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## STUDY ON MODERN METHODS OF CONSTRUCTIONS USED IN SRI LANKA

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**Abstract:** With the end of world war two, the demand for building construction increased together with inadequate supply of traditional constructions. To cater the increased demand the modern methods of constructions (MMC) came to practice as it yields high quality and less construction time. Nowadays the off-site MMC play a significant role in construction industry worldwide in terms clients' fundamental needs by restraining problems in traditional brick, block constructions. However, the application of MMC seems limited and few building constructions have used MMC in the Sri Lankan construction industry. This research therefore aims to explore current practice of off-site MMC in Sri Lankan construction industry and identify the barriers in adopting MMC.

Questionnaire survey has been carried out among 33 respondents including engineers, quantity surveyors and project managers to identify the applicability of off-site MMC and barriers in using off-site MMC. Data which have been gathered through the questionnaire survey have been analysed through statistical analysis and investigated that volumetric constructions are mostly used for single storey temporary buildings, hybrid constructions are mostly used for single storey office and temporary buildings while panelised constructions are highly used for single storey industrial and temporary buildings and sub-assemblies are mostly used single storey office and commercial buildings. Furthermore main barriers in implementing all above mentioned methods are public perception and poor awareness.

**Keywords:** Hybrid construction, modern methods of construction, Sri Lanka, volumetric construction.

### 1. Introduction

Construction, a cannonading industry is performing a vital role in rapidly growing global economy. In Sri Lanka, construction projects are facing different problems as the industry is labour intensive and wet trade. Off-site Modern Methods of Constructions (Off-site MMC) has been found as a solution to these problems [7]. But the practice of off-site MMC are very less in Sri Lankan construction industry. Therefore this paper focuses to identify the current practice of off-site MMC and the barrier in the construction industry to uplift the usage of off-site MMC.

### 2. Modern Methods of construction

MMC, which was originated in the United Kingdom used as a common term for both

off-site methods of construction and on-site methods of construction [4]. The off-site MMC are prefabricated elements or parts of structures which are transported and assembled on-site even though they are manufactured in a factory. Off-site MMC includes categories of component and subassembly, non-volumetric pre-assembly and volumetric pre-assembly [2]. Moreover off-site MMC can categorized as, modular building, hybrid construction, panelised construction and pre-assembly [1]. However following classification is considered for this research as it can be separately identified in Sri Lankan industry:

- Volumetric construction: volumetric constructions include two categories modular constructions and pod constructions. Modular construction comprises of prefabricated room-sized volumetric units that are normally fully fit-

out while manufacture and are installed on-site as load-bearing “building blocks” [5]. Pods are small volumetric rooms which are completed using light steel frame, timber, concrete or glassed reinforced plastic built in factories and finally set in building site [6]. These are usually used in washrooms, bathrooms and kitchens [9].

- **Hybrid construction:** Hybrid constructions are integration of volumetric units and panelised system. These are also named as semi-volumetric systems. If highly serviced areas such as kitchens or bathrooms can be constructed as volumetric units and rest of the dwelling constructed with panels, they are called as hybrid constructions [9].

- **Panelised construction:** Panelised constructions are flat panel units which are built in a factory and transported to site for assembly into a three dimensional structure or to fit within an existing structure. Systems can include wall, floor and roof panels to create the complete structural shell [9].

- **Sub-assemblies & accessory system:** This include larger components that can be incorporated into either conventionally built or MMC dwellings. These items are not full housing systems and are generally factory made [9].

## 2.1 Barriers in implementing off-site MMC

The use of off-site MMC has been limited in the construction industry due to main aspects:

- **Cost:** Off-site constructions are 7% to 10% costly than traditional constructions. High quality of off-site MMC and faster construction are responsible for the increased cost [8].
- **Industry capacity:** The shortage of skilled workers and factory capacity to manufacture parts have hindered the usage [8].
- **Public attitudes:** most of the public prefer to have traditional brick block constructions over off-site MMC [8].

Moreover logistics also can be identified as a barrier.

- **Issues in logistics:** transporting fully manufactured houses or partially completed modules is complex, costly, and very difficult [1].

In additionally lack of awareness among public and poor technology are also key barriers [3]. Synthesizing the views cost, public perception, poor awareness, poor technology and capacity of the industry have influenced the limited use of off-site MMC in the industry.

## 3. Methodology, Data collection and Analysis

The data was gathered using questionnaire survey administered to investigate

- Applicability of off-site MMC in Sri Lankan construction industry and
- Barriers in Sri Lankan construction industry acting on each off-site MMC

Even though professionals in construction industry is high, knowledgeable professionals on this area is difficult to find. Therefore data was corrected from quantity surveyors, engineers, project managers who have involved in at least one off-site MMC used project. In proper recording of constructions companies which are using off-site MMC and limited practice resulted difficulty in identifying the population size. Therefore 33 number of professional having different professional backgrounds had been selected as sample through non-probability convince sampling technique. Data was collected directly as well as via electronic mail.

