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Tsugaru Strait Bridge

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Summary

The Tsugaru Strait Bridge is proposed over the Tsugaru Strait, with the distance of 19km and the greatest depth of 270m,between Honsyu and Hokkaido in Japan. The Bridge is planned with 1 continuous suspension bridge with 2 spans of 4,000m in the center, to secure the international navigation route, and 2 suspnsion bridges with 2,000m central span on both sides. To realize these bridges, a suspension system with a combination of 3 main cables and sub-cables, 2 separated steel decks, cable stayed prestressed concrete decks, jacket piers with inclined legs and joint anchorages between 2 suspension bridges are proposed. Through these measures, such benefits as reduction of cable tension, wind stability, possibility of re-erection, minimizing displacements of tower tops and decks for seismic force, reducing preparatory works, cancellation of tractions at the anchorages etc. can be obtained. The Tsugaru Strait Bridge shall be the new goal of bridge engineering in Japan, after the Akasi Strait Bridge.

1.Situation of the Bridge site

The 4 main islands in Japan are connected with some highway bridges except Hokkaido, where exists Seikan Railway Tunnel as shown in fig.1. Hokkaido with the population of 5.7 million and the area of 77 thousand km^2 desires to be linked to Honsyu with a highway bridge over the Tsugaru Strait for the development of industries by more reliable and free-moving transportation. The Strait has distances of 19 km and the greatest water depths of 140 m and 270 m along two favourable routes. The bridge is advantageous over the tunnel in points of ventilation, disaster prevention, preferable sight, maintainance costs, better trafficability, etc. However, very long spans are requested due to the international navigation course where many large-scaled vessels and submarines are passing. Furthermore the natural conditions of this region are severe with strong wind, great earthquakes, cold and snowy climat, etc.

2.Design of the Bridge

In order to solve these problems, we propose a combination of a continuous suspension bridge with 2 spans of 4.000 m in the center, and 2 suspension bridges in scale of Akasi Strait Bridge on both sides (see fig.2). This continuous suspension system has 3 main cables hanging 2 separated steel decks, cable stayed portions with concrete decks, ellipse steel-concrete tower columns in A shape, footings in shell structure, jacket foundations with inclined legs, shown in fig. 3-7, and joint anchorages. A sub-cable pulls the main cable at a midway point to the end of the cable stayed portion and has to be designed in state of no compression by live loads. In order to keep long life of this valuable Bridge, 3 cables and 2 decks system makes it possible to replace when the superstructure wears.

The near parts to the tower are precast concrete decks hanged by stayed cables and other parts are hexagon steel box girders with heating inside against freezing. The long span continuous steel girders are sustained on Warren trusses hanged from 3 main cables. The space between girders shall contribute stability against strong wind. The tower consists of steel structure at the upper part to decrease its weight and steel-concrete composit structure at the lower to endure very strong reaction. The pier and the footing are designed as shell structure of reinforeced concrete to keep rigidity and to reduce weight. The jacket acts as a working platform for piling and becomes a foundation together with piles inside of legs. The inclined legs give inverse rotation of footing to horizontal forces and cosequently the displacements of the tower top and the decks become small. The joint anchorage between the central and the side suspension bridges has the minimum dimensions required, by cancellation of each tension.

3.Computer analysis

The results from calculation for the structures in fig.2-7 show tension of 80 thousand tf in the main cable ($200kgf/mm^2$), tension of 20 thousand tf in the sub-cable, vertical force of 350 thousand tf at the tower and so on. Based on these results, we get fig.8 which shows that the unit weight of the Bridge with the center span of 4.000 m is corresponding to the suspension bridge with 2.500 m and is 95% of total load. This proposal is one of many possible cases. We must make more case studies for each dimensions to save the construction cost and to improve the functions of the Bridge, when completed.

