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A Review on the Critical Success Factors (CSF) Influencing Modular Integrated Construction

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Abstract: *By sending some of the work done on-site to fabrication facilities, modularization, a new emerging approach, can improve the construction industry. Yet, there are few uses for it in the sector. To achieve higher degrees of modularization, the Engineering, Procurement and Construction (EPC) business needs new strategies. The goal of this study is to ascertain what modifications to the current EPC procedures are required to establish the ideal conditions for a wider and more efficient application of modularization. The success criteria must be understood in order to create such an atmosphere. The success factors are to be obtained from various reputed journals. With the addition of CSF enablers, a research team with expertise in this area created a comprehensive list of the most important critical success Factors. CSF enablers are extra measures that can help.*

Keywords: Critical Success Factors (CSF), Modular integrated Construction (MiC)

I. INTRODUCTION

Pre-fabricated homes or buildings are known as modular buildings. They are made up of numerous, independently repeated pieces, or "modules." The process of building the modules or parts off-site and bringing them to the construction site is known as modular construction. In contrast to regular or traditional construction methods, modular construction has many advantages. With modular construction, we can reduce the risks and produce work of a higher calibre. Because time and money are interrelated, modular building will lure people in that direction. The well-established method can boost the construction industry's production and efficiency. The importance and advantages of modularization have been generally acknowledged since its inception. Benefits include less capital expenditures, enhanced productivity, better scheduled performance, higher overall quality.

II. ADVANTAGES OF MODULAR CONSTRUCTION

Modular construction provides various advantages when compared to traditional construction methods. The prefabrication of building components offsite allows for parallel processing, reducing construction time and labor expenses. The controlled factory environment ensures improved quality control, reducing material waste and improving efficiency, resulting in cost savings. The flexibility of modular construction enables easy assembly and disassembly of building components, making it suitable for both temporary and permanent structures. Additionally, modular construction can offer environmental benefits, such as reduced site disruption, less material waste, and the use of sustainable building materials. Overall, modular construction offers a faster, more efficient, and adaptable solution to traditional construction methods, making it increasingly popular in construction projects.

A Case Study of Atlantic Yards (David Fransworth, 2014) The Atlantic Yards B2 building in Brooklyn, designed by architect David Farnsworth, is a prime example of modular construction in a tall building. The building, also known as the "B2 Tower," is 32 stories high and comprises 363 residential units. It was constructed using pre-fabricated modules manufactured offsite and transported to the site for assembly. The modular design allowed for faster construction, reduced material waste, and improved quality control. The building's design also incorporated sustainable features, such as green roofs, energy-efficient systems, and the use of recycled materials. One of the unique features of the B2 Tower is the use of a "modular core" that provides structural support and contains elevators, stairs, and utility shafts. This allowed for the modules to be stacked around the core, creating a taller building without compromising its structural integrity. Despite some setbacks during the construction process, the B2 Tower was completed in 2016 and has since become a successful model for modular tall building design. Its innovative design and construction methods demonstrate the potential for modular construction to revolutionize the way tall buildings are built in the future.

According to a 2011 survey (McGraw-Hill 2011), nearly 98% of industry players are expected to be using modularization by 2013. However, fewer than half (37%) of these companies were using it at high or very high levels. Early studies has validated that modularization with current trends but that studies has failed to highlight the fact of modularization and its trend in the existing fields. A sum of few studies has tried hard in finding various factors for successful implementation of modular construction projects. The critical success factors will give a clear view of the critical factors that are to be considered by companies for implementing MiC.

III. REVIEW OF JOURNALS

Akagi, K., Murayama, K., Yoshida, M., & Kawahata, J. (2002), the use of modularization technology in the building of power plants is discussed. The authors claim that the modularization process entails building substantial power plant components off-site before having them shipped to the site and put together there. Compared to conventional building techniques, this technology has a number of benefits, including faster construction, better quality control, and less disruption on the job site. The drawbacks of modularization technology, including the requirement for specialized transportation and assembly tools as well as meticulous planning and coordination to make sure that all the parts fit together properly.

