Prefabrication in the South African Construction Industry – Challenges and Solutions

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Abstract

Despite the inherent benefits in the delivery of construction through prefabrication, its adoption is still considered to be low in most developing countries like South Africa. This paper presents the result of an assessment of the challenges facing the adoption of prefabrication in the South African construction Industry (SACI) and the measures for improving same. The study adopted a quantitative survey approach with information gathered from participants within selected construction organisations in Gauteng province, South Africa. Data gathered were analysed using percentage, mean score and standard deviation. Findings revealed that the most significant challenges facing the adoption of prefabrication are lack of prefabrication branding and promotion, low awareness and knowledge, need for specialized equipment for installation, difficulty in getting tender, negative perception, improper assembly of prefabricated components, high investment on equipment, and clients doubts in using prefabricated materials. If the system of prefabrication in construction is to be adopted considerably within the SACI, then there is the need for the adoption of measures such as, conducting research and testing to prove feasibility of design, organizing workshops to train individuals on prefabrication projects, providing skills development programmes, creating awareness among parties involved in construction, adequate government support, regular training of machine operators, and advanced technology in assembling.

Keywords

Building Construction, Industrialised building system, off-site construction, Precast, Prefabrication

1. Introduction

Construction industry still faces many challenges as there are issues that are not yet resolved coming from the adoption of traditional construction system, which is characterised by delays, poor quality, cost overruns and safety issues (Khalil *et al*., 2016). Ghosh (2002) opined that available traditional technologies and processes adopted for construction of buildings are inefficient and resource wasteful due to the enormous amount of resources consumed. This unhealthy situation has led to an increasing demand for the further development of technologies and construction process in most countries around the world. One of such development is the Industrialised Building System (IBS) which makes uses of prefabricated materials in the delivery of construction works. Hamid *et al.* (2008) portrayed IBS as an improved method whereby building components are created in a controlled environment (off-site), transported, situated and assembled into a structure with less extra site work. IBS is simply seen as a way of achieving construction through prefabrication. This can be in the form of precast component frameworks, manufactured steel structures, innovative mould systems, block system and pre-assembled timber structures as development segments (Muhammad *et al*., 2016). The repetitive building parts that take time to be casted on site are designed and detailed as standardised components at the factory and brought to the site to be assembled. Kamar *et al*. (2012) described this system of construction as an alternative construction strategy which is expected to deliver fast, increase quality, reduce wastage and safer environment on construction site (Kamar *et al*., 2012).

In developed countries, the construction industry has attempted to utilize prefabrication as a strategy for getting improved construction quality and productivity, alleviating risks related to occupational health and safety, reducing issues related to a shortage of skilled workers and achieving the goal of reducing the overall cost of the project

(Gibb *et al*, 2012). Khalil *et al*. (2016) added that countries such as Japan, United Kingdom and Sweden have successfully implemented the building system in their construction industry. According to Aladeloba (2015) prefabrication offers cost saving, simplified construction methods, reduction of labour requirement at the site, faster construction time, and flexibility in architectural design among several others. However, despite these mouth-watering benefits proposed by this method of construction, its adoption in most developing countries (South Africa inclusive) is still low (Aladeloba, 2015; Ayoola and Aghimien, 2017; Kamar *et al*, 2012). It is based on this knowledge that this study assessed the challenges facing the use of prefabrication in construction as an alternative to the conventional building system in the South African construction industry (SACI) as well as the possible measures for improving its usage. Subsequent parts of this paper include the review of existing literature, the methodology adopted for the study, the findings and conclusion drawn from the findings of the study.

2. Literature Review

The Industrialised Building System which is the process of delivering construction through prefabrication is the term used to present the adoption of construction industrialisation and the usage of prefabricated parts in building improvement. This system is characterised as a method whereby components are created in a controlled environment, transported, position and assembled into a structure with less extra site work (Kamar *et al*, 2012). Likewise, the process uses building parts, such as walls, floor slab, beam, column and staircase which are made in an industrial facility under strict quality control in delivering construction projects (Muhammad *et al.*, 2016). Shamsuddin *et al*. (2013) emphasised that the principle preferences of this system of construction are the quality, speed of construction process and cost investment funds. Notwithstanding all the specified advantages of prefabrication, the contractors are still moderate at grasping this system not just in South Africa alone but also in other developing countries (Kamar *et al*, 2012).

