Design and Construction of “Chiapas” Bridge, Mexico

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Summary

When finished The Chiapas Bridge will have a total length of 1838.8 m (with a 1208 m main bridge). The piers of the main bridge were built using offshore technology in 80 m deep of water. The superstructure is formed by a continuous orthotropic steel box deck, and is placed by launching using a provisional mast/stays system and a steel nose. The main span is 168 m long and will be the world record span for a launched bridge. This article contains a description of the main bridge and the most relevant aspects of construction techniques.

Keywords: Long span bridge, launching Bridge, orthotropic steel deck, deep water jacket, offshore engineering, earthquake.

1. Introduction

The Mexican Government is constructing the express highway between Mexico City and Tuxtla Gtz. (Chiapas). The highway crosses the artificial lake formed by the Netzahualcoyotl dam in the southern state of Chiapas, which requires the construction of a major bridge. The gap to be crossed is around 2 km long (Fig. 1), and the mean depth of water is 80 m, with yearly changes of 11.5 m in water level due to dam operation. The bridge site is also exposed to high intensity earthquakes and hurricane winds.

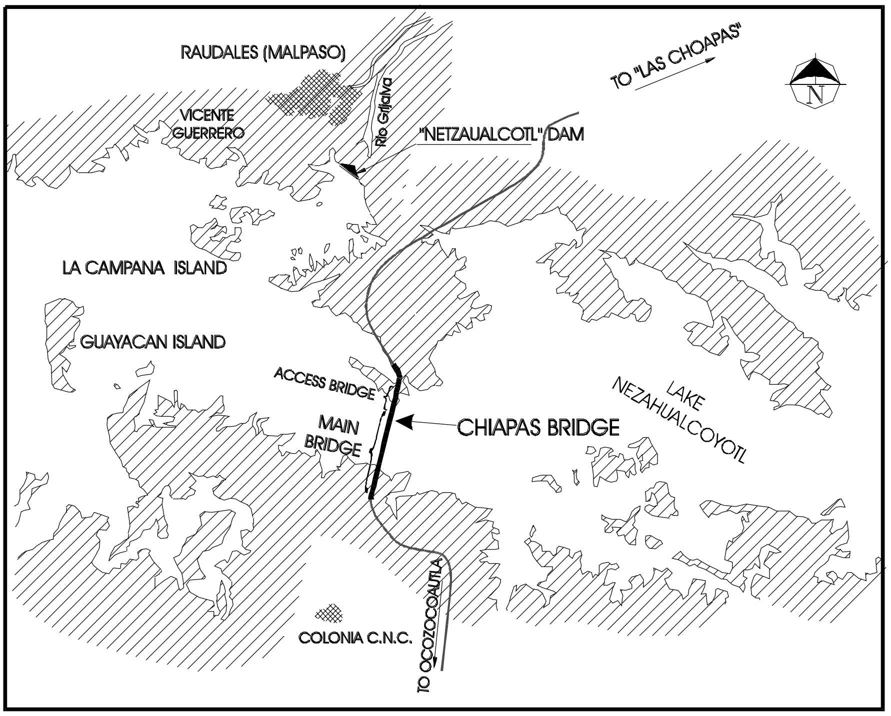

Fig. 1: General arrangement of Chiapas Bridge

2. Description of the bridge

To minimize the investment, in a first stage the highway is designed to carry two traffic lanes. In a second stage, when traffic rises, the highway (and bridges) will be improved to carry four traffic lanes. The main bridge will be, 1208 m long (with 124,168,168,168,168,168, 152 and 92 m. spans, see Fig. 2). The superstructure is formed by a continuous orthotropic steel box deck, and is placed by launching using a provisional mast/stays system and a steel nose. The main span is 168 m long, and will be the world record span for a launched bridge.

