Optimization of Cost and Time adopting the Prefabricated Prefinished Volumetric Construction (PPVC) technique in building construction

Dr.Venkatesan Renganaidu
National Institute of Construction Management and Research, Hyderabad, India.

Prof. Onkar K. Chothe
National Institute of Construction Management and Research, Hyderabad, India.

Dr. Vikrant Yadav
National Institute of Construction Management and Research, Hyderabad, India.

Abstract

In the current study, the time and cost of prefabricated prefinished volumetric construction are described briefly. According to the study, up to 40% of the productivity can be improved by prefabricated prefinished volumetric construction in terms of manpower and savings of time. It is depending on the complexity of the project. The use of PPVC is necessary to maintain the environment of the site. The input of this volumetric construction should be taken for the PPVC supplier or manufacturer by the developer or the project manager. The use of PVCC is implemented on the prefabricated technology through the 3-dimensional modules which are produced and complete with the finishes of buildings and fittings. A better construction environment also helps in productivity on the other side. The use of PPVC is necessary to maintain the environment of the site. The input of PPVC should be taken for the PPVC supplier or manufacturer by the developer or the project manager. The secondary data collection process helps to get information for the study. Qualitative data are used in this study.

Keywords: PPVC, manpower, productivity, construction, installation activity.

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Introduction

In this present study, the times and costs of the prefabricated prefinished volumetric construction will be discussed briefly. The aims and objectives of the study will be mentioned in this study. The importance of the use of PPVC will be described in detail in this study. The time and cost will be analysed in this study. The implementation of PPVC in a different area will also be described (Fig. 1). The use of PPVC has a great contribution which will be described in the current study.

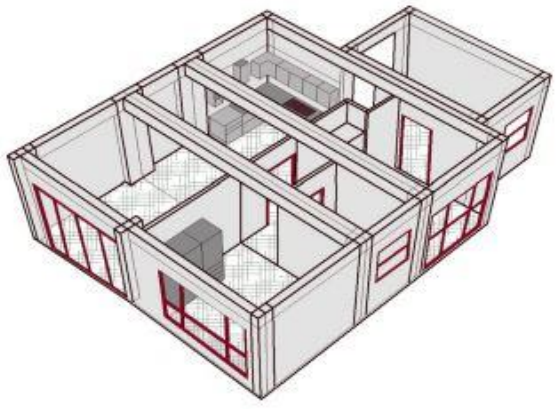


Fig. 1 Architecture arrangement in building

Balasbaneh & Sher (2021) conducted a study to estimate the life cycle assessment of different concrete construction techniques. The study site selected for work was Malaysia. To evaluate the materials authors have used TOPSIS model along with soft computing tools the parameters

assessed like ozone depletion, greenhouse gas percentage, temperature and toxicity level. The outcomes of experiment shows that PPVC is best technique which lowers the greenhouse gas emissions by 6% and also it optimize cost by 12% (Table 1).

Table: 1 Cost analysis for building construction

Construction method	Details of material	Production cost	Maintenance cost	Service life
On site concrete	Cement concrete	25100	1740	4200
	RCC Bar	9800		
	Transportation	1100		
Individual Panel System	Cement concrete	24200	2900	4300
	RCC Bar	8500		
	Transportation	5800		
PPVC	Cement concrete	23700	2150	4500
	RCC Bar	8450		
	Transportation	6700		

Greenhouse gases (GHGs) are responsible for global warming, world is emphasizing zero emission concept under the SDG-17 program. Brambilla et al (2018) carried out study to achieve the nearly zero energy emission during the building renovation project. The authors worked on case study from Europe and observed that construction activity accounts 40% of energy consumption and 36% CO_2 emissions. The authors have set the goal as zero emission and to achieve that considered the appropriate strategies. Authors have simulated the construction and demolition process for Atika building and concluded with PPVC is best technique for sustainable construction.

Aims and objectives

Aims: The current study is aimed at the times and costs analysis for Prefabricated Prefinished Volumetric Construction.

