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DETAILED STUDY OF LARGEST SUSPENSION BRIDGE AKASHI KAIKOI OF JAPAN

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***Abstract*: The aim of this paper is to study in detail various aspects of the largest suspension bridge, Akashi Kaikoi. The Bridge is situated on Akashi Strait. It is a 3 span-2 hinged stiffened girder. It carries 6- lane freeway linking Kobe with the island of Awaji in to the south. The bridge consists of stiffening girders, cables, main towers, concrete blocks for anchorage. The paper presents the structural elements of the bridge, purpose of construction, design consideration, functional consideration and aesthetic consideration of the bridge**.

Keywords: stiffening girder; cables; towers; bridge; anchorage; traffic

1. Introduction: It is also known as Pearl Bridge and is the largest suspension bridge in the world. Total length of bridge is 3911m. The central span is 1991m long and end span on each side are 960m. The towers measure 280m above MSL. It is situated on Akashi Strait which is one of the world's busiest shipping lanes with 1000 ships plying through it daily. It connects Maiko in Kobe and Lwaya on Awaji Island. The project was started in 1988 and finished in 1998. For construction purpose 1.4 million cubic meters of concrete and 181000 tons of steel were used. Over 2 million workers were used for construction. The total cost of construction is $4.3 Billion, making it the most expensive bridge in the world.

