THE HONG KONG POLYTECHNIC UNIVERSITY 香港理工大學
國家鋼結構工程技術研究中心香港分中心
Chinese National Engineering Research Centre For Steel Construction (Hong Kong Branch)
Address: Hong Kong Polytechnic University, Phase 8, Hung Hom, Kowloon, Hong Kong.
Telephone: (852) 3400 8441 Email: cnerc.steel@polyu.edu.hk Website: https://www.polyu.edu.hk/cnerc-steel/

Work Theme A: Structural engineering on modern steel construction

B2 Application of high performance steel materials Q690 to Q960 in super high-rise commercial buildings

Project Title:

a) "Structural Optimization of Super High-Rise Commercial Buildings using High Performance Q690 to Q960 Steel Materials"

Principal Investigator: Dr. Ivan W.H. LAU

Advisor: Prof. C.M. CHAN (HKUST)

1. Current Progress and Achievements

1.1 Overview of Phase A

In the past decades, most existing tall buildings in Hong Kong were constructed with concrete material. Before the benefit maximization of steel or composite construction, it is necessary to review the main benefits of concrete construction on a benchmark existing building. The objective of this phase of research is to review the benefits of concrete construction in the past decades and then examine the benefits of structural steel or composite construction based on current trend and market conditions. Incorporating the latest design requirements and the current cost parameters, several alternative design schemes utilized steel material were conducted to examine the efficiency and the scopes of this optimization research.

Two International Financial Centre (IFC2), a 93-story 420-meter tall building in Hong Kong, was selected as the illustrative example to provide some preliminary findings for this research phase. When the construction of IFC2 completed in 2003, IFC2 was the tallest building in Hong Kong and the fifth tallest building in the world. Nowadays, IFC2 is the second tallest building in Hong Kong and one of top 30 tallest buildings in the world.

The existing structural system for IFC2 represents one of the most popular structural systems for super tall building design. To maximize the interior space usage, structural systems of tall buildings are typically located at the main core and the perimeter of the building. As shown in

Figure 3.1, IFC2 is located at Central Business District of Hong Kong near Victoria Harbour. A wind tunnel study was conducted to determine the wind load applied for the design of lateral structural system of IFC2.

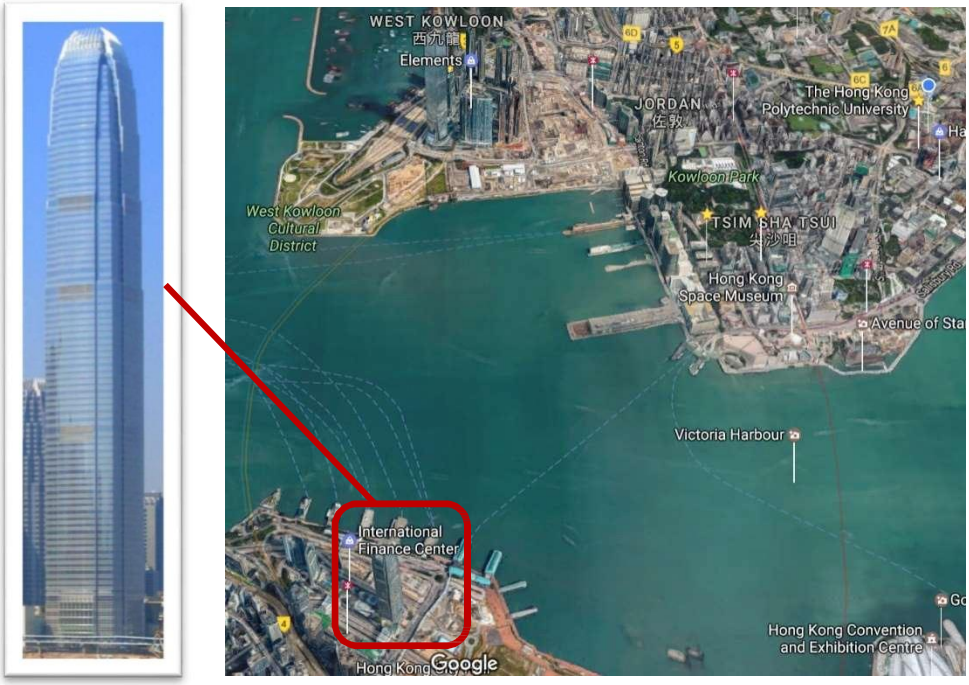

Figure 3.1 *Location map of IFC2 building*

1.2 Summary of Current Findings

i) Floor Framing:

Through revising the existing composite floor framing plan, a large number of the stiffness controlled members of original design can be redesigned as strength controlled members. Utilized the characteristic of high strength steel material, this modified floor framing is estimated to save approximately 25-35% construction cost over the original design. This saving can be further increased if this concept is introduced during the early design phase by adjusting the locations of columns and core walls.