Azhar, S., Lukkad, M. Y., & Ahmad, I. (2013) investigates the critical factors and limitations that affect the decision to choose modular construction rather than traditional stick-built methods in construction projects. To find these determinants and limitations, the writers polled experts and professionals in the building industry. gives insightful information on the factors and limitations that impact the decision to use modular construction rather than traditional stick-built methods in construction projects. The results can assist specialists and professionals in the building industry in making defensible choices on the usage of modular construction in their projects.

Baldwin, C. Y., & Clark, K. B. (2000), demonstrates how the division of a product into separate and replaceable components, known as modularity, can have a number of advantages, including better productivity, lower prices, higher quality, and greater flexibility. The various forms of modularity, such as modular product architecture, modular process architecture, and modular organisation, are also covered.

Benjaoran, V., & Dawood, N. (2006), shows an innovative method of production scheduling for customized precast concrete items. The authors emphasis that custom precast concrete products, which demand a high level of customization and diversity in design, are complicated and cannot be managed using conventional production planning methods.

Bryan, B. (2019, March), The article explores the possible advantages and difficulties of this strategy for the construction industry while discussing the growing trend towards off-site building. The author emphasizes that off-site construction has the potential to completely transform the construction industry by bringing a host of advantages like improved quality control, decreased waste, increased productivity, and improved safety.

Carriker, M., & Langar, S. (2014), The paper goes over the elements that have an impact on massive modular construction projects. The authors emphasis that modular construction is a practical substitute for conventional construction techniques, providing advantages including shorter construction times, higher quality, and lower costs. However, a number of factors, including as design complexity, logistics of transportation, site limitations, and legal concerns, might affect the success of modular building projects.

Choi, J. O. (2014), The relationship between project performance in the construction sector and key success factors (CSFs) for modularization is examined in the thesis. The author emphasizes that by speeding up construction, enhancing quality, and cutting costs, modularization can enhance project performance. Yet, a number of critical success criteria, such as project management, design and engineering, supply chain management, and logistics, are necessary for modularization to be a success.

Choi, J. O., & O'Connor, J. T. (2014), The most important success criteria for modularization, according to an analysis of three case studies in the US, were project management, design and engineering, supply chain management, and logistics. The authors also discovered that successful modular construction projects need strong stakeholder participation and communication. The study concludes by offering helpful suggestions for project managers and decision-makers to enhance the execution of modular building projects. Overall, this study is helpful for construction professionals and policymakers who are interested in employing modular construction in their projects since it offers insightful information about the difficulties and potential associated with it.

Construction Industry Council. (2018), describes MiC as an innovative construction method that involves the off-site fabrication of modular components, which are then transported to the construction site and assembled into a complete building. MiC offers several advantages over traditional construction methods, including faster construction times, higher quality, greater safety, and reduced environmental impact.

Freund, Y. P. (1988), describes a five-step process for identifying CSFs that includes defining organizational goals, identifying the key areas where success is critical, prioritizing these areas based on their impact on achieving the goals, developing performance indicators for each CSF, and tracking progress toward achieving these indicators.

Gosling, J., Pero, M., Schoenwitz, M., Towill, D., & Cigolini, R. (2016),attempts to offer a thorough definition and classification of modules in building projects from a global viewpoint. They list different kinds of modules, including structural, cladding, and services modules, and give examples of each kind. the advantages of employing modular construction techniques, including faster construction, better quality control, and higher safety. They emphasize the value of strong stakeholder participation and communication in modular construction projects.

Haas, C. T., & Fagerlund, W. R. (2002),performed preliminary research on off-site fabrication, prefabrication, pre-assembly, and modularization in the construction industry. The study's objectives were to evaluate the situation of the construction industry at the time it was conducted, identify potential advantages and disadvantages of employing these approaches, and determine the best procedures for doing so. To learn more about how these techniques are applied in building projects, the researchers examined case studies and polled experts in the field. Off-site fabrication and modularization, according to the study, have the potential to increase project quality, cut down on construction time, and lower costs, but their uptake in the market has been constrained by a number of obstacles, including a lack of knowledge, a disjointed supply chain, and resistance to change.