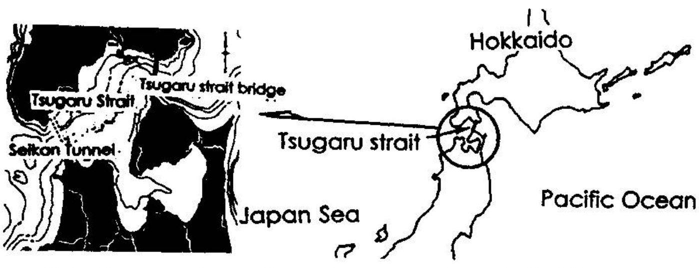

Fig.1 Location of the Tsugaru Strait Bridge

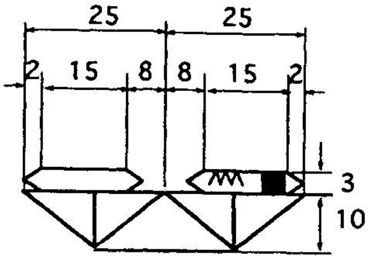

Fig.5 Warren truss & steel decks

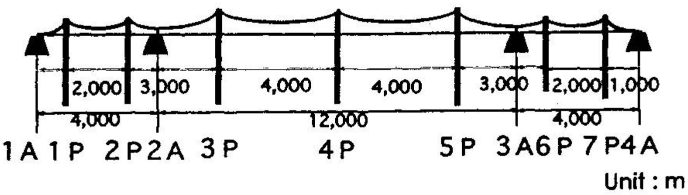

Fig.2 Skeleton of the Bridge

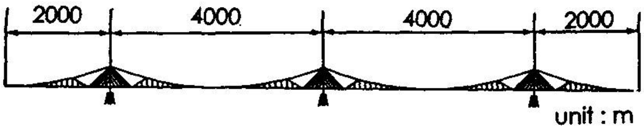

Fig.3 Tower & cables of continuous suspension bridge

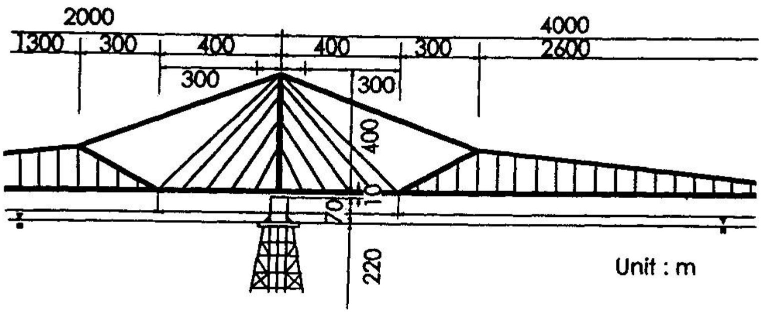

Fig 4 Detail of cables of cable-stayed & suspension portions

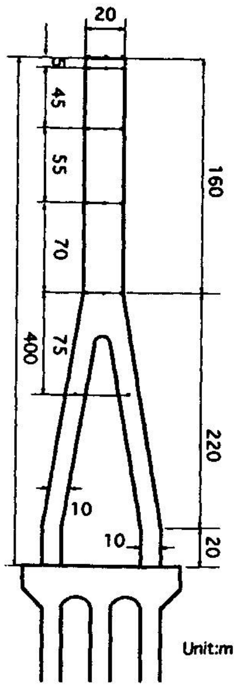

Fig.6 Main tower

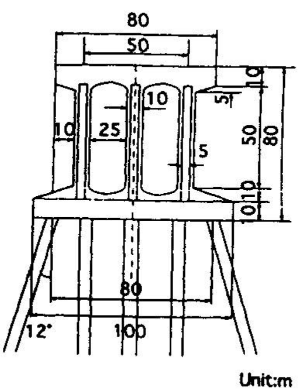

Fig.7 Pier & footing in shell structure

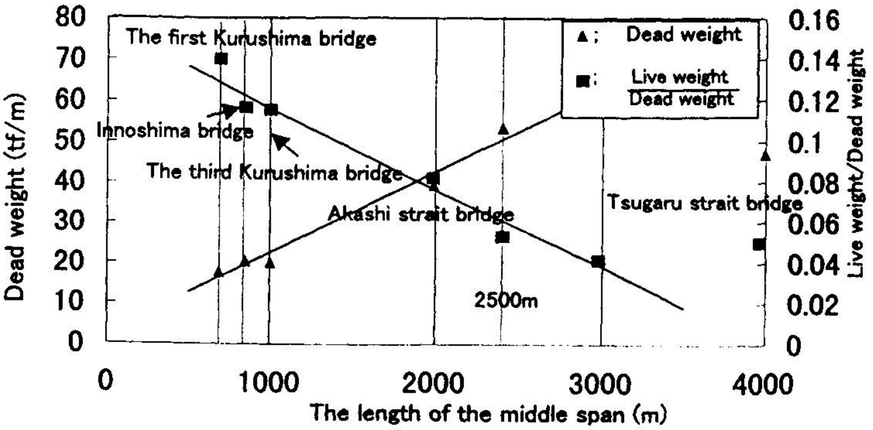

Fig.8 Relation between weights & central span length