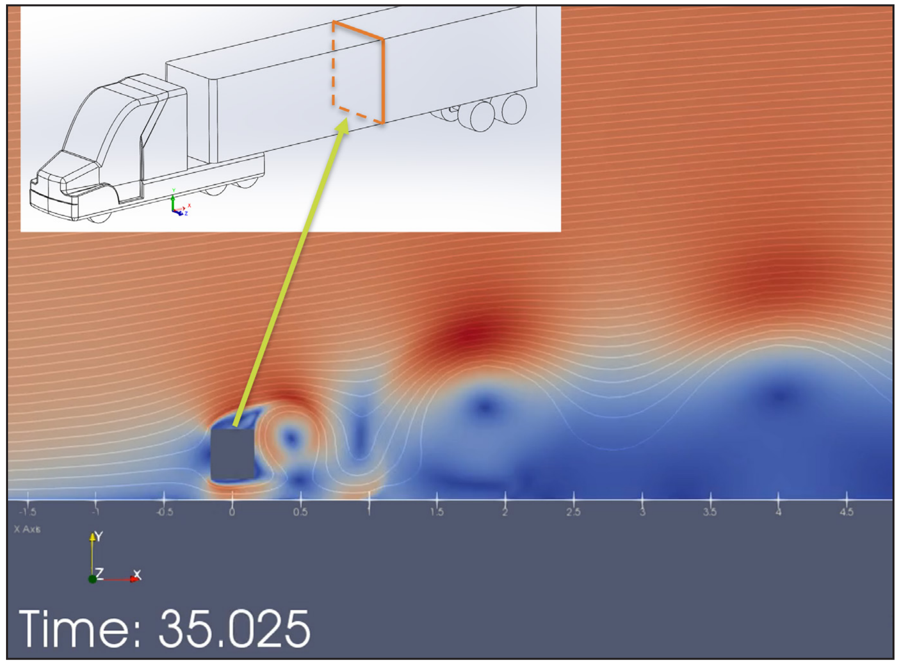
MOUNTAIN-PLAINS CONSORTIUM

RESEARCH BRIEF | MPC 24-561 (project 644) | September 2024

Crash Modeling of High-Profile Moving Vehicles Under Strong Crosswinds Based on Computational Fluid Dynamics



the ISSUE

Extreme wind events such as thunderstorms, winter storms, and hurricanes pose high crash risks for vehicles on highways. In addition to the safety implications, wind-induced vehicle crashes can also lead to extended highway closures, causing significant traffic disruptions and economic losses. Our current understanding of wind loads on high-sided vehicles comes mostly from wind tunnel tests, along with recent contributions from computational fluid dynamics (CFD) studies. However, limitations due to scaling issues of wind tunnel data have constrained the understanding of the nature/uncertainties of such extreme load distributions due to high lateral wind conditions.

the RESEARCH

This research presents an investigation of high wind flow around a simplified trailer section of a high-sided vehicle using CFD simulations. Researchers investigated the problem of overturning high-sided vehicles through a fundamental fluid mechanics perspective. The research conducted included a background on overturning high-sided vehicles, the aerodynamic coefficients of interest including the rolling moment coefficient, the considerations for this study given the United States geographical focus, the background on Reynolds number (a measure of the ratio between inertial and viscous forces that helps predict fluid flow patterns) dependency as it relates to an overturning high-sided vehicle, and fundamental fluid mechanics of flow around rectangular cylinders. CFD high resolution simulations were assembled for this study to investigate the wind flow field and related aerodynamic coefficients around a simplified geometry of a high-profile vehicle.

MOUNTAIN-PLAINS CONSORTIUM REGION 8

A University Transportation Center sponsored by the U.S. Department of Transportation serving the Mountain-Plains Region. Consortium members:

Colorado State University
North Dakota State University
South Dakota State University
University of Colorado Denver
University of Denver
University of Utah
Utah State University
University of Wyoming

Lead Investigator(s)

Karan Venayagamoorthy
vskaran@colostate.edu

Co-Investigator(s)

Suren Chen
suren.chen@colostate.edu

Research Assistant(s)

Daniel Sanchez, GRA, MS

Project Title

Crash Modeling of High-Profile Moving Vehicles Under Strong Crosswinds Based on Computational Fluid Dynamics

Sponsors | Partners

USDOT, Research and Innovative Technology Administration

the FINDINGS

For flow around rectangular cylinders, both in free flow and near a plane wall boundary, the coefficient of drag (C_D) has been evaluated with Reynolds numbers spanning 1e4 to 1e7, filling a significant gap in the research. There is a strong Reynolds number dependence for flow around a rectangular cylinder near a plane wall boundary, specifically with a length-to-height ratio of 0.887 and a gap ratio of 0.407.

In the application field of overturning high-sided vehicles, our findings suggest that it is premature to assume the critical threshold of Reynolds number has been surpassed, such that the rolling moment coefficient is Reynolds number independent.

the IMPACT

This research highlights the need for previous work on overturning high-sided vehicles to be revisited and is a step toward improving the safety guidance to mitigate crash risks for high-profile vulnerable vehicles.

For more information on this project, download the Main report at https://www.ugpti.org/resources/reports/details.php?id=1208

For more information or additional copies, visit the Web site at www.mountain-plains.org, call (701) 231-7767 or write to Mountain-Plains Consortium, Upper Great Plains Transportation Institute, North Dakota State University, Dept. 2880, PO Box 6050, Fargo, ND 58108-6050.