Hofman, E., Voordijk, H., & Halman, J. (2009), examines how supply networks and modular product architecture can function together in the construction of houses. The authors emphasize how a product's modularity might affect the supply network's structure and supplier selection. They create a framework that consists of three steps: describing the product architecture, choosing the best supply network, and configuring the supply network. Their framework allows supply networks to be matched with modular product architecture.

Hong Kong Buildings Department. (2018), provides information on Modular Integrated Construction (MiC) and its benefits, as well as regulations and guidelines for MiC projects in Hong Kong. It includes case studies, frequently asked questions, and a list of accredited MiC suppliers**.**

Hwang, B.-G., Shan, M., & Looi, K.-Y. (2018a), investigated the primary obstacles and prevention measures for prefabricated prefinished volumetric construction (PPVC). A comprehensive evaluation of the literature and content analysis of 96 academic articles and industry reports were used to carry out the investigation. The researchers discovered 40 mitigation measures that can be used at different stages of the PPVC project, along with 16 limitations. Three categories—technical, organizational, and institutional—are used to group the restrictions. The four groups of mitigation techniques include design, manufacture, logistics, and installation. Researchers and practitioners can use the study's insights to overcome the difficulties in implementing PPVC.

Ismail, F., Yusuwan, N. M., & Baharuddin, H. E. A. (2012), conducted a survey of Malaysian construction industry professionals and utilized factor analysis to identify the critical project management elements. Top management support, project team competence, good communication and coordination, procurement methods, and the design and manufacture of IBS are among the aspects noted. The report offers practical information that construction industry professionals and policymakers may utilize to enhance the execution of IBS projects.

Kamar, K. A. M., Alshawi, M., & Hamid, Z. A. (2009), The article looks at the critical success factors (CSFs) that may affect Malaysia's adoption of the Industrialized Building System (IBS). The CSFs were found through a review of the literature, which was followed by questionnaire surveys and interviews with professionals in the field to confirm their validity. The study identified six CSFs: supply chain management, design and engineering, government support, financial incentives, awareness and education, and quality control and assurance.

Lau, A. K. W. (2011), investigates the critical success factors (CSFs) for managing modular production design based on six case studies in Hong Kong, China, and Singapore. The study found six key CSFs: (1) technical competency in design, (2) effective communication and collaboration, (3) adequate planning and management, (4) close supervision and quality control, (5) teamwork and trust, and (6) experienced workforce. The paper recommends that companies adopt these factors to ensure successful modular construction.

Li, L., Li, Z., Wu, G., & Li, X. (2018), used a mixed-method approach, including a literature review, expert interviews, and a questionnaire survey, to collect data from industry professionals in China. They identified 18 CSFs, grouped into four categories: organizational, project team, technology, and external environment. The authors then used the Analytic Hierarchy Process (AHP) to prioritize the CSFs based on their relative importance.

Murtaza, M. B., Fisher, D. J., & Skibniewski, M. J. (1993), In order to assist in the planning and design of modular building projects, a knowledge-based decision support system was built, as is described in the article. The authors emphasize how challenging it is to design and manage modular building projects using conventional approaches and how a knowledge-based approach could help to address these issues.

Mydin, M. A. O., Nawi, M. N. M., Yunos, M. Y. M., &Utaberta, N. (2015), The usage of prefabrication systems in the Malaysian construction sector is discussed in the article, which also highlights a number of critical success elements that can help guarantee the deployment of these systems. The authors emphasizes that while prefabrication systems can provide important advantages in terms of cost reductions, quality control, and time savings, their effective deployment necessitates careful design and execution.

O'Connor, J. T., O'Brien, W. J., & Choi, J. O. (2014), explains how industrial modularization is used in the construction sector and highlights key success criteria and enablers for achieving maximum and optimum modularization. The authors emphasize that, while modularization can result in significant cost, quality, and time savings, its successful adoption necessitates careful planning and execution.