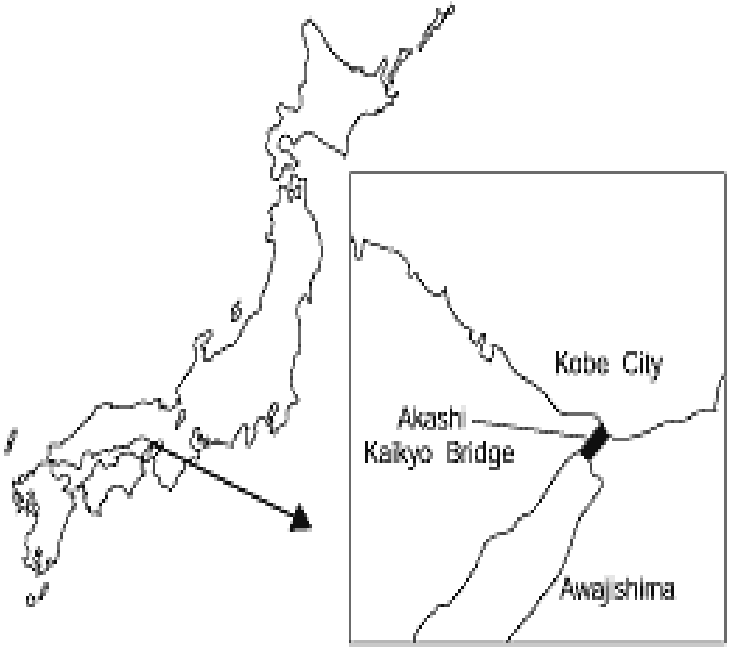

Fig 1: Location of Akashi Kaikyo Bridge

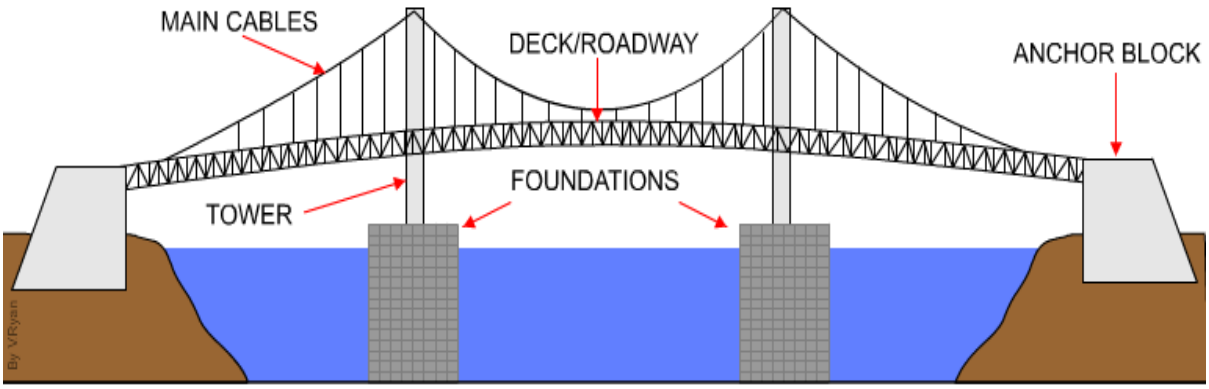

Fig 2 : Basic Diagram of Akashi Kaikyo Bridge

2. Purpose of construction: Before the construction of bridge, ships carried passengers and freight across the Akashi Strait. This strait often experienced severe storms. In 1955 two ferries sank resulting in the death of 168 children. The public outrage over the incident convinced the Japanese government to draw up plans to construct suspension bridge across the strait. Initial plan was to construct railway-road but it was later restricted to six lanes road.

Fig 3: Bridge Span

3. Components of Bridge: - The various components of Bridge are as:

3.1. Stiffening girders/trusses: - These are the longitudinal structures which support and distribute moving vehicle loads, act as chords for the lateral system and secure the aerodynamic stability of the structure. 90,000 tons of steel was used in constructing the stiffening girders. Material used for girders was high tensile strength steel. It made them very strong, relatively lighter and economical.

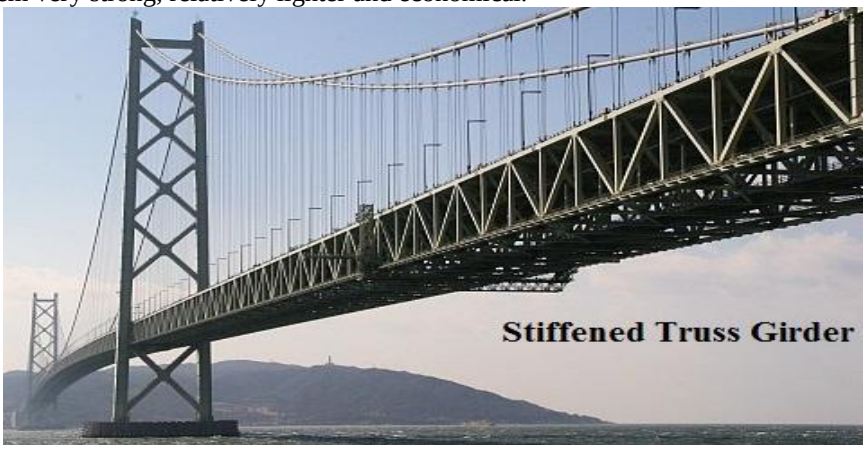

Fig 4: Stiffened Girder

***3.2. Main Cables*: -** A group of parallel-wire bundled cables which support stiffening girders/trusses by hanger ropes and transfer loads to towers. Each cable is composed of 290 strands. Each strand contains 127 wires made up of high tensile galvanized steel and measuring 5.23 mm in diameter. The total length of the cables used in the bridge is 300,000 km which is enough to encircle earth 7 times.

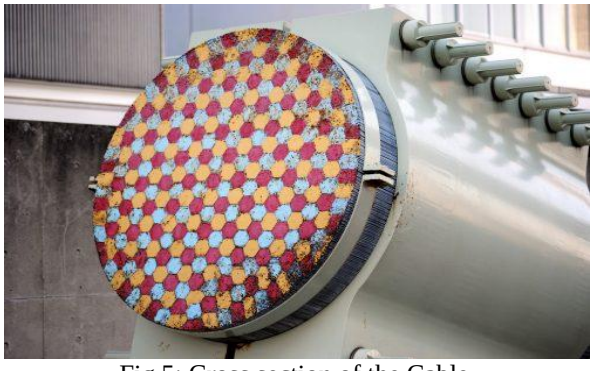

Fig 5: Cross section of the Cable

3.3. Main towers: **-** These are th**e** Intermediate vertical structures which support main cables and transfer bridge loads to foundations. The tower measures 280 m in height above mean sea level. It is are as tall as Eiffel tower. The towers are made up of steel and the shaft has cruciform shape. Tower was built of prefabricated parts which were joined on the site with the help of high-tension bolts. A coat of highly durable fluorine-resin paint was applied.

