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DRAG AND LIFT COEFFICIENTS FOR WIND LOADS ON LOUVERED HIGHWAY SIGNS (EXTENDED ABSTRACT)

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1 INTRODUCTION

Large highway signs with solid panels can be subjected to significant wind loads which would require relatively stiff and heavy supporting structures. The reduction of such loads would be beneficial since it would allow for the use of more economical and lighter supports. Louvered panels, which allow for airflow through the sign, have been proposed as an alternative to solid panels. The objective of this work is to quantify the percentage of reduction of wind loads that can be achieved by using louvered panels instead of solid panels. This is achieved through performing a series of wind tunnel tests a 1ft x 1ft louvered sign section under different flow and sign configurations.

2 EXPERIMENTAL SETUP

All tests discussed in this report were performed in the Stability Wind Tunnel at Virginia Tech. The tunnel is a continuous, closed jet, single return, subsonic wind tunnel with a 24 foot long 6'x6' square test section. The tunnel is powered by a 600 hp DC motor driving a 14 foot propeller providing a maximum speed of 275 fps (187.5 mph) and a Reynolds number per foot up to 1.66×10^6. The tunnel speed is regulated by a custom designed Emerson VIP ES-6600 SCR Drive which could be interfaced with the tunnel's computer data acquisition system. This drive system is a state of the art wind tunnel control which not only provides for efficient operation but more precise speed regulation than is possible with older style DC generator drives commonly found in tunnels of similar size. The precisely regulated DC power source eliminates all the cyclic unsteadiness in tunnel velocities normally associated with older tunnel drive systems as well as the turbulence inducing vibrations inherent with such drive systems. A Pitot-static tube connected to a calibrated differential pressure sensor was used to set the speed of the tunnel. A16-bit National Instruments AT-MIO-16-XE-10 Data Acquisition Card installed in a PC computer was used to acquire data. LabView 4.0 used under a Windows 2000 environment was used to record the data. The turbulence level in the Stability Wind Tunnel varies slightly with speed. Over the range of wind speeds considered in these experiments, the turbulence level is less than 0.055%. The tunnel speed was set using a single calibrated Pitot-static probe placed upstream of the model. Calibrated temperature and pressure sensors were used to simultaneously measure the ambient conditions as the load data was acquired.

The sign section is a louvered design that incorporated S-shaped louvers. It was constructed entirely out of aluminum and is shown in figure 1. Spacers were placed between each of the five louvers and four long threaded rods held the entire sign together. Two plates were attached to the top and bottom of the sign. The sign dimensions are 12in x 12in x 5in. A flat steel plate was attached to the bottom of the sign to enable its mounting in the wind tunnel. The sign section was mounted to a load cell that is attached to a steel sting which is capable of supporting loads exceeding a thousand pounds. The load cell is capable of measuring three forces up to $^{+}/_{-}$120 lbs and three moments up to $^{+}/_{-}$ 1,200 in-lbs with high sensitivities, for example the sensitivity in the axial (drag) direction is 0.029 $^{lb}/_{\mu V/5V}$. It has undergone an extensive calibration procedure which was verified during the experiment setup.

Figure 1: Aluminum louvered sign section as mounted in the tunnel

Testing was performed on the sign section mounted in three different configurations. In the first configuration, the sign was mounted at a zero degrees angle of flow incidence (forward wind). In the second configuration, the sign was mounted once again at a zero angle of flow incidence but with the bottom plate removed to get an assessment of the effects of this plate on the lift and drag coefficients. In the third configuration, the sign was mounted at 180° angle of flow incidence (backward wind). In all experiments, the sign section was subjected to speeds between 35 and 140 mph. The lift and drag forces were measured directly. The forces were sampled at one kHz for three seconds and averaged.

3 RESULTS

The measured lift and drag coefficients under the different mounting conditions are presented in figures 2, 3, and 4. In the case of forward wind, the measured values of the drag coefficient were near 0.74 which presents a reduction of about 42% in comparison with case of solid panels whose drag coefficient value is about 1.28. The lift coefficient is negative (in the direction of gravity); yet, its value is very small, near -0.02. In order to determine the effects of the top and bottom plates on the measured coefficients, the experiments were repeated but with the bottom plate removed. The results show that the drag coefficient is not affected (figure 3). On the other hand the lift is increased to values near -0.1.

Figure 4 presents the results for the case of backward wind. In this case, the drag coefficient is slightly larger than the one measured in the case of forward wind. Its average value is near 0.84 which is about 35% reduction in the drag when compared with the drag coefficient on a solid panel. The lift coefficient, acting in the opposite direction to gravity, is near 0.37. Uncertainties in the measured coefficients and an assessment of dynamic loads will be presented in the full paper.