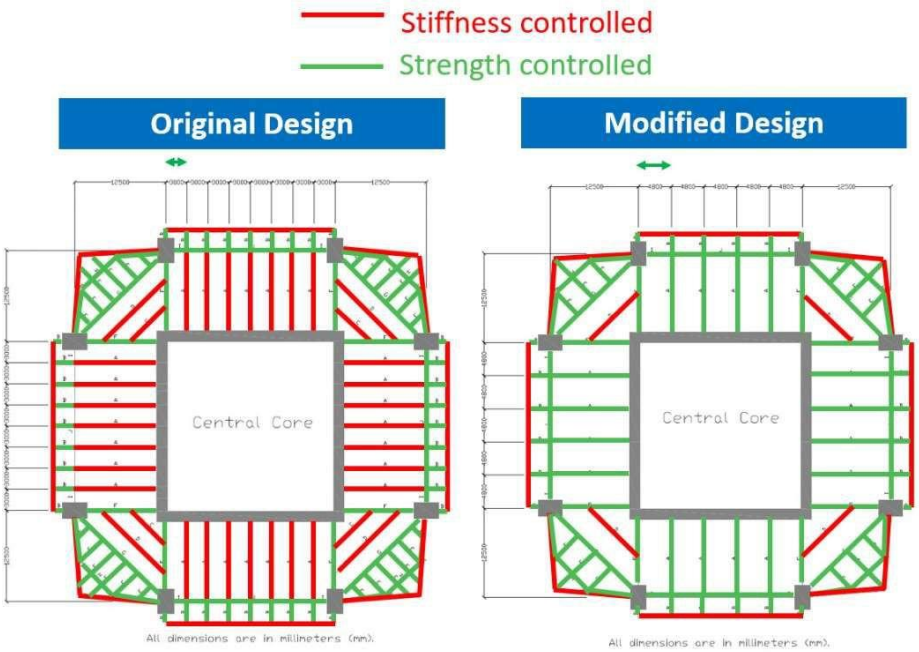

Figure 3.2 *The redesign of composite floor framing system*

ii)) Lateral Structural System:

Most structural members of a lateral structural system for a typical tall building is controlled by the stiffness. There is no exception for IFC2. An ETABS structural system as shown in Figure 3.3 are built to examine the efficiency of original lateral structural system. As shown in Figures 3.4 and 3.5, a few different structural schemes are also built to examine the efficiency using steel material at main core and building perimeter. Depended on the structural systems as well as material usages, the additional cost of composite construction is found to be 20-40% higher than original system. Nevertheless, given the rocket-high rent of office space in Hong Kong, there is a potential cost saving of composite system because composite structural elements can be significantly smaller than original structural members. Based on preliminary estimation, if the rent of saved floor area can be converted into actual rent income, the additional rent income easily offsets the additional construction cost of modified composite schemes. As structural systems for tall buildings vary significantly and often project dependent, more extensive and comprehensive studies in the later phase are necessarily to provide further evidence before any conclusion can be drawn.

