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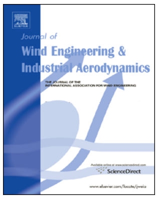

Interference effects of a neighboring building on wind loads on scaffolding

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ABSTRACT

This study investigates the interference effects of a neighboring building on wind loads on scaffolding. Wind tunnel experiments were carried out on scaffolding with nonporous cladding. Three scaffolding geometries were considered. Effects of neighboring building location, neighboring building height ratio and principal building opening ratio were studied, and mean panel force coefficients were determined. Based on experimental data, wind forces acting on tie members were estimated, and the largest peak tensile force among all tie members was evaluated. Interference factors were determined. When the neighboring building was located in front of the measured scaffolding, the interference effects on both the largest positive and largest negative mean panel force coefficients were dramatic. The largest positive wind loads on the scaffolding become larger when the neighboring building was located on the left or right side of the measured scaffolding. Interference factors were determined by the largest peak tensile forces in tie members. The largest interference factors were found when the neighboring building was located in front of the scaffolding for a building distance 1.5 times the building depth. When the neighboring building was located on the left or right side of the measured scaffolding, the interference factors were always larger than 1. The neighboring building height ratio had significant effects on the largest mean panel force coefficient but only slight effects on interference factors. The neighboring building had less effect on the wind direction causing the largest peak tensile force in the tie members.

1. Introduction

Scaffolding is widely used as a temporary structure in engineering construction. Wind-induced scaffolding collapse accidents are reported every year. Safety is the most important issue in civil engineering construction, so more attention is needed for wind resistant design of scaffolding. Ohdo et al. (2005) investigated scaffolding collapse accidents and found that about 10% of severe collapse accidents were due to wind. Thus, wind loads on scaffolding have become an important issue in scaffolding design. Yue et al. (2005) conducted force measurement experiments in a wind tunnel and practical design of a typical integral-lift scaffolding was carried out for a prototype. The results showed that the drag force coefficient of scaffolding increased almost linearly with increase in scaffolding solidity ratio. Irtaza et al. (2012) investigated models of sheet-clad and elevated sheet-clad scaffolding surrounding a cubic building. Experimental data and code recommendations were compared. Wang et al. (2013) investigated wind loads acting on nonporous-clad scaffolding for twelve scaffolding geometries and four building opening ratios. Mean and local peak net pressure distributions were investigated. Mean panel force coefficients and area-averaged wind force coefficients were determined and compared with relevant current design standards and recommendations.

Past research on wind loads acting on scaffolding have mainly focused on the isolated building condition. However, wind loads on structures in real environments can be quite different from those measured on isolated structures. Surroundings can significantly increase or decrease wind forces on interfered structures. Orlando (2001) carried out wind tunnel experiments on a rigid model of two adjacent cooling towers. Lam et al. (2008) investigated interference effects on a row of square-plan tall buildings arranged in close proximity. Kim et al. (2011) and Hui et al. (2012) discussed interference effects on local peak pressures on a principal building with various configurations and different height ratios of a neighboring building. Many studies have been done on interference effects on wind loads on buildings and other structures, which showed that a neighboring building may cause significant interference effects under some conditions.

As described in the literature, scaffolding with nonporous cladding may suffer severe wind loads. A neighboring building may also have significant effects on wind loads acting on scaffolding. Therefore, this study aimed to investigate interference effects

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on wind loads on scaffolding with nonporous cladding. Wind tunnel experiments were carried out based on a prototype of nonporous sheet-clad scaffolding. A medium-height building with rectangular cross-section was selected as the principal building. Buildings with the same cross-sectional dimensions but different height ratios were selected as the neighboring buildings. Effects of neighboring building locations, neighboring building height ratios, principal building opening ratios and wind directions were investigated. Mean pressure coefficients and mean panel force coefficients were determined. Moreover, tie members mainly contribute to the horizontal stability of scaffolding and prevent collapse. Thus, wind-induced external peak forces acting on tie members were estimated and interference factors were determined.

2. Experimental setup and data processing method

2.1. Wind speed and turbulent intensity profiles

Wind tunnel experiments were carried out in a Boundary Layer Wind Tunnel in Tokyo Polytechnic University, Japan. The test section was 2.2 m wide and 1.8 m high. The atmospheric boundary layer was simulated as a geometrical scale of 1:75. Open terrain characteristics were simulated and a velocity scale of 1:2.5 was adopted. The power law exponent α of mean wind speed was 0.2. The mean wind speed at the reference height z_{ref} (top of the principal building which is 318 mm above the bottom of the tunnel) was around 8.6 m/s, and the corresponding turbulence intensity was approximately 21%, as shown in Fig. 1.

