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A Study on Aizhai Suspension Bridge

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ABSTRACT

According to the China Hunan Roads Development III Project, the Aizhai bridge was built in a mountainous terrain and spans a sizable canyon. This bridge is crucial to the growth of the local districts. This study examines the design, construction, and describes the Aizhai Bridge's materials, parts, and components, as well as benefits and shortcomings. The steel truss gliding method and aerial spinning are two cutting-edge building methods for the suspension bridge. Results reveal that the project's structural design is unique, adapting to circumstances like complex geology, severe weather, and a wide space by implementing the design of the tower-girder separation for the bridge along with the design of the suspender cables and the materials implemented in the bridge. Comparisons of carbon emissions due to materials are made with other bridges to show the high effectiveness of the bridge design.

Keywords: Aizhai Bridge, suspension bridge and construction.

I. INTRODUCTION

The Aizhai Bridge was constructed between 2007 and 2012 to carry the G65 Baotou–Maoming Expressway across Dehang Grand Canyon in Hunan province, China. The impressive structure has a main span of 1,146 metres and a deck height of 350 metres above the ground. When built, it was the world's sixth highest bridge and fifteenth longest suspension bridge. It was also the world's highest and longest tunnel-to-tunnel bridge, and of the world's 400 highest bridges, none had a longer main span.

Suspension bridges offer strong seismic resistance and good span-ability. These bridges can decrease foundation excavation and eliminate the requirement for towering piers. For large-span bridges, suspension bridges are the preferred option. Four key structural elements make up a suspension bridge: anchorages, which act as the principal supporting structures; stiffening girders; main cables; and one or more bridge pylons. There are two types of suspension bridges: self-anchored and ground-anchored. Gravity-type anchorages and tunnel-type anchorages are two additional categories of ground anchors.

To withstand the significant tension from the main cable, a gravity-type anchorage produces frictional resistance between huge concrete anchors and their foundations. As a result, a gravity-type anchorage has a straightforward mechanical design. A concrete plug with an inverted wedge form that is larger at the bottom and smaller at the top is referred to as a tunnel-type anchorage. A tunnel-type anchorage can leverage the surrounding rocks' resistance to stay small (20–25% of the volume of a comparable gravity-type anchorage), cost-effective, and with less of an impact on the environment.

Fig-1: Aizhai Suspension Bridge

II. SCOPE

To provide a smooth and comfortable driving surface for cars at each end of the bridge deck while allowing the deck to move, rotate, and expand as needed by the bridge's design, Mageba supplied four substantial expansion joints—two at each end of the bridge. The type LR17 TENSA®MODULAR joints have 17 gaps between them and can accommodate 1,360 mm of mobility. The joints were made to accommodate both welded connections to the steel deck of the bridge and concreted connections to its abutments.

III. CONSTRUCTION PROCESS

The following are the primary steps involved in building the Aizhai Bridge.

a. Concrete anchorage:

Excavation of the foundation pit for the anchorage's construction. Installation of the pre-stressed pipe, positioning bracket, and layering of the concrete pour. Build several types of anchorages on the Jishou and Chadong banks as shown in below figure:

Fig-1: Construction of concrete anchorage

b. Main tower:

Concrete construction was used in the main tower's foundation. Cave excavation, cleaning, and backfilling. Construction pouring a tower. pillar architecture. Installation of a template. Placing and maintaining concrete. Vertical braces. Casting a beam. Installation of the Main cable saddle and the Bulk cable saddle. Installation of the anchoring system as shown in below figure:

Fig-2: Foundation of the tower

c. Installation of cable system

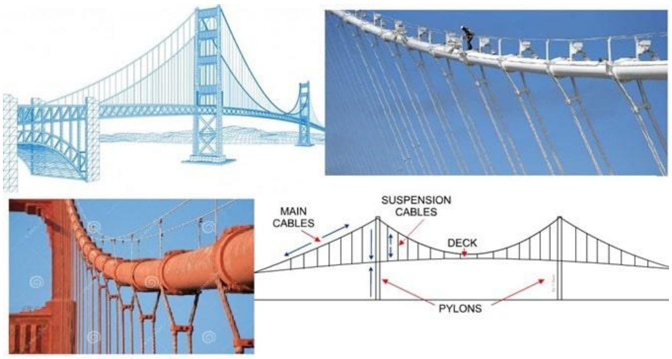

Fig-3: cable system

d. Erection of steel truss beam (rail cable moving beam section).

