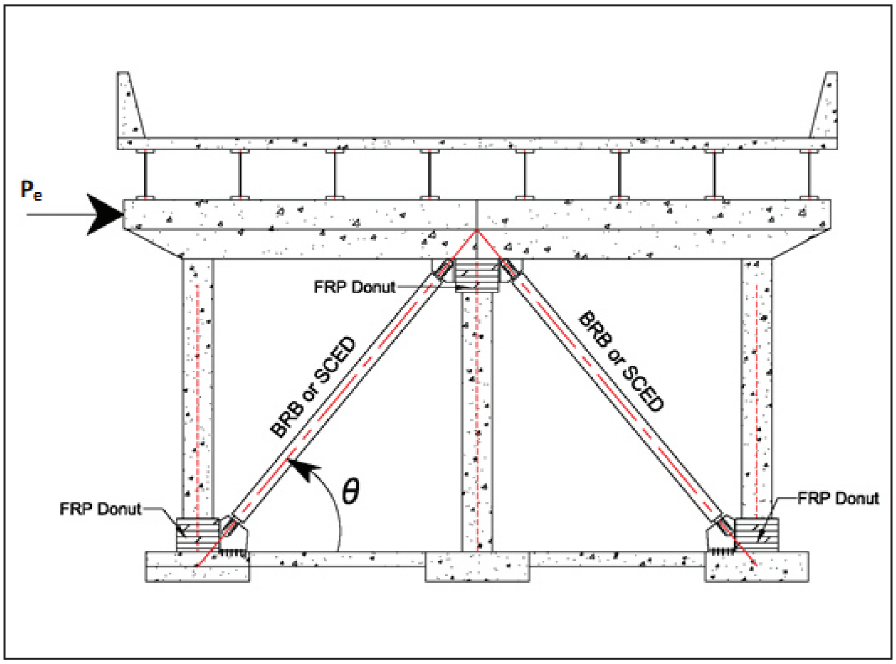
MOUNTAIN-PLAINS CONSORTIUM

RESEARCH BRIEF | MPC 18-348 (project 491) | April 2018

A Self-Centering Buckling Restrained Braces for Curved Bridges



the ISSUE

In recent large earthquakes, existing bridges designed and constructed according to older design provisions have suffered severe damage or collapse. Poorly detailed or deficient bridge structures cannot resist strong earthquakes and are vulnerable to collapse, which could lead to significant economic losses due to bridge closure. Structural pounding at expansion joints or at the abutments has caused damage to the deck and unseating due to irreparable rebound action. Columns of multi-column bridge bents experienced shear failure. Modern seismic design methods have improved the seismic performance of bridges by introducing elements capable of achieving high ductility. Although these bridges are less vulnerable to collapse, seismic damage may not be repairable and the bridges may be closed for weeks or months for repair.

the RESEARCH

The focus of this research is seismic retrofit of bridges with the possibility of achieving higher performance and keeping the bridges operational. The first part of this research investigates the repair of damaged bridge columns using CFRP donuts. Two severely damaged cast-in-place half-scale specimens representing a beam-to-column connection and a footing-to-column connection are repaired using a CFRP donut, which consists of a multilayered CFRP shell filled with concrete for confinement and headed steel bars drilled into the beam/footing for additional flexural and shear capacity. The second part of this research investigates the behavior of curved bridges with multicolumn bents by implementing BRBs/SCEDs as energy dissipation devices. A numerical model of the multi-span simply supported curved bridge is analyzed to assess seismic demand; in addition, probabilistic seismic analysis is performed using the original and retrofitted bridge models. Nonlinear

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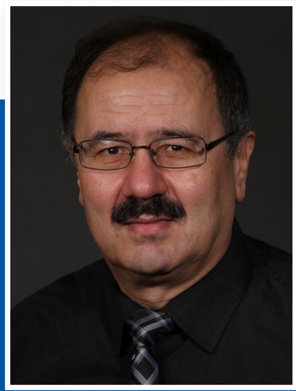

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Project Title

Self-Centering Buckling Restrained Braces for Curved Bridges

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the RESEARCH cont.

time-history analysis shows that after seismic retrofit, the BRBs in bridge bents are able to mitigate the influence of incidence angle. To predict the maximum bridge response, it is sufficient to apply the minor component of the ground motion along the bridge longitudinal axis and the major component of the ground motion in the transverse direction.

the FINDINGS

BRBs reduce peak drift demand experienced by the bridge bent by up to 60%, thus reducing structural response within the “operational” level. Longitudinal BRBs/SCEDs significantly reduce the pounding forces between the deck and abutment. For the majority of ground motions studied, BRB/SCED devices completely eliminated pounding. BRBs/SCEDs reduce displacement demand and seismic pounding damage to the bridge deck. SCEDs successfully bring the bridge bent close to the initial position after an earthquake and reduce the residual drift. This keeps the bridge’s structural response within the “operational” performance level. Bridges retrofitted with BRBs have a larger residual drift due to yielding of the BRB core. As-built bridges also have a larger residual drift because of damage to concrete, yielding and potential buckling of steel bars.

the IMPACT

The seismic retrofit rechniques described in this research can be implemented quickly thus reducing recovery time and improving resilience of communities.

For more information on this project, download the entire report at http://www.ugpti.org/resources/reports/details.php?id=905

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.