MOUNTAIN-PLAINS CONSORTIUM

RESEARCH BRIEF | MPC 24-524 (project 700) | June 2024

Numerical Analysis of ABC Hybrid Bridge Bents Constructed with Hybrid Reinforcement

the ISSUE

Accelerated bridge construction aims to enhance construction quality and speed, often employing prefabrication techniques to assemble structural elements near the site or at a precast plant, leading to significant time savings compared with traditional methods. Seismic design for reinforced concrete bridges has evolved with the adoption of ABC methods, focusing on connections between prefabricated elements to improve seismic response. Proper design can mitigate damage in critical components. In seismic zones, developing precise models is crucial for predicting bridge performance during earthquakes, particularly since damage is often concentrated around joints and plastic hinge regions.

the RESEARCH

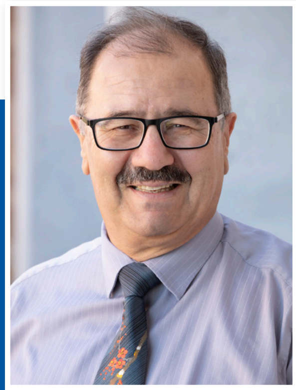
This research is focused on establishing a comprehensive numerical model for simulating an experimental study conducted on column-to-footing connections with grouted duct connections. The study investigated both all-steel and hybrid reinforcing details, where GFRP bars and mild steel reinforcing bars were used, with and without post-tensioning bars.

A comprehensive numerical model capable of emulating an experimental study conducted on column-to-footing connections with grouted duct connections was established. Both all-steel and hybrid reinforcing details, where GFRP bars and mild steel reinforcing bars were used, with and without post-tensioning bars were included in the model. The model incorporated various aspects, including hybrid longitudinal reinforcement, post-tensioning effects, intentional debonding, GFRP spirals, bond-slip behavior, and the plastic hinge length to estimate the actual seismic properties of the bridge bent. The model aimed to accurately predict initial stiffness, maximum lateral load, peak displacement, and hysteretic energy, aligning with the experimental results. The cumulative hysteretic energy

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)

Chris P. Pantelides
c.pantelides@utah.edu

Research Assistant(s)

Duc Tran, GRA, PhD
Suman Neupane, GRA, PhD

Project Title

Numerical Analysis of ABC Hybrid Bridge Bents Constructed with Hybrid Reinforcement

Sponsors | Partners

Geneva Rock

Owens Corning Infrastructure Solutions, LLC

USDOT, Research and Innovative Technology Administration

the RESEARCH continued

exhibited a maximum difference of 6% between the numerical model and the experiments, indicating that the numerical model satisfied the criteria for global response. For the local response, the reinforcing steel bar fracture was studied, and the numerical model accurately predicted the cycle in which the bar fractured during the experiment. Once the numerical model successfully predicted the response of the half-scaled specimens, an actual bridge bent was modeled, and the response was compared between two specimens: one with all-steel reinforcing bars and another with a hybrid arrangement comprising mild steel reinforcing bars and post-tensioning bars.

the FINDINGS

Based on self-collected images, we developed three AI models. After successful validation of the numerical model with the four column-to-footing experiments, an actual bridge bent was modeled, and the seismic response was compared between two cases: the first with all-steel reinforcing bars and the second with a hybrid arrangement of mild steel and GFRP reinforcing bars. Post-tensioning bars were used in both cases for self-centering. The analysis revealed that the hybrid bent with post-tensioning bars exhibited better self-centering performance under cyclic loads simulating earthquakes compared with the all-steel bent with post-tensioning bars. However, when compared with the hybrid bent, the bent with all-steel reinforcement dissipated higher hysteretic energy under cyclic loads that simulated earthquakes.

the IMPACT

This research will promote the construction of bridges in seismic regions using accelerated bridge construction methods, which will enhance construction quality and speed. The research has developed solutions that consider protection against corrosion using fiber-reinforced composite materials. Moreover, post-tensioning is used, which promotes self-centering and serviceable bridges after earthquakes. Finally, the research has developed a validated numerical model to assist in optimizing the design of such bridges.

For more information on this project, download the Main report at https://www.ugpti.org/resources/reports/details.php?id=1180

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.