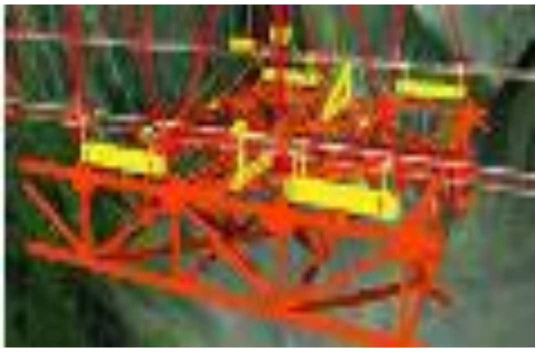

Fig-4: transportation of steel beam section

e. Deck installation

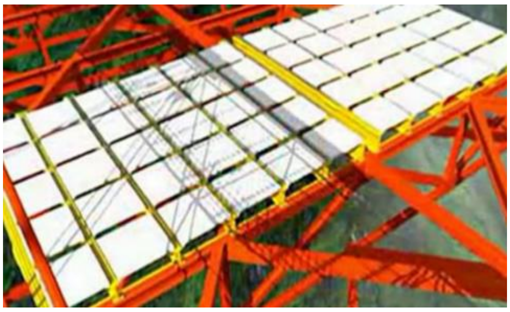

Fig-5: A decking section

f. Main cable protection and coating.

Fig-6: coating of main cable

IV. MATERIALS USED

The main bridge, two towers, cables, anchorages, booms, and connection tunnels make up the Aizhai Bridge. Using a tower and beam separation structure, it is a single-span suspension bridge with two towers and steel trusses, with the ends of the trusses being supported on both banks of the river. The tunnel and bridge are joined immediately, and the tower base of the Cha-dong bank is situated above the tunnel. Northwest to southeast is the direction of arrangement for the major bridge segment.

➢ **Main beam:**

A main joist, upper and lower flat joists, and a transverse joist make up the steel joist stiffener that supports the main beam, which is constructed from permeable joists. Upper and lower flat joists employ the K-shape system, as do upper and lower main joist chords, upper and lower crossbeam chords, upper and lower flat joist chords, and the web. Upper and lower flat joists also adopt the I-beam section. The longitudinal I-beam and orthogonal anisotropic bridge deck plate are combined to create the orthogonal anisotropic steel bridge deck. The longitudinal I-beam and concrete bridge panel are combined to create the concrete bridge panel.

The main truss beam's top chord serves as a simple support for the longer steel beam, and the precast concrete plate is used for the bridge panel. Through the shear nail on the longer beam at the junction, the bridge panel is attached to the longer beam.

- **Pylon (bridge tower):**

The pylon uses a portal frame with a quick-set concrete hollow room as its primary structural design. This design is made up of a divided expanded foundation, a tower base, a tower column, an upper crossbeam, and a middle crossbeam. Jishou Bank Cable Tower uses a steel and mixed soil combination structure, the tower column crossbridge is inclined from top to bottom, the tower column is equipped with upper and middle crossbeams, and the tower column bottom is equipped with a towering seat and situated on the separated expanded foundation. Cha-dong Bank uses a reinforced concrete structure, the tower column cross-bridge is vertical from top to bottom, the tower column is equipped with an upper cross-beam, and the tower column bottom is equipped with a towering.

- **Main cable:**

The main cable has a single parallel steel wire strand that is galvanised, has a positive six deformation cross section, is knotted with tying tape, and has a hot cast anchor head on both ends. Steel wire rope of the special span type (8X36SW+IWR, nominal tensile strength 1870MPa) is used to make the rope.

- **Cable saddle:**

The main rope saddle is built using a cast-welded combination, and the body of the loose rope saddle follows the same structural design. Cast steel is used to create the saddle groove. The loose cable saddle is of the swing shaft type, and the saddle body adopts the structure of cast-welded combination. The main cable maintenance channel (catwalk) is built up on the upper surface of the main cable, allowing the main cable maintenance people to pass.

The sling is constructed of straddling steel wire rope, the anchor heads at either end are fork-shaped hot-casting anchors, the sling clamp is constructed of cast steel, the left and right pairs are combined, the two halves of the clamp are connected and clamped together with screws, and the joints are filled with rubber waterproof strips.

- **Anchor:**

Three pairs of ground slings were added to the bridge to address the issue of a tower and girder suspension bridge without a sling region, and the longevity of the ground rod is essential to the security and smooth operation of the opposing project. Steel corrosion and ageing concrete are two common structural issues with the conventional ground fault system. Due to steel corrosion and concrete ageing, the typical ground fault system frequently encounters structural durability issues, which compromise the overall safety and durability of the structure.

A high-performance ground fault system made of bonded solids of reactive powder concrete (RPC) and advanced composite material CFRP (carbon fibre reinforced plastic) rod was created to increase the ground system's durability.

V. CONCLUSION

Given that many specific needs, including construction on hazardous terrain, complicated geology, and transit across the canyon, were satisfied, the bridge is a well-designed structure.

The suspension bridge is supported by a combination of conventional and cutting-edge materials. Although the bridge shares many characteristics with classic suspension bridges, the unique tower-girder separation structure has made it significantly safer and more environmentally friendly. Despite all its drawbacks, the steel used in the bridge's construction has shown to be relatively environmentally beneficial in terms of carbon dioxide equivalent emissions.

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