2.2. Experimental models

The dimensions of the prototype principal building were 19.2 m × 12 m in plane and 23.8 m in height. The building comprised seven stories 3.4 m high. The scaffolding was assembled by using typical door-type tubular-steel scaffold units 1.7 m high, 0.9 m wide and 1.8 m in span (one-bay). The prototype scaffolding was 27.2 m high, and comprised sixteen stories. The scaffolding was 3.4 m (two-stories) higher than the principal building. The distance between the building surface and the cladding of the scaffolding was 1.2 m in full scale. There were four scaffolding models for the four sides of the principal building. There was one pressure-measured model and three dummy models. Nonporous acryl models 5 mm thick were made to simulate the nonporous clad scaffolding (scaffolding pipes were ignored).

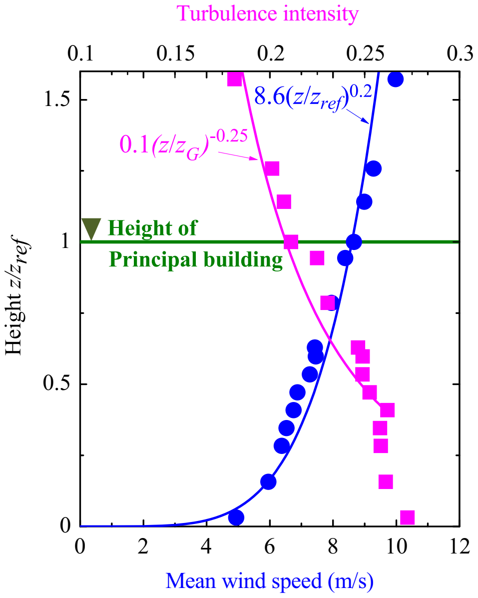

Fig. 1. Mean wind speed and turbulence intensity profile.

The experimental buildings were made from plexiglass. All the principal building models were 318 mm in height (H), 256 mm in breadth (B) and 160 mm in depth (D). Four principal building models were tested. The building opening ratios (Φ_B) were 0%, 20%, 40%, 80%. Three neighboring building models were tested. The neighboring building models had the same cross-sectional dimensions as the principal building. The neighboring building height ratio (Hr) was defined as the neighboring building height divided by the principal building height (H). The neighboring building height ratios were 0.5, 1 and 1.5. In this study, the neighboring building opening ratios were always 0%.

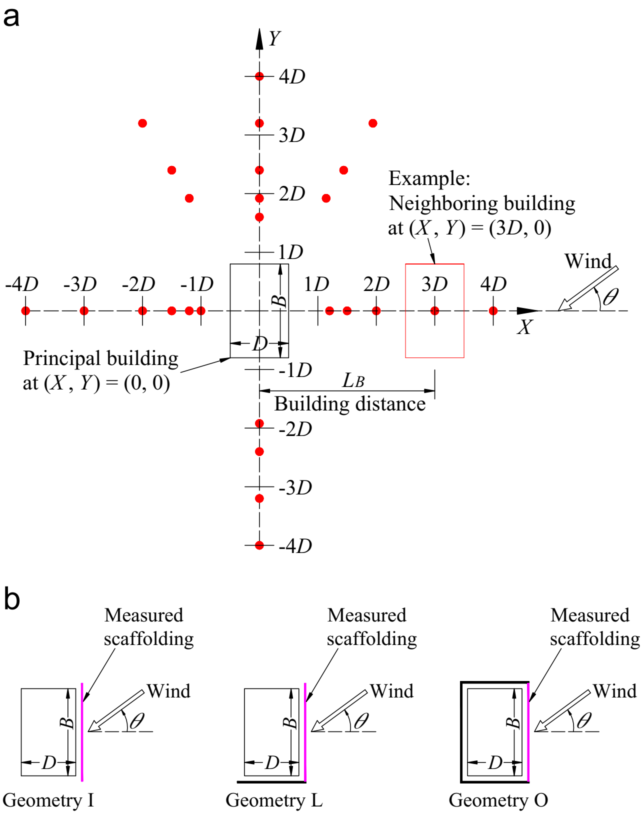

Fig. 2. Experimental arrangements and scaffolding geometries. (a) Experimental arrangements and (b) scaffolding geometries

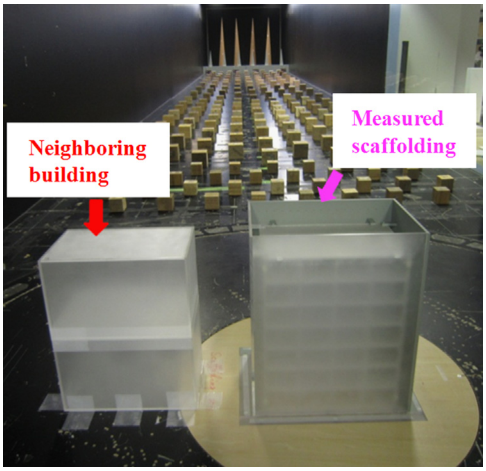

Fig. 3. Wind tunnel setup and models in experiment (Neighboring building at (X, Y)=(0, 2.4D), geometry O, Φ_B=80%, Hr=1).