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StopCrakEX Cold Expanding Bushing System

SP&R Part II, 775 Project# RB30-014

April 2019

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Background

The Iowa Department of Transportation maintains approximately 950 steel bridges with a median age of 48 years. It is understood that steel bridges can be susceptible to the development of fatigue cracks from vehicular loading. While new designs include details to minimize the potential for fatigue crack development, not all bridges are new and may have more potential for developing fatigue cracks. Additionally, even new designs may develop fatigue cracks. In order to maintain these bridges for safe operation, fatigue cracks must be identified and addressed as part of routine operations. The identification of the cracks is well understood and obtained thru scheduled inspections. Methods to limit crack growth have shown to be problematic at times.

A traditional method for addressing fatigue cracks to limit growth has been to place a crack arrest hole at or shortly ahead of the crack tip. In Iowa most of these holes are sized from ¾" to 1" diameter. The intent of this method is to remove the knife edge of the crack tip, thereby reducing the potential for further crack growth. Unfortunately this method is not always successful and multiple holes must be drilled at some locations.

The traditional crack arrest holes are made using a magnetic base drill press. These vary in size from smaller models weighing just shy of 30 pounds to the large models weighing 70 pounds.

Figure 1 – typical magnetic drill press and die grinder used for crack arrest holes

Based on the arrangement of components at the crack location, proper positioning of the magnetic drill may be difficult. Care must be taken when operating the drill as there is the possibility of the magnet breaking loose of the steel and the drill injuring the operator. Dependent on the equipment available, the holes are made with twist bits, annular cutters or carbide tooth cutters. After making the hole, the interior surface is polished with a flap sanding wheel mounted in a die grinder to remove all burs and cutting marks.

In order to provide a longer lasting solution and reduce maintenance costs, the use of the StopCrack EX was evaluated as an alternative to crack arrest holes. The StopCrack EX is manufactured by Fatigue Technology. The system is used to install a cold expanded bushing ahead of the crack tip. The cold expanded bushing will impart compressive stress into the steel adequate to limit further crack growth.

The technology is an outgrowth of similar technology used in the aviation industry. The evaluation team was not able to identify other manufactures of this type of system for use on bridge sized steel members.

Figure 2 – SropCrack EX system components

Evaluation Procedure

The system arrived in a sturdy case with a precut foam divider securely holding the components in place. The system includes all components necessary to use the system with the manual (hand) pump and a supply of bushings in varying lengths. The electric pump was supplied separately and does not fit in the system case. The only additional tools required were a hammer and handheld drill. Testing equipment necessary to identify the crack tip is not included in the system and was not part of this evaluation.

The initial system evaluation included installing bushings in scrap plate to understand how the system functioned and for operator training. One of these pieces was instrumented with strain gauges to monitor the compressive stress imparted by the bushings. The strain gauges measured approximately 98 ksi stress induced into the steel plate from the bushing expansion. Following the initial evaluation, bushings were installed on in-service bridges in lieu of traditional crack arrest holes.

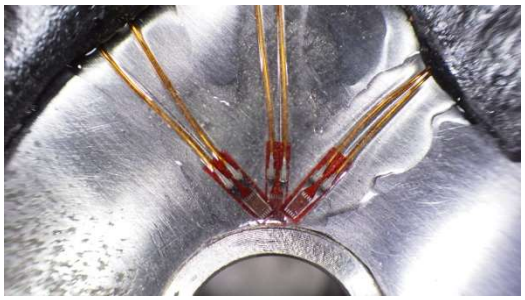

Figure 3 – strain gauge locations

In simple terms the operation of the system most closely resembles the use of pop rivets. A hole is drilled at the desired location. A bushing is placed on a mandrel. The mandrel and bushing are placed in the hole. The mandrel is pulled thru the busing, expanding the bushing in the hole.

The system was used to address fatigue cracks in bridge 6724.7S141 carrying Iowa 141 over the Maple River in Monona County. This bridge has fatigue cracks that had grown past the existing crack arrest holes. The installation appears successful although the long term success is beyond the timeframe of this evaluation.

Figure 4 – installation on bridge 6724.7S141

At the second location on this bridge the crack growth was along a vertical stiffener weld. For easier access the installation was made from the opposite face of the girder. When drilling one of the holes the hole overlapped a small part of the weld. This resulted in the drill bit binding in the hole and the reamer breaking during the reaming of the hole. It was necessary to grind a portion of the weld adjacent to the hole with a die grinder to complete the installation.

Figure 5 – second installation on bridge 6724.7S141

Results

The following observations were made during the evaluation:

- The manual provided with the system recommends that the holes be placed such that there is a 1/16-inch gap between the crack tip and the edge of the hole. Due to the sometimes uneven propagation of a crack thru steel plate, this is a tight tolerance to meet. In comparison, the placement of traditional crack arrest holes provides more flexibility in hole location.
- The drill bits and reamer have reduced shanks for use in 3/8 drive drills. The bits and reamer can grip tightly on the steel, twisting the drill. A ½ inch drill, with the associated larger handles, allowed better leverage for the operator to control the drill.
- The hydraulic puller and mandrel are designed to allow very close access to adjacent plates in locations such as the top of a web near the flange. The drill used will most likely limit the proximity of the hole to an adjacent member.
- The system can be operated without external power by using a battery powered drill and utilizing the hand pump. Operation of the hand pump will most likely require a second person as it is difficult for one person to both hold the puller in position and operate the pump.
- The electric pump allows for efficient one-person operation.
- The manual identifies the repair as "temporary". The same can be said of a traditional crack arrest hole. In most cases, it is the intent of the traditional crack arrest holes to last the remaining service life of the bridge or until such time as a retrofit is made. Based on test data supplied by the manufacture, the system should provide better, or at least as good, of performance as a traditional hole.
- Intersection with weld metal can make proper hole installation difficult. Care is needed in locating the hole to avoid weld metal.

Recommendations and Implementation

In summary, the CrackStop EX appears to be a well thought out and well-made tool. One of the biggest drawbacks is the tight tolerance on location of the hole with respect to the crack tip. With the reported improvement in crack containment over a traditional hole it has a potential home for use in bridge maintenance. The largest hindrance to widespread usage will probably be in bridge maintenance engineers trusting the system to perform as advertised. The long term effectiveness of the StopCrack EX system compared to a traditional crack arrest hole is beyond the scope of this evaluation.