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COMPARISON OF CONSTRUCTION COST OF RESIDENTIAL BUILDINGS IN SRI LANKA: OFFSITE VS ONSITE

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Abstract: Offsite construction (OSC) entails the planning, designing, manufacturing, transportation, and assembly of prefabricated building components at the construction site. As recommended in previous studies, the offsite construction technique can be considered a high-quality and cost-effective construction method that consumes less time and labour while delivering higher productivity. Consequently, it is recognized as a sustainable solution compared to existing onsite structures in countries like Sri Lanka, given the restriction on the availability of resources and high constructional cost. However, this technique is underutilized in the Sri Lankan construction industry, creating a significant void that must be addressed with sufficient cost data and broader access to knowledge regarding the positive impacts of the technique. This research seeks to evaluate current OSC practices together with a comparison of the cost of two similar-natured onsite and offsite residential projects to determine the economic feasibility of OSC in Sri Lanka. The required cost data were extracted through semi-structured interviews with the professionals who engaged in building projects and document reviews. The comparative analysis indicated that beams, columns, masonry walls, and wall finishes (plastering) are contributing to 100% cost-saving in offsite projects compared to onsite projects due to the offsite concrete wall. Further, concrete walls, stairs and ramps, roofs, and floor slab shows 25%, 16%, 12%, and 8% cost saving for the off-site project compared to an onsite project, respectively. Hence, the adoption of off-site elements would enable construction clients and investors to achieve substantial savings in the construction cost of buildings.

Keywords: *Construction cost; Offsite construction; On-site construction; Residential; Sri Lanka.*

1. Introduction

The construction industry has become a major influencer on the economic growth of a country. It has created a strong correlation between per capita Gross Domestic Production (GDP) and the per capita value added by construction (Giang & Sui Pheng, 2011). However, the construction industry is also one of the major energy consumers and a leading source of pollution and waste throughout its life cycle (Soussana et al., 2007). Thus, there has been an increasing focus on research and development of more sustainable construction methods in the wake of the impending energy crisis (Akmam et al., 2017). Throughout its evolution, the construction industry yearned for a better solution to numerous construction planning issues and the imperative need to optimize diverse and conflicting project objectives, such as minimizing construction time and cost while maximizing safety, quality, and sustainability (Kandil et al., 2010). This position has led to suggestions that site-based activities be transferred to a more controlled environment (offsite) as possible. The finished products are returned to the construction site for final assembly and installation as an effective solution (Gan et al., 2018).

Offsite construction (OSC) is a modern and more sophisticated method that offers numerous economic and environmental benefits. The core idea of the offsite technique is moving some effort away from the construction site to a more controlled manufacturing environment (Goodier & Gibb, 2007). The majority of recent researchers have identified that it is an effective and efficient strategy, hence, an ideal alternative to the traditional methodology for the construction industry to meet the upcoming demand (Shakya & Kodur, 2015). The advanced production process in a controlled environment provides multiple benefits, including improvement in construction speed and quality of finished product, and reduction of labour requirements and onsite costs (Mullens & Arif, 2006). All these benefits have led the industry to absorb offsite construction practices (Endzelis & Daukšys, 2018). Despite the rapid shift from conventional to modern offsite techniques in the global context, the Sri Lankan construction sector is yet to adopt OSC (Ramachandra & Uthpala, 2015). According to global researchers, the inadequacy of cost data and information on offsite construction available within the public domain has caused poor public perception, lack of awareness, and cost uncertainty despite its numerous revolutionary benefits (Sutrisna et al., 2019).

An investigation of the adoption of OSC in Sri Lanka reveals a scarcity of statistical data on the economic aspects of its applications (Jayasena et al., 2016), which might be the most common barrier, but also the best incentive if

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managed effectively. To this end, limited research on the financial aspect of the OSC in Sri Lanka can be acknowledged as a research gap. To address this gap, this research aims to compare the construction cost of OSC elements with onsite construction in Sri Lanka.

This paper is structured as follows: initially, a literature review was conducted to examine the current research on OSC, for the identification of research gaps. Accordingly, section 1 gives a brief introduction to the research by highlighting the knowledge gap, research aim, and objectives while section 2 presents the literature on the overview of OSC including its benefits, challenges, and economic considerations. The research methodology adopted for the current study is presented in section 3. Data analysis and findings derived are discussed in section 4. Finally, the paper presents the conclusion of the study.

