months. While the VE effectiveness percentage (85%) was used to predict the PIP of the organizations in the case of using the VE strategy in their projects, as shown in equation (3).

$$v\,PIP(\%) = 7.8\,n(months) + 0.5 \tag{3}$$

where,

PIP: Pandemic Impaction Percentage

n: number of months

v: (0.15) if the organization uses VE, (1) if the organization does not use VE.

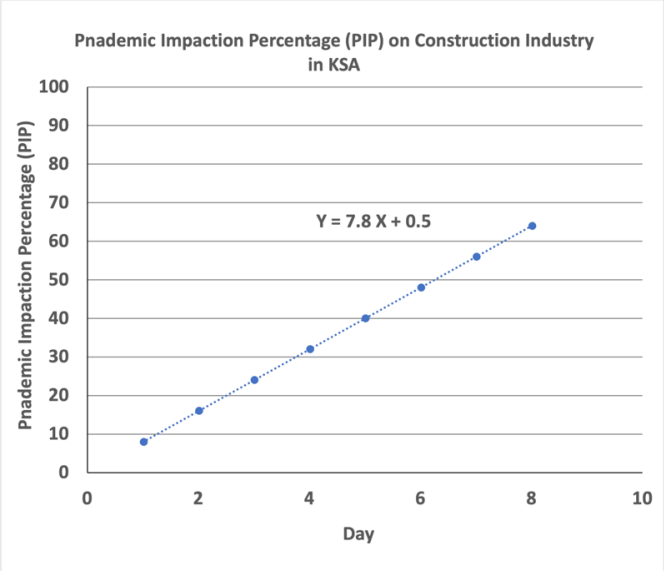

Fig 6. Pandemic Impaction Percentage (PIP) onthe Construction Industry in KSA

4 Conclusion

This article investigated and assessed the impacts of the COVID-19 pandemic on the construction industry in the Eastern region of KSA and highlighted the role of VE strategy in construction organizations' sustainability during the pandemic. Construction industry projects were running normally and improving gradually due to emanating the 2030 vision of Saudi Arabia, which considers enabling citizens to obtain housing and achieving financial balance in the government's general budget by improving the efficiency of spending in projects as one of its goals. Suddenly, the pandemic of COVID-19 occurs, and it has aggressively affected the construction industry by its consequences. The percentage of the pandemic impaction on the contractors was more than the impaction percentage on the consultants by 15 percent. Consultants and contractors utilized VE in their work by conducting online meetings with clients, sending, and receiving suggestions by email, finding a closer residential building, adjusting work hours with the allowable periods, and concluding new contracts with efficient suppliers. It is statistically proven that the most impacted project element was the project laborers (0.83 RII), and the least impacted project element was the project scope (0.63 RII). The project managers worked hard to mitigate the pandemic's consequences by reducing laborers' number, activating online applications in working, and crashing the tasks to finish the work within the required date. Contractors' work nature made them more affected by the time limitation and government restrictions than consultants. The impact of the civil roaming ban (77%) was more extensive than the flight ban (46%) on the construction organizations. Those construction organizations that applied VE have successfully overcome the crisis consequences by finding alternative solutions that help cross over the faced obstacles that affected the project's progress with the most negligible losses. VE concept is used in the construction industry in KSA either by the private sector or the municipal sector. Applying VE mitigated the financial losses of (42%) of the construction organizations and maintained the project quality of (15%) of them. A statistical equation, which is [v PIP(%) =7.8 n(months) + 0.5], was provided based on the induction of the participants' responses. The equation could be utilized to measure the size of the COVID-19 pandemic impaction on the construction industry in the Eastern region. It recommended that the equation be developed to cover the whole period of the pandemic, consider more KSA regions with different construction project types, and be utilized in software programs that can easily predict the pandemic impaction with more precision level. The article's findings are introductory to the construction industry stakeholders to be more aware of the VE and its applications and widely apply it in all projects phases in the future. These circumstances will help assure the project's progress and sustain the construction industry during pandemics worldwide.

5 Acknowledgement

The authors their appreciation to the Deputyship for Research & innovation, Ministry of education in Saudi Arabia for funding this research work through the project number 20-UQU-IF-P1-001

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