Objectives:

- To determine the importance of using Prefabricated Prefinished Volumetric Construction
- To analyze the times and costs of the PPVC
- To identify the loopholes involved in the system
- To recommend solutions for overcoming the challenges

Literature review

Importance of the use of Prefabricated Prefinished Volumetric Construction

Up to 40% of the productivity can be improved by PPVC in terms of manpower and savings of time. It is depending on the complexity of the project (Chougule et al. 2023). A better construction environment also helps in productivity on the other side. The movement of the installation activity and manpower are conducted off-site which reduces the dust and noise in the site and improves safety. In an environment of a company which is controlled off-site fabrication can produce high-quality products. The use of PPVC is necessary to maintain the environment of the site. The input of PPVC should be taken for the PPVC supplier or manufacturer by the developer or the project manager (Wuni et al. 2021). Several effective technical solutions can be developed by this for the project. For example, the size will dictate by the choice of material and the number of modules also has a great consideration in the hoisting of the modules.

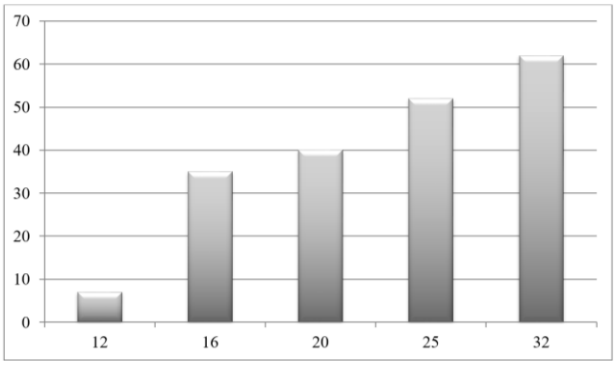
Member	Size
Ceiling beam	SHS 150x150x5
Floor beam	RHS 200x150x10
Column (Level 1-10)	RHS 300x20x16
Column (Level 11-40)	RHS 300x20x10

Table 1: Robustness of Prefabricated Prefinished Volumetric Construction

(Source: Created by Author)

Times and costs of Prefabricated Prefinished Volumetric Construction

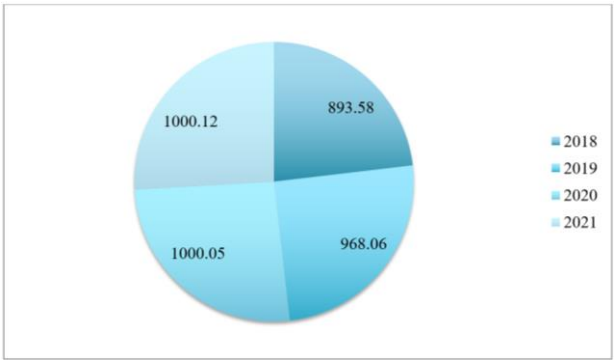
The rising urban population is the cause of demand for faster and cheaper methods of construction. Modern construction methods such as PPVC can benefit from the advantages in these regards. PPVC is the technology of construction (Tambichik et al. 2022). It comes from the modular construction system that applies modern technologies in the construction system. This approach is used to increase the high productivity of construction and decrease the high reliance on on-site manpower. The use of PVCC is implemented on the prefabricated technology through the 3-dimensional modules which are produced and complete with the finishes of buildings and fittings. The number of workers on-site is reduced by PPVC, it also increases the efficiency in the utilization of resources and minimize the waste of construction and decreases the costs and times of the construction (Ho et al. 2018). So this technology of construction is expected to the faster and cheaper and the implementation of more efficient construction compared to that which is offered by the 2D method of IBS.



Graph 1: Prospect of Prefabricated Volumetric Modular Construction

(Source: Created by Author)

In the United States, the use of PPVC is widely conducted for making dormitories and classrooms for universities and colleges. The reduction of the cost of construction is conducted around 5% to 10% and the shortened time is caused using PPVC (Hwang et al.2018). Using the PPVC method in the United States the developer can develop the building of the house within a short time period and low cost. The shortage skilled of manpower is addressed by this. The use of PPVC is necessary to maintain the environment of the site. The use of PPVC is also offered improvement in design and quality. A better construction environment also helps in productivity on the other side. Now PPVC is common in urban areas for the shorter installation period and the cheaper cost of repair after an earthquake.



