Effects of high speed trains on bridges

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Abstract

Dynamic analysis is commonly conducted to design bridges for high speed railway lines. Classically, two aspects are analyzed at design stage: the vertical acceleration and vertical deflection of the deck which are limited in order to prevent the track instability and the passenger comfort. These aspects were analyzed by Systra for the major international projects: Taipei – Kaohsiung line in Taiwan, “Channel Tunnel Rail Link” in the UK (CTRL), “Contournement Nîmes Montpellier” in France (CNM line), Tanger – Kenitra line in Morocco, Tianxingzhou Yangtze River Bridge in China and Dodam - Yeongcheon line in Korea.

More recently, some high-speed railway line projects have been designed to match a 400 km/h operation speed, such as Moscow-Saint Petersburg line project in Russia, and the European Research Project “Capacity for Rail”.

Keywords: Dynamic, analysis, comfort, acceleration, high speed, track, irregularities

1 Introduction

The interest in dynamic behaviour has increased in recent years, due to the introduction of high speed trains. The railway bridges are subjected to significant dynamic loading due to passing trains.
The dynamic response depends on a large number of factors involving the characteristics of the train, the track, the bridge and the substructure. For more than 100 years, dynamic effects have been taken into account in design of bridges by factoring the static response.
The dynamic aspects are of special interest and have often shown to be the governing factor in the structural design. In cases of ballasted track bridges, intense acceleration creates the risk of destabilising of ballast. For track stability and vehicle-bridge contact, it is important to ensure that the maximum accelerations of the bridge remain below 3.5 m/s^2 in case of ballasted tracks and 5 m/s^2 in case of ballastless track.

Furthermore, the maximum dynamic effects occur at resonance peaks. At resonance, a multiple of the load frequency coincide with a natural frequency of the bridge structure, and the dynamic response of the structure increases very rapidly. Resonance may lead to cracks and crumbles of concrete, high ballast attrition due to the high accelerations, and significant track irregularities.
Generally, for all railway bridges with train speeds over 200 km/h, dynamic analysis is required.

These analyses ensure a safe use both in terms of ballasted track stability and comfort in coaches.

The purpose of this article is to explain the dynamic phenomena and analyze the aspects governing the design of railways bridges in the major international projects in which Systra has been involved.

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