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Long-Span Bridge Stabilization under Balanced Cantilever Method

Stabilité des ponts de grande portée lors du montage en encorbellement

Stabilität von Brücken grosser Spannweiten beim Freivorbau

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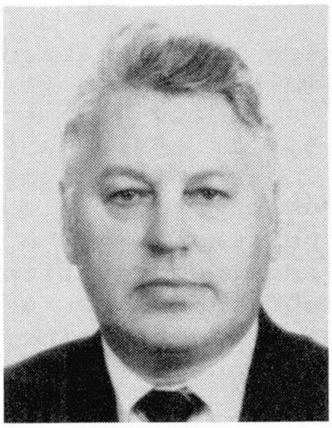

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SUMMARY

The necessity of the uniform security of aeroelastic stability of long-span suspension, cable-stayed, continuous and cantilever bridges not only during service but also during balanced cantilever erection is demonstrated in the paper. The peculiarities of the aeroelastic interaction of the erecting span structures with the wind flow are described here. The effectiveness of the definite types of the balanced erection is also shown here.

RESUME

L'article met en évidence la nécessité de la sécurité uniforme de la stabilité aéro-élastique dans les ponts de grande portée, ponts suspendus, haubanés, à travées simples ou continues non seulement durant l'exploitation mais également durant le montage par la méthode en encorbellement. Cette communication expose en outre les particularités de l'interaction aéro-élastique en cours de montage des travées suspendues sous l'action du vent. Il montre l'efficacité de quelques types choisis pour cette méthode de montage.

ZUSAMMENFASSUNG

In diesem Beitrag wird die Notwendigkeit der Sicherstellung der aeroelastischen Stabilität bei mehrfeldrigen Hänge-, Schrägseil-, Durchlaufträger- und Auslegerbrücken nicht nur im Gebrauchszustand, sondern auch während des Freivorbaus begründet. Die Besonderheiten des aeroelastischen Zusammenwirkens für die im Freibau auszuführenden Überbauten und dem Windstrom werden behandelt. Die Effektivität gewisser Freivorbauverfahren wird erläutert.

1. INTRODUCTION

The security of bridge structure reliability and stability not only in the process of exploitation but also under the transportation and erection is one of the major demands of their design. A considerable attention is paid to the general problem of the aerodynamic stability of the flexible bridge structures. Actually the same problems during the erection and the design of the construction tsite are not described. Therefore the present day design technology must guarantee the aerodynamic stability of bridge structures and the security during all the stages of the erection despite its duration and the season. This design technology must be uniform calculation system.

2. LONG SPAN BRIDGE QUALITIES

The major qualities of the flexible bridge structures under erection are: 1)the increased sensitivity to the wind effects; 2)the reduced flexural rigidity (in vertical and horizontal planes) and torsional rigidity; 3)considerably lower values of the critical velocity of the appearance of the aeroelastic instability phenomena. The above-mentioned qualities were observed both during aerodynamic model experiments and in the engineering practice [1-4]. The causes of bridge construction failures may be various. The analyses of 143 damages and other critical situations during long bridge construction are described in [5]. About 10% out of them are connected with the wind effects.

3. THE WIND EFFECT PECULIARITIES UNDER ERECTION

During the long-span steel bridge erection various changes in various kinds of aeroelastic instability may occur. Such types of aeroelastic instability as galloping, vortex excitation and flexure-torsion flatter is the most specific for the erecting pylon in particular. The aeroelastic instability of the flexure-torsion flatter is the most characteristic for the suspension bridges under erection, while the aeroelastic instability of the stalling flatter is possible for the cable-stayed continuous and cantilever bridges under cantilever erection (especially for the pedestrian bridges).
The changes of the frequencies (Fig.1,a) and oscillation decrements under erection show the possibility of the wind critical velocity reduction (Fig.1,b) in comparison with the calculated wind velocity values, under which the aerodynamic instability appears. The reduction of the wind critical velocity below the calculated value shows that the reliability of the structure and operation safety are not guaranteed at some stages of the erection. Therefore, it's necessary to work out the appropriate calculation and the definite measures to improve the erection and to guarantee the aerodynamic stability of structures despite the method of operation at the construction site.
The dynamic effect of the wind flow pulsation component on the suspension and cable-stayed bridges under the cantilever erection posseasses a number of specific qualities due to the special character of the space oscilation natural frequency spectrum of these bridges. The calculations for Ulyanovsk bridge across the Volga (having infralow-frequency spectrum) show that the dynamic reaction for the