Graph 2: Growth rate of PPVC

(Source: Created by Author)

In Singapore, the use of PPVC has been conducted since 2013 as a part of efforts to develop productivity in the design and the process of construction (Balasbaneh et al. 2020). The cost of the commercial construction of the NTU-3A project was found to be higher approximately 18% than the cost of the conventional construction which was carried out using the 2D method of IBS. Moreover, the PPVC methods used in the construction of the Clement Canopy Tower project has saved successfully the time of construction by up to 30%. It was observed that the improvement of the Kwasa Sentral project, The Malaysian Resources Corporation Berhad introduce the method of PPVC in Malaysia using the building system of PPVC (Hwang et al. 2018). After the experimental study it reveals that advantage over the IBS 2D method was offered by this system, where 95% of the work of construction was carried out off-site compared to only 30% of off-site activities performed using the 2D method of IBS. Thus the implementation of the PPVC method expects a shorter period of construction.

Precast building components	Percentage
Column	14
Beam	16
Lintel	4
Slab	21
Lintel with Chajja	3.5
Stair case	22.5

Table 2: Percentage in cost reduction

(Source: Created by Author)

Few case studies shows that used foundry sand can be used in concrete as partial replacement of fine sand or river sand. To maintain the ecological balance in some countries the government has banned the usage of natural sand. Sabale et al. (2023) carried out the experimental work and replaced natural sand with foundry sand. Authors found that about 40 % sand can be replaced with hampering the strength aspect.

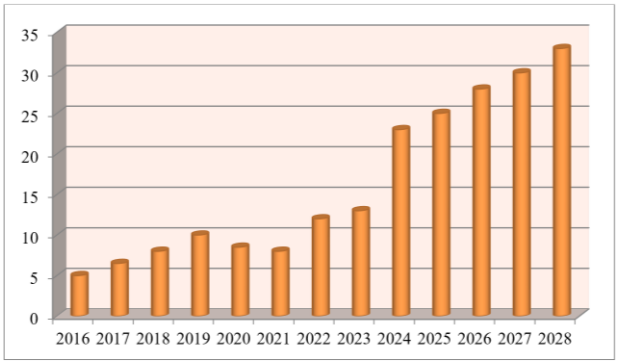
Methodology

In the study, secondary data collection methods are used out of the primary and secondary data collection methods. This collection process of data is conducted by several books, journals, newspapers and websites. A website is an important way to get more information about the study. More sites help to get a larger amount of data which helps to get detailed information about the study. These data need to be analysed after the collection process. The analysis of data is important to get the accuracy of the data. This data collection method is used to get sources of the data and the problems of the study to get the solution through this data. There are two types of data such as qualitative and quantitative. In this current study, qualitative data is used. The statistical data helps to get accurate information about the mentioned study. Qualitative data helps to maintain the study properly. This data helps to understand the focus of the study and the problems and challenges are analyzed through this data. Through this data, brief information related to the study is getting.

Data analysis

From this study, the analysis of the times and costs of the PPVC is conducted. It is analysed that the use of PPVC is necessary to maintain the environment of the site (Chong and C.H. 2021). The input of PPVC should be taken for the PPVC supplier or manufacturer by the developer or the project manager. Several effective technical solutions can be developed by this for the project. The reduction of the cost of construction is conducted around 5% to 10% and the shortened time is caused by the use of PPVC. The cost of the construction of the NTU project was found to be higher approx 18% than the cost of the construction which was carried out using the 2D method of IBS (Wuni et al. 2020). It is also analysed that now PPVC is common in urban areas for the shorter installation period and the cheaper cost of repair after an earthquake.

The times and costs analysed that this volumetric technology is the technology of construction. It comes from the modular construction system that applies modern technologies in the construction system. The analysis of the use of PVCC is implemented on the prefabricated technology through the 3-dimensional modules which are produced and complete with the finishes of buildings and fittings. The number of workers on-site is reduced by PPVC, it also increases the efficiency in the utilization of resources and minimize the waste of construction and decreases the costs and times of the construction (Yap et al. 2021). It is found that during the improvement of the Kwasa Sentral project, The Malaysian Resources Corporation Berhad introduce the method of PPVC in Malaysia using the building system of PPVC.



Graph 3: Prefabricated Prefinished Volumetric Construction Market research

(Source: Created by Author)

For example, the size will dictate by the choice of material and the number of modules also has a great consideration in the hoisting of the modules. The approach is used to increase the high productivity of construction and decrease the high reliance on on-site manpower. In Singapore, the use of PPVC has been conducted since 2013 as a part of efforts to develop productivity in the design and the process of construction. Using the PPVC methods the construction of the Clement Canopy Tower project has successfully saved the time of construction by up to 30%. During the improvement of the Kwasa Sentral project, The Malaysian Resources Corporation Berhad introduce the method of PPVC in Malaysia using the building system of PPVC.

