The 2016 World Congress on
The 2016 Structures Congress (Structures16)
Jeju Island, Korea, August 28-September 1, 2016

Numerical Study on the Dynamic Amplification Factor of Cable-Stayed Bridges Due to Cable Failure

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ABSTRACT

This study examined the influence of cable failure on the dynamic behavior of cable-stayed bridges through numerical study and review of the available design guidelines. To validate the applied analytical method, a cable cutting laboratory test was carried out on a model cable-stayed bridge. Then, multiple simulations were carried out with different choices of single or multiple cable cuttings. The major concerns in this study were the selection of a proper cable rupture duration for dynamic analysis and a reliable determination of the dynamic amplification factor from the analytical results obtained when single or multiple cables are cut.

1. INTRODUCTION

For cable-stayed bridges, it is required to evaluate the structural behavior carefully because the stay-cables, as one of the critical members, are inherently exposed to various types of accidental loads including blast or impact due to earthquake, tsunami or any other accident. Table 1 summarizes available design guidelines relevant to cable cutting. In the guidelines, load combinations of dead loads, live load, and impact load are considered. The design criteria of all the guidelines for the case of cable cutting are based on the calculation of the dynamic amplification factor (DAF).

This paper aims to investigate the influence of a cable cutting on DAF of cable-stayed bridges through analytical study and laboratory model test. An analytical method using linearly decreasing triangular cable force has been applied for simulating the dynamic behavior of a cable-stayed bridge after a cable is cut. The analytical approach has been examined through a laboratory test on a small scale model cable-stayed bridge. For the examination, the analytical model for the tested cable-stayed bridge was updated using the measured dynamic responses.

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Note: Paper to be submitted to "Computers and Concrete, An International Journal" for the purpose of Special Issue.

Table 1. Design guidelines relevant to cable cutting

Design guideline	Load combinations	DAF
Design guidelines for steel cable bridges (KSCE 2006)	1.0D + 0.5L(1+I) + {member forces due to cable cutting} D : Dead Load L : Live Load I : Impact Factor	Static analysis : DAF = 2.0 Dynamic analysis (Nonlinear) : DAF $\geq$ 1.5
PTI (2012)	$1.1D_c + 1.35D_w + 0.75(LL+IM)$ + 1.1{cable loss dynamic forces} D_c : Dead Load (components and attachment) D_w : Dead Load (wearing surface and utility) LL : Live Load IM : Dynamic Load Allowance	Static analysis : DAF = 2.0 Dynamic analysis (Nonlinear) : DAF $\geq$ 1.5
SETRA (2002)	0.75TS + 0.4UDL TS : Tandem System UDL : Uniformly Distributed Load	Instant rupture : DAF = 2.0 Progressive rupture : 1.5 ≤ DAF ≤ 2.0
Korea Highway Bridge Design Code (Limit State Design, LSD) – Cable Bridge (KRA 2014)	γ_p (D_c+D_w) + 0.75(LL+IM) + {member forces due to cable cutting}	Static analysis : DAF = 1.5 Dynamic analysis (Nonlinear) : DAF $\geq$ 1.2

2. DYNAMIC ANALYSIS DUE TO CABLE CUTTING

Before a cable is cut, cable forces due to the applied load combinations are computed according to the design guidelines for steel composite bridges (KSCE 2006). Then, to simulate a cable cutting accident, a cable is replaced by the external forces applied to the opposite directions as shown in Fig. 1. The cable rupture is simulated by the loss of cable tensile force as a time history triangular ramp function.

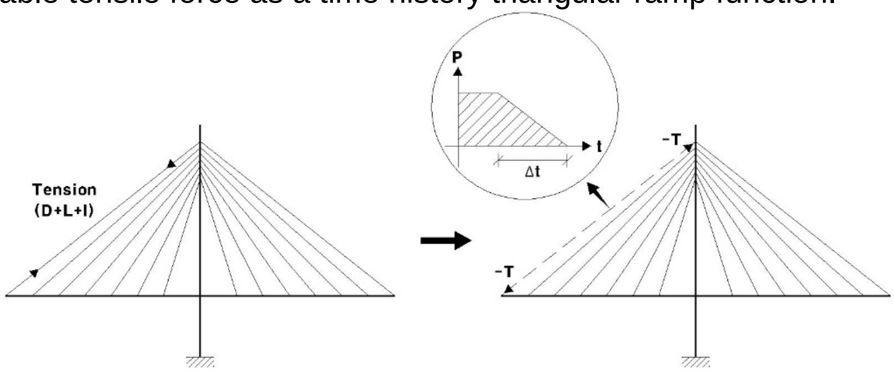

Fig. 1 Simulation of cable rupture (Park *et al*. 2007)

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