### 3.1 Rate of response

Out of the forty eight approached, only thirty three responded to the questionnaire. This yielded 69% response rate.

### 3.2 Demographic Characteristics of Respondents

The respondents could be categorized as follows based on their professional background as well as their experience on off-site MMC projects.

Table 1: Professional background

Table 1 presents the participants' professional background and demonstrate that the largest group of respondents were Engineers while others include only 6 quantity surveyors and 8 project Managers.

Professional Background	Number	(%)
Quantity Surveyors	6	18%
Engineers	19	58%
Project Managers	8	24%

Moreover respondents were asked about their experience on off-site MMC used projects based on the number of years they had worked in prefabricated building sector. In terms of no of experience 55% had worked in MMC related projects 5-10 years while 33% have less than 5 years' of experience and 12% have more than 10 years' experience as shown in Figure 1.

### 3.3 Applicability of off-site MMC in Sri Lankan construction industry

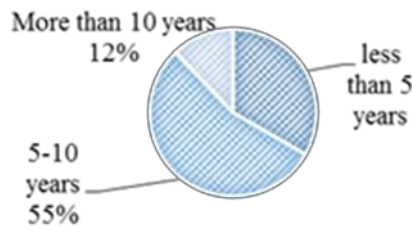


Figure 1: Experience of respondents

All the respondents are asked to respond on the applicability of off-site MMC in Sri Lankan construction industry. According to the responses which are shown in Figure 2, 82% of the respondents have given their response that volumetric constructions are used in temporary buildings and 76% of them have responded that volumetric constructions have been used in residential constructions. Moreover 73%, 64%, 58% and 6% have responded that volumetric constructions are used in commercial, industrial, offices and other buildings sectors respectively.

As per the responses volumetric constructions are mostly used for temporary buildings, residential buildings and commercial buildings. Reason for the high usage in temporary building sector is temporary buildings have small scales. It is difficult to transport the units for large scale constructions because of the traffic jam and the road width.

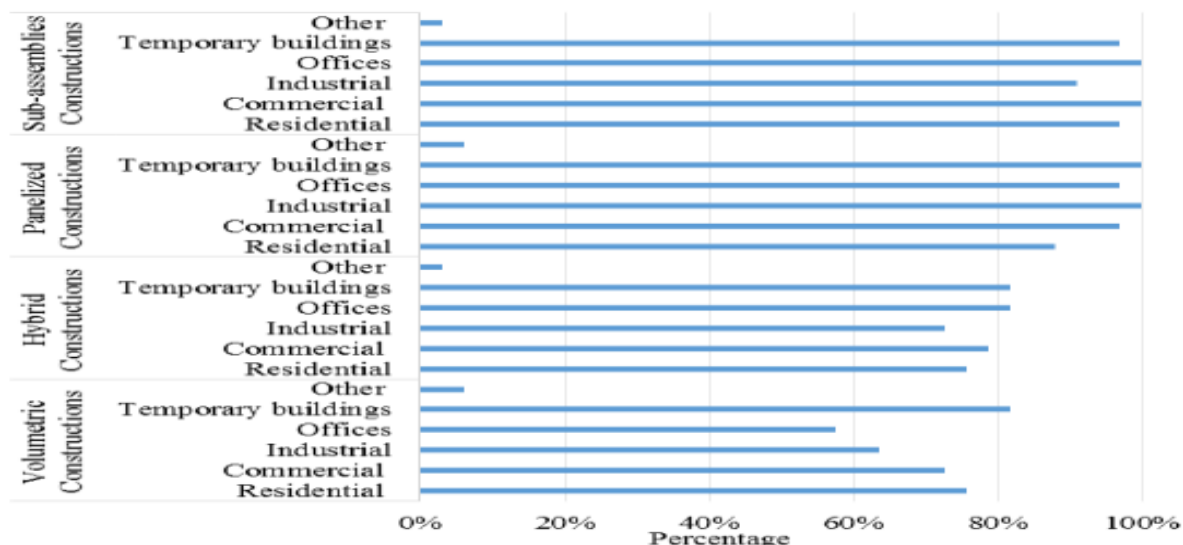


Figure 2: Applicability of off-site MMC in Sri Lankan Construction industry

Therefore for small scale building projects volumetric constructions are mostly used. According to the collected data shown in Table 2, in temporary building sector volumetric constructions are used to build single storey building and 2-11 storey buildings. 27 of the respondents have responded that volumetric constructions are used in single storey temporary buildings and 3 of the respondents have stated that they are also used in 2-11 storey buildings. Even though the category is 2-11 they are not used in more than three storey buildings. Furthermore 25 respondents have stated that volumetric constructions are used in residential buildings and 7 have responded as volumetric constructions are used in 2-11 storey buildings. In additionally 1 has responded that volumetric constructions are used in more than 12 storey residential buildings. In commercial sector it have been responded that 24 respondents to single storey commercial buildings, 6 respondents to 2-11 storey buildings and any of the respondents have not stated that they are used in more than 12 storey commercial buildings.