2. Literature Review

Over the past few decades, the use of traditional techniques in both public and private sectors has made projects specific objectives less achievable, and driven projects far exceed budgets and deadlines (Nanyam et al., 2017). Oti and Abanda (2020) stressed the fact that with the generation of significant waste and greenhouse gas emissions, and consumption of excessive energy compared to other sectors, the construction sector is often criticized for being inefficient. Hence, "sustainable construction" has become a significant factor in recent years. There is a rapid increase in attention towards sustainability because of the heightened awareness of the diverse life cycle impacts of buildings on the environment and society (Kandil et al., 2010). In many government reports, it is stated the need to overcome problems within the traditional construction industry and the solutions adopting innovations based on a modern and more sophisticated technique called "Off-Site Construction (OSC)" as a revolutionary sustainable solution to address these challenges faced by the industry (Abanda et al., 2017).

OSC is a technique where all the prefabricated components and modules are manufactured either on-site or offsite controlled factory environment and then transported, erected, and assembled into the on-site structure (Arashpour et al., 2018). Similarly, Smith et al. (2017) defined OSC as the planning, design, fabrication, and assembly of building elements at a location other than their final installed location to support the rapid and efficient construction of a permanent structure. The use of the OSC technique offers numerous benefits which are described in the following section.

2.1. BENEFITS OF OFFSITE CONSTRUCTION

Cost saving is one of the prime concerns in using the OSC technique. Hsu et al. (2019) indicated that the use of OSC help to save up to 5% to 10% of the total project cost due to a reduction in labour cost with enhanced productivity throughout the whole process. However, Blismas et al. (2011) stated that the OSC technique reduces the whole lifecycle cost of construction including the total cost of construction and the site-related costs.

Time-saving is another main benefit of OSC, compared to onsite construction. For example, a study conducted by Hsu et al. (2018) stated that a 20-module building project could be completed within 12 months using OSC while similar work will take 18 to 20 months when employing conventional onsite procedures. Similarly, Sturzenegger et al. (2012) stated that due to the capacity to manufacture all necessary components in a well-controlled industrial facility and then transport them to the site, OSC has the additional benefit of reducing onsite construction duration. Furthermore, Zhengdao et al. (2017) also underlined the modular structure's capacity to accelerate the design, procurement, and construction phases, and as a result of this innovative technique, the number of operations required is reduced and optimized, potentially saving time while mitigating the adverse effects of weather.

According to Akbarnezhad (2017), overcoming site resource limits for remote malicious sites is an additional advantage of OSC. Without this alternative construction approach, many diverse geographical locations would not be accomplished. Goh and Goh (2019) suggested that prefabricated components, as opposed to onsite buildings, can produce superior quality products. This is accomplished through improved quality assurance and supervision in a well-controlled manufacturing setting, as well as the employment of highly specialized and advanced equipment (Hsu et al., 2019). In addition, Arashpour et al. (2015) reported that OSC improves consistency, quality, and component life while reducing overall costs and defects.

Since most assembly work of OSC is performed in the manufacturing workshop, a higher level of safety may be attained since the industrial environment is conducive to safe practices due to the availability of the necessary materials and equipment (Sharma et al. 2017).

In a situation where the entire planet is concerned about the potential repercussions of construction projects on the local environment and infrastructure, the offsite approaches significantly reduce the environmental impacts compared to the conventional methods (Qian & Jiang, 2018). Experts in the field agree that OSC approaches have significantly decreased environmental and social consequences, making them the most acceptable and sustainable solution for a green future (Simon et al., 2018).

2.2. CHALLENGES AND ISSUES OF OFFSITE CONSTRUCTION

Despite its many benefits, OSC has not been widely adopted. One of the causes is the greater initial costs associated with prefabrication and setup (Zakar-ia & Akmam, 2018). Although OSC was suggested as the most innovative option for future sustainability, there appears to be a reluctance due to the unfamiliar flow of operations, particularly from the contractor side, and hence its cost stream (Blismas & Wakefield, 2006). Housebuilders were reluctant to embrace an "unknown" building method because they were concerned about unfamiliar expenses and cash-flow streams for delivering OSC projects (Wuni et al., 2017).