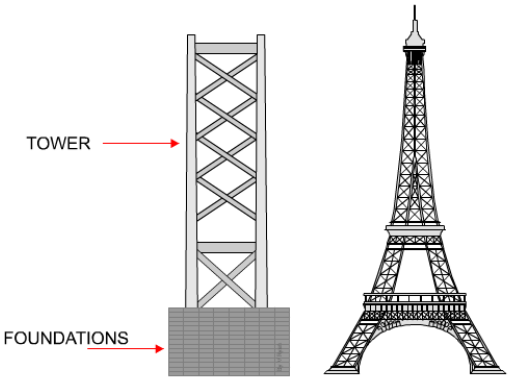

Fig 6: comparison of Eiffel tower and bridge tower

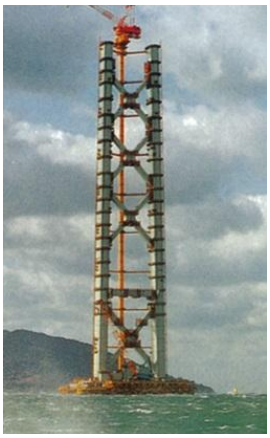

Fig 7: Main tower of the Bridge

3.4. Anchorages: **-** The anchorage was provided on the original shore line on the both sides. The anchorage is a massive reinforced concrete structure. Low heat generating cement was used to decrease the heat of hydration. Pre-fabricated panels were also used in the anchorage. These anchorage blocks anchor main cables and act as end supports of a bridge.

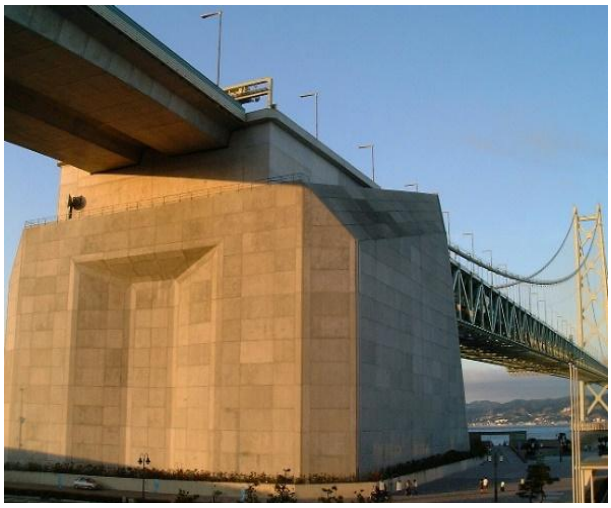

Fig 8: Massive Anchorage Block

4. Design Considerations: The following six conditions were considered for design purpose:

i. The width of the strait at the proposed site is 4 km while as the depth reaches up to 110m.
ii. The maximum tidal current has velocity of 4 m/s and the maximum wave height is 9.4m.
iii. The basic wind speed for design is 46 m/s.
iv. The base rock beneath the water is different on Kobe and Awaji side.
v. The site is earthquake prone. Earthquakes of magnitude 8.5 have been experienced near the site of construction.
vi. For heavy sea traffic, a waterway with 1500 m width has been provided.

5. Functional Considerations: The main function of the bridge is to support traffic coming on the 6-lane freeway. The Design Speed is 100 km/h. Akashi strait has a heavy water traffic of over 1400 ships per day. So minimum clear span length of 1500m is required. 91% of weight coming on bridge is due to self-weight. The remaining 9% is due to traffic load. The towers were erected and steel cables passed through it. The girder is connected to the cable by means of hangar cables.

Fig 9: Functional Requirement of the Bridge

6.Aesthetic Considerations:

While designing the bridge, keen focus was given to the effect of bridge on the area surrounding it. The towers were designed to meet the aesthetic themes. For suspension bridge truss was designed suitably. Anchorage was designed to make the huge concrete structures look small and balanced. The outer wall of anchorage was treated for durability. The color of the paint used is greenish grey to synchronize with the urban landscape. A coat of highly durable fluoropolymer paint was used to maintain luster and prevent corrosion.

6. Conclusion:

The government's plans to modernize Japan needed its island to be well connected with one another. The bridge fulfilled that condition. As exercise of this magnitude was never attempted before the bridge is a symbol of Japan's prosperity. The Akashi KaiKyo Bridge is located at a place where weather and sea is very rough. The site is located in earthquake prone area. Still the determination and dedication of the Japanese engineers was instrumental in gifting this marvel.

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