wind flow pulsation effect is influenced by more than ten space oscillation lowest forms. For all this the dominating may be the contribution into the dynamic reaction not of the first form, but of the higher ones.
For the long-span cable-stayed bridges, erected by the balanced cantilever method, a local effect of a single wind gust may become one of the calculating state (condition). In this case the calculating scheme is characteristic only for the erection stages (Fig.2).

4.THE EFFECTIVE WAYS OF STABILIZATION

The present day tendencies in bridge engineering are connected with the construction of long-span flexible bridges, with the use of new material with more reliable qualities. Therefore, the definite measures should be worked out to improve the erection for the guarantee of the structure aerodynamic stability during erection.
All these measures are more or less connected with the increasing of the damping and rigid qualities of the bridges at different erection stages.It should be mentioned that the traditional aerodynamic means of wind induced oscillation damping, which are rather effective at the stage of exploitation, are unacceptable at the erection.
Possible measures include temporary joints,guyropes, mass balances supplied by the elements with the increased dissipative qualities, adjoined masses with partial frequency close to the dominating frequency of the oscillations of the particular member or the whole structure, and many other various measures.
Suspension and cable-stayed, continuous and cantilever span structures may be erected by balanced cantilever method, as these structures needn't any reinforcement. Girder-split span structures are joined into continuous system with the help of the binder elements for the erection.
The elements of the span structures must satisfy the demands of the reliability and stability at all the stages of erection.
If the reliability or stability of some separate elements is not sufficient, they are strengthened by means of the increase of the cross-section area or the reduction of the free length. The erecting forces in the span structure elements may be reduced by means of arranging the accepting and supporting cantilevers or temrorary tie-rods, cables.
At the stage of span structure erection the limits of the natural oscillation period values are introduced by the soviet standards for the balanced cantilever method. These limits are caused by the demands of securing aeroelastic stability of span structures under erection.The maximum values of the natural oscillation periods are as following: for vertical and horizontal-2c, for torsional-1,5c.
The calculations show the possibility of the erection of the cantilever up to 110m of length, according to the above-mentioned limits for vertical oscillations. The limits for the horizontal oscillation period reduce the maximum size of cantilever to 88m, and for the torsional oscillation period - less than 70m.
Therefore, besides the traditional mounting of temporary inter mediate supports, the alternative method of the stabilization of the erecting cantilever is presented here (Fig.3 and 4).
The effective stabilization in the wind flow is achieved with the help of the additional prestressed elements. In this case the effectiveness of stabilization is caused by the increase of the

flexural (in vertical and horizontal planes) and torsional rigidity of span structures. For the creation of the preliminary stress such elements may be supplied at the ends by the counterbalances and damping devices increasing the dissipative qualities of the whole structure.

