



Investigation on the horizontal mechanical behavior of steel-concrete composite cable-pylon anchorage

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ABSTRACT

The configuration and mechanical behavior of steel-concrete composite cable-pylon anchorage in cable-stayed bridges are very complex. Considerable local deformation of composite cable-pylon anchorage zone could occur under the horizontal component of the inclined cable force. It is difficult and unfeasible to analyze the horizontal mechanical behavior of the composite cable-pylon anchorage by the traditional analytical theory of composite structures. In this paper, full-scale model tests were carried out according to an actual project to analyze the horizontal mechanical behavior of composite cable-pylon anchorage. Stress distribution patterns of the main members and the failure modes were obtained. Structural response of the anchorage was analyzed by spatial solid and shell finite element model. By analyzing and simplifying the configuration and details of the structure, the expression for calculating the horizontal force burdened by the main members of composite cable-pylon was derived based on the deformation compatibility principle. The equation for calculating internal forces of the main members in the composite cable-pylon anchorage was also obtained. It is shown that the proposed simplified method agree well with the experimental result and finite element method result.

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1. Introduction

As a new type of anchorage structure, the steel-concrete composite cable-pylon, as shown in Fig. 1, is mainly used in the long-span cable-stayed bridge nowadays [1]. The composite cable-pylon anchorage system consists of two parts, the concrete wall and the steel anchor box. The steel anchor box is arranged inside the concrete wall and connected to the concrete wall with the shear connectors. Due to its excellent mechanical performance, composite cable-pylon anchorage was adopted in several long-span cable-stayed bridges, such as Normandy Bridge in France, Rion-Antirion Bridge in Greece, and Sutong Bridge, Shanghai Yangtze River Bridge, No. 3 Huanghe River Bridge and Edong Bridge in China.

The vertical mechanical behavior of the steel-concrete composite pylon is similar to that of common composite members, such as the concrete filled steel tube and the concrete encased steel-concrete composite columns [2,3]. The mechanical response of the composite pylon due to global and local effects can be analyzed and calculated based on the theories of columns [4–6]. However, there are non-neglected huge local forces due to the horizontal components of the forces of the inclined cables, which would cause high local stress and large local deformations on the concrete wall and the steel

anchor box. Three key issues are related to in the analysis of the mechanical response of the steel-concrete composite cable-pylon anchorage, (1) local response of the support plate and the adjacent web plate of the steel anchor box due to the eccentric patch loading by the anchor heads of the stay-cables; (2) composite behavior between the concrete and the steel anchor box, or in other words the effective region of the steel anchor box to be taken account of in the composite behavior of the concrete wall; (3) response of the concrete wall due to the transverse force and the existence of the round holes for the stay-cables.

As for issue (1), extensive investigations have been conducted on the web plates of the steel beams [7–11], and there is no substantial difference between the web plates of beam and the support plates of the steel anchor box of the cable-pylon anchorage. With regard to issue (3), local cracking is prone to occur in concrete wall caused by the horizontal component of the cable forces, which becomes one of the most important issues that govern the design of the composite cable-pylon anchorage [12]. Previous researches were mainly focused on the concrete slab with cutouts [13,14], the concrete walls of cooling towers [15,16], and the walls of dams [17].

Many studies could be found on the load transmitting mechanism of the anchorage zones of concrete girder bridges with the method of numerical simulation and the method of model tests [18]. However, there is no relative study on issue (2) and the interaction behaviors between the three issues. Therefore, the percentage of the horizontal components of the forces carried by the concrete wall and the web plates of the steel anchor box can not be numerically determined.

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