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Interference effects between two tall buildings with different section sizes on wind-induced acceleration

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ABSTRACT

Wind-induced interference effects on the along-wind and across-wind acceleration responses between two tall buildings were detailed studied based on a series of pressure measurement wind tunnel experiments and response analyses. The modifications of acceleration response at the top of principal building from interference over a practical range of reduced velocities were represented by an enveloped interference factor (*EIF*). In this study, six types of interfering buildings were considered with breadth ratios ($B_r = 0.4$, 0.6, 0.8, 1.0, 1.2 and 1.4) and the influences of approaching turbulence intensity were investigated. Furthermore, the interference mechanism to wake vortex-excited resonance were explored. As a result, amplification effects were mainly dominant not only for along-wind *EIF*s but also for across-wind *EIF*s. When B_r equaled to 0.4 and 0.6, the maximum along-wind *EIF*s were 2.3 and 2.1, while the maximum across-wind *EIF*s were 3.0 and 2.1 because of wake vortex-induced resonance. Whether in along-wind or in across-wind direction, *EIF*s decreased with the increase in turbulence, and a strong linear correlation was discovered between low and high turbulences for all the breadth ratios. The interference mechanism of wake vortex-induced resonance to acceleration response, base moment response, and torsional response were the same for square section buildings.

1. Introduction

Comfort level was one of the most important control indexes for structural design of high-rise buildings, and it was usually quantized by the peak acceleration at the top of the building. With the rapid development of city construction, the height and number of tall building were also growing rapidly. For some of the high-rise buildings, comfort level was the main influence factor in their structural design. When strong wind flowed through these high-rise buildings, mutual interference effects occurred, and then the principal building would suffer a much larger wind-induced acceleration response, the occupants in the building might be panic even insecure. Although the present load codes (NRCC, 2010; GB50009-2012, Architectural Industry Press of China, 2012) had provided the suggestion items and calculation methods on along-wind and across-wind accelerations, they were only suit for isolated buildings. Besides the shape of high-rise buildings became more and more complicated and the mutual interference effects among them could not be avoided. Thus, it was significant and valuable to study the interference effects between/among high-rise buildings on wind-induced acceleration response, which could be referred to similar engineering structures.

Since the 1970s, wind engineering researchers had done a lot of investigations on interference effects between/among high-rise buildings. Khanduri et al. (1998) had reviewed the research progress of wind-induced interference effects on tall buildings in the last century. In the latest decade, the researches on interference effect were still active and mainly focused on surface pressure distribution and base moments/torsion.

In respect of cladding design, Kim et al. (2011) had investigated the local peak pressures between two buildings by wind tunnel experiments, it was shown that the smallest minimum peak pressure coefficient on principal building increased with increase in height ratios of an interfering building. Hui et al. (2012, 2013) studied the interference effects between two high-rise buildings with different shapes on local peak pressure coefficients. The results showed that interference effects greatly depended on building shapes and wind directions. Unfavorable positions were generally concentrated at the edges and corners of a building, the smallest minimum peak pressure were 40% large than that in the isolated condition. Block interference factor was employed by Yu et al. (2015) to describe the interference effect on the mean and peak pressure distributions between two tall buildings, six kinds of breadth ratios and four

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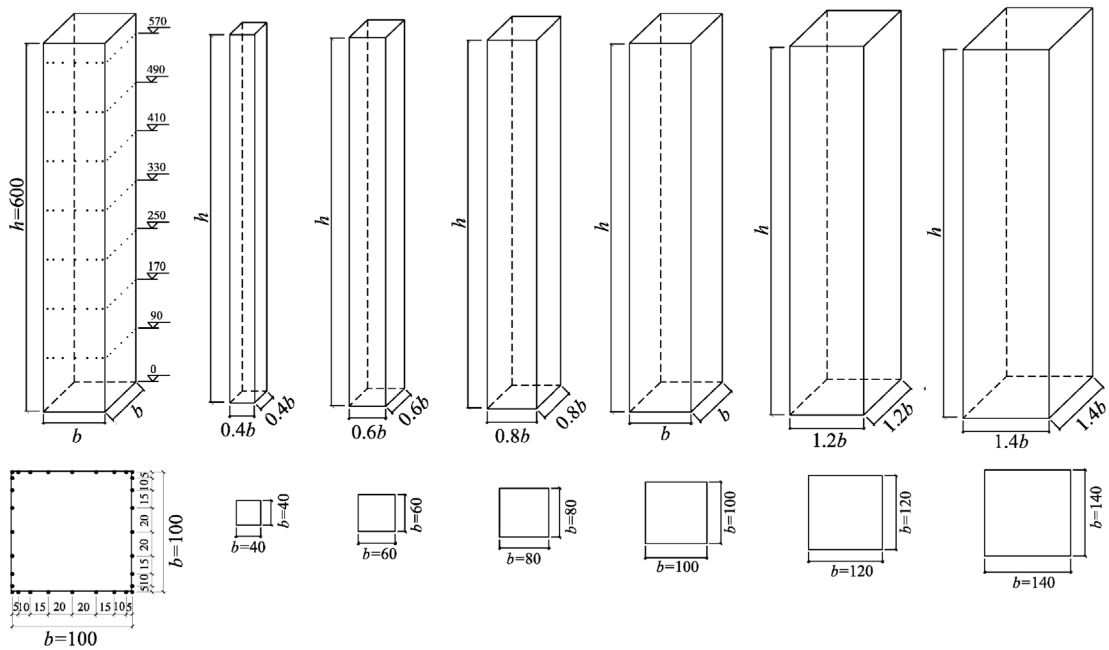

