Vibration of structurally connected high-rise buildings under wind force

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Abstract

Cities are organized around various underlying networks but building structures do not follow this trend. The isolation of structural systems causes difficulties in the case of tall structures. We investigate the possibility of improving structural behaviour by organizing buildings into urban-scale structural networks, with focus on vortex-induced vibration. We review our recent work, in which randomly generated collections of high-rise buildings were examined by numerical simulation using a conceptual model of the network composed of springs and point masses. Here we examine the behaviour of a realistic collection of buildings, generated by considering the existing building stock and urban fabric of Midtown Manhattan. The new simulation results suggest that connections among the buildings would enable the application of significantly softer bracing systems. This finding suggests that urban-scale structural networks is a promising direction of urban development.

Keywords: High-rise buildings, vortex shedding, vibration, wind, slenderness, network, Manhattan

1 Introduction

Cities undergo rapid growth in terms of population size, population density, and complexity. The efficient distribution of goods, services, energy, and other resources triggers the development of various underlying networks such as traffic, telecommunication, and transportation lines.

Despite this general trend, the building stock remains a collection of independent structures, which has obvious drawbacks. Most notably, tall, and slender structures are not efficient in carrying horizontal loads. One of the most challenging requirements of slender skyscrapers is to prevent the discomfort of occupants caused by wind-induced dynamic motion. We hypothesize that these problems may be addressed in the future by organizing high-rise buildings into urban-scale connected structural networks. The present paper aims to make initial steps towards uncovering the benefits of such structural systems.

Urban-scale structural systems have been popular as architectural utopias in the middle of the 20th century, but those ideas were never realized or even investigated from an engineering point of view [1]. We can find large-scale networks of bridges in some cities (like the Skywalk system in Minneapolis) but those connections do not have structural roles. Real-world examples of structurally linked buildings usually involve 2 or

https://doi.org/10.2749/ghent.2021.1598
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