Technical Note

Project:	**FRB Cable Band Bolt Replacement**	Job No:	**60267976**
Subject:	**The Use of Micrometers**		
Prepared by:		Date:	**15/07/2013**
Checked by:		Date:	**29/07/2013**

Purpose

The purpose of this note is to record the process by which the bolts were measured in the 2012/2013 Forth Road Bridge Cable Band Bolt Replacment Project. The aim is to provide a reference for any engineers wishing to design a similar proceedure or reuse it should it be required for future works.

Background

The new cable band bolts were installed to the correct load with use of a hydraulic torque wrench (Hydrotight - RSL8) by monitoring extension length. A practical method was needed to obtain accurate final extension measurements within upper and lower tolerances of the target predetermined from laboratory tests on sample assemblies. Thus, bespoke micrometers were fabricated as they were perceived to be a more reliable and practicable method than using ultrasonic measuring devices, as used when the bolts were last replaced.

The Micrometers

- Mitutoyo 350-351-10 micrometers accurate to ± 1 micron with a digital, single-value readout LCD display were used.
- These were fixed to rigid frames made out of welded steel sections of appropriate length and shape to measure the bolts between machined recesses at their ends whilst providing clearance to the cable band. The micrometers were fixed to the frame by resin and a tight fitting hole to the stem. A point anvil was fixed to the opposite end.
- Each micrometer was calibrated to its own rod (and could be cross checked with the other rods) with recessed ends of known length as engraved on the bar. Every time the micrometer was used, the micrometer would be checked to see if it is calibrated correctly.
- In order to differentiate between sets of micrometers, they were painted in different colours with each colour and the measurement stamped on the corresponding calibration rods.
- 6No. micrometers were produced in total, allowing for each gantry to have its own micrometer.
- In order to protect the micrometer assembly, micrometers were each housed in a bespoke box, strapped to the gantry when not in use.

Micrometer in its box

AECOM House
179 Moss Lane
Altrincham
WA15 8FH
United Kingdom

Method

Bolts were installed to Spencer's Method Statement MS07. They were measured at turn increments and at target lengths by the contractor/sub-contractor (Spencer/Davai). The bolts at each cable band were tightened in two stages, first all bolts to an intermediate extension target (e.g. 2.5mm) in the correct order (See drawing 60196243/W/200) and then all to a final extension target (e.g. 3.5mm) to ensure even distribution of load around the cable band and prevent over tightening of any one bolt. Turn increments between were reduced as the targets were approached. The general procedure is as follows per bolt:

New bolt being measured

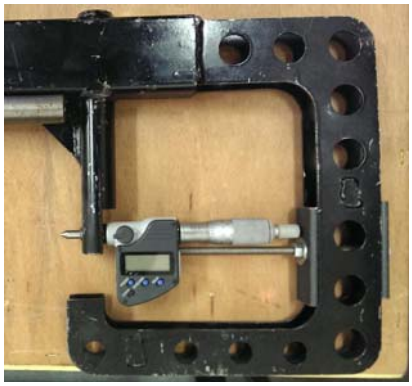
1. Date, temperature, weather, micrometer used and bolt ID all recorded on Bolt Tensioning Record template sheets.
2. Before use the micrometer was taken out of its box and to sit at air temperature for around 15 minutes.
3. Micrometer calibration checked using corresponding standard bar.
4. Unstressed length measured from machined recesses in the end faces of the bolt and recorded in Bolt Tensioning Records.
5. Target lengths were calculated to achieve the specified load application, as appropriate to specific production batch.
6. Standard initial rotation applied as a fraction of a bolt rotation.
7. New extension measured using micrometer and torque pressure recorded.
8. Additional rotation increments applied until intermediate target achieved with rotation fraction, torque pressure and extension recorded at each interval.
9. Once all bolts at intermediate extension, the same procedure followed for each bolt until final target reached.
10. Final extension values were checked by site supervisor (AECOM) to be within tolerance.
11. If the final extension was below tolerance, the contractor is asked to tighten some more. If the extension was above tolerance, the bolts were overtorqued and, having being extended too far into plastic behaviour, were to be instructed to be replaced with a new bolt assembly if deemed necessary by AECOM.

Measuring Technique

The micrometers were retracted/extended through use of the thimble alone. It was found that use of the ratchet was impractical and unnecessary for the requisite accuracy. However, the right technique had to be developed by those using the micrometer in order to get the correct reading. This technique was easily developed by all with sufficient accuracy by practising with the standard bar.

Evaluation

Whilst the micrometers were generally reliable, on one occasion the micrometer readings were found to be spurious. It is believed that the micrometer came out of alignment. The exact cause is unknown although it was probably knocked out of position. Being only fixed at one end, the micrometer is susceptible to this and providing fixity at two ends would minimise this likelihood. The solution was to clamp the micrometer. See Technical Note *SE54: Over Torquing of Cable Band Bolts* for more details and the resolution.



Micrometer clamped