Friedman et al., (2016) studied 15 Canadian home builders and concluded that prefabrication was roughly 15% more expensive than traditional methods. The reason was attributable to the factory's initial investment and the necessity to recruit employees year-round instead of the conventional approach. Blismas and Wakefield (2006) stated that long-distance transport of prefabricated structures increases design and transport costs. While prefabricated structures appear cheaper than traditional methods, several factors determine the final cost (Smith et al., 2017). On a similar note, Lu (2007) indicated that to evaluate the feasibility of OSC over onsite construction, construction costs, transportation costs, regulatory costs, cost overruns, and time overruns must be addressed (Lu, 2007). However, some experts claim that hidden expenses are not recognized when assessing the total cost of these prefabricated OSC solutions (Wang et al., 2020).

According to Gan et al. (2018), extra materials will be required to support the module's strength, rigidity, and stability during transportation and installation or as a permanent component of the structural frame, as these components are completed as independent units. Additionally, these units may require additional field connections (Wuni & Shen, 2019). Typically, increased supplies are accompanied by additional labor and construction expenses, and all of these factors may significantly raise transportation and logistics considerations (Kamali & Hewage, 2016).

In contrast to conventional procedures, OSC techniques are executed in parallel rather than sequentially, hence increasing the necessity for proper coordination of these interdependent tasks (Banihashemi et al., 2018). Coordination and management of important events, including design and shipping, handling, and installation, are required to keep these expenditures within a manageable range (Mingmin & Haolun, 2010). Poor site accessibility hinders the viability of OSC since it increases the cost of transporting prefabricated components to and within the site (Ahn et al., 2020). Before transferring prefabricated components, their size, construction, their accessibility to the site, and any potential constraints should be considered (Arashpour et al., 2015).

2.3 ECONOMIC CONSIDERATION

Previous studies have evidenced that using prefabrication techniques would result in cost savings in every stage of construction (Lu, 2007). Smith et al. (2017), also believe that prefabrication is touted as being more cost-effective, and contributes to cost savings in terms of material, labour, and time and any reduction in one will mean a reduction in costs. What is missed by Smith et al. (2017), and most of the other researchers but explained by Blismas and Wakefield (2006), is that prefabrication may suffer from an increase in design and transport cost if they are being transported over a long distance implying that although prefabrication appears to be a cheaper alternative to traditional methods. When considered further, many factors determine the overall final cost. However, some scholars say that when estimating the total expense of the prefabricated units of these OSC strategies, there are hidden costs that are not counted (Wang et al., 2020). In terms of economic considerations, construction cost, transportation cost, regulatory cost, cost overruns, cost from the time overruns are the primary components that are discussed below need to be considered for evaluating the feasibility of offsite construction rather than onsite construction (Lu, 2007).

2.3.1 Construction Cost

According to Musa et al. (2015), the cost factors used to evaluate the OSC include the cost of preliminaries, the cost of major construction works, the cost of external costs, continuous funding, and capital investment. Not like in onsite construction, it would be much more essential to evaluate the aforementioned components along with many other required factors before stepping for a choice of offsite construction for a particular project (Meehleis, 2009). Most of the preliminary items will be cost-saving and less testing at the sites, less amount of insurance and quality management procedures are required at the site, less site waste management plans, less amount of staff and welfare clearance, water, electricity, and furniture would reduce the total cost up to a substantial level (Razkenari et al., 2020).

2.3.2 Transportation Cost

Ineffective logistics might incur additional costs as well as severe delays in delivering prefabricated components to construction sites (Martinez et al., 2020). Ahn et al. (2020), suggested that most manufacturers set their fabrication yards in remote areas for cheaper labour and land cost, resulting in longer transportation routes and other difficulties. Further, Razkenari et al. (2020) stressed that during the transportation of prefabricated components, various dynamic effects have to be considered to make the cost overruns and time overruns influence the offsite construction with less impact. Meehleis (2009), articulated that in order to assess the feasibility of offsite construction over conventional construction, transportation costs are very important. Ahn et al., (2020) stated that during the transportation of modular components, various dynamic effects have to be considered to reduce the effects of cost overruns and time overruns. Sajeevan (2020) further elaborated on the importance of transportation costs in offsite construction. There are many factors including the weight, and dimensions of the components, choice of routes for transportation, and necessity of resources to lift and handle the heavy prefabricated components which often play a crucial role in the offsite construction cost.