Rahman and Omar (2006) noted that the use of prefabrication in construction is regularly misconstrued with the awful picture because of its past disappointments. Its structures are described with low quality, spillages, surrendered ventures and unsavoury building appearances. General society has demonstrated no enthusiasm to prefabrication in construction because of the poor structural outline and old pre-assembled structures. According to Conrads and Othman (2009), the old industrialised buildings were associated with pre-fabricated mass construction method, low-quality buildings, leakages, abandoned projects, and unpleasant appearances. Mardhiah (2009) also noted that most of these houses were not maintained properly, thus contributing further to the poor image of the building system. Rahman and Omar (2006) further observed that prefabricated building elements are to a great degree overwhelming and require some particular hardware for the establishment. Ayoola and Aghimien (2017) noted that a lack of sophisticated plants and equipment needed for the proper execution of prefabrication projects a major factor affecting its usage.

Aside issue of equipment, delays are sometimes encountered on site due to late delivery of prefabricated components which can be caused by site location such as city centre where there is traffic, overcrowding, loading restrictions and restricted space (Polat, 2008). In addition, there are limitations produced by the government and road agencies such as lane restrictions and parking space. These restrictions may lead to a bad impact on the delivery of prefabricated elements to the construction site and will cause a reduction on productivity since the workers will have to wait for these elements to be delivered on site. Rahman and Omar (2006) noted that poor connection may cause problems when connections are not properly joined together due to poor construction details thus leading to safety issue on the construction site. This is also the issue of high investment cost such as cost of acquiring machineries needed (Ayoola and Aghimien, 2017; Rahman and Omar, 2006), poor awareness issue and lack of knowledge of the system of construction among construction participants (Kamar, 2009; Milad *et al.*, 2012; Rahman and Omar, 2006).

If construction is to be delivered within the construction industry, then there is the need for proper awareness among construction participants through enlightening them of the benefits related to its successful adoption. Also, the adoption of this system of construction needs sufficient push from the government in order for it to be embraced by both the public and private sector (Kamar *et al*., 2009). Kamar *et al*. (2009) further suggested that the decision to use prefabricated materials must be made from the design stage so as to ensure proper implementation at the construction phase. Additionally, IBS requires proper planning and control from commencement to finish of the construction project is necessary so as to achieve the objectives and lessen deformity and mistakes. Rahman and Omar (2006) suggested that testing and research must be directed to demonstrate th achievability of drawing plans.

3. Research Methodology

This study adopted a quantitative survey design in which information was solicited from construction participants within selected construction organisations in Gauteng province, South Africa. The choice of conducting the study in the selected study area is based on the availability of a high number of construction organisation within the province. A questionnaire was used as the research instrument due to its ease of use and ability to get quantifiability and objectiveness in research (Ackroyd and Hughes, 1981). The questionnaire used for the study was designed in two sections, with the first section designed to harness information on the background information of the respondents. The second section gathered information on the factors affecting the use of IBS in the SACI and the possible measures for increasing its usage. A 5 point Likert scale was adopted in the second section with respondents being asked to rate certain identified factors and measures based on their level of significance. Level 5 was set for very high significance, 4 for high significance, 3 for average significance, 2 for significance, and 1 for very low significance. Twelve (12) construction organisations were identified from preliminary studies based on their active involvement in construction activities within the study area. The study set out to assess the opinion of at least 5 construction professionals within each of the 12 organisations, thus, making an initial sample size of 60 for the study. However, due to the unavailability of some participants, a total of 54 questionnaire were distributed. The 54 questionnaires were all returned with 50 ascertained fit for analysis. The remaining 4 were dropped as a result of some missing vital information that was omitted by the respondents. Data analyses were done using percentage for the background information of the respondents, while mean score and standard deviation (SD) were used to rank the assessed variables in order of their significance. These challenges were ranked from the highest mean score than to the lowest. However, where two variables have the same mean score the variable with the lowest SD is ranked first as suggested by Field (2005).

4. Results and Discussions

4.1 Background respondents

The findings that were obtained from the questionnaires showed that 70% of the respondents that took part in the study were male and 30% of the respondents were female. While the findings for educational qualification demonstrated that 18% had matric certificate, 40% with a national diploma, and 42% with bachelor's degree. The professional positions that were captured revealed that 6% architects, 12% quantity surveyors, 10% civil engineers, 4% construction managers, 50% project managers and 18% of the respondents were project site supervisors. Furthermore, the findings revealed that the number of years of experience of the respondents was 30% for respondents that had up to five years, 32% of respondents that had between 6-10 years of experience, 28% had between 11-15 years of experience, 6% of respondents had between 16-20 years of experience and 4% of the respondents had more than 20 years of experience. These findings revealed that the respondents for the study were well equipped in terms of years of experience within the industry and answers given can be relied upon as they were given based on experience.

