Just the Facts: Microscopic Imperfection on Tower Anchor Rod

After finding microscopic imperfections along the surfaces of two of the original 424 bay bridge tower anchor rods, Caltrans released a plan to objectively test the rods in laboratories to determine whether they will work as designed and during the largest earthquake expected to occur in a 1,500 year period.

The purpose of the tower anchor rods, which were installed in the tower base in 2007, is to prevent the tower from rising less than an inch during an earthquake. Engineering analysis shows that even if all anchor rods didn't exist, there would be no safety issue during or after a natural disaster.

One of the rods that will be inspected has already been subjected to hardness testing, chemical analysis, tensioning the rod in an aggressive salt bath to simulate decades of environmental exposure, and fracture analysis. These tests showed that even after long-term corrosion, the anchor rod withstood stress levels well-above allowable stress levels that currently exists on the bridge.

Since then, state inspectors discovered water under caulking in the tubes containing the anchor rods. Over time, standing water can be potentially harmful because it causes rust that weakens metal so Caltrans ordered the contractor American Bridge / Fluor, which took responsibility for the situation, to fix the problem and dry out the rods.

Engineers also removed a rod observed to be wet and sent it to a laboratory for inspection where it passed the industry standard magnetic particle testing for detecting surface irregularities. Next, inspectors examined the rod under 1000x magnification—a test not required for any metal bridge components under American Society for Testing and Materials national bridge standards—and found microscopic imperfections 1/10 the width of a human hair on the surface, even in locations where there may have been no standing water.

Caltrans will now send the two anchor rods to nationally-accredited laboratories where they will be subjected to conditions experienced during an earthquake and that simulate decades of use. The test results will be documented in a written report, which will be peer reviewed by members of the National Academy of Sciences and the Seismic Safety Peer Review Panel, and then published for the Oversight Committee, at which point it will be made available for comment and public peer review.

The Toll Bridge Program Oversight Committee also asked Caltrans to confirm that none of the 24-foot-long rods are already broken. To verify this, Caltrans measured the length of the rods with an ultrasound machine to find any rod shorter than the extra inches of thread extending below the nut. Only one rod varied in length by six inches, which required further testing to explain why it is shorter than the other rods. (42 rods varied in length by a half inch to two inches, but such variation cannot signal a break because

there is no tension below the nut and threads are longer than necessary to extend well beyond the nut.) Caltrans contractors will now pull up on that six-inch-short rod to confirm it is simply six inches shorter, and not actually broken. All rods have been previously stressed with large hydraulic jacks during the construction phase.

Q: Is the bridge safe despite these surface imperfections?

A: Yes, the bridge is safe. Ultrasonic testing determined that 421 rods are not broken. One of the rods that will be inspected has already been through a battery of tests in 2013, including hardness testing, chemical analysis, tensioning the rod in an aggressive salt bath to simulate decades of environmental exposure, and fracture analysis. These tests showed that even after long-term corrosion, the anchor rod withstood stress levels well-above allowable stress levels that currently exists on the bridge. Engineering analysis shows that even if all anchor rods didn't exist, there would be no safety issue during or after a natural disaster.

Q: Why use the term "imperfections," aren't these just "cracks"?

A: The term "crack" implies something has somehow broken or malfunctioned since manufacturing and that is not proven. Without more information, using the term "crack" is misleading. The industry standard test for determining whether an imperfection matters is called "magnetic particle testing," which involves using magnets to visually identify any potentially problematic invisible cracks. The rod passed that industry standard testing. Inspectors then went beyond what is even required by the American Society of Testing and Materials and looked at the surface under a 1000x microscope. Such inspection is above and beyond what the industry requires, into the area of academic research. But with the imperfections identified, now inspectors will verify that such features do not compromise rod integrity or performance now or in the future.

Q: Will these imperfections turn into cracks or broken rods?

A: This is exactly what the stress and load tests will determine. These tests will pull incredibly hard on sections of these rods while exposing them to salt water, until they break. If they break only above the stress and tension levels they will experience on the bay bridge, even in a 1,500 year ground motions earthquake, then the imperfections don't impact integrity and performance on the bridge.

Q: Is a retrofit necessary?

A: There's no evidence to support such a move right now—and no evidence that any rods are broken—and it would be premature to speculate without the benefit of laboratory tests to determine whether the anchor rods perform as designed.

Q: If water caused bolts to break in the past, won't that happen here?

A: The rods that broke at Pier E2, did so within days of being under tension. In contrast, these rods have been under high tension for years and none are broken. The purpose of the laboratory tests is to determine whether these anchor rods will break, and whether their integrity and performance is compromised.

Q: Who will review the test results and analysis report?

A: Caltrans hired internationally-renowned metallurgists to assist with the research and analysis including HERBERT TOWNSEND JR., Ph.D., P.E.; KARL H. FRANK, Ph.D., P.E.; LOUIS RAYMOND, Ph.D., P.E.; ALAN W. PENSE, Ph.D.; SHELDON W. DEAN JR., SC.D., P.E.; BOB HEIDERSBACH, Ph.D., P.E.; THOMAS J. LANGILL, Ph.D.; JEFF GORMAN, Ph.D.. In addition, the department will also consult with the Toll Bridge Seismic Safety Peer Review Panel, whose members are Doctors JOHN FISHER, Ph.D., P.E., M.S.CE.; I.M. IDRISS, Ph.D., P.E., G.E., Dist.M.ASCE; and FRIEDER SEIBLE, Ph.D., P.E., M.Sc.. Copies of the report will also be available for public comment and provided to other engineers and interested parties who have previously commented on various bolt test results.