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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"

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Project Outline:

This project aims at maximizing the benefits of structural steel materials on the modern tall building design utilized the latest structural optimization technology. A comprehensive research study will be carried out to determine the advantage and disadvantages of using modern high strength steel materials in some tall buildings in Hong Kong and China. This research will have the following salient components:

1. To develop an interactive computer program which couples with existing analysis software for tall building behavior assessment and facilitates an integrated analysis and design optimization platform;

2. To devise a unified optimization solution approach for large-scale tall building structures in which normal and high strength steel, structural concrete, or composite steel and concrete may be considered as the construction materials;

3. To validate the effectiveness of advanced optimization technique using a vast range of tall building projects in Hong Kong and China;

4. To evaluate the structural and cost effectiveness of various high strength composite structural system for high-rise commercial buildings

1. Project Background

Determining an optimal structural system on a tall building is considered as an optimization problem to search the optimized sizes and locations of numerous structural members for the tall building. In the early development of structural optimization, the Optimality Criteria (OC) technique is a rigorous member sizing optimization method to minimize the structural cost with a fixed structural form. As the costs of optimal structures still vary significantly for different structural forms and systems, topology optimization is needed to effectively determine the optimal structural system for a tall building. Thus, a novel evolutionary technique incorporating OC techniques with a Genetic Algorithm (GA) was developed to further improve the optimization by examining the structural forms. The hybridization of the OC-GA is strategically designed such that the GA is applied for the global exploration of optimal topologies, whereas the OC is served as an efficient local search operator for optimally sizing elements of selected topologies. Although OC-GA generally gives a structural system with a lower cost than OC alone, the computational efficiency of OC-GA is usually low and often restricted by local convergence. The Shifting Balance Genetic Algorithm (SBGA) and Decomposition-based Strategies were therefore developed to improve the overall efficiency and the solutions of structural optimization. These optimization techniques will be incorporated and applied in this research to ensure the efficiency of structural optimization and maximize the benefit of composite construction on tall buildings. A technical guide and a book are planned to summarize the results and the findings of this research.

2. Research Plan and Methodology

The research activities are scheduled as follows:

Phase	Description
Phase A	Examine the efficiency and maximize the usages of steel construction for actual tall buildings in Hong Kong
Phase B	Quantify the structural system efficiency for various building heights
Phase C	Develop an optimization platform to quantify and validate the utilization of composite construction
Phase D	Summarize the results and recommendations in a technical publication “A Technical Guide to Maximizing Benefits of Composite Concrete-Steel Construction for Tall Buildings”
Phase E	Develop an innovative platform to incorporate additional considerations and algorithms for modern tall building design
Phase F	Refine and extend the results in a comprehensive tall building book “Structural Optimization on Modern Tall Building Design”