Wind suction effect on long-span stiffened steel truss bridges during erection

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A B S T R A C T
During the erection of long-span steel truss bridges, the bridge decks and the steel truss girders are commonly constructed simultaneously in order to shorten the construction period, leading to wind suction effect on the decks when wind strikes. This effect may have a remarkable influence on the wind-resistant behavior of stiffened steel truss bridges which hold long-span cantilevers during erection, as wind suction can act together with the gravity load to increase the structural response. However, neither current codes nor studies have taken this effect into account. This paper is intended to investigate the wind suction effect and its influence on the static wind-resistant behavior of stiffened steel truss bridges during construction. Two wind tunnel tests, including a high-frequency base balance (H-FBB) test and a synchronous multi-pressure sensing system (SM-PSS) test, were carried out with the world’s longest arch-stiffened steel truss bridge as a model. On the basis of the experimental results, two net pressure coefficients which could be used to determine the wind suction are proposed. A finite element analysis considering the wind suction effect is also performed, through which the wind suction influence on the model bridge during erection is obtained.

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1. Introduction
The history of steel truss bridges, the majority of which serve as railway bridges, can be traced back to the late nineteenth century when steel began to replace wrought iron as the preferred material. The widespread use of steel truss bridges was seen in the period between 1920 to 1950, aided by the popularity of railways during this time. Since then, the number of newly-built steel truss bridges had declined due to the slowing development of railways [1–4]. The rapid development of high-speed railways in recent years around the world presents new opportunities as well as challenges to steel truss bridges, because not only the demand of steel truss bridges is increasing, but also an improvement of spanning capability is called for in order to compete with other types of bridges.

It is generally accepted that steel truss bridges perform efficiently spanning from 50 m to 150 m, but uneconomically when spanning beyond this range, which has limited the application of this traditional type of steel bridge. To address this problem, two effective measures were proposed in China in order to stiffen the steel truss girders. The first measure which has gained increasing usage in modern bridge practice is to stiffen the steel truss girders with flexible arches (Fig. 1b). The flexible arches, being different from traditional steel arches, are applied in steel truss bridges primarily to improve the spanning capability rather than to carry the design loads. Representative examples include the Min River Bridge with a middle span of 198 m, and the Yellow River Bridge with a main span of 168 m. The other measure, which was proposed in 2006 and successfully applied in the Dong River Bridge (with a total span of 432 m and a main span of 208 m), is to stiffen the steel truss girders with rigid cables (Fig. 1c). Such type of bridges has the appearance of suspension bridges, but is steel truss girder bridges actually, because the “suspension cables” and the “suspenders” are fabricated from rigid steel sections (circular steel tubes or square steel tubes which are called “rigid cables” in general) instead of flexible pre-stressed cables.

The construction of the superstructure of a stiffened steel truss bridge normally involves two stages: stage one, being the same as that of traditional (unstiffened) steel truss bridges, is to erect the steel truss girder; stage two is to construct the stiffened arches or cables on top of the completed girder. During the first stage, almost all steel truss bridges are built using cantilever methods [5–7]. This is very helpful when temporary supports, or falsework, cannot be used to support the structure while it is being built (e.g., over a busy roadway or river, or in a deep valley). On the other hand, such construction method leads to concerns for the safety of the cantilevers, because the stiffened steel truss bridges have relatively longer spans than traditional (unstiffened) steel truss bridges, and in the first stage they need to carry all the loads or actions without the aid of stiffened structures.

At the first constructional stage, a cantilever model subjected to gravity load and wind action is generally used to investigate its structural behavior (Fig. 2a)). The gravity load is evenly applied as vertical concentrated forces on each joint, and the wind action is imposed as horizontal loads on each joint [8–10]. However, this treatment may...