Dynamic loadings of moving vehicles on curved concrete segmental single box girder bridges

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Abstract

This paper presents the dynamic behaviors of curved concrete segmental bridges. The bridges are modeled as thin-wall structures and analyzed using the thin-wall finite element method. The effects of bridge torsion and distortion are considered in the analysis. A vehicle is simulated as a three-dimensional nonlinear model. The road profile is modeled as a stationary Gaussian random process that is described by a power spectral density (PSD) function. The effects of vehicle speeds, bridge radii, bridge span lengths on the bridge dynamic loadings are analyzed. Through an extensive numerical analysis on 20 typical curved bridges, an approximate method for determining the concrete segmental bridges is proposed. The research results are applicable to the design of concrete segmental bridges.

Keywords: Segmental bridge; single box girder; cantilever bridge; continuous bridge; vehicle model; bridge model; road surface roughness; vehicle induced vibration; impact.

1 Introduction

Due to a prevailing desire for expedited construction with minimal traffic disruption, lower life cycle costs, appealing aesthetics and adaptability to curved roadway alignment, segmental concrete bridges have become a primary choice of major transportation projects throughout the world [1]. Extensive research on concrete segmental bridges has been undertaken. Compared to research efforts involving static analysis, there has not been much attention focused on the dynamic analysis of concrete segmental bridges. Currently, AASHTO LRFD [2] highway bridge design specifications adopt a dynamic allowance factor of 0.33, when considering the dynamic effect of moving vehicles. This factor of 0.33 was derived from limited field test results on short span girder bridges. The actual dynamic behaviors of concrete segmental box girder bridges remain largely unstudied.

The dynamic behavior of curved steel box girder bridges has been of interest to numerous investigators since the 1970's[3-8]. Huang [9] reported full-scale dynamic tests on two curved steel box girder bridges, showing that the theoretical results well match the tested results.

The purpose of the study presented here is to investigate the dynamic behaviors of concrete segmental single box girder bridges, including continuous, cantilever, and curved segmental.

2 Analytical Model and Numerical Method

2.1 Truck Model

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