



MEASURING THE FACTORS AFFECTING CONSTRUCTION METHOD SELECTION: A CASE STUDY EGYPT

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Citation:

A.F. Zaki, E. O. Elgendy, N. H. El Ashkar, " Measuring the factors affecting constructin method selection: A case study Egypt", Journal of Al-Azhar University Engineering Sector, vol.19 , pp. 1298 - 1304, 2024.

Received: 16 May 2024

Revised: 11 July 2024

Accepted: 23 July 2024

DOI: 10.21608/aej.2024.290102.1664

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ABSTRACT

Selecting an appropriate construction method is considered to be a persistent need to save cost, time and achieve high quality for construction projects. Especially as the selection depends on many complex manifold factors that affect project cost, time and quality. In addition to, the great calamities which happened latterly in the world such as covid-19 pandemic, inflation, resource depletion and prices rising which definitely affects construction industry. Wherefore it's momentous to measure the factors affecting construction method selection, to facilitate decision making in project's early study stages such as feasibility study stage or scheme stage to avoid its negative influences. Therefore, this research aims to explore and measure the factors affecting construction method selection for residential buildings in Egypt to facilitate decision making process, especially in current time that witness revolution in construction and difficult economic conditions. The exploring and measuring process will be based on three construction methods which are conventional construction, prefabricated on-site and prefabricated off-site. The results achieved by this research found that, there are eight main factors affecting construction method selection, three related to construction cost, three related to construction time and two related to construction quality. Moreover, the results showed that the factors related to construction cost and time were the extreme factors that affecting construction method selection.

KEYWORDS: construction method, conventional method, prefabricated method, Decision making, construction industry, Delphi method.

قياس العوامل المؤثرة على اختيار طريقة التنفيذ: دراسة حالة مصر

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المخلص

يعتبر اختيار طريقة البناء المناسبة حاجة ملحة لتوفير التكلفة والوقت وتحقيق الجودة عالية في مشاريع الإنشاءات. خصوصاً أن الاختيار يعتمد على العديد من العوامل المتعددة والمعقدة التي تؤثر على تكلفة ووقت وجودة المشروع. بالإضافة إلى المشاكل الكبيرة التي حدثت مؤخراً في العالم مثل جائحة كورونا والتضخم واستنزاف الموارد وارتفاع الأسعار مما يؤثر بالتأكيد على صناعة البناء. لذلك من الأهمية قياس العوامل المؤثرة على اختيار طريقة البناء لتسهيل عملية اتخاذ القرار في مراحل الدراسة المبكرة للمشروع مثل مرحلة دراسة الجدوي أو مرحلة التخطيط الأبتدائية لتجنب التأثير السلبي لاتخاذ قرار خاطئ. لذلك يهدف هذا البحث إلى استكشاف وقياس العوامل المؤثرة على اختيار طريقة البناء للمباني السكنية في مصر، وذلك لتسهيل عملية اتخاذ القرار خاصة في الوقت الحالي الذي يشهد طفرة في أعمال البناء في ظل ظروف اقتصادية صعبة. ستعتمد عملية الاستكشاف

والقياس على ثلاثة طرق تنفيذ وهم الطريقة التقليدية، الطريقة سابقة الصنع داخل الموقع ، والطريقة سابقة الصنع فى المصنع. خلصت النتائج التى حققها هذا البحث الى أن هناك ثمانية عوامل رئيسية تؤثر على اختيار طريقة البناء، ثلاثة عوامل تتعلق بتكلفة الأتشاء، وثلاثة عوامل تتعلق بمدة الأتشاء، وعاملان يتعلقان بجودة الأتشاء. علاوة على ذلك ، أظهرت النتائج أن العوامل المتعلقة بتكلفة ووقت الأتشاء هى العزامل التى لها التأثير الأقصى على اختيار طريقة البناء.

الكلمات المفتاحية : طريقة التنفيذ، الطريقة التقليدية، الطريقة سابقة الصنع، اتخاذ القرار ، صناعة البناء، طريقة دلفى.

1. Introduction

Selection wrong construction method may lead construction projects to suffer huge losses in cost, time overruns and poor quality, and the project may be exposed to non-completion [1]. Furthermore, in the age of Corona virus pandemic, and resources depletion that the world is currently facing that increases the global economic crisis, which leads to rising in global prices in general and especially in energy and building materials prices.

These difficult conditions are increasing the crisis and makes construction projects suffering more [2-4]. Therefore, selecting an appropriate construction method for a certain project is considered extreme need in project' early study stages, whether in feasibility study stage or scheme stage to achieve minimum cost, minimum time and high quality [5]. There are many criteria that may affect appropriate construction method selection such as cost, time, quality, health and safety, environmental, waste, weather condition and site issues... etc., [6].

The construction revolution that Egypt witness nowadays, consumes huge manpower', and contributes in providing more job opportunity, that leads to decreasing unemployment problem. In addition, it provides huge amount of housing units, which decreasing housing gap and eliminating slums in different governorates [6,7].