4 CONSLUSIONS

In this work, wind tunnel measurements are conducted to determine drag and lift coefficients on a 1ft x 1ft louvered sign section under different flow and sign configurations. The measured values of the drag coefficient are reduced by 35% to 42% in comparison with values of the drag coefficient on solid panels. Removing the bottom plate of the provided section did not affect the measured drag coefficient significantly. This shows that the drag is not affected by the presence of the top and bottom plates on the section as provided. In the case of backward wind, the lift coefficient is positive and has a value of about 0.37. This coefficient is negative, yet much smaller near -0.02, for the case of forward wind. This coefficient increased to about -0.1 when the bottom plate was removed.

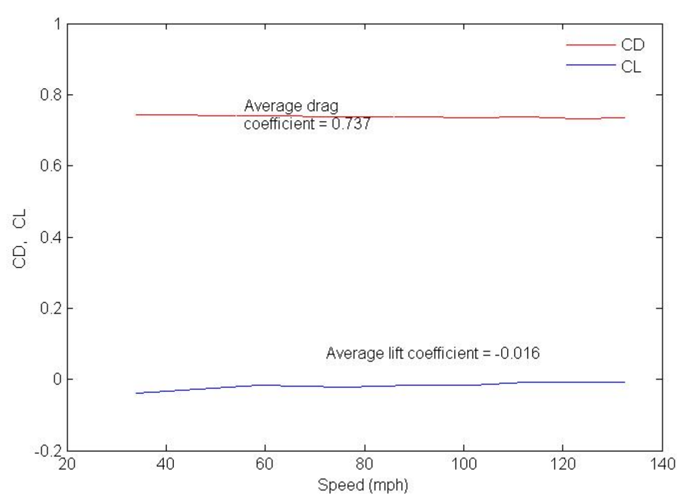

Figure 2: Drag and lift coefficients as measured for the sign mounted in forward configuration.

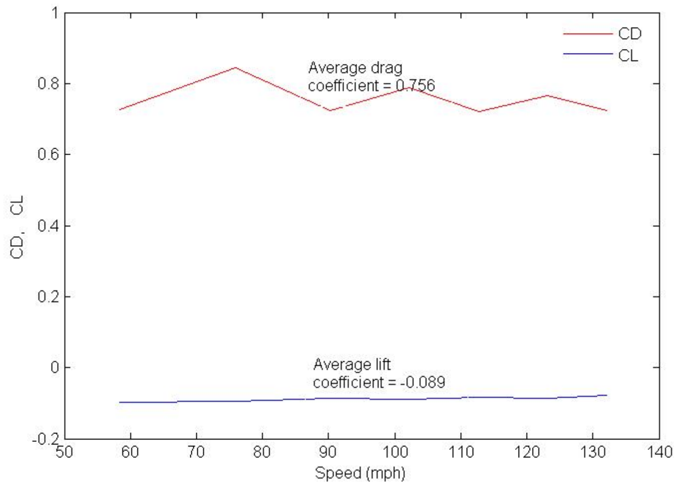

Figure 3: Drag and lift coefficients as measured for the sign mounted in forward configuration – bottom plate was removed to determine the effects of its presence on the measured coefficients.

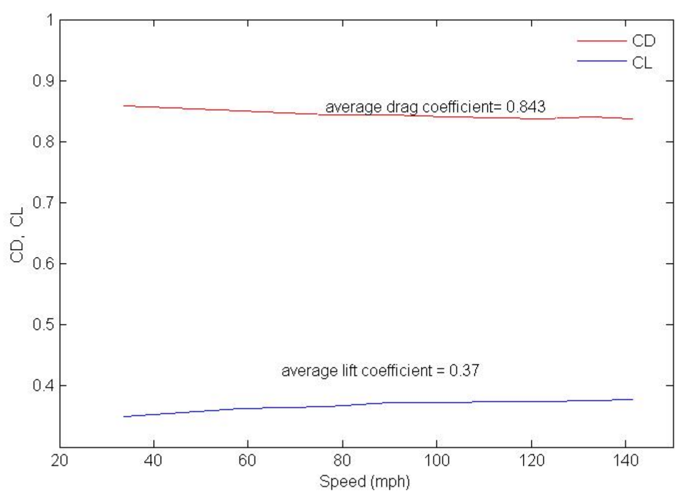

Figure 4: Drag and lift coefficients as measured for the sign mounted in backward configuration.