4.2 Challenges facing the adoption of prefabrication in the SACI

In assessing the challenges of using prefabrication in the SACI, some challenges were identified from the review of related literature and presented to the respondents. The respondents were asked to rate these challenges based on their level significance using a scale of 1 to 5. The result in Table 1 shows the ranking of these challenges, their mean value and associated standard deviation (SD). The result from the table reveals that almost all the assessed challenges have their mean score to be well above the average of 3.0 aside professionals doubt if prefabrication technology which has a mean score of 2.40. This means that the assessed challenges to a considerable extent have a significant effect on the use of prefabricated components within the study area. However, professionals seem not to have doubts about this technology, hence this factor has no significant effect on the use of this method of construction. A look at the SD column shows that there is a considerable agreement in the view of the respondents as regards these challenges as a SD value of less than 1.0 was derived for all the assessed challenges. According to Field (2005), a SD of below 1.0 shows little variability in the data and consistency in agreement of respondents. However, the reverse is the case when SD is above 1.0.

The most significant challenges of the use of prefabricated materials within the SACI industry are lack of prefabrication branding and promotion (*mean score = 4.52, SD = 0.505*), low awareness and knowledge about prefabrication (*mean score = 4.46, SD = 0.503*), requires specialized equipment for installation (*mean score = 4.40,*

SD = 0.495), difficult to get a tender (*mean score = 4.38, SD = 0.490*), negative perception (*mean score = 4.38, SD = 0.490*), improper assembly of prefabricated components (mean score = 4.34, SD = 0.593), investment on heavy equipment (*mean score = 4.30, SD = 0.544*), and clients have doubts on using prefabricated materials (*mean score = 4.30, SD = 0.614*). For any innovation to be adopted there is always the need for a proper introduction to those it is made for. This can be achieved through proper banding and promotion which in turns increases the awareness and knowledge of such innovation in the intended market. However, this is not the case with prefabrication in developing countries of which South Africa is no exception. Issues surrounding the lack of awareness and knowledge of this approach has been observed in previous researches (Kamar, 2009; Milad *et al*., 2012; Rahman and Omar, 2006). Findings of this study agree with these submissions as lack of promotion of prefabrication among construction participants and lack of awareness and knowledge are key challenges facing the use of this approach within the SACI. Lack of specialized equipment for installation is seen as another crucial challenge facing the adoption of this beneficial construction method. This finding further corroborates Ayoola and Aghimien (2017) submission that the lack of plant and equipment is a major problem of the adoption of prefabrication in Nigeria.

Rahman and Omar (2006) noted that the use of prefabricated materials is still being misinterpreted with negative meaning as it is always linked with industrialized buildings that were built in1960s. According to Conrads and Othman (2009), the old industrialised buildings were associated with pre-fabricated mass construction method, low-quality buildings, leakages, abandoned projects, and unpleasant appearances. Mardhiah (2009) also noted that most of these houses were not maintained properly, thus contributing further to the poor image of the building system. It suffices to say that this stigma still lingers on, as the negative perception of prefabrication in construction is seen as a major challenge facing its usage within the SACI. This further corroborates Nawi and Nor (2011) submission that the challenges of prefabrication in construction include negative perception from customers and professionals. Unlike the conventional construction system, IBS through the use of prefabricated materials requires the use of some specialised plant and equipment which can be capital intensive especially for construction industries of developing countries where small and medium contractors are rampant. This high cost of investing in equipment can to a large extent discourage the use of this method of construction. This finding is further corroborates Baharuddin *et al*., (2016) submission that prefabrication in construction requires specialised machinery and equipment to carry out the work. This leads to high investment capital in purchasing machinery and adopting technology from other countries.

Table 1: Challenges of facing the adoption of prefabrication in the SACI

Challenges	**MS**	**SD**	**Rank**
Lack of prefabrication branding and promotion	4.52	0.505	1
Low awareness and knowledge about prefabrication	4.46	0.503	2
Lack of specialized equipment for installation	4.40	0.495	3
Difficult to get a tender	4.38	0.490	4
Negative perception	4.38	0.490	4
Improper assembly of prefabricated components	4.34	0.593	6
High investment on heavy equipment	4.30	0.544	7
Clients have doubts on using prefabricated materials	4.30	0.614	8
Lane restriction for heavy trucks	4.28	0.454	9
Transportation delay of prefabricated components	4.24	0.476	10
Installation difficulties	4.20	0.495	11
Fear of rejection by customers	4.10	0.707	12
Lack of push factors from government	4.00	0.350	13
Poor precast components connections	3.94	0.314	14
Limiting designers creativity	3.92	0.085	15
Lack of trust in prefabricated components	3.76	0.657	16
Identical buildings decreases value of building	3.60	0.670	17
Professionals doubt prefabrication technology	2.40	0.495	18