Due to current economic' difficult conditions [8], the construction industry' most important criteria to study are cost, time and quality. That means, these influence factors on project' performances are the most attractive for construction developers and investors to focus on to avoiding construction projects losses under the current circumstances [9]. Pasquire *et al.* 2005, identified six main factors to be considered, when selecting the appropriate construction method, which are cost, time, quality, health and safety, sustainability and site issue to prompt prefabrication in UK [10]. Alaghbari, *et al.* 2007, identified ten major factors causing delay in building construction in Malaysia. They found that financial and coordination problems are the two extreme factors causing that delay, the researchers investigated 31 variables but not include effect of wrong construction method selection [11].

Chen, *et al.* 2010, developed construction method selection model, to prompt prefabrication over traditional construction method during project feasibility study stage in USA. They identified 12 factors grouped in four main groups, which are project characteristic, site condition, market attributes and local regulations [5]. Ferrada, *et al.* 2013, proposed a knowledge system to improve the selection of construction methods of a project in Chile. Additionally, they identified the key criteria that used in construction method selection, which include project duration, cost, construction method characteristic, product characteristic and environmental characteristic [12].

The researchers studied the selection in activity level and for any type of projects. Ikediashi *et al.*, 2014, developed a framework for identifying and classifying causes of project failure in Saudi construction industry, they defined 24 factors which grouped in eight main groups and

confirmed the most extreme ten factors that causing infrastructure projects failure in Saudi Arabia [13].

Shahpari, *et al.* 2020, defined 24 confirmed factors related to 7 indices that affecting three construction method productivity, traditional, semi- prefabricated and prefabricated method in Iran. They excluded factors affecting method' quality [14]. Shibani, *et al.* 2021, investigated the main causes of time overruns in construction industry in Egypt in last ten years, they defined top ten factors causes delay in construction project in general [15].

Despite, several researches had discussed the factors affecting project delay, time overrun causes, construction method productivity, but neither construction method was considered as one of studied factors, nor the factors effecting on it. In addition, few researches mentioned factors affecting construction method selection but without measuring or evaluating.

Therefore, these gap is representing the rational of this research, which is investigating and measuring the factors affecting selection between three construction methods conventional method, prefabricated on-site or prefabricated off-site, based on three main criteria cost, time and quality, these criteria are representing the most interesting criteria for construction industry' stakeholder in Egypt.

In addition to that, selected criteria have extreme importance to help in determining the appropriate construction method, that the project' stakeholder will use, especially in the residential buildings which are the current trend in Egypt. Wherefore, the government focus on it to cope with the extreme population increasing and housing gap problems [7]. Finally, data will be collected for this research from Egypt's construction industry experts to confirm the factors that affecting construction method selection.

2. Research method

Form the trough review conducted in this research, it is well known that there are many criteria that can affect construction method selection for residential buildings such as cost, time, quality, health and safety, environmental pollution consideration, waste, weather condition and site issues... etc.. However, this research will focus on three main criteria cost, time and quality as these are the focus to the most construction developers and investors in Egypt, especially in light of construction boom, that Egypt is witnessing nowadays to deliver more residential buildings, to cover its housing needs and eliminates the slum problem. Based on comprehensive literature review to factors that affect construction method selection for residential buildings, 41 factors were extracted and presented to academic and industry experts, through physical interviews as a pilot study to filter, merge and select the appropriate factors for Egypt.

The experts selected eight main factors related to cost, time and quality, which are acting as the most interesting three criteria in the construction industry in Egypt. Moreover, a questionnaire was developed and presented to academic and industry experts through physical interviews for revision. Hence, these questionnaire was updated for final edition. The questionnaire included two parts, first part developed to gather general information about respondents including age, current job position, academic qualifications and experience.

While, second part designed to gather information about factors evaluation whether is it affect construction method selection or not. The questionnaire was presented to construction experts in Egypt, whom chosen as a random sample to collect the required data subject to this research. They

had been asked to rate the factors in terms of a 5-point Likert scale [14] and also mention any other factors that may affect construction method selection and not mentioned in the questionnaire. Delphi rounds were run to collect required data through physical interviews with the 14 construction experts whom were more than 15 years' experience in construction field. The specialization of the construction experts interviewed in this research are shown in **Table 1**. Moreover sample distribution percentage of these experts are shown in **Figure 1**.

Table (1): Experts classification.