Table 1: Applications of volumetric constructions

Sector	Scale of the building	Frequency
Residential	Single storey	25
	2-11 storey	7
	More than 12 storey	0
Commercial	Single storey	24
	2-11 storey	6
	More than 12 storey	0
Temporary buildings	Single storey	27
	2-11 storey	3
	More than 12 storey	1

According to Figure 2, 82% of the respondents have responded that hybrid

constructions are used in temporary buildings and office buildings. 79% of the respondents have stated that are used in commercial buildings and 76% and 73% respondents have responded that hybrid constructions are used in residential and industrial sectors respectively. Moreover 3% of the respondents have responded that hybrid constructions are used in other sectors than above mentioned sectors. According to the responses hybrid constructions are mostly used in temporary building and offices.

As shown in Table 3 hybrid construction are practiced in single storey offices and temporary buildings as well as 2-11 stories buildings. According to the responses, 27 of the respondents have responded that hybrid constructions are used in single storey offices and single storey temporary buildings and 17 and 6 respondents have said that hybrid constructions are used in 2-11 stories buildings in commercial and temporary buildings respectively. In industrial buildings usage of hybrid constructions have been marked as 24 for single storey and 16 for 2-11 storey buildings.

Table 3: Applications of Hybrid constructions

Sector	Scale of the building	Frequency
Commercial	Single storey	26
	2-11 storey	17
	More than 12 storey	0
Offices	Single storey	27
	2-11 storey	17
	More than 12 storey	0
Temporary buildings	Single storey	27
	2-11 storey	6
	More than 12 storey	0

As per the Figure 2 respondents have responded that panelised constructions are used in industrial and temporary building sector the most. All of the respondents have

marked that panelised constructions are used in industrial and temporary building sector. 97% of the respondents have given their response that panelised constructions are used in commercial and offices. 88% of the respondents have responded that panelised constructions are used residential sector and 6% of the responses have been given that it has been used in other sectors rather than residential, commercial, industrial, offices and temporary buildings. Therefore panelised constructions are mostly practiced in industry building sector and temporary buildings sector. Reason for this higher usage can be identified since most of the factories and warehouses are constructed with steel panels. Because of the easiness in construction and usage.

Table 2: Applications of Panelized constructions

Sector	Scale of the building	Frequency
Industrial	Single storey	33
	2-11 storey	20
	More than 12 storey	5
Temporary buildings	Single storey	33
	2-11 storey	9
	More than 12 storey	0

According to the responses given by the respondents, shown in Table 4 panelised constructions are mostly used in single storey industrial and temporary building sectors. 20 and 9 respondents have responded that panelised constructions are used in 2-11 storey buildings in industrial and temporary building sectors respectively. 5 respondents have identified panelised constructions are used for more than 12 storey industrial buildings.

According to the Figure 2 subassemblies are mostly used in commercial and offices. They have 100% equal usages. 97% has responded that sub-assemblies are used in residential and

temporary building sector. 91% and 3% have been responded that sub-assemblies are used in residential and other sectors respectively. Tables, figures and equations should be provided as appropriate and as indicated in this document.

As shown in Table 5, commercial sector and office buildings sector all the respondents have given that sub-assemblies are used in single storey buildings. 24 respondents have answered in commercial sector sub-assemblies are used in 2-11 storey buildings, 6 respondents have answered that they are used in more than 12 storey buildings in commercial sector. Moreover 11 respondents have answered that for 2-11 story office buildings are also construct with panelised constructions. 5 respondents have responded that they are used in more than 12 storey buildings.

Table 3: Applications of sub-assemblies constructions

Sector	Scale of the building	Frequency
Commercial	Single storey	33
	2-11 storey	24
	More than 12 storey	6
Offices	Single storey	33
	2-11 storey	11
	More than 12 storey	5

### 3.4 Key barriers in implementing off-site MMC methods in Sri Lanka

As per previously described heading off-site MMC are not used in all scales in all sectors of Sri Lankan industry. Therefore usage of off-site MMC is limited in Sri Lankan industry. Limitations or the barriers of implementing each off-site MMC is identified through this heading. In order to fulfil this requirement respondents are requested to mark the barriers in each sector and using MS Excel following graphical representations have been formed.