Osei-Kyei, R., & Chan, A. P. C. (2015),presents a thorough analysis of research from 1990 to 2013 on the key success determinants for public-private partnership (PPP) projects. The authors point out that PPP projects are becoming more and more common as a way to offer public infrastructure and services, and that knowing the critical success elements for these projects is critical for their effective implementation. The writers also noted a number of new issues, such as the necessity of creative and adaptable contract structures, the significance of stakeholder cooperation and trust, and the influence of institutional and political elements on PPP project performance.

Pan, W., & Hon, C. K. (2018), explains how modular integrated construction (MIC) can be used to build high-rise structures. The authors emphasize that, especially for projects with confined sites or limited timetables, MIC can provide considerable advantages in terms of cost savings, quality control, and time savings. The authors outline the MIC procedure, which entails building components being manufactured off-site before being assembled on-site. They also go over the advantages of MIC, such as faster construction, better quality control, and higher safety.

Rashidi, A., & Ibrahim, R. (2017), gives a chronological account of the growth of industrialized building in Malaysia, highlighting significant turning points and obstacles the sector has had to overcome. The writers also point out the critical success aspects that have supported the industry's expansion and toughness. The authors go on to list the major success elements that have helped the sector remain resilient. They include government incentives and support, successful stakeholder collaboration, the deployment of equipment and technology that is appropriate, and the growth of a competent workforce.

Shahtaheri, Y., Rausch, C., West, J., Haas, C., & Nahangi, M. (2017), focuses on the problem of risk management in modular construction, a technique that entails building parts off-site and putting them together on-site. The authors point out that because prefabricated components must adhere to exact dimensions and geometric standards, modular construction poses special risks for risk management.

Smith, R. E. (2016), gives a summary of off-site and modular construction techniques, along with the advantages and drawbacks of each. Off-site and modular construction, according to the author, entails the manufacture of building components at a factory or other off-site location, followed by assembly on-site. This strategy may provide a number of benefits, including quicker construction timeframes, better quality control, and less waste.

Triumph Modular Corporation. (2019), discusses the key success factors for implementing volumetric modular construction projects. The author defines volumetric modular construction as a process where building components,

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such as complete rooms or sections, are manufactured off-site in a controlled environment and then transported to the project site for assembly.

Wuni, I. Y., Shen, G. Q. P., & Mahmud, A. T. (2019), The research found that design, production, shipping, assembly, and site management were the most important risk factors in MIC projects. According to the authors, managing these risk factors necessitates the adoption of a comprehensive strategy that involves including all relevant parties, utilizing the right tools and technologies, and setting up efficient communication and coordination structures. The paper also emphasizes the need for additional study to create risk management plans and tools that are more useful for MIC projects.

IV. CONCLUSION

In summary, modular construction is a cutting-edge method of building that has been more well-known in recent years because of its potential advantages, including enhanced effectiveness, cost savings, and less environmental impact. Reviewing the literature on modular building and creating a system for assessing its performance were the study's main goals. The analysis of the literature showed that institutional, commercial, and residential settings have all explored and used modular building extensively. Faster building periods, better quality control, less waste, and lower prices are all benefits of modular construction. Modular building can present some difficulties, though, including logistical and transportation concerns, design restrictions, and potential opposition from traditional construction partners. The future scope includes (1) Quantitative assessment of the CSFs for specific MiC projects and to Rank the CSFs, (2) To create a stage–gate framework for the CSFs, (3) To Develop a set of strategies, critical success processes and key performance indicators for the MiC CSFs, (4) To Develop MiC project success model based on (3)

REFERENCES

[1]. Akagi, K., Murayama, K., Yoshida, M., &Kawahata, J. (2002). Modularization technology in power plant construction. In Proceedings of ICONE10 10th international conference on Nuclear engineering (pp. 21–27),

[2]. Azhar, S., Lukkad, M. Y., & Ahmad, I. (2013). An investigation of critical factors and constraints for selecting modular construction over conventional stick-built technique. International Journal of Construction Education and Research, 9(3), 203–225. doi:10.1080/15578771.2012.723115

[3]. Baker, J. D. (2016). The purpose, process, and methods of writing a literature review. AORN Journal, 103(3), 265–269. doi:10.1016/j.aorn.2016.01.016

[4]. Baldwin, C. Y., & Clark, K. B. (2000). Design rules: The power of modularity, Vol. 1. Cambridge: MIT Press.