Expert classification	Number
Contractor	5
Consultant	5
Designer	3
Developer	1

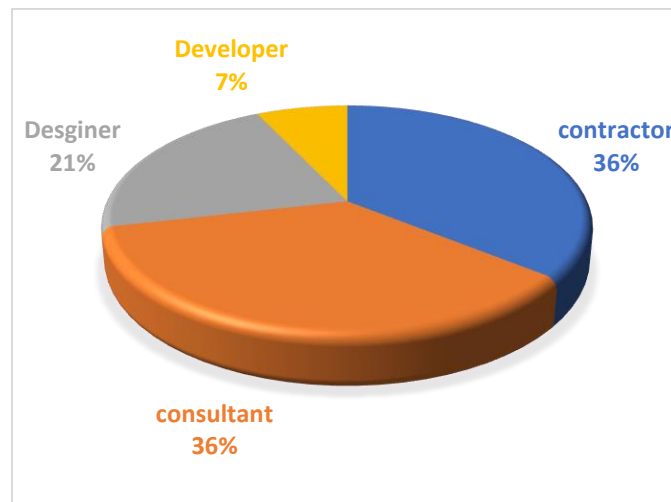


Figure 1: sample distribution percentage

The collected data were analyzed by Statistical Package of Social Science SPSS; to calculate reliability coefficient of the questionnaire to confirm the factors. Once the reliability of the questionnaire was confirmed, which mean the factors that affect the construction method selection are consensus formation, as shown in **Table (2)**. In additions to that, the confirmed factors can act as a base for further research to develop model to select the appropriate construction method.

Table (2): Main criteria and corresponding factors.

Main criteria	Factors	Code
Cost	Construction cost.	Q1
	Transport costs.	Q2
	Machinery & equipment cost.	Q3
Time	Construction time.	Q4
	Transport time.	Q5
	Machinery & equipment time.	Q6
Quality	Tolerance levels.	Q7
	Rework	Q8

3. Data collection and results

Delphi rounds were run to collect required data related to construction method selection for residential building. First round, the experts rate the factors based on 5 point Likert scale, the collected data were calculated using SPSS method to calculate reliability coefficient, the result was more than 0.70 and the reliability was confirmed [14,16, 17]. While, second round, the factors were presented again to the experts for rating with respect to first round total mean that provided to experts, to confirm first round’ results. The two rounds’ results were more than 0.70 therefor the reliability were confirmed and Delphi rounds were stopped after second round [16]. Questionnaire was conducted through personal interviews with the experts. Additionally, they were requested to mention any other factors that affecting the construction method selection and not mentioned in the questionnaire. The SPSS was used to calculate the reliability coefficient of questionnaire according to Equation. 1 [17].

$$\alpha = rk / [(1+(k-1) r)]. \tag{1}$$

Where:

α is a Cronbach’s α

K is number of factors.

The confirmed factors are construction cost, transportation cost, equipment and machinery cost are three main factors related to construction project cost. Construction time, transportation time, equipment and machinery time are three main factors related to construction project time. Tolerance and Rework are two factors related to construction project quality.

Table (3): Factors Statistics – R1

	Construction cost	Transport cost	Machin & equip. cost	Construction time	Transport time	Machin & equip. time	Tolerance level	Rework
Mean	4.64	2.86	3.57	4.64	2.36	3.00	2.21	2.79
Minimum	4	2	1	4	1	1	1	1
Maximum	5	4	5	5	5	5	4	5
Geometric mean	4.62	2.78	3.32	4.62	2.24	2.83	1.94	2.48
Std. deviation	0.497	0.663	1.222	0.497	1.151	0.961	1.122	1.251

Table (4): Factors Statistics- R2

	Construction cost	Transport cost	Machin & equip. cost	Construction time	Transport time	Machin & equip. time	Tolerance level	Rework
Mean	4.68	2.79	3.36	4.79	2.21	2.86	2.29	2.64
Minimum	4	2	1	4	1	1	1	1
Maximum	5	4	5	5	4	4	4	4
Geometric mean	4.84	2.73	3.11	4.77	2.06	2.73	2.14	2.52
Std. deviation	0.363	0.579	1.216	0.426	0.893	0.77	0.825	0.745

Conclusions

Selecting an appropriate construction method is considered to be a very important issue in construction project first stages such as feasibility study stage. It affects directly the project' cost, time and quality. Especially, these selection depends on complex and manifold factors.

This research measured factors affecting three construction methods, which are conventional method, prefabricated on-site and prefabricated off-site. Eight factors related to three main criteria cost, time and quality were selected and measured in this research. These are considered the most related and stimulating to Egyptian construction market. The factors were construction cost, transportation cost, machinery and equipment cost, construction time, transportation time, machinery and equipment time, tolerance level and rework.

Measuring factors done through collecting data by questionnaire and physical interviews using Delphi rounds with 14 constructions' experts in Egypt, whom asked to rate the factors based on 5 point Likert scale. Data were analyzed using Statistical Package of Social science SPSS for the two Delphi rounds to calculate questionnaire reliability.

The questionnaire results confirmed eight factors that affecting construction method selection. The results showed that the construction cost, construction time and machinery and equipment cost are the most factors affecting construction method selection with respect to mean, which was 4.86, 4.79 and 3.36 respectively. The results are considered a guide for Egyptian construction industry to select appropriate construction method for residential buildings.

Limitation:

Although, the research had achieved its results and confirm eight factors affecting construction method selection in Egypt. It will be more gorgeous to explore the effect of other factors such as factors related to safety, weather condition and site issues... etc. to make more attention for the appropriate construction method in the coming eras.

Future work:

This research is a part of a huge research plan (thesis), that aim to develop a computerized model to facilitate construction method selection for residential construction projects in Egypt, in consideration of user interests based on cost, time and quality.

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