4.3 Measures for improving the adoption of Prefabrication in SACI

In order to increase the use of prefabrication within the SACI, some measures were identified from the review of related literature and presented to the respondents. The respondents were asked to rate these measures based on their level significance using a scale of 1 to 5. The result in Table 2 shows the ranking of these challenges, their mean

value and associated SD. The result from the table reveals that all the assessed measures have their mean score to be well above the average of 3.0. This means that the respondents believe that all the assessed measures to a considerable extent have the tendency to improve the adoption of prefabrication within the SACI if implemented. A look at the SD column also shows that there is a considerable agreement in the view of the respondents as regards these challenges as an SD value of less than 1.0 was derived for all the assessed measures. Chief of these measures are conducting research and testing to prove feasibility of design (*mean score = 4.44, SD = 0.501*), organizing workshops to train individuals on prefabrication projects (*mean score = 4.40, SD = 0.495*), providing skills development programmes (*mean score = 4.38, SD = 0.490*), creating awareness among parties involved in construction (*mean score = 4.38, SD = 0.490*), adequate government support(*mean score = 4.36, SD = 0.485*), regular training of machine operators(*mean score = 4.32, SD = 0.471*), and advanced technology in assembling (*mean score = 4.30, SD = 0.463*).

Following the technicality and the need for precision in constructing using prefabricated materials, there is a need for proper testing of the feasibility of the design. This will go a large extent in reducing the possibility of failure during construction and by extension increasing individual's confidence in the system. The study of Rahman and Omar (2006) also agrees with the findings of the study which reveals that research should be conducted to test prefabrication in construction. There is also the need for proper training and improving skills of construction workers in the handling of prefabricated materials and constructing with same. This can be achieved through organized workshops and skills development programmes. Through these programmes, awareness of the system of construction can be increased among construction participants, and the negative view of the system can be eliminated. These findings agreed with the study of Kamar *et al.* (2009) which reveals that the way forward with the adoption of prefabrication in construction is inclusive of encouraging environmentally friendly techniques, awareness and provide proper training. Ayoola and Aghimien (2017) suggested the involvement of government in the promotion of prefabrication in construction. A similar submission was made by Kamar *et al*, (2009). Findings of this study agree with these submissions as adequate support is seen as crucial measures which can help improve the adoption of prefabrication within the SACI.

Table 2: Measure for improving the adoption of prefabrication in the SACI

Measures	**MIS**	**SD**	**Rank**
Conduct research and testing to prove the feasibility of design	4.44	0.501	1
Workshops to train individuals on prefabrication projects	4.40	0.495	2
Provide skills development programmes	4.38	0.490	3
Create awareness among parties involved in the construction	4.38	0.490	3
Adequate government support	4.36	0.485	5
Regular training of machine operators	4.32	0.471	6
Advanced technology in assembling	4.30	0.463	7
Educate students about prefabrication at the early stage	4.28	0.454	8
Introduce more technology in the manufacturing process	4.28	0.497	9
Impose taxes on non-environmentally friendly techniques	4.28	0.573	10

5. Conclusion and Recommendations

This study set out to assess the adoption of prefabrication system within the SACI with a view to providing faster and better quality construction within the country. Using a quantitative survey with information gathered from participants within selected construction organisations in Gauteng, the major challenges of the adoption of prefabrication as well as the measures for improving its adoption were identified. Based on the findings of the study, it is, therefore, concluded that the most significant challenges facing the adoption of prefabrication within the SACI are lack of prefabrication branding and promotion low awareness and knowledge about prefabrication, need for specialized equipment for installation, difficult to get a tender, negative perception, improper assembly of prefabricated components, investment on heavy equipment, and clients have doubts about using prefabricated materials. If the system of prefabrication in construction is to be adopted considerably within the SACI, then there is the need for the adoption of measures such as, conducting research and testing to prove feasibility of design, organizing workshops to train individuals on prefabrication projects, providing skills development programmes, creating awareness among parties involved in construction, adequate government support, regular training of machine operators, and advanced technology in assembling.

It is believed that the findings of this study will go a long way in contributing to the increased use of the concept of prefabrication in the SACI. The study contributes the knowledge as it showcases some of the key challenges of the use of prefabrication within the SACI and the possible ways of improving its usage. However, despite the immense contribution the study brings, care must be taken in generalizing its findings as it is limited based on the geographical scope and sample size. The study was conducted in Gauteng, hence further studies can be conducted in other provinces within the country, in order to compare results and also garner information on a larger sample size.

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