Dynamic Response of Concrete Cable-Stayed Bridges due to Cable Rupture

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Summary

This paper aims to analytically investigate the effects of cable rupture on the dynamic responses of concrete cable-stayed bridges. Analytical methods for simulating the cable rupture using a time history function have been examined and the dynamic amplification factor (DAF) is considered as a design criterion. The calculated DAFs from a concrete cable-stayed bridge were compared with those from a typical steel composite one. DAFs were calculated for member forces of the deck system and stay cables. The comparison verified that the current design guideline for DAF may be reliable in general sense but underestimate DAFs in some parts of concrete cable-stayed bridges.

Keywords: cable rupture; concrete cable-stayed bridges; analytical method; DAF; design guideline.

1. Introduction

Cable-stayed bridges are structurally efficient because they can combine the tensile strength of stay-cables and the axial-flexural strength of pylons and deck systems effectively. Since the appropriate control of cable strength and tensile forces can reduce the bending moments at the deck system remarkably, an economical design may be achieved. Appearances of cable-stayed bridges are acknowledged as pleasing and their sights are relatively open and wide. In addition, it is easy to modify its design by a selection of the girder system or pylon type, and also the arrangement of stay-cables.

The number of concrete cable-stayed bridges designed and constructed in Korea is increasing due to their eco-friendly aspects and economical maintenance compared with steel composite cable-stayed bridges. Since compressive forces to the deck system become larger in marching with the size and span length of cable-stayed bridges, the use of concrete cable-stayed bridges is considered as an economical alternative within a certain limit of span length. Due to the application of high strength concrete to cable-stayed bridges, it is expected that more concrete cable-stayed bridges will be constructed in near future around the world.

Stay-cables in bridges are always exposed to the surrounding environments so that they can be accidentally ruptured by unexpected vibration due to earthquake, wind, blasting, or fire. Therefore, it is important to examine the bridge safety due to the cable rupture for securing the user safety and the structural reliability [1,2,5,7]. The dynamic amplification factor (DAF) is the only design criterion for the bridge vibration due to cable rupture [3,4,6]. However, the design guidelines for concrete cable-stayed bridges have not been solely established but rather have adopted that for steel composite cable-stayed bridges. In most practical engineering cases, DAFs are checked only at some critical sections based on engineering judgement. Since DAFs vary severely along a bridge due to the cable rupture, it is necessary to evaluate DAFs in overall sense [8].

Since it is almost impossible to investigate DAFs of cable-stayed bridges experimentally, DAFs can be evaluated through numerical dynamic analysis. The paper examines analytical methods for simulating the cable rupture using a time history function and compares the calculated DAFs from a concrete cable-stayed bridge with those from a typical steel composite one.

https://doi.org/10.2749/222137912805112185