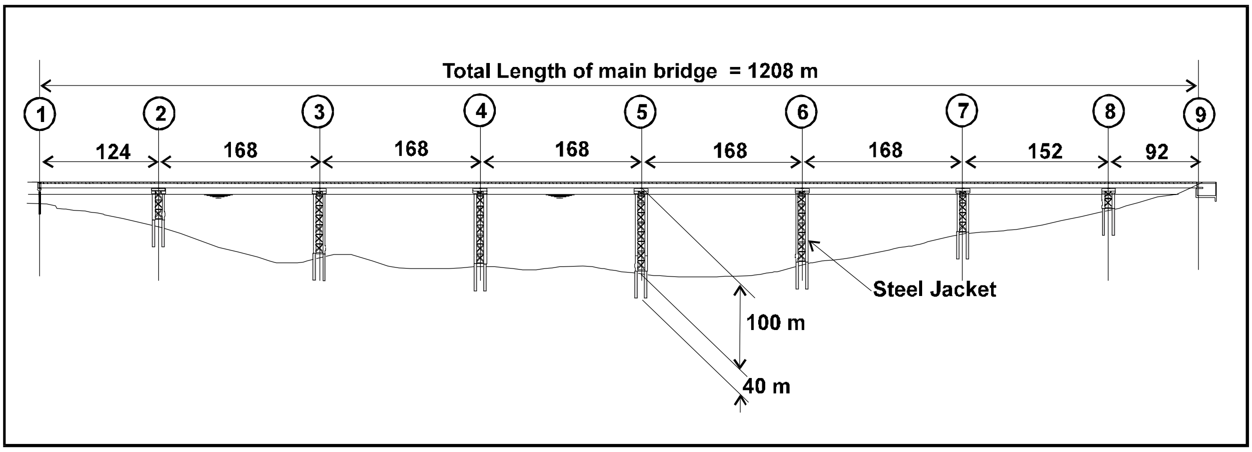

Fig. 2: General view of Chiapas main Bridge

2.2 Superstructure

The superstructure system is a steel box girder supported on a steel jacket type substructure. The steel box girder cross section consist of orthotropic top-deck, bottom flange, and two webs. The box is 5.5 m deep by 5.4 m wide between webs (Fig. 3). Transverse diaphragms are spaced at 4 m. There are two longitudinal stiffeners on each web. There is a 0.3 x 0.25 m wide edge beam along the edge of the first stage top deck. For the second stage, a 3 m wide deck will be added to each side. Diagonal braces supported against the bottom flange will support the second stage deck extension. The deck has a crown in the middle and a 2 % cross slope. There will be a 20 mm asphalt-wearing surface. Structural steel with minimum yield stress of 3520 kg/cm^2 is specified for the superstructure (ASTM-A50).

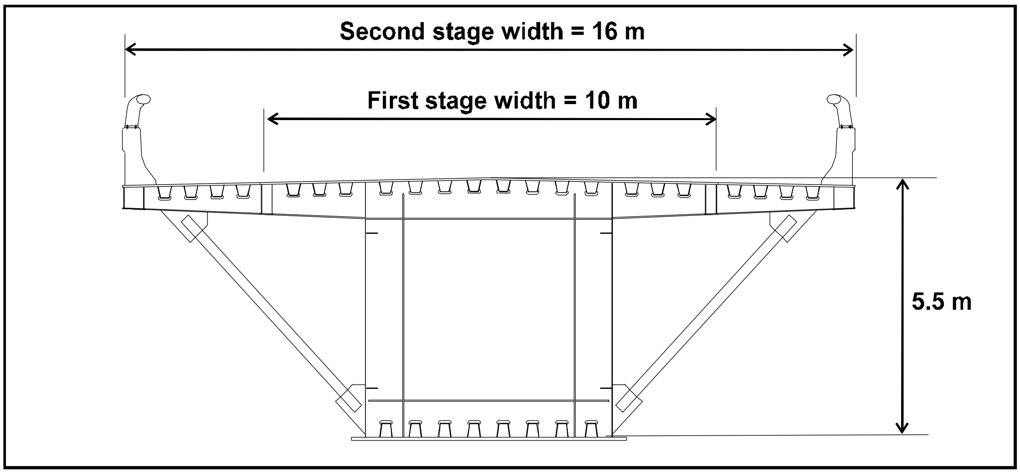

Fig. 3: Deck cross section

The box girder is fabricated in a shop near Mexico City and transported by truck to the bridge site. Due to the shipping size limitation, the box is fabricated in 102 segments, each 12 m long. Each segment is further divided transversely into 10 pieces: 4 pieces for the top deck, 4 pieces for both webs and 2 pieces for the bottom flange. These pieces are welded first longitudinally to form a box segment. The segments are then spliced together by transverse welding.

The total weight of the main bridge in first stage is 8900 tons.

The deck steel box will be launched from the right bank. A steel nose of 44 m length will be used in conjunction with a provisional mast/stays system (Fig. 4).