Conclusion

From the above study, it is concluded that the implementation of prefabricated prefinished volumetric construction is important for faster and cheaper technology. The objectives of the study are briefly described in the above study. The number of workers on-site is reduced by PPVC, it also increases the efficiency in the utilization of resources and minimize the waste of construction and decreases the costs and times of the construction. The movement of the installation activity and manpower are conducted off-site which reduces the dust and noise in the site and improves safety. In an environment of a company which is controlled off-site fabrication can produce high-quality products. Several effective technical solutions can be developed by this for the project.

References

Arianna Brambilla , Graziano Salvalai , Marco Imperadori , Marta Maria Sesana , Nearly Zero Energy Building renovation: from energy efficiency to environmental efficiency, a pilot case study., Energy & Buildings (2018), doi: 10.1016/j.enbuild.2018.02.002

Balasbaneh, A.T., Sher, W. Life cycle sustainability assessment analysis of different concrete construction techniques for residential building in Malaysia. Int J Life Cycle Assess 26, 1301–1318 (2021). https://doi.org/10.1007/s11367-021-01938-6

Chougule, A.B. and Chothe, O., 2023. Review of Time and Cost Analysis for Prefabricated Prefinished Volumetric Construction (PPVC). In *Recent Advances in Structural Engineering and Construction Management* (pp. 937-949). Springer, Singapore.

Wuni, I.Y., Shen, G.Q. and Osei-Kyei, R., 2021. Evaluating the critical success criteria for prefabricated prefinished volumetric construction projects. *Journal of Financial Management of Property and Construction*.

Tambichik, M.A., Sherliza, Z.S. and Abdullah, N.A., 2022, May. Comparative Study between Prefabricated Prefinished Volumetric Construction (PPVC) and IBS 2D: A Case Study of School Extension Project in Malaysia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1022, No. 1, p. 012016). IOP Publishing.

Ho, K.M., Lam, J.P. and Max, S., 2018. Pre-fabricated pre-finished volumetric construction (PPVC) for residential projects. *Threesixty Cost Management Pte Ltd.: Bukit Merah, Singapore*.

Hwang, B.G., Shan, M. and Looi, K.Y., 2018. Knowledge-based decision support system for prefabricated prefinished volumetric construction. *Automation in Construction*, *94*, pp.168-178.

Balasbaneh, A.T. and Ramli, M.Z., 2020. A comparative life cycle assessment (LCA) of concrete and steel-prefabricated prefinished volumetric construction structures in Malaysia. *Environmental Science and Pollution Research*, *27*(34), pp.43186-43201.

Sabale, R., Karande, U., Kolhe, A., Kulkarni, A., Tapase, A. (2023). Recycling of Used Foundry Sand and Fly Ash in Concrete as a Partial Replacement for Conventional Ingredients. In: Agnihotri, A.K., Reddy, K.R., Chore, H.S. (eds) Proceedings of Indian Geotechnical and Geoenvironmental Engineering Conference (IGGEC) 2021, Vol. 2. IGGEC 2021. Lecture Notes in Civil Engineering, vol 281. Springer, Singapore. https://doi.org/10.1007/978-981-19-4731-5_15

Hwang, B.G., Shan, M. and Looi, K.Y., 2018. Key constraints and mitigation strategies for prefabricated prefinished volumetric construction. *Journal of Cleaner Production*, *183*, pp.183-193.

Chong, C.H., 2021. *The Status of Industrialised Building System (IBS) and Prefabricated Prefinished Volumetric Construction (PPVC), and the Challenges of PPVC Adoption* (Doctoral dissertation, Tunku Abdul Rahman University College).

Wuni, I.Y. and Shen, G.Q., 2020. Critical success factors for management of the early stages of prefabricated prefinished volumetric construction project life cycle. *Engineering, Construction and Architectural Management*, *27*(9), pp.2315-2333.

Yap, L.S., Aminudin, E., Zakaria, R., Kiong, M.T. and Darus, N., 2021, November. Factor affecting the adaptation of prefabricated prefinished volumetric construction (PPVC) in Malaysia industry. In *AIP Conference Proceedings* (Vol. 2428, No. 1, p. 050003). AIP Publishing LLC.