Radar Simulation and Radar Improvement of the Galecopperbridge

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Summary

Galecopperbrug is a 3 span cable-stayed bridge with a main span of 180m over the canal.

During strengthening of the Galecopper bridge, the design team was tasked to solve problems caused to ships radar when using the canal caused by multiple reflections of radar waves amongst the bridge beams. Alternative solutions were considered and a computer simulation was undertaken to determine a solution. Work is completed and the solution that involves fixing radar absorbing material to the bridge will be implemented with the works to strengthen the bridge.

Keywords: steel-composite, cable-stayed, bridges over waterways, navigation, radar.

1. Introduction

Galecopperbrug spans the Amsterdam Rhine Canal in Utrecht, the Netherlands. It is a 3 span cable-stayed bridge with a main span of 180m. The design of strengthening works to the bridge is currently nearing completion. At the time of the strengthening study the design team was requested to come up with measures to address radar hindrance caused by the bridge. This paper explains the phenomena and how a solution was developed and tested using computer simulation.

2. The Phenomenon of Radar Hindrance Caused By Bridges

From end of the 1950's radar started to be used for inland waterway navigation in Germany with ships permitted to sail at night and in foggy conditions. Several collisions occurred especially in the zone of steel bridges and it was deduced that the problem was caused by multiple reflections of radar waves causing unclear radar images.

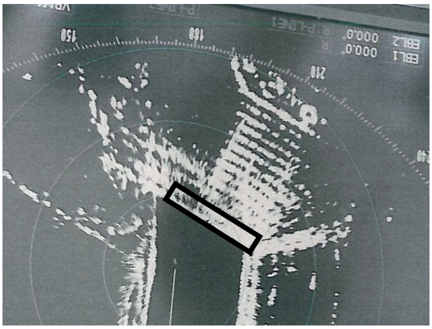

Fig. 1: Radar Image of Muiderbrug with RAM partially fitted

In the late 1960's steel coatings and fabrication organisations in Germany collaborated to develop a radar absorbing material (RAM) to apply to bridges to address the problem.

Fig. 1 shows a radar image of a bridge part way through installation of RAM. The outline of the bridge has been drawn onto the image. The left side of the bridge with RAM fitted has a clearer image while on the right multiple reflections are giving "ghost reflections" masking potential obstructions.

Design guidance such as the Richtlijnen Vaarwegen in Holland now make reference to the phenomenon, which still occurs with currently used radar systems.

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3. The Mechanism of Radar Hindrance on Galecopperbrug

The deck of Galecopperbrug comprises 12 number deep I girders (to be supplemented with 4 additional girders as part of the strengthening works [1]. Transverse girders square to the main girders are provided to support the orthotropic deck. The 38° skew angle of the bridge means that radar waves bouncing between the main girders propagate along the longitudinal axis of those girders. Structures forming vertical right angles with a main girder web both direct energy back to the radar and reverse the direction of longitudinal propagation: the latter keeping a wave within the view of the radar. In the existing bridge, the vertical web stiffeners on the main girders are significant in this regard. After strengthening with additional longitudinal and transverse beams added, new full-depth transverse diaphragm beams at the piers are also important.

4. Solutions Considered

Several solutions were considered; horizontal infill at beam soffit level; use of inland AIS transponder systems; inclined plates attached to beam webs to direct radar waves downwards; and two solutions involving attaching radar absorbing material to the bridge. An evaluation was carried out and the solutions using radar absorbing material were selected for further development.

5. Computer Simulation to Investigate and Refine Solutions

Radar cross section modelling was undertaken with the bridge in both its existing and post renovation configurations (we are not aware of this sort of simulation being conducted for a bridge before). This allowed the mechanisms responsible for its radar signature to be identified and the efficiency of various RAM layouts and types to be assessed [2]. Modelling of the impact of applying RAM to different heights above the bottom of the girders was also investigated.

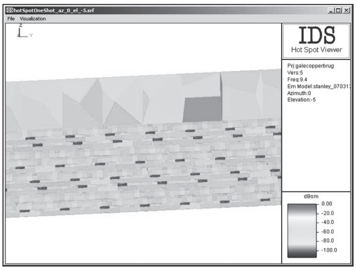

Fig. 2: Radar Simulation Output Showing High Radar Returns (Dark) from Corner Reflectors on the underside of the bridge deck

6. The Solution Adopted

A best value RAM material in an optimal configuration was selected. RAM is to be fitted to inner surfaces of the main girder webs over the canal, as well as on the new transverse diaphragm beams. The panels are to be 500mm high. The simulation indicated that this represented a good compromise between cost and performance. It is salient to note that trying to completely eradicate erroneous radar waves is not possible the aim is to clean up the quality to an acceptable level.

7. Conclusions

Whilst undertaking the strengthening design of Galecopperbrug the opportunity has been taken to correct a problem with the potential to lead to ship collisions. It has been an interesting experience to investigate the phenomena and we believe that this is possibly the first time that radar simulation has been carried out for a bridge. We look forward to verifying the solution after installation.

8. Acknowledgements

We would like to thank Noretec for their advice and assistance in the preparation of this paper.

9. References

[1] BLANKEN DEN S.M, NAGTEGAAL G, and TUINSTRA D., “Strengthening Solutions for the Extended Service Life of the Galecopperbridge in the Netherlands”, IABSE 2012 Congress, Seoul, 2012.m

[2] RAM types modelled were Emerson and Cumming AN-73 and Noretec RAD 80 10 26 PL.