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Implementation Challenges of Concrete Prefabrication Panel Construction Technologies in Building Reconstruction and Development Programme (RDP) Housing Units in South Africa: A Literature Review

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Abstract
Prefabrication is a construction process that involves producing components of construction in off-site facilities before assembling them on-site, and it has emerged as an appealing alternative to conventional techniques for construction. The prefabrication implementation setting presents a number of issues unique to the South African construction industry. Such challenges are documented in this study with regard to the building of low-cost type of housing units under the government framework/initiative known as the Reconstruction and Development Programme (RDP). In pursuit of alternative construction methods that support environmentally friendly practices, this research's purpose is to gather insights from construction professionals as well as previous literature regarding the challenges of implementing prefabrication construction technologies in the South African construction industry. The data for this study included literature review data and that of the experts from Gauteng province, South Africa. Both the data and the literature agree that a number of challenges must be overcome before prefabrication construction technologies can be used. The challenges include effects of fabrication towards jobs opportunities, lack of knowledge, and issues with procurement departments to mention a few. It is recommended that to draw attention to the benefits of prefabrication, the African government and construction industry ought to allocate funds towards marketing and advertising. To increase efficiency and quality in RDP house construction, construction professionals should investigate innovative construction techniques which enable the use of prefabricated concrete panels. Future research may examine the longer timelines for delivery of prefabrication technology compared to traditional techniques of building.

Keywords
Concrete Prefabrication, Construction Technologies, Prefabrication, Reconstruction and Development Programme, South Africa.

1. Introduction

The term "prefabricated construction" is commonly used to refer to the off-site production of building elements. In this study, the umbrella term for a prefabricated building aligns with the definition provided by Mao et al. (2013), which characterizes it as a structure assembled using factory-built, off-site prefabricated parts, including floor slabs, facade, or stair features. Structures that combine in-situ cast concrete with these precast elements are termed semi-prefabricated buildings. All four structures under investigation fall within this category, as they incorporate both prefabricated and in-situ cast concrete components (Mao et al., 2013).

According to Mao et al. (2013), complete prefabrication involves the assembly of prefabricated parts only. Semi-prefabrication, a prevalent technique in various countries, particularly in Europe (e.g., Sweden), became prominent during post-World War II reconstruction efforts. During this period, prefabricated panel construction technology made of reinforced concrete spread across Europe, including the United Kingdom, Hungary, and Germany (Hrabovszky-Horváth et al., 2013).

The prefabricated rate, defined by Liu and Chen (2019) and Du et al. (2019) as the proportion of prefabricated concrete to all concrete in situ combined with precast in a building, is a key metric in this investigation. Furthermore, Du et al.

(2019) and Hong et al. (2016) provide a definition of prefabrication that quantifies both the number of prefabricated components, and all materials used in the construction of buildings employing this method. Prefabricated construction systems consist of materials pre-selected and assembled into an integrated system (Attia, 2018).

While prefabricated construction technologies offer notable advantages, including environmental friendliness and the assurance of compliance with industry regulations, several challenges hinder their implementation. Notably, the limited infrastructure coverage of materials for basic prefabrication in many developing countries poses a challenge. Additionally, prefabricated materials are not widely available in Africa, encompassing the majority of developing countries (Blismas et al., 2006; Dupwa, 2017).

In Africa, the implementation of prefabricated construction and building methods remains inadequate within the construction industry (Kenny et al., 2022). Furthermore, in the context of South Africa, concrete prefabricated panels have been adopted in few constructions of RDP housing units. Additionally, there is few empirical studies in South Africa that focuses on the challenges related to the concrete prefabricated systems in construction of RDP housing units. Therefore, this paper aims to highlight that despite the increasing global adoption of prefabricated construction, South Africa, like many other countries, faces challenges in adequately implementing this technology, particularly in the context of low-cost housing such as RDP units.

2. Research Methodology

The study was founded on an in-depth evaluation of previous and current research on prefabricated construction. To collect responses from construction professionals, a qualitative methodology, was used. Based on their experience, the number of projects they worked on, and the types of projects they worked on, such study participants helped to shed light and offer insights on the challenges of implementing prefabrication technologies in the South African construction industry, particularly on building RDP units. Furthermore, the research was based on books, journal articles, credible online sources, as well as published and unpublished theses on topics related to prefabrication construction.