[5]. Barlow, J., Childerhouse, P., Gann, D., Hong-Minh, S., NaimM., & Ozaki, R. (2003). Choice and delivery in housebuilding: Lessons from Japan for UK housebuilders. BuildingResearch and Information, 31(2), 134–145. doi:10.1080/09613210302003

[6]. Benjaoran, V., & Dawood, N. (2006). Intelligence approach to production planning system for bespoke precast concrete products. Automation in Construction, 15(6), 737–745. doi:10.1016/j.autcon.2005.09.007

[7]. Bryan, B. (2019, March). Prefabricated construction: 'Is off-site the future of the industry'. NEWS, 1–11. Retrieved from https://bondbryan.co.uk/2019/01/29/prefabricated-construction-is-off-site-the-future-of-the-industry/

[8]. Carriker, M., & Langar, S. (2014). Factors affecting large scale modular construction projects. In 50th ASC annual international conference proceedings (pp. 1–8). Fort Collins:Associated Schools of Construction.

[9]. Choi, J. O. (2014). Links between modularization critical success factors and project performance. Austin, TX: The University of Texas at Austin.

[10]. Choi, J. O., & O'Connor, J. T. (2014). Modularization critical success factors accomplishment: Learning from case studies.Construction Research Congress, 1636–1645. doi:10.1061/9780784413517.167

[11]. Construction Industry Council. (2018). About modular integrated construction. Hong Kong: Construction Industry Council. Retrieved from www.cic.hk/eng/main/mic/whats mic/aboutmic/

[12]. David Fransworth (2014) Modular tall building design at Atlantic yards B2, CTBUH2014 Conference proceedings.