Fig. 1. Configuration of principal and interfering building models (unit: mm).

kinds of height ratios were considered in the wind tunnel experiments. Results indicated that the local mean and peak pressures on the lateral façade increased by 56% and 53%, respectively, because of the three-dimensional flow effects when upstream interfering building was shorter than downstream principal building in tandem arrangement.

In respect of structural design, many researchers had investigated the base aerodynamic loads and base load responses. Kim et al. (2015) had studied the interference effects of five types of adjacent buildings with different heights on overall and local wind loads of principal building by a series of wind tunnel tests. It was found that interference effect on along-wind base moment coefficients with height ratio $H_r = 1.5$ and 1.0 significantly increased when the interfering building was close to the principal building. Variations of along-wind and across-wind local force coefficients along the height levels depended on the locations and height ratios of the interfering building. Hui et al. (2017) measured the aerodynamic torsion load on two adjacent buildings through wind tunnel experiments. It was discovered that the extreme aerodynamic torsion under interference effects was higher at 1.8 times that of the isolated case. In fact, the wind-induced responses of a high-rise building depended on not only aerodynamic forces but also structural dynamic characteristics. If the aerodynamic forces were only considered, it meant the final structural response just contained background component (quasi-static response) but without resonant component. Thus, Xie et al. (2007) had systematically studied the interference effects of base bending moment responses among three high-rise buildings. It was found that two interfering buildings could produce stronger along-wind dynamic interference effect than a single interfering building, but the across-wind dynamic interference effect caused by two interfering buildings seemed to be somewhat weaker than that by a single interfering building. Lam et al. (2011) investigated wind-induced interference effects on a row of five square-plan tall buildings arranged in close proximity. It was discovered that the design values of peak dynamic responses of a tall building were not significantly magnified when placed in a row. Yu et al. (2016) studied the interference effects between two high-rise buildings on wind-induced torsional response. Results showed that the maximum value of envelope interference factor reached up to 2.98 when the breadth ratio B_r equaled to 0.4.

Few researches have systematically examined the interference effects

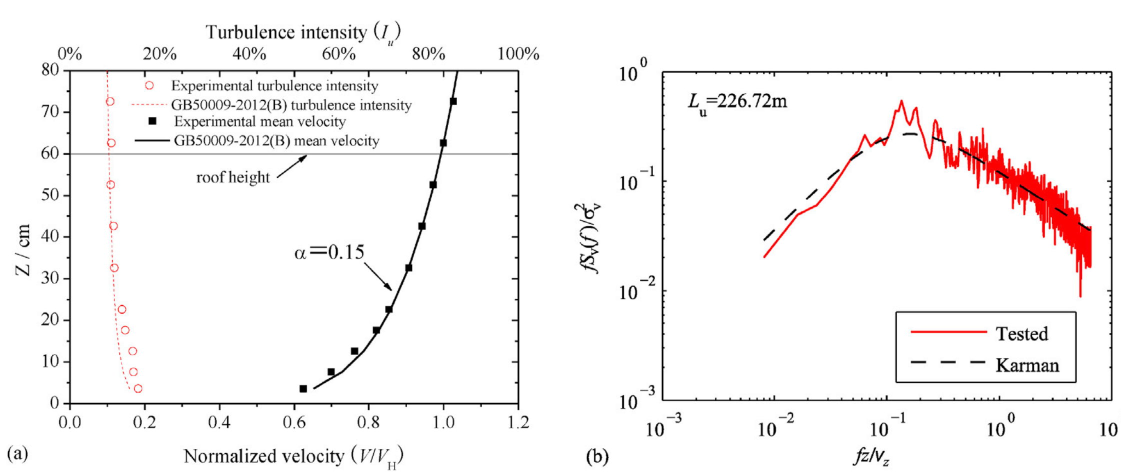

Fig. 2. Simulated wind parameters in suburban terrain (category B): (a) mean speed and turbulence intensity profiles; (b) longitudinal turbulence spectrum at the roof height.