2.8.3 Site Accessibility

The negative impact due to the poor site accessibility which would add additional costs in transporting the prefabricated components to the site and within the site is also to be noted in deciding the feasibility of offsite construction (Ahn et al., 2020). Hence, the size of prefabricated components, the scale of the structure, and possible restrictions should also be examined and prior measures to be taken before transporting (Arashpour et al., 2015).

2.8.4 Loading and Unloading

The methods and techniques used for loading and unloading are other important factors to be considered by a project manager who is going to manage an offsite construction towards better control of the project within the pre-determined budget (Pan et al., 2012). It is also important to handle these loading and unloading with maximum care and diligence to minimize the risk as their cost component is so high (Ahn et al., 2020).

2.8.5 Regulatory cost

According to Gao and Tian (2020), when it comes to the choice of a suitable construction technique, the regulations prevailing in the country along with the legal considerations as formulated by Hasmori et al. (2020), will be among the most important limitations to be considered. It would also incorporate the rules and regulations for the standard size of the materials and that would finally lead towards the inefficiency in terms of bespoke customization.

2.8.6 Cost overruns

Gbadamosi et al. (2019) emphasized the indefinite returns of innovative integrations to the construction industry since it would be a considerably cost-intensive investment among the kinds of industries. Ambiguity in the concept of cost barrier, lack of cost information on offsite construction, and scarcity of knowledge in reducing the construction cost has been identified as the root causes for the frequent cost overruns (Kumar & Bhattacharjee, 2019). In addition, when it comes to innovative modern type of techniques, it would be much higher due to the unfamiliarity and the lack of skill and experience of labourers as well as professionals who are poor in adapting to a new change withinin a shorter time other than the costs such as transportation damages, onsite fixation damages, intermediary changes in the bespoke customization (Lu, 2007).

3. Research Methodology

The study primarily used a quantitative approach where a preliminary survey was carried out initially to select the most appropriate off-site construction project for the case study. Following that, a comparative analysis of the construction cost of on-site vs off-site was done. The details of these methods are explained in the following sections.

3.1 PRELIMINARY SURVEY

Initially, a preliminary survey was carried out to identify the current practice of OSC in Sri Lanka through a survey into the internet, construction firms, as well as suppliers. Accordingly, it was feasible to find out offsite construction project types, and their purposes. The summary of identified cases is illustrated in Table 1 and further discussed in the following sections.

Table 1: OSC application in Sri Lanka

OSC Type / **Purpose**	**Steel Building Constructions**	**Container Box Conversions**	**Precast Concrete Buildings**
Warehouse	3		
Factory	4		
Hotel		5	
Houses		3	
Apartment			2
Hospital		2	
Office		1	
Showroom		1	
Solar Power Station		1	
Hostel			1
Total	**7**	**13**	**3**

As observed in Table 1, among the identified projects, steel building construction seems to be widely used in the manufacturing industry for warehouses and factories. In terms of container box conversions, there seems a substantial tendency for this modern technology to be used in most of the upcoming construction projects such as hotels, houses, hospitals, and office buildings. However, the OSC technique incorporated in steel building construction and the container box conversions were not even up to 60% of the total work done. According to the opinions of the respondents and all other investigations and inquiries, it was revealed that there are three offsite precast concrete constructions in which at least more than 50% of work is done offsite.

3.2 CASE STUDY SELECTION

As observed in Table 1, of the three precast concrete constructions, two were apartment buildings and one was just a small portion of a university hostel building. To ensure the reliability and accuracy of the research findings, among the apartment buildings, the one that is with substantial scale has the highest number of units, to be compared with an onsite project was chosen.

When selecting the onsite project, location, purpose, building shape, size, and other similar factors that could affect the cost behaviour were considered closely equal to that of the offsite project where possible, to ensure the effective comparison and thereby accuracy of the research results. Based on the aforementioned factors, an onsite project was selected and project details are presented in Table 2.

Table 2: Project details of the selected Offsite and Onsite buildings

	Offsite (Case A)	Onsite (Case B)
Type of building	Residential	Residential
Project location	Colombo	Colombo
Project duration	36 Months (2018-2021)	48 Months (2017-2021)
National Grading of the Contractor	CS2	CS2
Method Used	Sub-Assemblies (Offsite Construction)	In-situ Construction
Foundation	Raft Foundation	Pile Foundation
No. Floors	4	8
Gross Floor Area per floor	820 m^2	1520 m^2
No of building units	8	6
GFA of total building	26,240 m^2	72,910m^2
Height of a floor	2.8 m	3 m
Project cost (Rs.)	3,440 MN	13,282 MN
Cost per GFA (Rs/m2)	0.13 MN/m^2	0.18 MN/m^2

After the selection of suitable cases, the required data for the comparative cost analysis was collected by referring to documents including Bills of Quantities (BoQ), drawings, and log books. The analyses performed on the collected data are presented in the following sections.

