Civil Engineering
Volume 171 Issue CE1 February 2018

https://doi.org/10.1680/jcien.2018.171.1.19

Monitor: Discussion

Discussion

1600037 Failure analysis of high-strength bolts in steel truss bridges

By Man Zhou, Dingyi Yang, Mostafa Fahmi Hassanein, Jiandong Zhang and Lin An (November 2017)

Contribution by Chris Atkins

In the paper by Zhou *et al*. (2017) it was good to see someone quantify the numbers of high-strength steel bolts failing on a sample of bridges. It was also a good summary of the failure mechanisms. However, the link between hydrogen formation and corrosion should be added to the list of problems. Many high-strength steels under tension are prone to hydrogen-induced stress cracking. For this to occur, hydrogen needs to be generated – and corrosion processes can be a source. Hydrogen-induced stress cracking is mentioned with regard to cathodic reaction in Section 2.4 of the paper on 'Other possible reasons for failure' with regard to cathodic reaction, but it is not mentioned in Section 2.3 on 'Environmental corrosion'. The process can occur without significant obvious corrosion.

Authors' reply

We agree it is worth paying attention to hydrogen-induced stress cracking and it is something we are currently working towards, being one of the main problems during welding of high-strength steel. We will publish more technical research about hydrogen-induced fracture mechanisms in the near future.

Contribution by John Sreeves

Do Zhou *et al*. (2017) have experience of whether tension-control bolts perform better or worse than the ordinary bolts illustrated in the paper? UK practice tends to prefer use of tension-control bolts due to ease of installation and better consistency in the tightening process.

Authors' reply

High-strength friction bolts are usually used in steel truss bridges in China. We would be glad to know more of the use of tension-control bolts in the UK and associated anti-corrosion technology measures. We hope we can learn from each other and exchange ideas.

Contribution by Norman Rodda

There are many learnings from the offshore oil and gas industry in the use of high-strength bolts. I recall three examples from my experience in the 1980s. It was found that upper hardness limits need to be specified to reduce risks of brittle failure. The standards in use at the time either had no upper limit of hardness or too high a limit. Specifying closer tolerances on threads also reduced damage to the threads themselves and coatings. This was very relevant on larger-diameter bolts. In addition, the use of hydraulic bolt tensioners to ensure the correct tension was very successful. Hydraulic bolt tensioners have been used for over 40 years within the process industry for making up flanged joints tightly, and these tools can be successfully applied to structural bolting applications. It was very important to achieve the correct tensile load to avoid fatigue failures.

Authors' reply

We will attempt to adopt the contributor's suggested method to control bolt tension on a steel truss bridge we are currently monitoring in China.

Contribution by Chris Hendy and Chris Dolling

We believe the warning from Zhou *et al*. (2017: p. 175) that, 'the fracture and corrosion of joint bolts in steel bridges is a worldwide problem that needs urgent attention' does not apply to the UK. The quoted sources of problems – namely procuring bolts that do not conform to recognised specifications, not controlling tightening properly and not applying suitable corrosion protection – are all well-known issues which can be addressed by proper quality assurance and quality control.

Within the UK, CE marking, factory production control, national highway sector schemes and steelwork specifications all assure the quality of materials and workmanship. The specific issues raised in the paper are all addressed by the UK Steel Construction Institute's guide on steel bridge construction (Hendy and Iles, 2015), which provides extensive guidance on steel bridge design, construction and fabrication issues in general. The UK bridge industry makes extensive use of the part-turn method for bolt tightening, which ensures the minimum preload is always achieved and is simple to control and supervise on site. Similar details are directly available at the UK steel construction website (Steelconstruction.info, 2017).

We would also draw attention to the guidance in Highways England's steel specification (Highways England, 2014).

Authors' reply

We appreciate the UK references from the contributors and hope to learn more from these.

References

Hendy C and Iles D (2015) Installation of preloaded bolts. In *Steel Bridge Group: Guidance Notes on Best Practice in Steel Bridge Construction*, 6th issue. Steel Construction Institute, Ascot, UK, SCI P185, guidance note 7.05. See https://www.steelconstruction.info/File:SCI_P185.pdf?internal_link (accessed 04/12/2017).

Highways England (2014) *Manual of Contract Documents for Highway Works (MCHW). Volume 1: Specification for Highway Works. Series 1800 Structural Steelwork*. The Stationery Office, London, UK.

Steelconstruction.info (2017) *Installation of Preloaded Bolts*. See https://www.steelconstruction.info/Preloaded_bolting#Installation_of_preloaded_bolts (accessed 04/01/2017).

Zhou M, Yang D, Hassanein MF, Zhang J and An L (2017) Failure analysis of high-strength bolts in steel truss bridges. *Proceedings of the Institution of Civil Engineers – Civil Engineering* **170(4)**: 175–179, https://doi.org/10.1680/jcien.16.00037.