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PUTTING RESEARCH TO WORK

BRIEF

Testing Less Expensive Steel for Bridge Bearings

Bridge superstructures move, especially under wide temperature variations and heavy truck traffic. Bearings—plates on each structure that cushion contact—allow movement while minimizing the force transmitted to the substructure. This helps to retain substructure integrity and durability. Because bearings are very difficult to replace, they must work well over a long design life with minimal care. One type of bearing that allows the bridge to move with very little resistance is made from stainless steel and polytetrafluoroethylene, or PTFE, often known by its trade name Teflon. Teflon is very slippery and slides easily against a smooth, hard surface such as stainless steel. Backing plates are attached to a sheet of each material, and the assembly is placed between the bridge girders and the supports, thereby allowing the girders to move freely.

What's the Problem?

Bridge design specifications from AASHTO for Load and Resistance Factor Design provide values for the coefficient of friction for sliding bearings generally, with specific values for various types of PTFE, but only offer a value for the most highly polished type of stainless steel, #8 mirror polish. Though effective, #8 remains expensive and sometimes difficult to acquire. Its polishing process can require impractical lead time, and the finish can be sensitive to scratches and surface imperfections.

A less polished stainless steel finish such as 2B, used widely in food processing, may be sufficient. Produced by cold rolling with highly polished rollers, it requires no secondary polishing, making it more available and economical than #8.

Research Objectives

This research investigated the friction properties of multiple stainless steel surfaces with PTFE to provide design values for an alternative surface finish. The specific goal was to compare #8 and the less expensive, more readily available 2B finish.

Methodology

Investigators tested performance of 18 PTFE-stainless steel bearing pairs. These included three steel surface finishes: #8, 2B rolled finish and a rough as-rolled finish of stainless steel. Researchers subjected samples of each pair to standard sliding tests of warm-up cycles, a multispeed test, a long slide-path mimicking long-term bridge behavior and a second multispeed test. The sliding tests consist of four-inch cycles of movement of two plates across one another for a typical long distance of 1,600 inches.

Friction properties in terms of coefficient of friction—the higher the coefficient, the greater the friction—and slide-path distance were the key measures of performance in this study, but samples were also examined in terms of surface finish, sliding speed, contact pressure and cyclic displacement amplitude. Sliding speed and friction were correlated when materials were new and again after significant wear to show the progression of change.

Researchers also conducted special tests on 2B specimens to explore different sliding speeds and displacements, all at the lowest contact pressure.

Results

Tests showed the following:

- The coefficient of friction of stainless steel sliding against PTFE varied with each parameter in the test program, and single values used for design were inevitably approximations.

Investigator

"The 2B was splendid stuff. We went in thinking it was second class, but it was wonderfully stable through the life of the bridge."

–John Stanton
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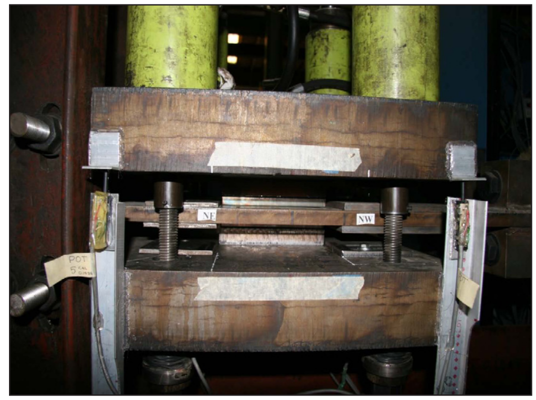

Bearing plates and plates with PTFE disks like these (left) were put under pressure and slid against one another in slide-path tests (right) to measure friction performance of bridge bearings over time.

Project Manager

"A bearing made with a 2B surface finish can be utilized on our inventory of bridges without a sacrifice in performance. A 2B finish is significantly cheaper to manufacture than the #8 mirror finish, so it will help to lower the cost of these types of bearings."

—Travis McDaniel
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- #8 mirror polished stainless steel friction remained low for virgin material and low sliding speeds, but increased significantly with longer slide-paths, higher speeds and lower contact pressure.
- Though its initial coefficient of friction was slightly higher than that of #8, 2B rolled finish stainless steel proved relatively stable. Friction changed little with slide-path, and after a long slide-path of 1,600 inches, the 2B friction was lower than the comparable #8 mirror finish. 2B seems suitable as an alternative to #8 mirror.
- Although rough stainless steel performed surprisingly well, it is typically hot-rolled in plate—rather than sheet—form. The greater thickness makes it more expensive and therefore unsuitable as an alternative.
- Slide-path appeared to be the best single indicator of the effects of long-term wear.
- PTFE wear in all 2B specimens was the same as or less than that in comparable #8 mirror polish specimens.

2B should substitute effectively for #8 mirror finish, provided other pertinent bridge components are designed to accommodate initial friction at a level slightly higher than published in AASHTO specifications for #8. Proposed coefficients of friction for various situations correspond to slide-path values within the range of those tested and are provided in the project report.

Further Research

Coefficients of friction for #8 mirror polish stainless steel published in the AASHTO LRFD Specifications appear to be slightly low, and testing should be done to identify better values.

The wearing of PTFE in depth should also be investigated further, and actual bridge slide-path accumulation should also be studied to help estimate bearing life.

Lab conditions were likely cleaner and more temperate than conditions faced by bearings in the field. Cold weather, which is known to contribute to increased PTFE wear, contamination and other effects, may impact field performance.

Brief prepared by
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