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Autor(en): **Nagai, Masatsugu / Xie, Xu / Yamaguchi, Hiroki**

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Identification of Minimum Width-to-Span Ratio of Long-Span Cable-Stayed Bridges Based on Lateral Torsional Buckling and Flutter Analyses

Masatsugu NAGAI
Professor
Nagaoka University of Technology
Nagaoka, Japan

Xu XIE
Kaihatsu Consultant Co., Ltd.
Tokyo, Japan

Hiroki YAMAGUCHI
Professor
Saitama University
Urawa, Japan

Yozo FUJINO
Professor
University of Tokyo
Tokyo, Japan

Abstract

Using a 1400-meter cable-stayed bridge model, in which four cross sections of the girder having different widths with a fixed depth of 3.5 meters are selected, static and dynamic instability analyses are carried out. Their behavior under wind load is made clear and the design material for identifying a minimum width-to-span ratio of the girder is presented, which ensures safety against the instabilities.

1. Introduction

In the design of long-span cable-stayed bridges, ensuring safety against static and dynamic instabilities under wind load is an important issue, because the shape and dimension of the girder are controlled mainly by above instabilities. In this paper, using a 1400-meter cable-stayed bridge model, a nonlinear static analysis under displacement-dependent wind load and a flutter analysis based on multi-mode coordinate are carried out. Four types of cross section of the box girder having different widths of 25, 28, 32 and 35 meters with a fixed depth of 3.5 meters are chosen. The employed box girders are preliminary designed, in which the yield point of steel is only selected to be an instability criterion. By carrying out above instability analyses, the critical wind velocities of lateral torsional buckling and flutter are investigated. Finally, the design material for obtaining minimum cross-sectional shape and dimension of the girder is presented.

2. Bridge Model

The bridge model for the analyses is shown in Fig.1. A height of the tower from the deck level is one fifth of the center span length. Since the total normal stress induced by the dead and wind loads becomes large, the girder near the tower has to be reinforced (see fig.1(c)).

3. Results and Discussions

Considering appropriately the aerodynamic forces, the finite displacement analysis is carried out to check the static instability. Flutter analysis based on modal coordinate is also carried out for the dynamic instability. Fig.2 shows lateral displacements, vertical (upward) displacements and rotational angles at the middle of the center span of the bridges. They diverge in the range of the

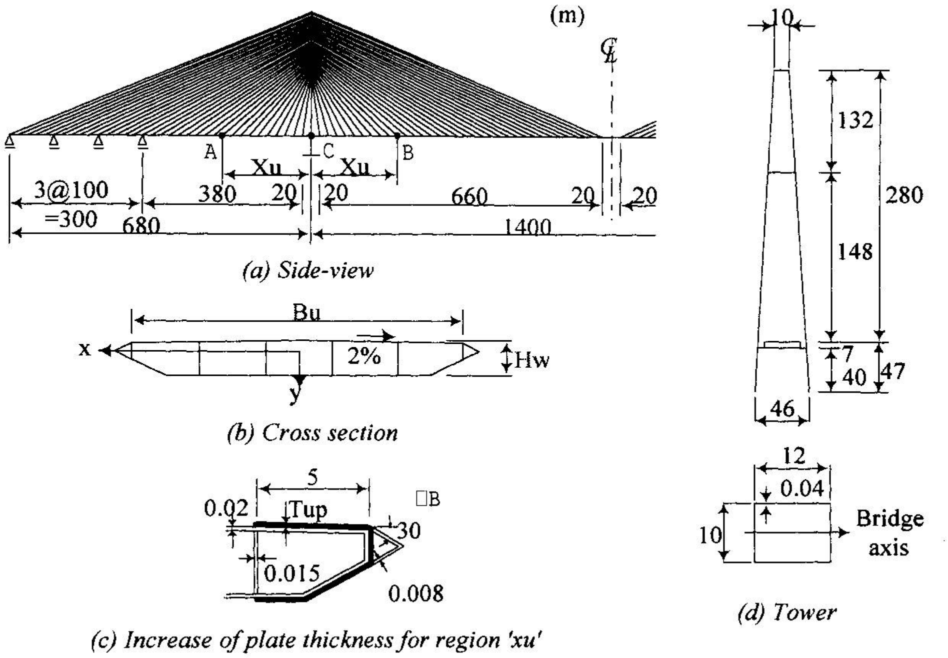

Fig.1: Bridge model

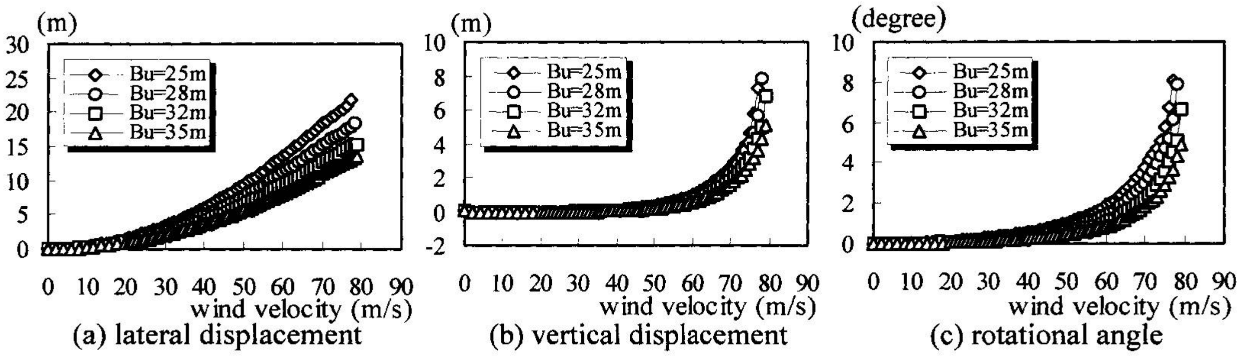

Fig.2: Displacements at the middle of the center span

wind velocity from 75 to 80m/s which is high enough compared with the design wind velocity of 60m/s. The static instability of the bridge under construction was also analyzed and assured to be safe enough. From the result of flutter analysis, it is interesting to know that the flutter wind velocity is higher than the above critical wind velocity under static wind load.

4. Concluding Remarks

The followings are main results obtained from this study. 1) Flutter onset wind velocity is higher than critical wind velocity under static wind load. 2) It is found that static instability under displacement-dependent wind load controls the dimension of long-span cable-stayed girders. 3).On condition that the bridge is designed based on the procedure proposed, the girder with a width-to-span ratio of around 1/55 (corresponding to the case of Bu=25m) can be used.