Experimental Investigations of Wind Shear from Passing a Vehicle

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Introduction

Experimental investigations of the wind load generated by vehicles on road signs have shown that the force exerted on these signs varies depending on both the vehicle's aerodynamics and the sign's positioning. These insights highlight the complex interaction between moving vehicles and roadside structure locations. The highest force on the road sign is imposed by the front of the vehicle, and the amount of the load depends on the distance between the vehicle and the sign. Depending on the force amplitude and its duration, the impact on the road sign could result in dynamic reactions and material fatigue. We conducted experimental research on wind generated by passing vehicles to assess the results of our previous numerical investigation which showed its potential for electric power generation.

Study Methods

We performed both wind tunnel experimentation and field tests using scaled Ahmed bodies (generic car bodies) as vehicles. For the wind tunnel experiment, an open circuit low-speed wind tunnel at a free-stream mean velocity of 23 m/s was used. Five PVC pipes of 6 cm OD and 90 cm long were placed on a flat plate platform adjacent to the wind-blowing domain in the streamwise direction at 2D from each other. The pipes simulate the columns under a freeway overpass. Ahmad's body dimensions were 17.36 cm in height, 15.67 cm in width, and 52.7 cm in length. The spanwise distance between the Ahmad body and the pipes was 0.75 w where w is the width of the vehicle. The middle pipe was used as a reference pipe for circumferential and vertical pressure measurements. The streamwise locations of the vehicle were according to our previous transient numerical simulations as the vehicle approached and passed the columns at 0.1–0.5 s. Field tests were performed using a moving scaled Ahmad body. The vehicle speed was measured by a hand-held speed gun with an accuracy of 0.44 m/s and was approximately 22 miles/hr (10 m/s.). Wind measurements were made up to 0.75 W adjacent to a vertical wall with static and total pressure taps.

Findings

Wind Tunnel Experiment

The vertical pressure coefficients are negative between the ground and the top of the vehicle at all times, which corresponds to air movements from the passing of the vehicle at these locations. This means that to extract wind energy from the passing of the vehicles, the wind turbine system should be placed between the ground and the top of the vehicle.

Field Tests

Figure 1 shows the variation of static pressure coefficient from the passage of the vehicle with positive pressure corresponding to the front and immediate tail of the vehicle while the negative pressures correspond to the passage of the body and the wake area. The total difference in pressure coefficients is approximately 0.5. Similar variations in pressure coefficients are seen for other axial pressure taps with delayed times. The pressure differential is associated with the level of wind power generated.

The transient vertical pressure coefficient changes between -0.6 and 0.2 with the passage of the vehicle (Figure 2). These results indicate the ground effect that reduces wind energy has disappeared at elevations beyond 25% of the vehicle height. In the spanwise direction between the vehicle and the wall, with the passage of the vehicle, there is an approximately linear increase in the mean velocity with increased distance from the wall, and at approximately 50% of the vehicle's width, the mean velocity is more than 12 m/sec., higher than the velocity of the vehicle (Figure 3). These results show the wind energy potential is high at the mid-section height of the vehicle at about 50% vehicle width with a maximum static pressure coefficient of 0.8.

Under the freeway overpasses, near a wall or column, the wind generated is contained and has more uniform power for electric power generation. With an optimized wind turbine system, this energy potential can be harnessed to generate electricity for lighting the freeways and powering signs and notification systems for improved safety.

Policy Recommendations

Funding support for innovation and technology development for capturing wasted wind energy from passage of the vehicles on freeways and highways results in increased renewable energy and sustainability.

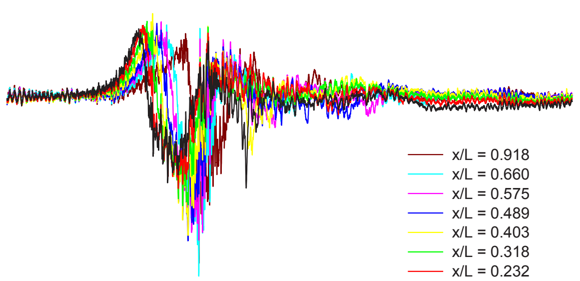

Figure 1. Transient Axial Pressure Coefficient

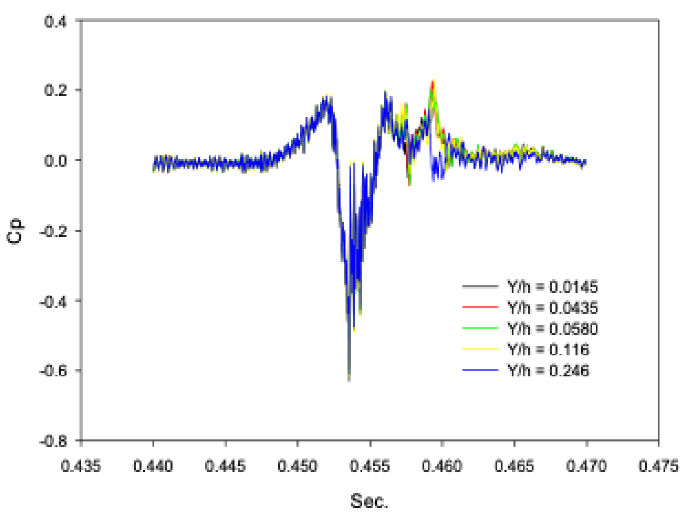

Figure 2. Transient Vertical Pressure Coefficient

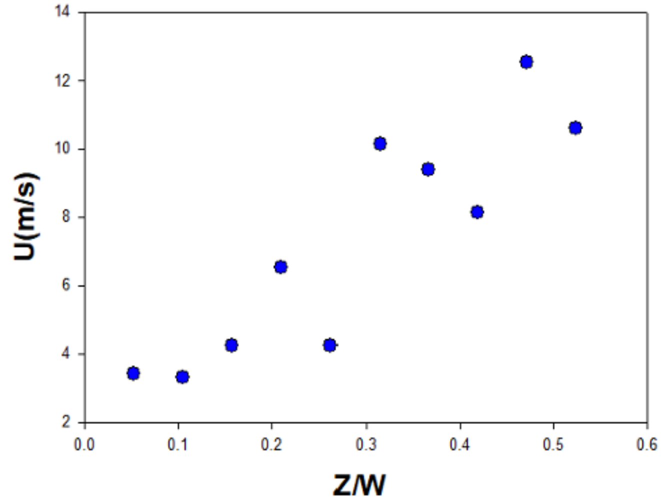

Figure 3. Spanwise Velocity From Passing Vehicle

About the Authors

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To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2334

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