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Dynamic load testing and FE model updating based on frequency response of a plain concrete arch bridge

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Abstract

This paper describes modal identification and finite element updating of an existing plain concrete arch bridge, so as to create a reliable numerical model that enables the accurate numerical simulation of the dynamic behavior of the bridge under locomotive loads. The inherent complexity in the behavior of the bridge and modeling uncertainties such as boundary conditions and material properties will seek out more accurate studies and researches, the bridge FE model was developed using ANSYS software. In this paper dynamic behavior correlation between highly detailed FE model and the experimental result is studied; natural frequency is selected as benchmark criteria. For this purpose, the nonlinear behavior of the material, support conditions and soil properties beneath the piers were identified as modeling parameters which the dynamic behavior of the bridge is much influenced by.

Keywords: arch bridge, dynamic analysis, finite element method, dynamic characteristic.

1. INTRODUCTION

An appropriate modeling of plain concrete arch bridges is the subject that is highly regarded by researchers in recent years. Since there are large number of these type of old bridges in rail network and due to increasing rail capacity in recent years, assessment of the structure under dynamic load has became an important issue. Due to the complex behavior of these kinds of structures, field tests are an unavoidable part by which an accurate model for a proper assessment of the bridge can be done.

The behavior of arch bridges has been studied by many researchers using different methods. Studies by Pippard and Hayman, respectively, resulted in the MEXE experimental method and the mechanism theory for evaluation of load capacity of arch bridges [1]. Finite element analysis of masonry arch bridges was first done by Towler. He compared results of his model with the laboratorial data. In his model contact operation was not considered between the arch and the filling materials thus Crisfield showed under these conditions, finite element method causes less collapse load compared to the mechanism method. To resolve this problem, he considered wills having nonlinear behavior to simulate the lateral resistance of filler materials. Towler's studies were based on straight beam element. Rouf continued Tower's activities, and used curved beam elements. Choo tried to fulfill Tower's works and he used tapered beam elements assuming that the arch has no resistance [1]. Following them others studied the behavior of arch bridge under dynamic and static load. A dynamic behavior of an Arta bridge was investigated by Hatzigeorgiou et al. the bridge behavior was considered to be plane stress and they observed bridge behavior under dynamic and static load. Assuming linear and nonlinear behavior they compared the results. They were the first that have done time history analysis on masonry arch bridge [2]. In one of their article, Brencich and Sabia investigated Tanaro bridge in north of Italy. By means of experimental testing like core drilling test, schmidt hammer test, and sonic test. They obtained a relationship between elasticity modules and compressive strength of masonry units and determined dynamic characteristics of the arch. They analyzed several models and compared to each other. They used linear analysis for materials under service condition [3]. Recently a two span arch bridge was investigated by Bayraktar et al under human induced load. They used three dimensional FE model to obtain bridge dynamic characteristics. Their approach was on the basis of model updating to minimize the difference between analytically and experimentally estimated dynamic characteristics by changing boundary condition [4].

On the basis of construction material masonry arch bridges maybe divided into three groups, namely, brickwork arch, stone arch, and plain concrete arch. Although field and laboratory test on brickwork and stone arches have been reported frequently, there is a few studies about plain concrete arch bridge [5]. In this paper, using the results of field test, a plane concrete arch bridge has been modeled and the model tuned.