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Characteristics of wind induced net force and torque on a rectangular sign measured in the field

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ABSTRACT

Full-scale field tests for a billboard sign are conducted at the Wind Science and Engineering (WISE) field site to provide a benchmark for model scale tests performed in the wind tunnel. The field site is located at the Reese Technology Center in Lubbock, Texas. The aspect and clearance ratios for the sign are 2.0 and 0.5, respectively. Wind induced forces and torques on the full scale sign are established using 470 15-min duration records. All the records used are stationary in speed and direction and have mean wind speeds greater than or equal to 15 mph (6.7 m/s). The characteristics of the parent and joint distributions for force and torque acting on the sign are presented herein. The characterization includes empirical functions to describe the mean, standard deviation, skewness, kurtosis, and their correlation in time as a function of angle of attack. Mean extreme force and torsion coefficients are provided along with mode and dispersion parameters for the Fisher–Tippet Type I distribution. Two estimation techniques to compute the mean extreme value are investigated. The performance of each technique is evaluated by comparison of the mean extreme value to measured peak values. Model scale mean force coefficients obtained in the wind tunnel and available in the literature tend to overestimate those from the full scale tests.

1. Introduction

The recent trend in the sign industry is to use enclosed signs with significant depth such as the one shown in Fig. 1, instead of the single plate thin signs (Fig. 2). Back to back thin plate signs with open sides are also commonly used today (Fig. 3). The International Sign Association (ISA) and the Outdoor Advertising Association of America (OAAA) sponsored a comprehensive study of the force and torsion of enclosed signs at Texas Tech University (TTU) Wind Science and Engineering (WISE) Center. The study includes both full- and model-scale test(s). The full-scale tests are used to provide validation of the wind-tunnel tests which are presented in Zuo et al. (2014). This paper details the full scale test, its results, and compares these results with model-scale results in published literature. The sign that was tested in the field is shown in Fig. 4.

Forces and torques on the full scale sign are established using 470 15-min duration records. All the records used are stationary in speed and direction and have mean wind speeds greater than or equal to 15 mph (6.7 m/s). Net pressures across the two faces of the sign are measured in the field study. Net force coefficients and torsion coefficients about the vertical axis of the sign are computed from the measured net pressures.

The characteristics of the parent and joint distributions for force and torque acting on the sign are presented herein. The characterization includes empirical functions to describe the mean, standard deviation, skewness, kurtosis, and their correlation in time as a function of angle of attack. Mean extreme force and torsion coefficients are provided along with mode and dispersion parameters for the Fisher–Tippet Type I distribution. Two estimation techniques to compute the mean extreme value are investigated and the performance of each technique is evaluated by comparison to measured peak values.

Gust factors for the collected data are investigated and used to compute pseudo-steady force coefficients that can be used with a quasi-steady formulation of wind loads. The gust factors when considered as a function of turbulence intensity exhibit large scatter and low correlation around a best fit line. The pseudo-steady and mean force coefficients are approximately equal over the angles of attack that generate the largest forces, however deviate significantly from each other as the angle of attack of wind on sign becomes parallel to the face of the sign.

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Fig. 1. Sign with significant thickness.

Fig. 2. Thin plate sign.

Fig. 3. Back to back thin plate sign.

Fig. 4. Sign tested at the WERFL Field Site.

2. Experimental setup

2.1. Field site

The full scale test is performed at the Reese Technology Center located approximately 12 miles (19.3 km) west of the Texas Tech University campus. Fig. 5 shows the location of the sign on the field site. The terrain surrounding at the field site is flat, smooth, and uniform as can be seen in Fig. 4.

2.2. Sign dimensions and characteristics

The full scale test specimen, shown in Fig. 4, has a width, *B*, of 24 ft-7 in. (7.5 m), a height, *s*, of 12 ft-3$\frac{1}{2}$ in. (3.75 m) and has a thickness, *T*, of 5 ft-8$\frac{3}{4}$ in. (1.75 m). It is mounted on a 10 in. (254 mm) diameter standard steel pipe section (AISC, 2005) that has a 10.8 in. (274 mm) outside diameter with a wall thickness of 0.365 in. (9.3 mm). The diameter of the pipe section is purposely chosen smaller than normally used in industry to obtain larger