MOUNTAIN-PLAINS CONSORTIUM

RESEARCH BRIEF | MPC 20-423 (project 448) | October 2020

Reducing Flood Vulnerability of Communities with Limited Road Access by Optimizing Bridge Elevation

the ISSUE

Currently, bridge superstructures are designed based on the 100-year flood (flood level that can be expected once every 100 years) plus a required amount of freeboard, or clearance distance between the water surface and the low chord of the girder. This freeboard allows wave surges and debris to pass under the bridge. This design standard results in bridge superstructures not being properly analyzed for flood forces, specifically lift forces, that occur during inundation. These lift forces can be especially significant for fast moving rivers such as the Big Thompson River in Colorado. The research was prompted by damage to several bridges in Colorado during a September 2013 flood, which resulted in the need for residents of several communities to be evacuated by helicopter.

the RESEARCH

A linear network of eight bridges, including three unique structural configurations, near Drake, Colorado, was selected for analysis. Flood analysis was performed using the design format prescribed by the American Association of State Highway and Transportation Officials. Fragilities were developed for the most critical internal and external composite girders for each bridge. Results from the fragility analysis were then used to determine the elevation adjustments needed to reach a level that would reduce post-flood repair cost, increase bridge safety during a low-probability storm event, and increase the transportation system's flood resiliency.

MOUNTAIN-PLAINS CONSORTIUM REGION 8

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Project Title

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the FINDINGS

Based on the analysis, researchers found that the forces associated with bridge deck inundation, particularly those in fast-moving mountain rivers, are substantial and must be considered in design. Consequently, for the bridges used in the analysis, bridge superstructures should be designed based on the 500-year flood, which would incorporate inundation forces in the initial design. The methodology presented in this thesis can be used to assess and improve the flood vulnerability for the bridge network in any community.

Bridge substructure components take into account the numerous forces associated with flood flows. This study solely analyzed the superstructure to quantify the risk associated with inundation. With the trend of low-probability flood events occurring at higher frequencies, the risk of inundation and damage will only rise. Also, the uncertainty in discharge estimates increases the probability of failure. Future research should be based on the analysis of several different bridge configurations under varying velocity flows to assess vulnerabilities under all kinds of flow conditions. The fragility of roadway embankments and approaches and their failure due to erosion under flood conditions should also be assessed.

the IMPACT

The methodology gives bridge engineers the ability to optimize a road segment and all bridges on the roadway for height above a river or creek. This would help reduce bridge damage potential to a more consistent risk level and assure transportation access for residents during flood conditions.

For more information on this project, download the entire report at https://www.ugpti.org/resources/reports/details.php?id=1008

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.

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