[13]. Freund, Y. P. (1988). Critical success factors. Planning Review, 16(4), 20–23. doi:10.1108/eb054225
[14]. Gosling, J., Pero, M., Schoenwitz, M., Towill, D., &Cigolini, R. (2016). Defining and categorizing modules in building projects: An international perspective. Journal of Construction Engineering and Management, 1–11. doi:10.1061/(ASCE) CO.1943-7862
[15]. Greenhalgh, T., & Peacock, R. (2005). Effectiveness and efficiency of search methods in systematic reviews of complex evidence: Audit of primary sources. BMJ, 331, 1064– 1065. doi:10.1136/bmj.38636.593461.68
[16]. Haas, C. T., &Fagerlund, W. R. (2002). Preliminary research on prefabrication, pre-assembly, modularization and offsite fabrication in construction. Austin, TX. Retrieved from https://smartech.gatech.edu/handle/1853/10883
[17]. Hofman, E., Voordijk, H., &Halman, J. (2009). Matching supply networks to a modular product architecture in the house-building industry. Building Research and Information, 37(1), 31–42. doi:10.1080/09613210802628003
[18]. Hong Kong Buildings Department. (2018). Modular integrated construction. Hong Kong. Retrieved from https://www.bd. gov.hk/en/resources/codes-and-references/modular-integra ted-construction/index.html Hsu,
[19]. Hwang, B.-G., Shan, M., &Looi, K.-Y. (2018a). Key constraints and mitigation strategies for prefabricated prefinished volumetric construction. Journal of Cleaner Production, 183, 183–193. doi:10.1016/j.jclepro.2018.02.136
[20]. Ismail, F., Yusuwan, N. M., &Baharuddin, H. E. A. (2012). Management factors for successful IBS projects implementation. Procedia – Social and Behavioral Sciences, 68, 99– 107. doi:10.1016/j.sbspro.2012.12.210
[21]. Jagoda, K., & Samaranayake, P. (2017). An integrated framework for ERP system implementation. International Journal of Accounting and Information Management, 25 (1), 91–109. doi:10.1108/IJAIM-04-2016-0038
[22]. Jonsson, H., &Rudberg, M. (2015). Production system classification matrix: Matching product standardization and production-system design. Journal of Construction Engineering and Management, 141(6), 05015004. doi:10. 1061/(ASCE)CO.1943-7862.0000965
[23]. Kamar, K. A. M., Alshawi, M., & Hamid, Z. A. (2009). Industrialised building system: The critical success factors. 9th international postgraduate research conference (IPGRC) (pp. 485–497). Salford: University of Salford.
[24]. Lau, A. K. W. (2011). Critical success factors in managing modular production design: Six company case studies in Hong Kong, China, and Singapore. Journal of Engineering and Technology Management, 28(3), 168–183. doi:10. 1016/j.jengtecman.2011.03.004
[25]. Li, X. (2018). Critical success factors for project planning and control in prefabrication housing production: A China study. Sustainability, 10(836), 1–17. doi:10.3390/su10030836
[26]. Luo, L., Shen, G. Q., Xu, G., Liu, Y., & Wang, Y. (2019). Stakeholder-associated supply chain risks and their interactions in a prefabricated building project: A case study in Hong Kong. Journal of Management in Engineering, 35(2), 1–14. doi:10.1061/(ASCE)ME.1943- 5479.0000675
[27]. McGraw-Hill(2011)"Prefabricated and Modularization: Increasing Productivity in construction industry, Smart Market report
[28]. Mydin, M. A. O., Nawi, M. N. M., Yunos, M. Y. M., &Utaberta, N. (2015). Decisive success factors in executing prefabrication system in Malaysia. Australian Journal of Basic and Applied Sciences, 9(97), 160–163. Retrieved from www.ajbasweb.com
[29]. O'Connor, J. T., O'Brien, W. J., & Choi, J. O. (2014). Critical success factors and enablers for optimum and maximum industrial modularization. Journal of Construction Engineering and Management, 140(6), 04014012. doi:10. 1061/(ASCE)CO.1943-7862.0000842
[30]. Osei-Kyei, R., & Chan, A. P. C. (2015). Review of studies on the critical success factors for public-private partnership (PPP) projects from 1990 to 2013. International Journal of Project Management, 33(6), 1335–1346. doi:10.1016/j.ijproman. 2015.02.008
[31]. Pan, W., & Hon, C. K. (2018). Modular integrated construction for high-rise buildings. Proceedings of the Institution of Civil Engineers – Municipal Engineer, 1–12. doi:10. 1680/jmuen.18.00028

[32]. Rashidi, A., & Ibrahim, R. (2017). Industrialized construction chronology: The disputes and success factors for a resilient construction industry in Malaysia. The Open Construction and Building Technology Journal, 11(1), 286–300. doi:10.2174/1874836801711010286

[33]. Shahtaheri, Y., Rausch, C., West, J., Haas, C., &Nahangi, M. (2017). Managing risk in modular construction using dimensional and geometric tolerance strategies. Automation in Construction, 83, 303–315. doi:10.1016/j. autcon.2017.03.011

[34]. Smith, R. E. (2016). Off-site and modular construction explained. Retrieved from https://www.wbdg.org/resou rces/site-and-modular-construction-explained Song, J., Fagerlund,W. R., Haas, C. T., Tatum, C. B., & Vanegas, J. A. (2005). Considering prework on industrial projects. Journal of Construction Engineering and Management, 131(6), 723– 733. doi:10.1061/(ASCE)0733-9364(2005)131:6(723)

[35]. Triumph Modular. Retrieved from https://triumphmodular.com/ permanent-modular/how-to-start/critical-success-factors/ Warszawski, A. (1999). Industrialization and Automated building systems (2nd ed.). London: E & FN Spon.

[36]. Wuni, I. Y., Shen, G. Q. P., & Mahmud, A. T. (2019). Critical risk factors in the application of modular integrated construction: A systematic review. International Journal of Construction Management, 1–15. doi:10.1080/15623599. 2019.1613212