Getting a GRIP

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An emerging coating option for bridge components—metallizing—shows promise thanks to slip-resistance testing based on parameters set in U.S. and Canadian steel standards.

THE DESIRE FOR ENHANCED, long-term performance for both new steel bridge construction and maintenance applications is shifting the paradigm from today's paints to coatings with more complex chemistry and application requirements.

Metallizing has recently emerged as a protective coating for steel bridge elements and is seeing increased recognition by multiple transportation agencies, including the U.S. Federal Highway Administration (FHWA) and the Canadian ministère des Transports du Québec. The practice can be used alone or in combination with compatible topcoats to not only provide an extended service life but also to add additional aesthetic quality to the bridge structure.

So what, exactly, is metallizing? The term is commonly used to describe the practice of thermally spraying molten zinc, aluminum or zinc/aluminum alloy on surfaces of exposed steel elements to provide both physical barrier and effective sacrificial protection through galvanic action. It can be applied to steel bridge components either at fabrication shops or in the field, and there is no size limitation on members that can be metallized. Strict surface preparation is essential for reliable adhesion, and a minimum of SP-10 (near-white blast-cleaned surface) is required per SSPC-CS 23.00.

In order to derive the maximum benefits of metallizing, bridge designers need to know the slip coefficient of metallized faying surfaces required to develop slip-critical connections in the bridge structure. This helps to eliminate the current labor-intensive and time-consuming practice of masking off all connection faying surfaces to preserve their conditions prepared in accordance to prevailing design standards. Therefore, the ability to design for and supply coated faying surfaces is an important option—and achieving a reliable slip coefficient is an essential variable in this option.

As no code provision for this design coefficient exists, Université Laval and Canam-Bridges (NSBA Member) decided to perform their own research in accordance with the slip tests described in Appendix A of the *Specification for Structural Joints Using High Strength Bolts* published by the Research Council on Structural Connections (RCSC), with the results being based on the slip coefficient values in the 2006 *Canadian Highway Bridge*




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Design Code and the 2010 AISC *Specification for Structural Steel Buildings*. For maximum slip resistance, the highest established slip class in both standards is Class B, with a slip coefficient of 0.50, which represents a blast-cleaned connection surface or blast-cleaned with Class B coatings.

Testing Slip Resistance

Laval and Canam performed two sets of tests to evaluate the slip resistance of zinc-based (99.99% pure) metallized faying surfaces with no top coat. Short-duration slip tests in tension and compression were conducted first to determine the mean slip coefficient. Subsequently, long-term creep tests were performed under sustained tension loading to ensure that the coating did not undergo excessive deformation (meaning creep deformation did not affect the observed slip resistance).

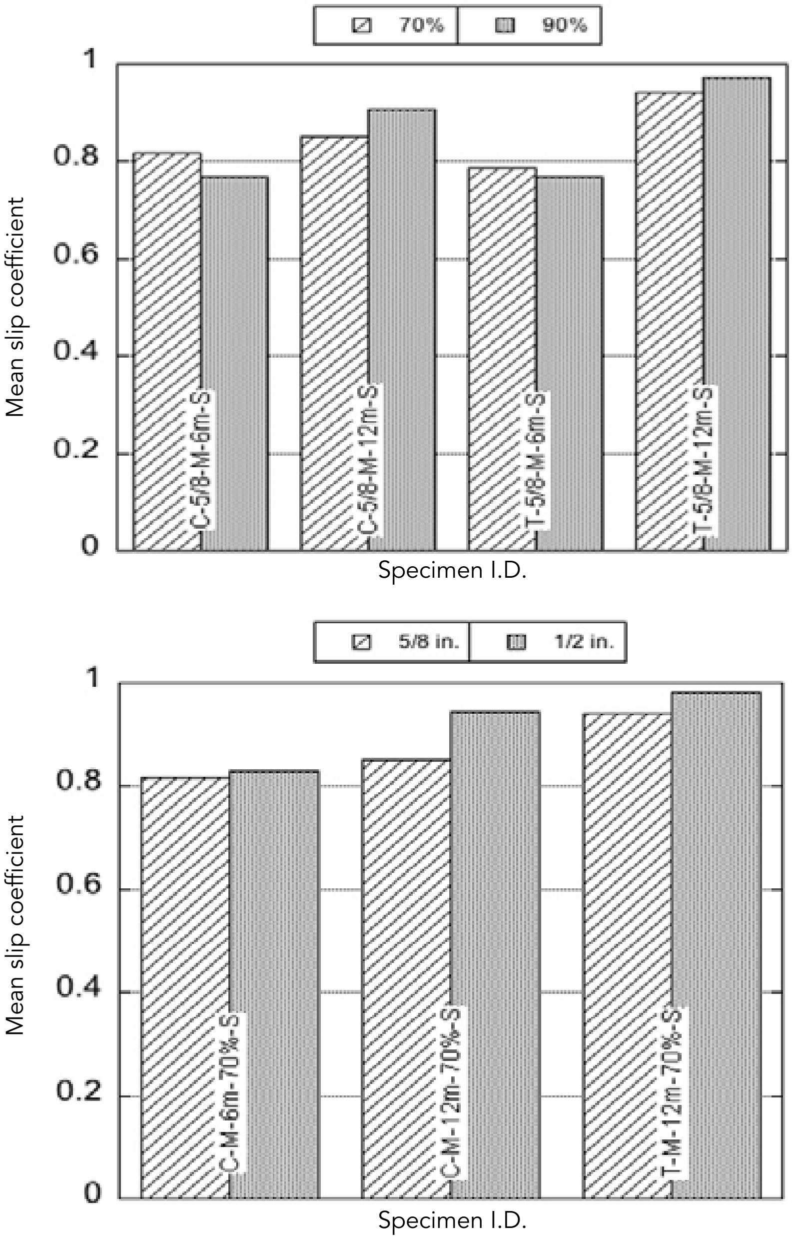
For the short-duration tests, close to a hundred specimens were fabricated and prepared for testing in compression and tension. The metallizing coating was applied through an electric arc spray gun from zinc wire. Other parameters investigated other than the testing regime included the thickness of coating (6 mils and 12 mils), plate thickness (½ in. and ⅝ in.), and the amount of bolt preload (70% and 90% of the tension capacity of bolt material). The specimen plates were fabricated from weathering steel and the plates were clamped using ⅞-in.-diameter ASTM A325 high strength-bolts. For each set of parameters, the mean slip coefficient was obtained from five replicates.