4. Data Analysis and Findings

Within this section, the economic feasibility of OSC (Case A) is analysed in comparison to a similar type of onsite construction (Case B), in terms of elements that were constructed off-site. In any construction project, certain parts of the construction are essential to be done with in-situ methods. So even if it is an offsite project, there would be no difference in executing such elements compared to the onsite methods. Hence, such cost elements have been purposely excluded in this calculation and the analysis since they do not count for the cost difference between offsite and onsite constructions. Accordingly, substructure, doors and windows, fittings and fixtures, and services were excluded from the comparative analysis.

In order to compare the cost of OSC and onsite construction, the unit cost of each off-site element was derived by dividing the total cost of each element by the volume/area of the particular component or element. Table 3 illustrates the unit cost of elements in both offsite and onsite projects.

As observed in Table 3, beams, columns, masonry walls, and wall finishes (plastering) are contributing to cost-saving in offsite projects. Concrete walls in off-site projects serve the collective functions of beams, columns, and masonry walls. Thus, the cost of beams, columns, and masonry walls was considered a saving against on-site construction. Similarly, the cost of wall finishes (plastering) was offset by the precast elements.

Table 3: Cost comparison of offsite Vs onsite elements

Element	**Unit**	**Unit Cost (Rs)**		**Specifications**	**Off-site element cost impact**
		Offsite (Case A)	**On-site (Case B)**		$\frac{\textbf{Case A} - \textbf{Case B}}{\textbf{Case B}} \times \mathbf{100\%}$
Superstructure					
Beams	per m³	**The functional requirements of all these elements have been fulfilled through precast concrete walls.**	100,672.89	* R/F Concrete, grade 30	-100%
Columns	per m³		118,177.21	* Columns 200x300, 2800mm	-100%
Masonry Walls	per m²		2,663.69	* 100mm Block wall	-100%
Masonry Walls	per m2		***4,068.23***	**** 200mm Block wall***	**-100%**
Wall Finishes-plastering	per m²		969.12	* Internal wall plaster 1:5 cement sand mortar	-100%
Floor Slab	per m³	41,607.33	45,426.72	#* R/F Concrete, grade 30	-8%
Roofs	per m³	44,599.55	50,587.08	#* R/F Concrete, grade 30	-12%
Stairs And Ramps	per floor	215,880.97	255,525.37	#*R/F Concrete, grade 30	-16%
Walls – Concrete	per m³	19,508.16	26,055.24	# Both 100mm and 140mm * Self-compacting concrete grade 35	-25%
# Specifications for offsite (Case A) * Specifications for onsite (Case B)					

The cross-case analyses performed on each element are presented below.

4.1. BEAMS AND COLUMNS

The onsite project consists of non-load-bearing masonry block walls that act as the external walls or internal partitions of the building. So, it is essential to have the reinforced concrete beams and columns in case B, the onsite project. However, in the case of A, the offsite project, the reinforced concrete wall panels are being used as load-bearing walls to the structure. Hence, there are no requirements for beams or columns in case A and that would contribute to a substantial cost-saving as well as time-saving to the project. Otherwise, those columns would have to be built up first and then erected walls once they cured. And most advantageously, these precast concrete walls can be built up as a stock and keep them ready for fixation even before other works are executed.

As shown in Table 3, the unit cost of beams and columns is Rs. 100,672.89 per m3 and Rs. 118,177.21 per m3 respectively, in the case of B while there is not any cost for the beams and columns in case of A, offsite project. But still, it is not convenient to conclude that offsite is less costly without comparing the cost of concrete walls in case A.

4.2 FLOOR SLABS

Even though, generally, these kinds of elements are analysed in relation to square meters, when it comes to this particular analysis, a comparison with cubic meters is considered more rational. The unit cost of floor slabs in case B is Rs. 45,426.72 per m^3 while the same in case A is Rs. 41,607.33 per m^3. So, in terms of unit cost, the cost in case A is lower than case B and shows an 8% saving in off-site elements over on-site construction.