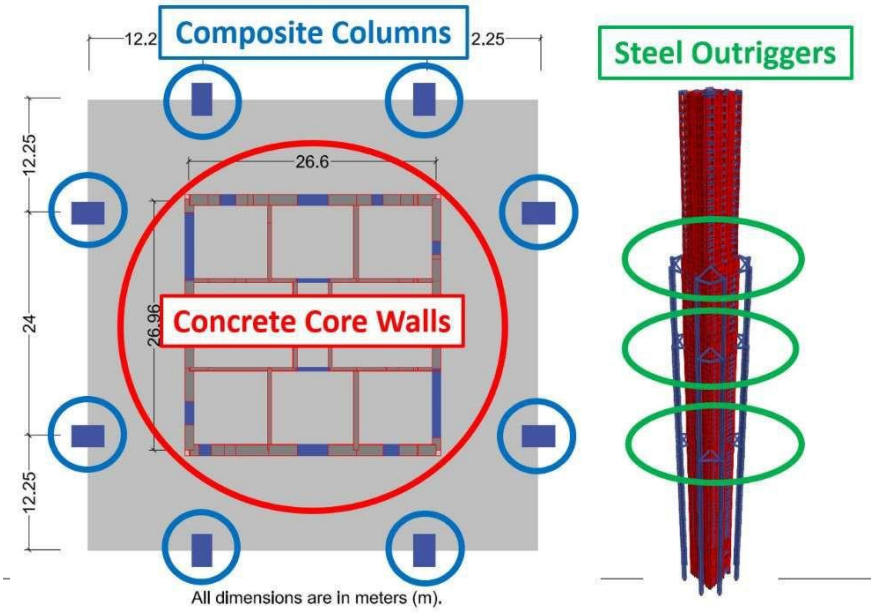

Figure 3.3 *Current lateral structural system of IFC2*

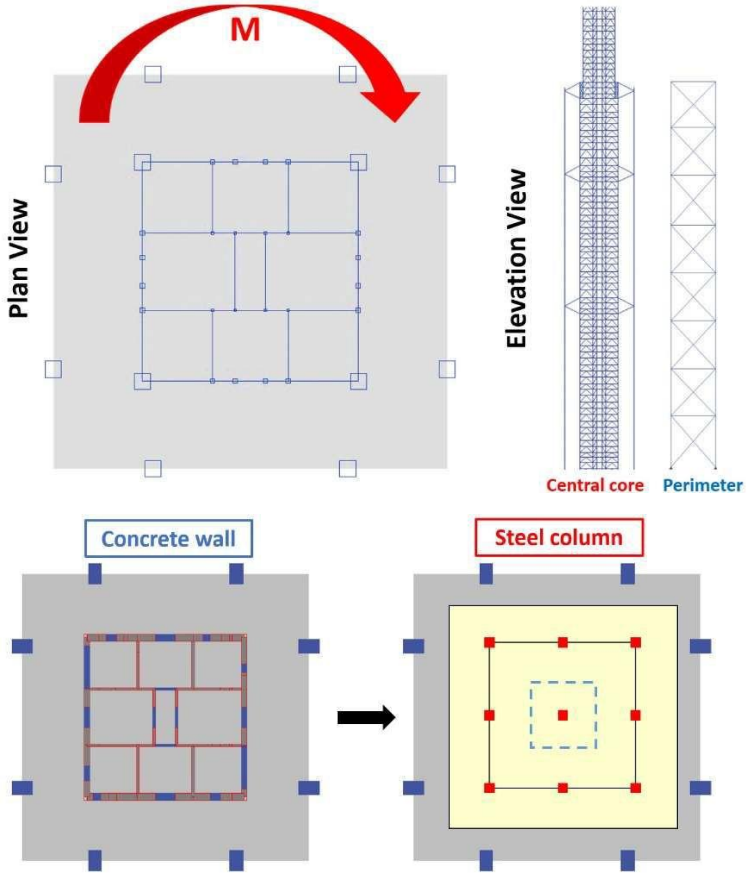

Figure 3.4 *The alternative design examples of lateral structural systems at main core*

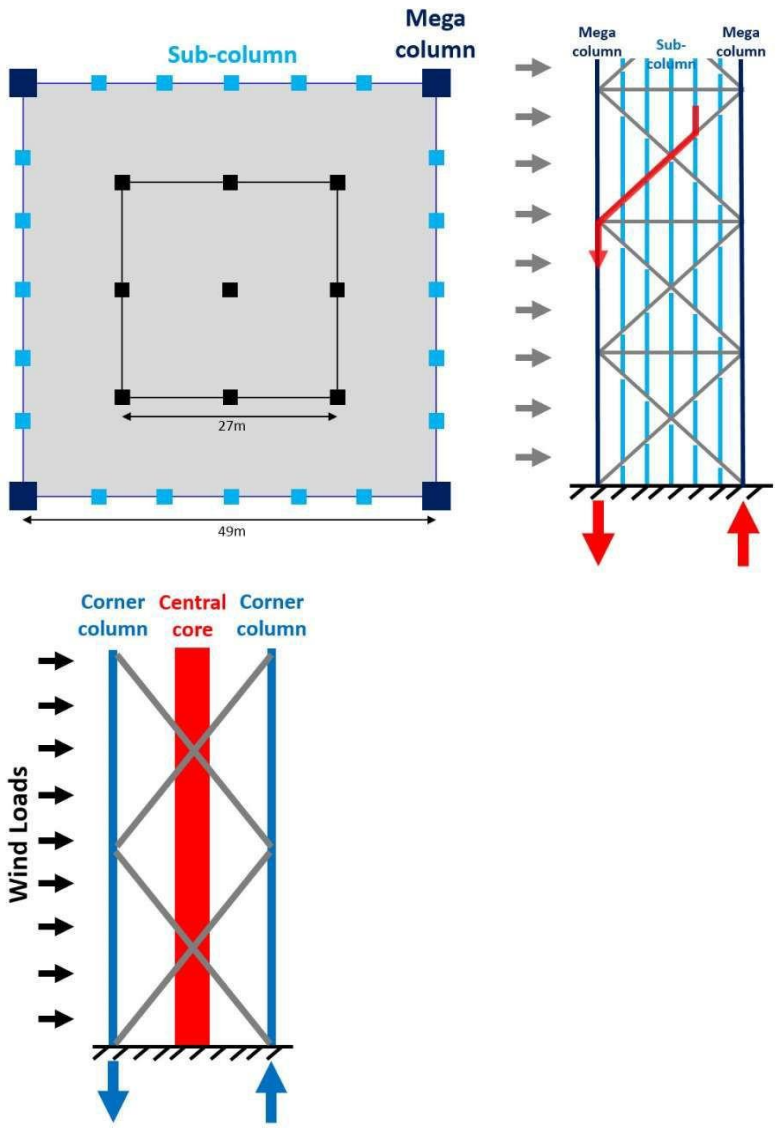

Figure 3.5 *The alternative design examples of lateral structural systems at building perimeter*

iii) Foundation System, Construction Time and The Other Considerations:

By increasing the steel usage for a tall building, a lighter structure and faster construction time are expected. However, IFC2 is currently built near the bedrock level and no construction schedule information is available for comparison. During the later phase, the potential advantages for both foundation design and construction time will be further investigated for general tall building design. Conversely, the other serviceability design issues such as the lighter structures for acceleration and the durability for earthquake effects will also cautiously be considered for the comprehensive and fair recommendations.