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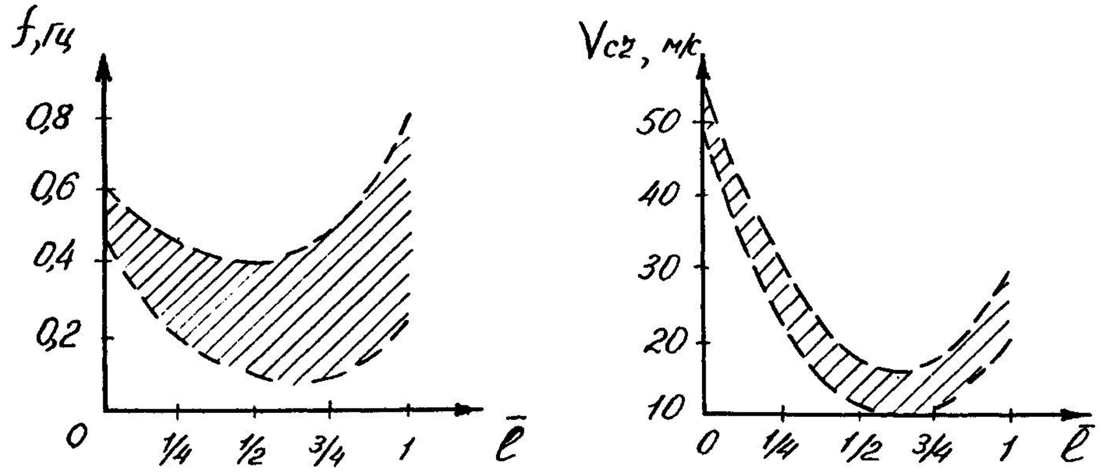

Fig. 1. The changes of the oscillation natural frequency values and wind critical velocity values under cantilever erection

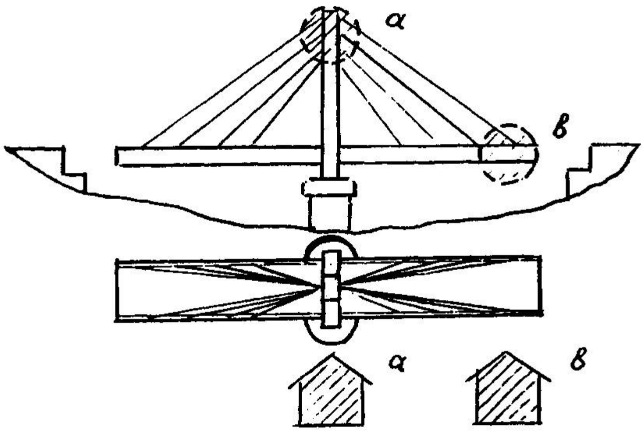

Fig. 2. The effect of the single wind gust on the pylon (a) and cantilever (b) of the bridge

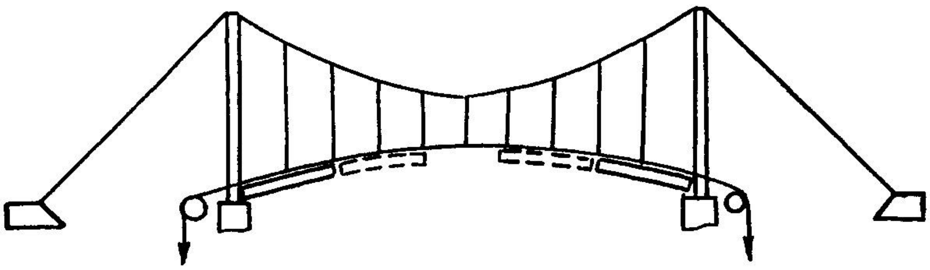

Fig. 3. Suspension bridge stabilization under erection

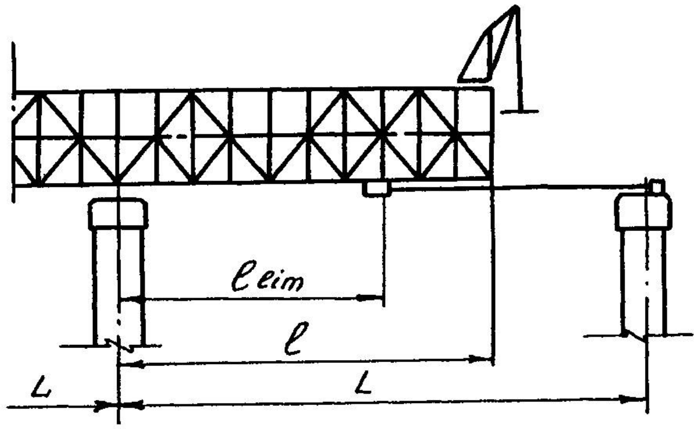

Fig. 4. Continuous span structure stabilization under erection

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