Bridge Vibration Monitoring using Passing Train Loads

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Summary

In order to appropriately conduct maintenance of railway bridges with progressed deterioration, 1) Understanding the actual behavior of bridges under the passing train loads, and 2) Identifying vibration characteristics such as natural frequency, damping ratio and vibration mode shapes, are extremely important issues. In this paper, focusing on open deck bridges, a vibration monitoring method using the passing train loads is proposed. In order to verify the effectiveness of the proposed method, vibration measurement tests were carried out on an actual bridge and vibration characteristics were identified. Furthermore, by quantitatively evaluating the contribution rate of each mode component of actual behavior, the difference from the response characteristics of a general impulse hammer impact is clarified, and the significance of vibration monitoring using the passing train loads is discussed.

Keywords: open deck bridges, passing train loads, vibration characteristics, mode contribution rate, vibration monitoring

1. Introduction

As for railway bridges, the ratio of concrete bridges is high. In particular, for railway lines that accompany high-speed trains, many elevated bridges are built and in most cases a closed floor structure is adopted. Recently, as maintenance is a main issue, there are many studies on the evaluation of performance (durability, load carrying capacity, etc.) and prevention of and measures for damage[1)]. In fact, identification of vibration characteristics focused on in this paper, such as the natural frequency, damping ratio and vibration mode shapes (hereinafter, “vibration characteristics), have been conducted in the past and have been put to practical use in quantitative index for countermeasures against noise and earthquakes, etc.

On the other hand, in some snowy-cold regions there are some elevated bridges with open floor structures of latticed decks, instead of a closed floor structure. By using an open floor structure, accumulation of snow on the bridge can be restrained, ensuring safety of passing trains and reduction of snow loads. Also, the efficient deck structure contributes to cutting costs. However, it can be expected that the vibration characteristics are different from general closed floor structures, as the coupled effect of the decks cannot be achieved. In addition, taking into consideration the recent deterioration of bridges and the high speed of trains, the need for understanding the dynamic behavior and vibration characteristics of open deck bridges is increasing, but as far as the authors know there is no precedent of this kind of research.

For identifying the vibration characteristics of railway bridges, most studies in the past have used ambient vibration or impulse hammer force as the excitation on bridges. The merits of these excitation forces are that they are convenient and that signal processing of the dynamic response is easily conducted. However, problems have been pointed out, such as the fact that the S/N ratio is small in comparison to the structure and lower order modes are difficult to excite. This paper endeavors a solution to these problems by identifying bridge vibration characteristics using the

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