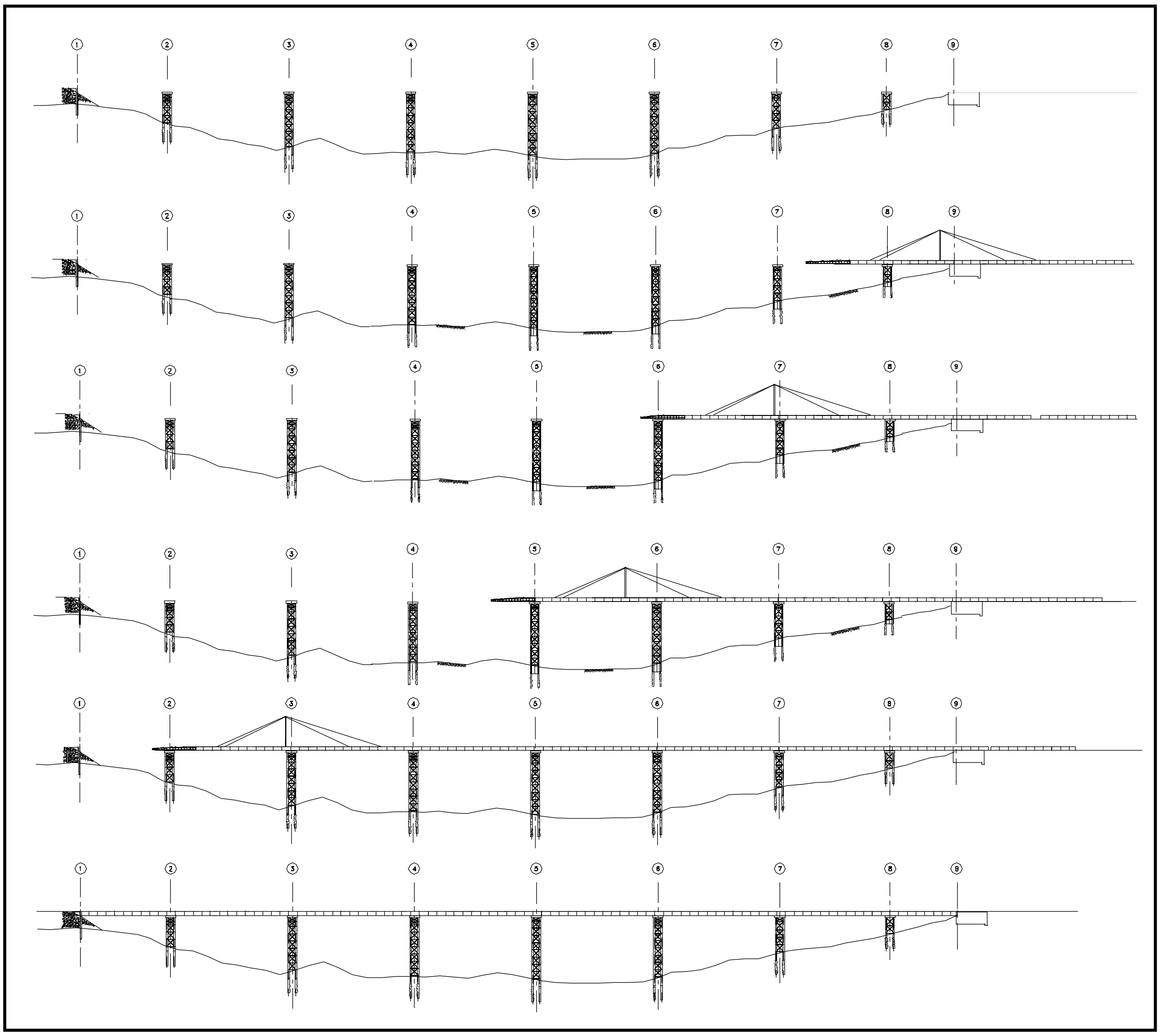

Fig. 4: Deck construction scheme

After launching, the deck will be embedded on the A9 abutment to resist a 4000-ton force from longitudinal seismic excitation. The deck is longitudinally free with respect to the P1 to P8 piers.

Due to the record length span to be launched, extremely high forces will appear on bearing zones of the steel box deck. Considering a traditional launching procedure (with a fixed bearing points in piers) the thickness of webs became very important and uneconomical (because the web sections between diaphragms have to be designed to resist the bearing forces). For that reason the proposed procedure considers ”moving” bearings on each pier. These bearings will be placed under the diaphragms and will move with them during each launching step. At the end of each step, the jacks placed on each pier will push upwards the deck to liberate the “moving bearings” and return them to “back” diaphragm (see Fig. 5). The length of each lunching step is 4.0 m.

