High-rise Modular Buildings for Rapid Urbanisation

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Modular construction has been generally used worldwide for low-rise buildings due to its numerous advantages: faster, more efficient, better quality control, reduced workforce, lesser site work, and etc. In Singapore, as the challenges of shortage of workforce and limited land use becomes more critical, the Building and Construction Authority (BCA) began to introduce incentives to increase the use of innovative construction methods. This is to boost the productivity and efficiency of the construction industry as well as making the buildings to go higher for land optimization purpose. With these aims, prefabricated prefinished volumetric construction (PPVC), whereby free-standing volumetric modules complete with finishes for walls, floors and ceilings are constructed off-site and assembled on-site, has been fast evolving in Singapore recently. Nonetheless, to make high-rise PPVC building, its robustness and structural integrity are very essential due to its relatively novel structural form which are made of many interconnected modular units. It is different from conventional system because there are numerous connections among PPVC modules for vertical and horizontal tying, as well as effective transfer of lateral load to the lateral resisting system. The continuity of the beam-column frame is uncertain and the reliance on lateral resisting system is essential especially for high-rise buildings. To date, there are still less than 1% of high-rise building implementing the PPVC technology despite of its potential for rapid construction, while the tallest modular building in the world is 32 stories high. Therefore, to go for high-rise, the understanding on the structural integrity and stability of PPVC building to resist lateral loading is essential. This paper investigates the global behavior of high-rise PPVC building using a finite element software such as ETABS. The challenges of modelling PPVC and the effects of connections between PPVC modules are discussed.

A 40-storey residential building is selected in this study. The PPVC modules are arranged around coupled core walls. Coupled core wall is selected due to its higher stiffness and strength resulting from coupling effects. The horizontal forces are resisted through a combination of flexural action of the walls and frame action between the coupling beams and the walls, resulting in better performance than uncoupled walls that contribute their stiffness and strength separately. In this design, it is assumed that the core walls resist most of the lateral load to ensure the stability of the high-rise building, whereas PPVC modules take most of the gravity load. To promote standardization of all the members and connections design, the columns remain the same size throughout the height of the building, by varying their thickness in order to account for the increment of gravity loads along the height of the building.

Current practice in PPVC involves on-site grouting of joints to ensure the slabs of adjacent modules are tied together and to provide diaphragm action. In some PPVC projects, the core walls are surrounded by cast in-situ walkway so that all the modules can be tied to the walkway and work as single diaphragm to transfer lateral load to the core wall. However, the in-situ grouting may slow

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