### Barriers in implementing volumetric constructions

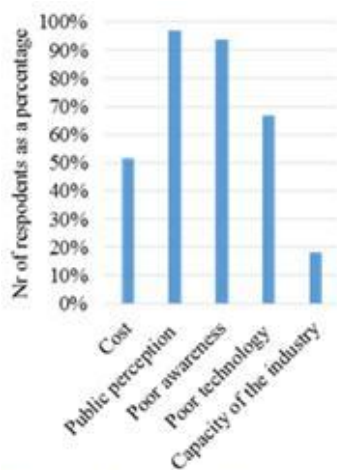


Figure 3: Barriers in implementing volumetric constructions

The professionals' responses on barriers to implement volumetric constructions in Sri Lankan industry is depicted in the following Figure 3.

As per the responses 97% of the professionals have identified public perception as a barrier in implementation of volumetric constructions in Sri Lankan industry. 94%, 67%, 52% and 18% of professionals have identified that barriers in implementing volumetric constructions in Sri Lankan industry as poor awareness, poor technology, cost and capacity of the industry respectively. According to the results volumetric constructions are limited highly in Sri Lanka because public is not well knowledgeable about this method.

### Barriers in implementing hybrid constructions

As per the responses of the professionals on barriers to implement hybrid constructions in Sri Lankan industry is depicted in the above Figure 4. 100% of the respondents have identified that poor awareness about hybrid construction as a barrier to implement hybrid constructions in Sri Lankan construction industry. 91% of the respondents have identified that public perception is a barrier and 36%, 24% and 12% have identified poor technology, cost and capacity of the industry respectively as barriers in implementing

hybrid constructions in Sri Lanka. As per the responses it can be identified that less awareness on hybrid constructions is the main reason for less usage of this method.

### Barriers in implementing panelised constructions

The respondents' opinions about barriers of implementing panelised construction is depicted in above Figure 5. 100% of the respondents have identified that poor awareness about panelised constructions as a barrier to implement panelised constructions in Sri Lanka. 85% of the respondents have identified that public perception as a barrier. 30%, 12% and 6% of respondents have identified poor technology, cost and capacity of the industry respectively as barriers in implementing hybrid constructions in Sri Lanka. Therefore main barrier acting on panelised construction is poor awareness.

### Barriers in implementing sub-assemblies constructions

The professionals' responses on barriers to implement sub-assemblies constructions in Sri Lankan industry is depicted in the above Figure 6. 94% of the professionals have identified poor awareness as a barrier in implementation of sub-assemblies constructions in Sri Lankan industry.

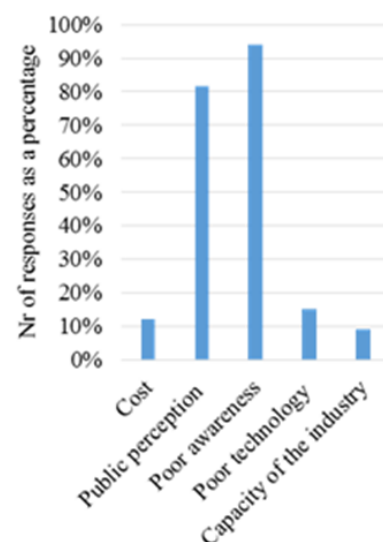


Figure 6: Barriers of implementing sub-assemblies constructions



82%, 15%, 12% and 9% of professionals have identified that barriers for implementing volumetric constructions in Sri Lankan industry as public perception, poor technology, cost and capacity of the industry respectively. Accordingly poor awareness is the key barrier which limited the practical applicability of sub-assemblies.

#### 4. Conclusions

Traditional constructions are facing difficulties with less labour and limited time. Off-site MMC can be identified as an emerging solution for difficulties which a construction client face because of the traditional construction methods. But in Sri Lankan construction industry the practice of off-site MMC are lesser than the other countries. Therefore this research is conducted to find out the current practice and barriers to implement off-site MMC in Sri Lankan industry. Through the research it has been identified that volumetric constructions are mostly used for temporary building construction as the transportation issues as the units are difficult to handle. Hybrid constructions are mostly used in offices and temporary building according to the professional responses. Moreover panelised constructions are mostly used in industrial and temporary building construction as the warehouses and factories can be easily made out of steel panels. Sub-assemblies and accessories are mostly used in commercial and offices and its' usage in other sectors such as residential, industrial, temporary buildings are also more than 95%. As per the responses of the professionals volumetric constructions are limited in Sri Lankan industry mainly because of the public perception. As identified through the research volumetric constructions are used in Sri Lankan industry in the type of container houses. Therefore the knowledge of the public on these area is grey. Therefore the usage is limited. Same as volumetric constructions, hybrid constructions, and panelised constructions and sub-assemblies

constructions are also limited due to poor awareness and the poor public perception. Therefore in order to increase the usage of off-site MMC the public perception and awareness have to be made positive.

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