Figure 1 shows comparisons of the evaluated mean slip coefficient for different sets of parameters. All specimens tested far exceeded the Class B slip coefficient value of 0.5. The lowest mean slip coefficient was evaluated as 0.77, representing a ⅝-in.-thick plate specimen with 6-mils metallized coating and 90% bolt preload tested in compression. The highest mean slip coefficient was obtained as 0.98, representing a 12-mils coating on a ½-in. plate with 70% bolts preload tested in tension. Most importantly, we discovered that for the same set of parameters, an increase in coating thickness from 6 mils to 12 mils resulted in an increase in slip resistance, while the bolt preload, plate thickness and test regime had no significant effect.

In the long-term creep tests, three replicate assemblies were clamped and loaded in series for 1,000 hours in tension

▲ Metallizing could become a viable option for bridges such as the Highway 15-640 overhaul project in Boisbriand, Quebec, Canada, fabricated by Canam-Bridges.

▼ Figure 1. Comparisons of mean slip coefficient—e.g., notation C-M-6m-70%-S represents compression test (C) with 6 mils metallization and a 70% bolt preload.



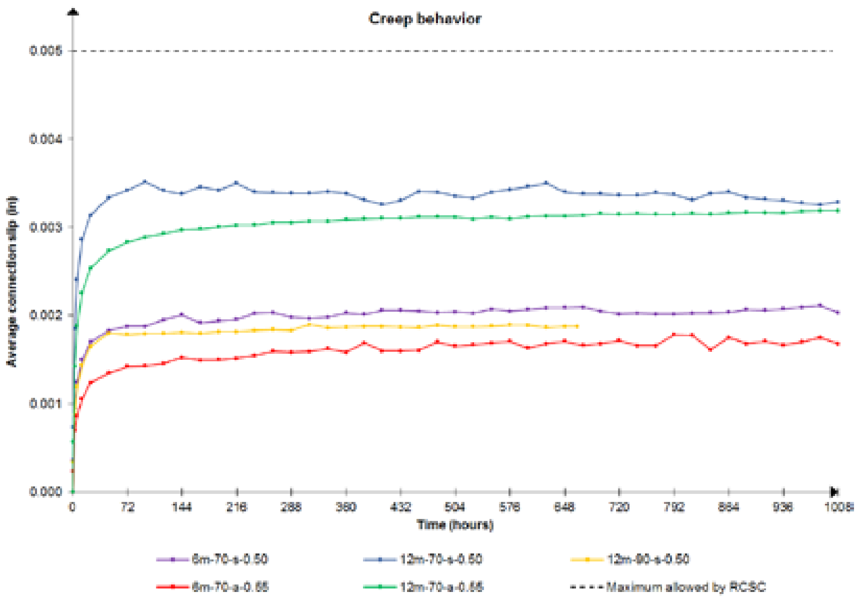


Figure 2. Creep deformation versus time.

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Masking off of connection faying surface before metallizing.

Long-term creep test set-up.

at the service load associated with the design slip coefficient of class B. Specimens were evaluated for two design slip coefficients, 0.5 and 0.55, to verify creep performance in accordance with the revised Class B coefficient of 0.52 specified in the 2014 *Canadian Highway Bridge Design Code*. The creep deformation, defined as the relative displacement between adjacent plates in a clamped specimen, was measured using extensometers in compliance with the RCSC specifications and compared with the acceptable limit of 0.005 in. The applied clamping force was monitored continuously from the time of assembly through to the end of testing to assure that relaxation in the bolt preload wasn't excessive. At the end of the creep loading, the test assemblies were loaded to the design slip load to ensure that the creep behavior did not adversely affect the design slip resistance. Figure 2 shows plots of average creep deformation versus time for five sets of parameters and also shows the maximum allowed deformation.

All the specimens showed acceptable creep behavior, with the 12-mils metallized coating exhibiting more creep deformation than the 6-mils coating. For the 12-mils coating, the specimen with a 70% bolt preload showed higher creep deformation compared with specimens with 90% bolt preload. Also, more relaxation of the clamping force was observed for the 12-mils metallized coating versus the 6-mils coating. When loaded to the design slip load at the end of the creep test, all the test assemblies showed a slightly increased deformation, much lower than the RCSC specified limit of 0.015 in.

Additional research is in the works, but these initial results are very encouraging. The fact that metalizing has been demonstrated to meet the Class B requirements for slip-critical connections without having to perform additional and potentially expensive connection preparation means that it could potentially become a viable, efficient option for bridge components. ■