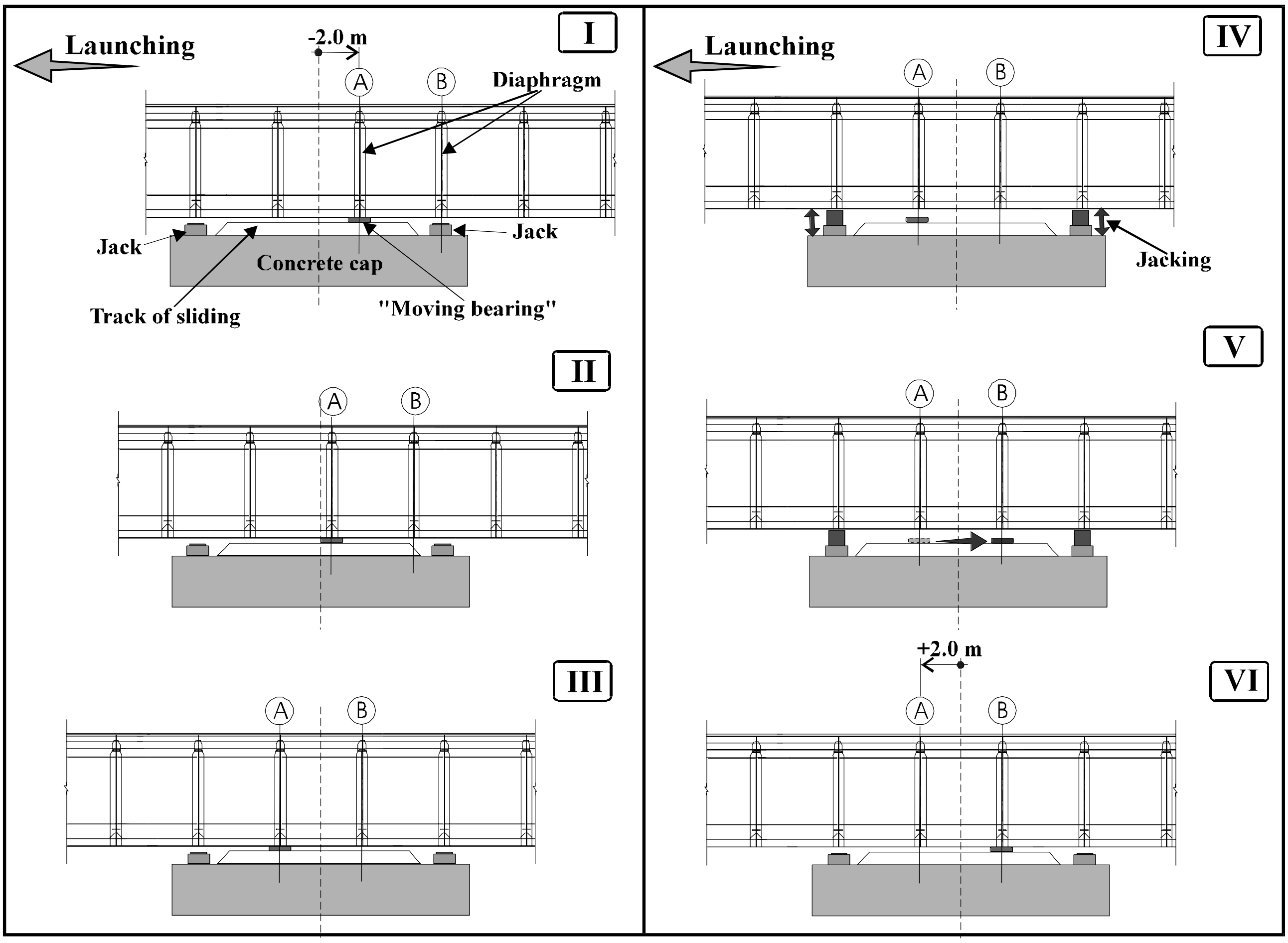

Fig. 5: Detailed launching step

2.1 Piers and foundations

The foundation and pier technology are innovating for bridge engineering. Due to the important depth of water, the piers are formed by steel jacket structures, used until now only in offshore industry.

Each pier (jacket) consists of four 2.78 m diameter and 25 mm thickness steel pipes interconnected by cross bracing formed by steel pipes of small diameter. The union between the cross bracing tubes and the main pipes is made by using a steel plate. This steel plate transmits the bracing loads to the main tubes by means of an outer steel rings system. The steel rings system also has the function to increase the rigidity of the main tube to avoid the hydrostatic collapse of the same one during the operation of immersion and the positioning of the jacket.
To improve the stability of the jackets against earthquake forces, the main pipes of the biggest jackets (piers 3,4,5,6 and 7) are separated 18 m in transverse direction, and 10 m in longitudinal direction. In the "small" jackets (piers 2 and 8) the separation of main pipes is 10 m in each direction.
Structural steel with minimum yield stress of 2530 kg/cm^2 (ASTM-A36) was specified for the piers. The biggest pier (jacket 5) rises about 100 m above ground (with 90m under water).

