The analysis of differentiation Between Prefabrication and Modular Construction

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Abstract: Prefabricated construction and modular construction have been developing many years, and most of the stakeholders agree that both of them have provided a significant improvement to schedule, productivity, quality, safety performance waste-reducing in Architecture, Engineering and Construction (AEC) industry. This study will illustrate the differentiation between modular construction and prefabrication construction from various perspectives, i.e. impact of BIM implementation, influencing factors as well as performance between prefabrication and modular construction.

1. INTRODUCTION
At present, prefabrication construction is one of the most innovative construction since many advanced features, such as eco-friendly mode, the waste produced from these constructions can be recycled in the manufactory itself. There is very little site disruption since almost entire structure materials are created in the factory and transported to the construction site. Due to its simultaneous construction work on site and off site, much lesser time is took compared to traditional construction (Chen J. H., Yang. L. R., Tai. H W, in 2016). Therefore, it is also a cost-effective form of construction.

Although modular construction and prefabrication are quite similar since both are the type of offsite construction, a factory-based process, building components are produced inside the factory and transported to the construction site (C.Z. Li et al, in 2017), they are not the same thing. All modular buildings are prefabricated buildings, but not all prefabricated buildings are modular structures. This study will focus on the differentiation between general prefabrication and modular construction from various perspectives, i.e. frequent building types, the impact of schedule performance, BIM implementation for model-driven, top factors influenced the use and top positive impacts.

2. LITERATURE REVIEW
Prefabricated construction indicate that the production of precast panels and modules inside a factory with stable environment. There are many different types in prefabrication projects such as Modular structure construction and panelized construction, which have different features.

General prefabricated construction needs to lay the foundation and the floor first. Once these are in place, appliances may be added—or staircase. Then, each completed wall will be lowered and installed.

Panel construction will be an excellent example to represent another type of precast projects compared to modular construction when offices and other commercial structures are being built. A panel construction project will have priority to be chosen since this type of construction can acquire higher level of openness inside buildings (H. Liu, B. Holmwood, C. Sydora, G. Singh, M, 2017).
Modular construction is assembled through different kinds of materials, like cold-formed steel framing, timber frame, as well as hot rolled steel. Modular construction always apply an inside-out method to assemble a building. Modular components are produced and fitted in the boxes, and then completed from the inside out. At present, modular construction most frequently adopted type in prefabrication projects as much lesser time and higher quality performance gained compared to traditional alternatives (M. Kamali, K. Hewage, 2016).

Modular constructions are built out of pre-assembled modules, which can be visualised as completed rooms assembled. This method of construction offers tremendous adaptability. Modular construction can consist of just one unit, or be assembled in any orientation. Rooms can be added or removed at any time (Lacey, A. W. et al, 2017).

Therefore, modular construction will be separated from prefabrication projects to collect relevant information about the schedule performance, productivity and so forth to discover the differentiation between modular construction and prefabrication projects(Li, G.Q. Shen, X. Xue, 2014.).

3. METHODOLOGY
To support this study, a mixed qualitative and quantitative method of literature study, questionnaire survey, interviews will be engaged to collect information.

3.1. Literature review
An extensive literature study in the current circumstances of prefabrication and modular construction will be carried out, containing articles, publications, and reports. Selected literature would contain the field of most frequent building types, impact of schedule and BIM implementation in prefabrication and modular construction projects. The objective is to develop the breadth and depth knowledge of the differentiation in the modular construction and prefabrication industry.

3.2. Questionnaire survey and interview
Questionnaire survey will be established and distributed to professionals in the prefabrication and modular construction industry about the differentiation identified in the literature review. This method has a simple, direct, efficient and low-cost characteristic to acquire the answers of the research question. However, the main problem would be a low response rate with ambiguous answers. Therefore, the interview would be carried out to complement these disadvantages. Semi-structured interviews will be carried out to professionals in the modular construction and prefabrication industry to enable a more in-depth investigation of differentiation through professional insights.

4. DISCUSSION
4.1. Frequent building types for modular construction and prefabrication
Based on the collected data from the literature and questionnaire survey, which building types have been frequently used for prefabrication projects in the last three years has shown below in chart 1. In among, healthcare facilities top the list about 40% of manufacturing buildings take the second position, about 27% and followed by the offices low-rise, commercial warehouses and multifamily residential buildings occupied about 26%.
In contrast, most frequent building types for modular construction is different from prefabrication. Multifamily types took the leading position, about 34% and followed by the hotels and motels about 29%.

To sum up, simple structural and functional building occupies higher market proportion in modular construction compared to prefabrication industry due to its technical features, i.e. low self-weight, suitable for buildings with multiple repeated units, and low-rise buildings (X. Cao, et al, 2015). Therefore, multifamily, hotels and motels take significant possession of market share.

4.2. Impact of schedule and cost performance:
Compliance with the project schedule is one of the most critical metrics in the AEC industry. This comparison between prefabrication and modular construction would illustrate the positive impact on the schedule (T. Holden, J. Restrepo, J.B., 2003.). As shown in chart 3 and 4 below, the percentage of schedule performance improvement has been separated into three sections, more than 10%, between 6-9% and lower than 5%.
Since modular construction is even more suitable for projects with site constraints and independent of weather condition compared to other prefabricated projects, most of the modular construction can shorten the project schedule performance.

4.3. BIM implementation for model-driven

Most of the respondents state that BIM has been deployed on their ongoing projects. Chart 3 below states the percentages of BIM that are operating with model-driven prefabrication and modular construction at different levels of adoption, and the percentages which will be engaging at the next three years.
Chat 4: BIM implementation in modular construction

By comparing the BIM implementation for model-driven in current and next three years, it shows the percentage using BIM for prefabrication and modular construction on at least a quarter of the projects will enhance dramatically in the next three years. Besides, all BIM users (99%) will be applying in model-driven projects.

4.4. Top factors influenced use
The level of influence rate has been asked through a questionnaire survey and interview. Relevantly collected data have been interpreted into chart 5 below to illustrate the top six influence factors to prefabrication and modular construction projects.

Chart 5: top factors influence
According to chart 5, productivity and workforce shortages are the most effective factors on modular construction compared to prefabrication projects in the last three years.

4.5. Top positive impacts

To understand the future expectations of the shareholder in the AEC industry, the most positive impacts are analysed and indicated in chart 6 to assist the AEC industry to develop.

![Chart 6: top positive impacts on prefabrication and modular construction](image-url)

As with the findings for modular construction and prefabrication, project schedule performance are the top future driver followed by the decreases construction cost.

5. CONCLUSION:

This study has acquired perspectives of the most recent circumstances and trends in the next three years through comparing prefabrication and modular construction projects. Based on the collected data, building types, impact of schedule and BIM implementation, top positive factors are analysed to illustrate the differentiation, which would enable a more in-depth understanding of the situation to improve prefabrication industry through professional insights. However, there is still some limitation existing in this study. Firstly, the scope of this study is only focused on the US construction industry since its prefabrication industry is relatively mature with reliable data. Secondly, most of the respondents are general contractors and construction managers, which are not comprehensive enough to indicate the differentiation precisely. Therefore, future research is suggested to solve the limitation of this study.

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