The method utilized in this study is Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA). The following keywords were formulated to conduct a literature search, which are ‘concrete prefabricated’, ‘prefabricated panel construction technologies’, ‘reconstruction and development programmes (RDPs), and ‘South Africa’. Moreover, from the founded articles, the inclusion and exclusion criteria were applied. Due to few empirical studies conducted in this concept, there was no limitation in the year(s) of the articles. However, the only articles related to the RDPs in South Africa and Africa were considered as the study focuses mainly in South African and African articles were considered to determine the performance of countries in this region.

The considered articles were subjected to screening to determine the suitable papers for this study. The articles were subjected to the screening of titles, and abstract. If the papers’ titles suitable for this study, then the abstract was screened to ensure that the articles align with the objectives of this study. Lastly, the considered papers were synthesized to determine the findings of this study, and the findings were interpreted which led to drawing up the conclusion and recommendations for this study.

3. The Context of Concrete Prefabrication Panel Construction Technologies’ Potential in South Africa

Concrete prefabrication panel construction technology holds significant potential in South Africa for constructing environmentally friendly housing. For instance, incorporating wood chips enhances mechanical characteristics, heat insulation, reduces cement consumption, and minimizes waste (Bourzik, 2022). This innovative approach is actively applied in affordable housing projects, specifically Reconstruction and Development Programme (RDP) initiatives in South Africa. The focus is on assessing the environmental footprint of various prefabricated construction technologies, comparing them with the conventional brick house construction method (Moghayedi, 2023).

While the comparison aims to evaluate the merits of traditional versus modern (prefabrication methods) or a combination of both, the adoption of the latter remains slow and inadequate. Rooted in historical socio-political

circumstances, South Africa, especially the government and the construction sector, needs to thoroughly explore the potential of prefabrication to address the shortage of affordable housing, particularly within the RDP framework (Amoah, 2023).

Research by Van der Watt (2022) reveals that poor construction quality in brick-and-mortar constructions can compromise water resistance, leading to wall fractures. This finding advocates for the use of prefabrication in South Africa, where superior quality prefabricated concrete parts are less likely to fracture, and precast concrete buildings exhibit prolonged water resistance with lower maintenance needs. Researchers, including Saad, Zulu, & Dulaimi (2023) and van Oorschot et al. (2021), recognize the potential for innovation in prefabricated construction technologies, contributing to the sustainability of the construction sector.

Traditional construction methods present challenges in the context of the Reconstruction and Development Programme (RDP) dwellings in South Africa. The need for a large number of houses in a short time clashes with the slow speed of brick-and-mortar construction (Harsch, n.d.). Quality concerns also arise, with beneficiaries expressing worries about structural stability, sagging walls, and roofs (Berrisford et al., 2008). Instances of shoddy construction techniques in RDP projects have been documented, resulting in poor-quality and unsafe dwellings (Amoah, 2023).

The challenges encountered in traditional construction for RDP homes highlight the necessity for alternative building methods, such as prefabricated construction, capable of producing high-quality homes quickly and efficiently. While brick and mortar will always have a place in the construction sector, its limitations become increasingly apparent, particularly in large-scale and low-cost housing projects like the RDP (Kamali & Hewage, 2016).

4. The Challenges in Implementing Panel Construction Technologies in the Building of RDP Houses

First and foremost, it is crucial to emphasise that brick and mortar construction has historically been the most common conventional building method in South Africa and many other regions worldwide (Chang & Swenson, 2020). In discussing the challenges of implementing prefabrication in the construction of RDP housing units, it is essential to acknowledge that traditional brick and mortar building, despite its various advantages, also has certain drawbacks. One of the main disadvantages is the extended construction time, as brick and mortar construction is labour-intensive, requiring skilled masons to precisely place bricks and ensure the structural integrity (Chang & Swenson, 2020). This can lead to prolonged building delays, particularly for major projects. Additionally, dependence on wet crafts like plastering and rendering may cause further delays, especially during adverse weather conditions (Gálvez-Martos et al., 2018).