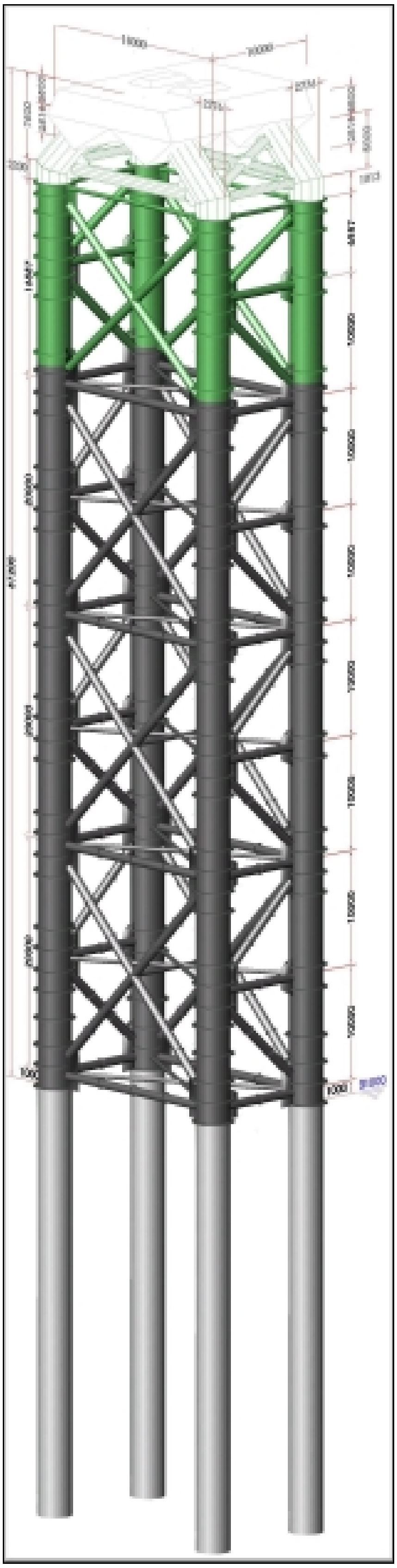

Fig.6: Shape of typical pier

The foundations of each jacket are formed by 2.5 m diameter and 40 m length cast in place reinforced concrete piles, drilled from surface. The forces supported by the main steel pipes are transmitted to concrete piles by a 5.5 m height zone placed at bottom part of jackets using shear stud connectors. At the top of the jacket a 2.5 m height reinforced concrete cap is placed. The concrete cap was chosen instead of one of steel, since the concrete allows correcting easily imperfections in the position, inclination and final elevation of each pier (Fig. 6). To minimize the size of concrete top cap, the final zone of steel pipes (placed after drilling and cast of concrete piles) is inclined transversally.

Construction

The piers are built on the side of the lake over launchways. In order to install properly the jackets internal closures were placed into the main tubes. Additional buoyancy was also provided to the jackets by using additional floaters placed at ends of main tubes. The construction procedure of each jacket include the following stages:

- Jack the jacket “over the hump” onto the launchway,
- Lower the jacket into the water restraining the movement by holdback jacks,
- Tow the jacket towards its final position,
- Upend the jacket allowing controlled entry of water on the main pipes and floaters,
- Remove the flotation tanks,
- Position the jacket horizontally by using mooring pontoons,
- Add water to lower the jacket to desired vertical position,
- Install the skirt piles (one pile placed outside of each main pipe),
- Cut skirt piles to desired height,
- Install temporary bearing of jackets over skirt piles,
- Ballast the jacket onto the piles,
- Install equipments and drill the piles,
- Cast piles,
- Remove temporary bearing of jackets over skirt piles,
- Install final zones of main pipes (inclined),
- Cast concrete top cap.

See Figs. 7 and 8.

Fig. 7 Launching, transportation, positioning and drilling of pier (jacket) 8

Main quantities of the bridge

- Total length of bridge, more than 1.8 Km.
- Steel, more than 18000-ton,
- Welding, more than 150 Km,
- Reinforced concrete, more than 15000 m^3.

Fig. 8 General view of piers during construction

3. Conclusion

We have presented the main technical characteristics, and some relevant construction aspects of this exceptional bridge. Innovative techniques have been proposed to solve the problems related with launching a long span bridge. The bridge is also an example of the association of bridge and offshore engineering.