Why strengthen? Repair mitigation with finite element assessment

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Abstract

The use of finite element analysis in bridge assessment is presented as a refined method to assess the structural capacity of bridges and their components, as compared to the use of resistance expressions prescribed by structural design standards. Case studies of the application of the methodology presented in this paper to historical steel bridges are presented. The majority of structural components, which had previously been assessed insufficient against structural codes, were assessed with significantly improved capacities by employing advanced finite element analysis. The use of sophisticated analytical methods allowed a reduction in the scope of required strengthening works, eliminating them entirely in some cases.

Keywords: Assessment, strengthening, historical steel riveted bridges, finite element analysis, rail.

1 Introduction

The road and rail networks in the United Kingdom rely on a large number of historical riveted steel bridges built in the late nineteenth and early twentieth centuries. The rail and highway loads carried by these bridges have typically increased over time. This load increase, combined with degradation due to corrosion, has necessitated the re-establishment of the bridges' structural capacity. The bridges pre-date the development of modern design codes and often contain structural details that are non-compliant, significantly reducing their code-assessed capacities.

This paper presents four case studies of historical riveted steel bridges that were found inadequate to withstand the present traffic and railway loads using conventional code assessment methods – "conventional" meaning that load effects were determined using simple static rules (first principles, simple grillage models or similar) and capacities were determined using codified resistance expressions. The bridges were conventionally assessed in accordance with NR/GN/CIV/025 "The Structural Assessment of Underbridges" [1], an addendum to BS 5400 Part 3 [2], and were found structurally deficient; in some cases the bridges were assessed incapable of resisting their self-weight. The main reasons for structural deficiency were typically: non-compliant structural details and structurally significant section loss from corrosion.

This paper presents a broadly applicable finite element (FE) assessment methodology with the example case study bridges. The examples demonstrate how the capacities, obtained using FE analysis and design techniques, improved for all the assessed bridge components; the improvements were significant for some of the failure modes. The discrepancy between conventional and FE methods are discussed in this paper. The qualitative benefits of mitigated strengthening works allowed by the improved capacities are also discussed.

Recommendations are provided for simple alternative assessment methods, which could be employed for the purpose of a conventional assessment. Recommendations and various

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