Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 190 (2017) 554 – 559

Procedia Engineering

www.elsevier.com/locate/procedia

Structural and Physical Aspects of Construction Engineering

Experimental Verification of Indirect Bridge Frequency Measurement Using a Passing Vehicle

Shota Urushadze[a,*], Jong-Dar Yau[b]

[a]Institute of Theoretical and Applied Mechanics, v.v.i., ASCR, Prague, Czech Republic.
[b]Department of Civil Engineering, Tamkang University, Tamsui, New Taipei City, Taiwan

Abstract

Based on the coupling nature of a vehicle moving on a bridge, Yang et al. [3] proposed an indirect bridge frequency approach, in which the bridge response can be recorded by the passing vehicle. Then the bridge frequencies can be detected from the dynamic response of the moving test vehicle. According to this concept, in this study an experimental setup was designed for a test vehicle moving on a beam to measure the beam frequency. From the present experimental results, the indirect bridge inspection method is feasible for monitoring the dynamic characteristics of a bridge.

Peer-review under responsibility of the organizing committee of SPACE 2016

Keywords: Bridge health monitoring; indirect method; moving load; vehicle-bridge interaction;

1. Introduction

For conventional bridge structural healthy monitoring (SHM), a lot of sensors are installed on a bridge directly, which is cost-expensive and work-intensive. To simplify the bridge monitoring procedure in practice, Yang et al. [3] proposed a vehicle-bridge interaction (VBI) model to extract beam frequencies from the response of a passing sprung mass unit. This approach is referred to as *indirect monitoring method*. As a test vehicle is traveling on a bridge, the passing car can be regarded as an active actuator to excite the bridge and also as a response receiver to capture the

* Corresponding author. Tel.: +420 222 363 071; fax: +420 286 884 634.
E-mail address: urushadze@itam.cas.cz

Peer-review under responsibility of the organizing committee of SPACE 2016
doi:10.1016/j.proeng.2017.05.379

vibration data of bridge on which it moves [4], [5]. With this concept, an experimental setup for measuring the bridge frequency will be carried out for verification of the indirect method. From the present experimental results, the indirect method is verified to be an efficient in assessment techniques appropriate for bridge structural health monitoring.

2. Response of a vehicle running on a simple beam

Let us consider the simplified model shown in Fig. 1 for a sprung mass moving on a simple beam with smooth pavement. [2]. For the case of a moving load across the span of a beam, which is transient in nature, the response of the beam can be well simulated by considering only the fundamental mode of vibration [1]

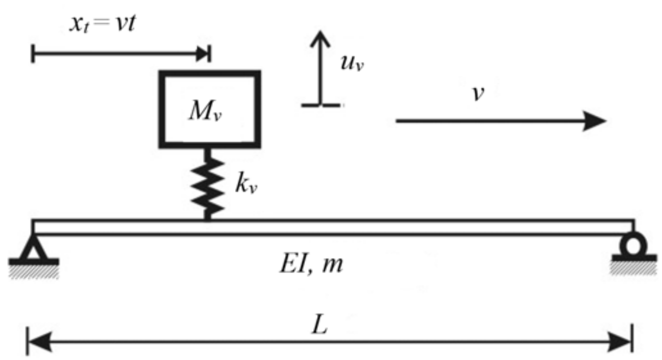

Fig. 1. Schematic diagram of a sprung mass moving on a beam.

In Fig. 1, the following parameters are adopted for the beam: m = mass per unit length, c = damping, L = span length, EI = flexural rigidity, and the following for the sprung mass unit: v = moving speed, M_v, = lumped mass, and k_v = spring stiffness. We can write the equations of motion for the beam and the sprung mass moving over the beam as [3]:

$$m\ddot{u} + c\dot{u} + EIu'''' = -\left(p_0 - M_v\ddot{u}_v\right)\delta\left(x - vt\right) \quad 0 \le t \le L/v \tag{1}$$

$$M_v\ddot{u}_v + k_v u_v = k_v u(x_t, t) \tag{2}$$

where $(\bullet)' = \partial(\bullet)/\partial x$, $(\dot{\bullet}) = \partial(\bullet)/\partial t$, $u(x,t)$ = vertical deflection of the beam, u_v = vertical displacement of the sprung mass, $p_0 = M_v$g = weight of the sprung mass, g = gravity acceleration, L = span length, $\delta(\bullet)$ = Dirac's delta function, and $x_t = vt$ = the position of the moving sprung mass on the beam. For a simply supported beam, the following boundary conditions are adopted:

$$u(0,t) = u(L,t) = 0, \quad EIu''(0,t) = EIu''(L,t) = 0 \tag{3}$$

From the viewpoint of practical bridges, the mass of a bridge mL is usually much larger than that of a running vehicle M_v, i.e. $M_v/mL \ll 1$ [6], As shown in reference [6], the numerical studies demonstrated that once the mass ratio of a coach to a simply supported bridge is smaller than 0.05, the dynamic effect of moving vehicles moving on the bridge could be neglected, which is the case studied in this paper. So the inertial force ($M_v\ddot{u}_v$) in Eq. (1) can be neglected and the deflection $u(x,t)$ of the beam subjected to a moving static force can be approximated as [3]