Analytical Study on Safety Level of Stay Cables of Cable-stayed Bridge and Extradosed Bridge under Fatigue and Ultimate Limit States

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Abstract

Cable-stayed bridges and extradosed bridges are thought to be similar kinds of structures because both bridges use stay cables for reinforcement. However, the safety factors of stay cables of both bridge types are stipulated differently in many international standards i.e. Japanese specifications suggest the safety factors of 2.5 and 1.67 for the design of cable-stayed bridges and extradosed bridges respectively. In this paper, an analytical study is carried out for the investigation of the safety level of stay cables of both bridge types at fatigue and ultimate limit states. Subsequently, the Mean Value First Order Second Moment (MVFOSM) reliability method is also performed for the verification of safety factors of stay cables. Finally, it is found that the safety factors of stay cables in the range of 2.3 to 2.5 and 1.67 are essential to satisfy the fatigue and ultimate limit states and target reliability index of 4.0 of cable-stayed bridges and extradosed bridges respectively.

Keywords: cable-stayed bridge; extradosed bridge; stay cable; safety factor; reliability.

1 Introduction

The extradosed bridge is thought to be a special form of the cable-stayed bridge [1] because both bridges use inclined stay cables for supporting the girder load elastically at points along its length so that the girder can span a much longer distance without intermediate piers. The dead load and live load on the girders are transferred to the towers by the axial action of inclined stay cables. Thus, the safety of these kinds of flexible structures is mainly dependent on the safety of stay cables, which is usually assured by applying a safety factor to provide a margin between theoretical strengths (R) and theoretical load effects (S). For example, the allowable stress (σ_{all}) at serviceability limit state (SLS) as per the Japan Prestressed Concrete Engineering Association's Specifications, may be determined as $0.4\sigma_{UTS}$ and $0.6\sigma_{UTS}$ for the design of stay cables of the cable-stayed bridge and extradosed bridge respectively [2]. However, the problem of how much allowable stress should be used for stay cables of extradosed bridges is still controversial because these cables are considered external cables arranged outside the box girder. Moreover, the safety factors of stay cables have not been verified for various loading effects and unexpected damage conditions. And the stress range in a stay cable due to live load is one of the most important considerations for the design of stay cables against failure due to fatigue [3]. Due to variations in live loads, it is difficult to precisely examine the safety of these kinds of flexible structures through an evaluation method comprising safety factors based on experience. It, therefore, seems reasonable to conduct the safety and reliability assessment using a reliability

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