# Super long-span suspension bridge with 3-chord truss and 3 cables

# Super Long-Span Suspension Bridge with 3-Chord Truss and 3 Cables

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Yoshiaki Nakayama, born 1928, received his degree of Dr. Eng. from the Univ. of Osaka in 1985. He was engaged in designing of bridge in Yokogawa Bridge Works Ltd for 10 years and then worked for Nippon Kikan K.K. on the design and development of bridge and maritime civil structures for 26 years.

## Summary

A suspension bridge with a three-chord-member stiffening truss girder and three main cables was proposed as a super long-span suspension bridge with improved wind stability. The stiffening truss girder of the bridge has a triangular cross section. Each chord member is suspended directly from each main cable locating right above it. The sag ratio is slightly varied between the center main cable and the side main cables. As a result, the torsional rigidity and the structural damping capacity of the bridge can be increased and, therefore, the wind stability is expected to be improved. The basic concept and the structure of the bridge are presented.

## 1. Principle and Mechanism for Improving Wind Stability

### 1.1 Damping of the First Antisymmetric Torsional Oscillation by Center Main Cable

Among the various oscillation modes of a free-hanged single main cable, the oscillation on vertical plane with a node at around a center of the span hardly needs energy and, then, hardly causes damping. In the case of conventional bridges without sufficient torsional rigidity in their bodies, a torsional oscillation of the stiffening truss girder caused by aerodynamic forces, in combination with such a oscillation of the main cable, easily generates the first antisymmetric torsional oscillation. In order to avoid this catastrophic oscillation, the mode of the main cable oscillation has to be suppressed by increasing energy for the oscillation. In the proposed bridge, the shear center is located in the comparatively lower portion of the stiffening truss girder cross section. If the first antisymmetric torsional oscillation is generated and the horizontal displacement of the third chord member is supposed to be $\delta_T$, the deformation of the chord member in a horizontal direction can be illustrated as Fig. 1-C. Since the chord member is connected to the main cable by hangers, the deformation of the chord member is propagated to the main cable through the hangers. However, the main cable can not easily be deformed horizontally because the large tension is applied to the cable. Therefore, the deformation of the chord member is strongly constrained. This effect is comparable to that of increasing the torsional rigidity of the stiffening truss girder. As a result, the torsional oscillation generated in the bridge can rapidly be damped.

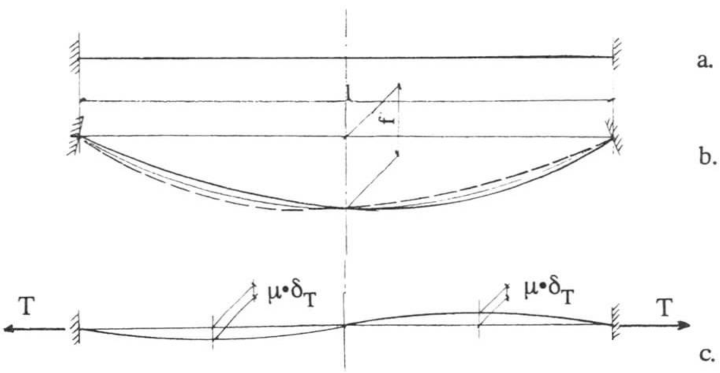


*Fig. 1. Deformation of center main cable.*

### 1.2 Damping Capacity against Bending Oscillation

Natural frequency is different between the center main cable and the side main cables because of the different cable tension and sag ratio. Therefore, for example, when the first antisymmetric oscillation is generated in the side main cables, the absorption of the oscillation by another oscillation system including the center main cable can be expected to occur. As a result, the oscillation energy is not accumulated and the action to disturb the oscillation is generated due to the difference in the phase of oscillation, and, then, the divergence of the oscillation, that is the flutter, can be avoided.

## 2. Outline of Bridge Structure

The cross section of the proposed stiffening truss girder is shown in Fig. 2. The rigid triangular frames (sway bracings) on a vertical plane are required to be installed at intervals of 50 m to connect the three main cables with the stiffening truss girder. This type of structure can easily be established with recent structural engineering technologies. All the truss girder members including frames have sufficient capacity to absorb the aerodynamic oscillation energy and sufficient torsional and bending rigidity because of the increased elastic deformation due to their extended length as compared to the conventional bridge members. These long members need to have a circular cross section in order to resist wind pressures and buckling by compression forces. As for the technologies for fatigue resistance of the bridge to pulsating forces by wind, they have already been well established through experiences in constructions of maritime structures.

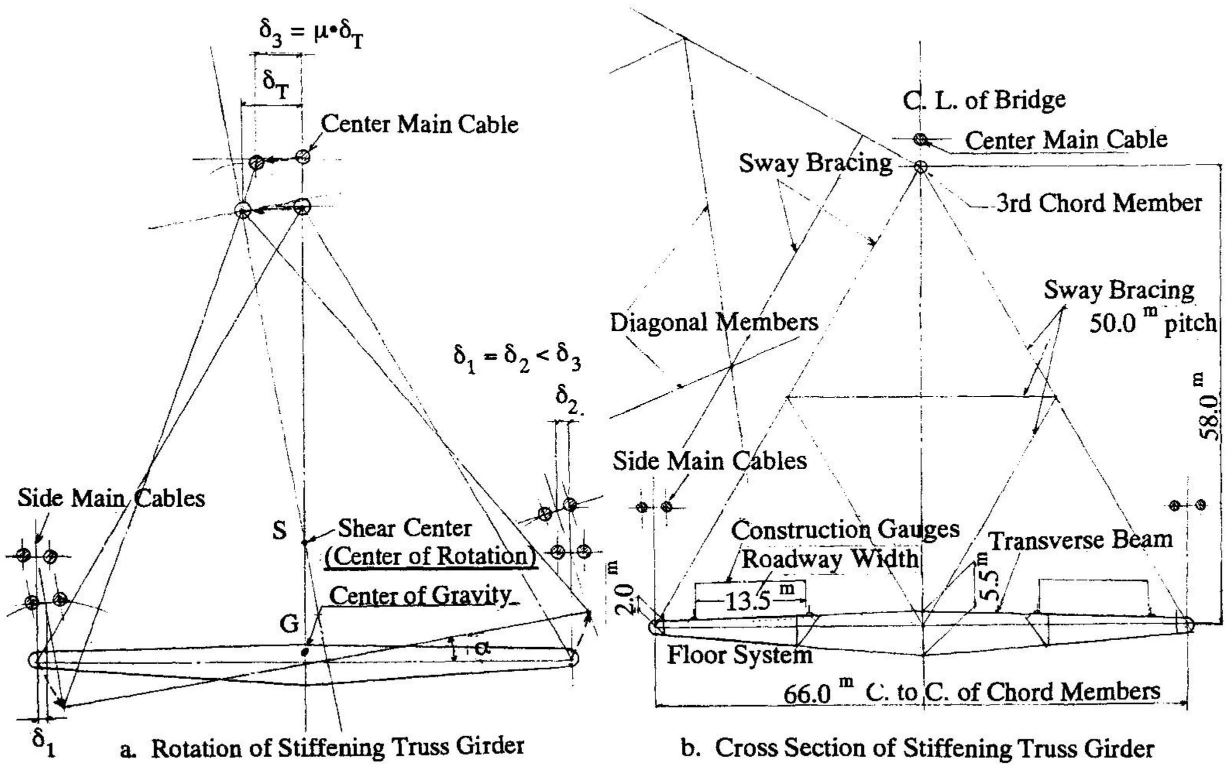


*Fig. 2. Cross section of stiffening truss girder.*