Application of Smart Façade System in Reduction of Structural Response During Wind Loads

by
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Certificate of authorship/originality

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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ABSTRACT

Strong wind causes severe shaking, mostly lateral, over a large area that applies strong excitation to building structures. These winds are extreme actions, from which buildings may not survive unless being properly designed in advance. In recent years, many new devices, such as energy-absorber systems, have been introduced. But, most of them have some disadvantages such as complexity of design and requirement of large spaces for installation. To date the engineering community has seen structural facade systems as non-structural elements with a high aesthetic value and a barrier between the outdoor and indoor environments. As an integral part of all structural buildings, they are susceptible to potential failure when subjected to severe environmental forces such as earthquake and high wind in case they are not designed properly. Wind loads can potentially impose a significant loading on the facade system and may lead to damage and racking in the case of an insufficient connection detailing correspondingly.

The role of facades in energy use in a building has been also recognized and the industry is witnessing the emergence of many energy efficient facade systems. Despite these advancements, the facade has been rarely considered or designed as a potential wind-induced vibration absorber for structural buildings. Development and implementation of advanced facade systems for enhancing the wind response of building structures have been a topic of debate for structural and architectural engineers. Considering this issue,

An alternative method using façade systems incorporated with energy-absorbing devices were proposed in order to damp the amount of energy transferred to the main structure during wind activities.

Various configuration and specification scenarios of the proposed system were suggested in this thesis. Multiple design variations were evaluated as well. To prove the concept and find the optimum value of damper properties, a series of non-linear structural analysis and finite element modelling was done in ANSYS program. First, conventional façade brackets were replaced with the so-called smart elements, which can have back and forth movement during wind load. Predefined elastic-plastic behaviour was suggested for the façade bracket elements in a double skin façade system. Second, façade bracket properties in terms of stiffness and damping of the proposed system were optimized to obtain the desired response. Third, the potential of utilizing a movable exterior facade in a double-skin facade was investigated and it was found that, with optimal choices of façade out-plane movement and appropriate bracket

stiffness, a substantial portion of wind-induced vibration energy can be dissipated, which could lead to avoiding expensive wind designs.

A series of dynamic time history analyses was also carried out to determine the behaviour and response of the proposed system on typical concrete frame structures under different intensity wind. ANSYS and Matlab programs were used for the numerical analyses in all phases of the feasibility study. The initial works demonstrated that the wind response for mid- and high-rise structural buildings subjected to wind loads can be substantially reduced by the introduction of a smart design of a double skin system. Application of flexible connections in façade systems can, if properly designed, reduce the top acceleration response of structural models in comparison with the case without flexible connections.

KEYWORDS: Façade Systems, Multi-Skin Façade, Tall Building, wind Load

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