Investigation on the Unsteady Aerodynamic Force on a 3:2 Rectangular Section under Accelerating Airflow

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Abstract

Unsteady characteristics of aerodynamic force and wind-induced pressure on a 3:2 rectangular section under accelerating airflow are investigated through wind tunnel experiments. Three aerodynamic coefficients, drag coefficient $C_d(t)$, RMS of lift coefficient $C_l^{rms}(t)$, Strouhal number of the rectangular section in the accelerating airflow with or without initial velocity are compared with those of the steady flow. Results show that in the cases of airflow accelerated from the static state, significant unsteady feature appears in all three aerodynamic coefficients, $C_d(t)$ and $C_l^{rms}(t)$ decreases and *St* number increases in the early accelerating stage. For accelerating airflow with an initial velocity, the three aerodynamic characteristics fit well with steady flow values, indicating negligible impact on any of these variables.

Keywords: accelerating airflow; rectangular section; unsteady aerodynamic force; wind tunnel test.

1 Introduction

Accelerating airflow is a distinguishing feature of extreme wind hazards such as tornadoes and downbursts. Unlike the atmospheric boundary layer wind environment, the wind speed of the above two disasters increases intensely in a short time, resulting in significant unsteady features of the wind force on the structure. Among them, the rectangular section is widely used in bridge members, such as stiff hangers and support columns of arch bridges, and pylons of cable-supported bridges. Efforts have been made by many researchers [1-7] on wind tunnel experiments and numerical simulation of aerodynamic characteristics of the rectangular section in uniform flow, such as lift coefficients, drag coefficients, Strouhal number, wake region et al. Nevertheless, relatively fewer studies are carried out on unsteady wind force of rectangular section under accelerating airflow.

Sparyaky firstly studied the development of vortices around the section of an accelerating bluff body in a water tunnel [8, 9]. Matsumoto simulated accelerating airflow by suddenly switching a louver-shaped device installed downstream of the wind tunnel test section, and found the maximum drag force coefficient is 1.14-1.25 times of that under steady flow [10]. Takashi investigated the force on the ellipse and rectangle section prism under the 0.2s accelerating time airflow generated by the actively controlled rotation of the horizontal plate blades in the wind tunnel [11]. Yang investigated the effect of the accelerating flow on the aerodynamic forces of three two-dimensional rectangular prisms through a series of unsteady wind tunnel manometric experiments [12]. Zhao and Cao [13] simulated the

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