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Structural and Physical Aspects of Construction Engineering

Identification of some Dynamic Characteristics of a Bridge Structure

Daniela Kuchárová[a], Jozef Melcer[a,*]

[a]*University of Žilina, Univerzitná 8215/1, 010 26 Žilina, Slovak Republic*

Abstract

There are the characteristics which uniquely characterized the properties of a dynamical system. They are for example frequency response functions. These characteristics can be obtained by numerical and experimental ways. Some possible advances how to obtain these characteristics by numerical way in the sense of adopted bridge computing model are described in this paper.

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Keywords: Dynamic characteristics; bridge structure; frequency response function; kinematic excitation; Fourier transform.

1. Introduction

As we know there are the characteristics which uniquely characterized the properties of every dynamical system. They are natural frequencies and corresponding natural modes, frequency response functions and damping. These characteristics can be obtained by numerical or by experimental way. Frequency response functions are useful especially for the solution in frequency domain. Their calculation is associated with adopted computing model of the structure. Three span bridge construction where each span acts as a simply supported beam is the object of solution in this paper. For the 2nd bridge span the computing model as Bernoulli-Euler beam with lumped masses is adopted. The bridge response due to kinematic excitation in the support is analyzed. The frequency response functions are numerically calculated for such kinematical excitation. There are a few possibilities of calculation. Some of them are described in this paper. The results can be used for the evaluation of the effect of micro-tremor due to railway transport passing under the bridge span.

* Corresponding author. Tel.: +421-41-513-5612; fax: +421-41-513-5510.
E-mail address: jozef.melcer@fstav.uniza.sk

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2. Frequency response function

2.1. Definition of frequency response function

Dynamical properties of linear system are fully characterized by the response on excitation by simple harmonic functions [1]. Frequency response function $H(p)$ for ($p = \mathrm{i}\omega$) is defined as the ratio of steady state response to harmonic excitation

$$H(\mathrm{i}\omega) = r_{sst} / F\mathrm{e}^{\mathrm{i}\omega \cdot t} \,. \tag{1}$$

If the entering values is periodical with unite amplitude

$$F(t) = Ff(t) = 1\mathrm{e}^{\mathrm{i}\omega \cdot t} \tag{2}$$

the exciting value can be written as

$$r(t) = H(\mathrm{i}\omega)\mathrm{e}^{i \cdot \omega \cdot t} \,. \tag{3}$$

Frequency response $H(\mathrm{i}\omega)$ is the complex function and can be quoted as vector sum of real $\mathrm{Re}[H(\mathrm{i}\omega)]$ and imaginary part $\mathrm{Im}[H(\mathrm{i}\omega)]$, Fig. 1.

$$H(\mathrm{i}\omega) = \mathrm{Re}[H(\mathrm{i}\omega)] + \mathrm{Im}[H(\mathrm{i}\omega)] \tag{4}$$

or

$$H(\mathrm{i}\omega) = \left|H(\mathrm{i}\omega)\right|\mathrm{e}^{\mathrm{i}\varphi} \tag{5}$$

where $\left|H(\mathrm{i}\omega)\right|$ is the absolute value of frequency response and it represents the amplitude of the response $r(t)$. The character φ in equation (5) represents the phase the frequency response.

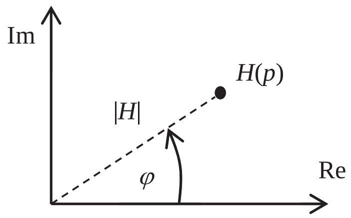

Fig. 1. Frequency response function as a complex function.

Substituting (5) to (3)

$$r(t) = \left|H(\mathrm{i}\omega)\right|\mathrm{e}^{\mathrm{i}\varphi}\ \mathrm{e}^{\mathrm{i}\omega \cdot t} = \left|H(\mathrm{i}\omega)\right|\mathrm{e}^{\mathrm{i}(\omega \cdot t + \varphi)}. \tag{6}$$

Then we can write

$$\left|H(\mathrm{i}\omega)\right| = \sqrt{\mathrm{Re}^2[H(\mathrm{i}\omega)] + \mathrm{Im}^2[H(\mathrm{i}\omega)]} \tag{7}$$

and

$$\varphi = \varphi(\omega) = \mathrm{arctg}\,(\mathrm{Im}[H(\mathrm{i}\omega)] / \mathrm{Re}[H(\mathrm{i}\omega)]) \,. \tag{8}$$