MOUNTAIN-PLAINS CONSORTIUM

RESEARCH BRIEF | MPC 24-541 (project 623) | August 2024

Static and Dynamic Experimental Evaluation of Precast Columns with Grouted Splice Sleeve Connectors

the ISSUE

Accelerated bridge construction cuts construction time and costs, reduces risk for workers and the traveling public, improves quality assurance, and is more environmentally friendly. As adoption of the construction technique has grown, so has the use of grouted splice sleeve (GSS) connections, mechanical couplers between two pieces of rebar that help maintain capacity, structural integrity, and continuity of joints between precast bridge elements. Research is needed to study the load distribution and load transfer mechanism within the sleeve region of these couplers under the combination of compressive and shear loads. Such efforts would determine the load paths and dynamic behavior of bridges under normal loads and when subjected to low-velocity impact loading.

the RESEARCH

The objectives of this study are twofold: 1) investigate the material load-bearing percentages and forces' transmission rules of grouted couplers in static testing; and 2) evaluate impact responses and failure processes of specimens under low-velocity impact. To conduct the first objective, precast concrete specimens with two different types of pier-footing connections are designed, cast, and tested under sequential compressive and lateral loads. The strain-time history at five critical areas on longitudinal reinforcements and GSSs are recorded and analyzed. The compressive and shear behaviors between the piers with couplers in the footing and those with connectors embedded in the pier base are then compared. Finally, the compressive and shear load transmission mechanisms from a detailed model perspective are proposed.

(continued)

MOUNTAIN-PLAINS CONSORTIUM REGION 8

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

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Project Title

Reliability of ABC Grouted Coupler Connected Bridge Piers Subject to Vehicular Impact

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the **RESEARCH** (continued)

The second objective focuses on testing four precast concrete specimens with two categories of pier/footing connections under two different impacting velocities. Pull-out tests on post-impact GGS connectors are then conducted. The impact force-time relationships of the four specimens are recorded and analyzed. The strain/time history at five critical areas on longitudinal reinforcements and GSSs are collected and compared. The failure processes and the crack propagation of specimens at four characteristic moments are observed and analyzed.

the **FINDINGS**

For the static loading, the load distribution percentage of each GSS system component (i.e., rebar, coupler, grout, and concrete) is determined and compared with theoretical predictions, and the comparisons reveal that rebars on both ends of the coupler carry 11% to 26% more load than theoretical predictions, which may lead to a potential risk of rebar fracture. Mechanics of load transfer on structure are explained as three main load paths, and force transfer principles in the GSS region are further detailed. For dynamic loading, based on the final failure patterns, most specimens maintain the GSS connections' integrity and bond performance after impact loading, with major damage enacted as diagonal shear fractures occurring away from the GSS regions. GSS-F couplers (couplers embedded in the top of the footing) exhibit minimal tensile capacity reduction (4%–5%), demonstrating perfect bond integrity after impact, in contrast to GSS-C couplers (couplers embedded in the base of the pier), which show substantial tensile strength reductions of 10% and 98%.

the **IMPACT**

This study not only provides novel and in-depth insights into theoretical research on the mechanism of precast concrete construction utilizing a GSS system, but also contributes much-needed data related to impact testing of precast columns and novel insights into residual bond strength analysis of the post-impact GSS connectors.

The results of this research will help designers better understand load distribution in grouted splice sleeve coupler connections for ABC bridge construction. Additionally, this research supports previous conclusions about the performance of couplers located in the foundation to resist hazard loading such as seismic.

For more information on this project, download the Main report at https://www.ugpti.org/resources/reports/details.php?id=1184

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.