It is imperative to note that, despite being considered an alternative to brick-and-mortar construction, the rapid and effective implementation of prefabricated construction in South Africa has been slow (Kenny et al., 2023). Prefabrication is still considered a low-adoption form of construction in most emerging economies, including South Africa (Aigbavboa et al., 2018). Various challenges hinder its widespread acceptance, including a lack of promotion and advertisement for prefabrication, limited technological awareness and comprehension, the need for specialised equipment, challenges in obtaining tender bids, a negative reputation, incorrect installation of prefabricated components, high tool expenditures, and clients' reservations about using prefabricated materials (Aigbavboa et al., 2018). The evaluation and promotion of prefabrication, particularly concerning RDP supply, remain unclear, given the historical context described by Amoah (2023), where discriminatory laws in South Africa prompted the first attempts at constructing free, inexpensive, low-cost housing for the impoverished.

Addressing the challenges of implementing prefabrication in the construction of RDP housing units in South Africa, the following key issues can be highlighted:

4.1 Construction Tenders and Procurement-Related Issues

The government's practice of awarding tenders to unscrupulous contractors who use substandard materials for low-cost housing construction is a significant problem (Maluleke, Dlamini, & Rakololo, 2019). Poor-quality prefabricated concrete units have been identified, leading to concerns about the houses' durability (van der Watt, 2022). Issues with

procurement regulations, particularly in integrating prefabrication through the public works department in South Africa, further contribute to the challenges (De Klerk, 2013).

4.2 Lack of Inclination to Technological Acceptance

Resistance to switching from traditional building materials to prefabrication is observed in South Africa, particularly among older generations in the construction sector who prefer traditional low-cost home building methods like RDPs (Kenny et al., 2022). The younger, more technologically knowledgeable generation may be more inclined to endorse and prefer prefabrication construction technology.

4.3 Misinformed Perceptions, Lack of Understanding, and Knowledge About Prefabrication

Public misconceptions and aesthetic stigma surround prefabricated construction, with preconceived ideas about homogeneity and lack of architectural appeal (Kenny et al., 2022). Lack of awareness about prefabricated building and misinformation about its cost-effectiveness contribute to the challenges (Tadelle, 2018).

4.4 Fear of the Prospective Impact of Prefabrication on Employment

Concerns about the potential impact on jobs in the building industry arise due to the inherently less labour-intensive nature of prefabricated construction. While it offers financial savings, there is apprehension about on-site job losses, especially in countries with high unemployment rates like South Africa (Ebekozien et al., 2022).

Therefore, addressing these challenges is essential for fostering the effective implementation of prefabrication in the construction of RDP housing units in South Africa. It requires targeted efforts to educate stakeholders, dispel misconceptions, and develop supportive policies and regulations to encourage the adoption of prefabricated construction technologies.

5. Lesson Learned

Addressing the systemic issues in South Africa's building sector, such as corruption, poor construction quality, and inappropriate home placements, is critical. Prefabrication emerges as a solution capable of producing cost-effective, robust, and durable structures. However, the adoption of prefabrication faces challenges related to societal perception, industry awareness, public opinion, and concerns about costs. To shift the current perception and create a more receptive environment for prefabricated construction, a concerted effort is needed among stakeholders, including the public, government, construction industry professionals, and the industry as a whole.

Drawing lessons from successful implementations in other countries, especially in low-cost housing projects, it is evident that transitioning to prefabrication can lead to significant cost reductions for the government, the primary provider of RDP housing units. Additionally, it can enhance construction quality, reduce wasteful expenditure, increase the durability of housing structures, and contribute to long-term sustainability. These elements are crucial for providing affordable and environmentally friendly housing alternatives.

6. Conclusion

This study has explored the challenges associated with implementing prefabrication in the construction of RDP houses in South Africa. Various issues, including concerns about the potential impact on employment, misconceptions, lack of understanding and knowledge, construction tenders and procurement-related problems, and resistance to embracing technology, were identified.

The research recommends that to increase awareness and comprehension of the advantages of prefabrication, the South African government and the construction sector should allocate funds for marketing and advertising efforts. Furthermore, the exploration of cutting-edge construction models, such as Building Information Modelling (BIM) technologies, is suggested. These technologies can enable construction professionals to utilize prefabricated concrete panels as an alternative building approach in the construction of RDP houses, potentially improving construction productivity and quality.

Future studies on this topic may need to delve into the issue of construction delays associated with traditional construction methods compared to the potentially faster delivery timeline achievable with prefabrication construction technologies.

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