1. Introduction

It has been identified by the FRB maintenance team that the handstrand clamp which is attached to the Main Cable have undergone wear and is causing a knocking sound in a number of locations. The handstrand clamp was installed in 2005 and designed by consultant engineers W.A Fairhurst and Partners. This knocking sound is throwing out the Acoustic Monitoring System and therefore remedial measures to prevent this has ben considered below.

2. Cause of Issue

From site dimensions taken on the 21/07/2009 some dimensions are outwith fabrication tolerances however there does not appear to be any gross errors which would cause the wide spread issue we are investigating. It is unclear however if these dimensions vary due to wear or because of fabrication inconsistencies. It has been stated from general inspections carried out that the phosphur bronze washers appear to have undergone significant wear. See the following link for details of dimensional survey:

G:\filing\BC_FILES\BC07_Main_Cables\FRB_Inspection_Reports\Independent Inspections\HANDSTRAND CLAMP INSP. P.P.16 & 14 N.E. 21.07.09

As-built Drawings:

G:\DRAWINGS\BC 16 suspenders\Replacement of Hangers Drawing ifb11As-built.

The most significant variation between records are given below:

- 2.09mm bronze washer instead of a 3mm (East Arrangement)
- Internal diameter of Nylon sleeve 21.73 instead of specified 20.5mm (East Arrangement)

The diameter of the M20 bolt however has not been determined. Although M20's are specified the diameter of these bolts can vary marginally, in accordance with BS 4190:2001 the minimum diameter of the unthreaded shank is for an M20 is 19.16mm. The specification requires a phosphur bronze sleeve with internal diameter 20.5mm and therefore there could be a gap greater than 1mm between the sleeve and bolt before any wear has taken place. In the east arrangement taking into account the current sizes this gap will be about 2.5mm. Confirmation of the shaft diameter would help ascertain if this is a contributory factor to issue identified.

One inconsistency noted was that a Nylon sleeve (or bush) was used instead of phosphur bronze sleeve in one of the locations investigated. This was not recorded on the as-built drawings and therefore it is unclear if this variation to the specification was approved by the designers.

3. Liability

The issue at the handstrand does not appear to be a structural issue and although there is excessive wear of the bronze washers and the Nylon sleeve this will not cause a structural failure. It could be argued that the sleeves and washers are sacrificial components that are

designed to wear to prevent any corrosion issues with the connection detail. The handstrands have been installed for 10 years and approximately 3mm worth of wear on the sleeve is not likely to result in a structural failure over the 25 year design life (assumed).

The knocking however could be classed as a serviceability failure if it is not fit for purpose. The designers would not have been unaware that knocking had to be prevented as the acoustic monitoring system was not installed until 2005.

4. Potential Solutions

Additional Tension in Handstrand Cable:

Confirmation of how the tension was applied to the cable would be beneficial to determine if the tension in cable causing additional wear on the handstrand clamp. It can be seen that close to the towers no vertical movement in the handstrand has been detected. It is speculated that these handstrands are carrying the majority of the load from the cables which is preventing excessive wear and the resulting knocking.

If there was a significant load from the cable at each handstrand pulling in a vertical direction then knocking may be prevented throughout the structure. Unfortunately there appears to be no easy way of carrying out additional tensioning works without removing the entire length of the cable. A consistent force in each handstrand could potentially be achieved by providing incremental increases in tensioning at each hanstrand, however this would have to be carried out one handstrand at a time.

Further consideration to the forces within each handstrand would be required if this proposed remedial measure was to be considered further.

Alterations to Existing Connection Detail:

Due to the vibration of the existing cable any modifications to the existing connection detail would have to be substantial to prevent the excessive wear which is being experienced. An expandable foam rubber or sealant installed to prevent vertical and horizontal movement to prevent knocking could be used however this is unlikely to be a permanent solution. It is unclear why the current detail allows rotation, this arrangement would help distribute the tension load of the cable to adjacent handstrands however as the tension load is not very high it does not seem necessary. It assumed that the detail was designed in this arrangement to prevent a bespoke connection at each handstrand.

A proposed replacement detail has been attached which prevents rotation by friction of the HSFG bolts and can still be used at each location. The replacement of the existing detail for the full length of the cable would be a significant undertaking.

Further consideration into impact loads during use of the cable would have to be considered if this proposal was deemed favourable.

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