4.3 ROOF SLAB

The cost of the roof slab was calculated similarly to floor slabs. Accordingly, there is a difference, saving 12% in off-site construction over on-site. The onsite cost is Rs. 50,587.08 per m^3 while the offsite cost is Rs. 44,599.55 per m^3.

4.4 STAIRS CASES AND RAMPS

Generally, there is a tendency to construct staircases with precast concrete panels in most of the onsite constructions. The respondents of both offsite and onsite projects also indicated that precast staircases would result in cost-saving most of the time. The unit cost values derived from the calculations confirmed it. The cost of onsite and offsite projects was Rs. 255,525.37 per floor and Rs. 215,880.97 per floor, contributing to a 16% saving due to the off-site construction of staircases.

4.5 WALLS

As mentioned in section 4.1, beams and columns, case B is comprised of non-load bearing masonry walls with the sizes of 100 mm and 200 mm, and the cost of those two were Rs. 2,663.69/m^2 and Rs. 4,068.23/m^2, respectively.

When it comes to case A; offsite construction, there were no non-load bearing masonry walls as discussed earlier, and the cost of concrete walls was Rs. 19,508.16/m^3. This cost would counterbalance the cost of columns and beams. Thus, there is a substantial saving of cost of Rs. 118,177.21/m3 for columns and Rs. 100,672.89/m3 for beams. Further, there is some kind of a cost for the masonry walls as well and it could be noticed that the concrete walls with self-compacting features along with a higher grade would cost a lot when compared with the general concrete walls of grade 30.

Most importantly, when considering these precast wall panels, there are some allowed spaces inside them to pass the electric lines, small water lines, and other related service lines. This has been more advantageous as it avoids the labour and time taken for constructing chases for the service lines and saves much effort. Along with this special design, it also reduces material usage to an optimum level.

4.6 INTERNAL FINISHES

Among the types of internal finishes; wall finishes (plastering), floor finishes, and ceiling finishes, the plastering of offsite concrete panels is not required due to its high-quality finish gained by the concrete itself. All finishing types except plastering would basically depend on their specification and the brands and prime cost sums already determined by the client or by both parties. Therefore, there would not be any difference in the cost of the two methods, onsite and offsite.

Among the major advantages of offsite construction, this is crucial as it allows a lot of time, material cost, and labour saving to the project.

So, the amount spent on plastering has been a huge saving for the off-site project, case A. According to the equation for offsite element cost impact used in Table 3, positive impacts are savings to the onsite building whereas negative impacts are actual savings to the building which has the offsite elements. As seen in Table 3, all off-site elements result in cost-saving. Beams, columns, masonry walls, and wall finishes (plastering) are 100% cost-saving to the offsite projects compared to onsite projects due to the offsite concrete wall. In addition, concrete walls, stairs and ramps, roofs, and floor slab shows 25%, 16%, 12%, and 8% cost saving for the off-site project, respectively.

5. Conclusion

The study revealed that OSC is an advanced option in the modern construction industry, primarily in terms of cost-effectiveness. As a developing country, Sri Lanka has adopted the OSC technique in a few cases. However, the early adoption of OSC, even to a smaller extent, like steel building and container box conversions, within the Sri Lankan construction industry can be considered noteworthy. However, Sri Lanka still faces considerable barriers to transportation, technology, and skill shortage.

The offsite construction project considered in this study could save the costs of superstructure elements like beams, columns, masonry walls, and wall finishes (plastering) with the use of pre-casting. According to constructors, it also provided the advantage of higher productivity through producing precast stocks. The precious and high-quality design of precast walls must be highlighted mainly due to the allowed spaces for electricity and water lines, which was highly effective in saving time and labour while ensuring optimum material usage. Yet, OSC has a few disadvantages like less customizability and the requirement of highly detailed planning before pre-casting. However, offsite construction can provide an overall advantage to the construction industry in Sri Lanka, considering its higher economic feasibility.

This research study provides evidence for construction developers on the economic feasibility of off-site construction with regards to construction costs and re-shape the offsite construction to deal with the effect of higher economic benefits. It is recommended to develop a costing strategy to include the cost savings in off-site construction compared to conventional construction. The developers can be encouraged to look into a cost-benefit analysis in terms of all three sustainability pillars: social, environmental, and economic aspects rather than confining to economic aspects.

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