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Composite Rahmen Railway Viaduct of PPC Beam and Steel Box Beam

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Summary
The railway viaduct required aesthetic improvements, as the space under the bridge was to be used as a footpath, so it was required to reduce both the number of pillars on this viaduct and, further, to reduce the diameter of the pillars. Consequently, the beams were basically constructed in the form of a PPC box-type, and at places where the bridge is long, the structure fashioned as a steel box beam. The piers were made of steel pipe wound RC pillars. In order to increase the bridge's anti-earthquake properties, the structure was converted to a complex Rahmen viaduct which is unified between these 2 types of beams and piers. This report describes the materials and design of these connectors.

1. Circumstances
At the time of Nagano Winter Olympic Games in 1998, the Hokuriku Super Express will be extended to Tokyo Station. To accommodate this extension, a railway viaduct on the Chuo-Line (about 970 m in length) is to be constructed. This viaduct was constructed taking into considerations the scenery surrounding the Tokyo Station which is noteworthy as the gateway of Japan (Figure-1).

2. Whole structure
The pillars of this viaduct were made of reinforced concrete (RC) on the railway side and steel pipe wound RC on the road side, making the shape on each side very different (Figure-2). If a pier is made into a single gate-type structure, when a large sideways horizontal force is applied such as in the case of an earthquake, because of the difference in displacement in the upper end of the pier, a large distortion occurs in the pier. For this reason, the entire viaduct was made into a Rahmen structure of multiple lengths, and the rigidity of the entire body (against plane distortion) was increased.

3. Connection of beam and pier
As for the structural form of the upper area, the general parts were made of PPC beam, but the parts of the crossing over the road were made of steel box beam because the length of bridge was relatively long (39 m.) The viaduct was in the form of a complex Rahmen structure which unified 2 types of beams as well as the crossbeams of the piers. The connecting part of the beam and the pier is shown in Figure-3. The design of the connecting part was made so as to secure an adequate

safety ratio (F=1.0) against the destruction of the cross section material, and to prevent stretching stress at the time of active load effects, considering the influence of temperature. As an example of PC cable arranged to this connecting part, there is a 12E15.2×6 set at the upper position of original point.

Figure-1 Viaduct completion forecast picture

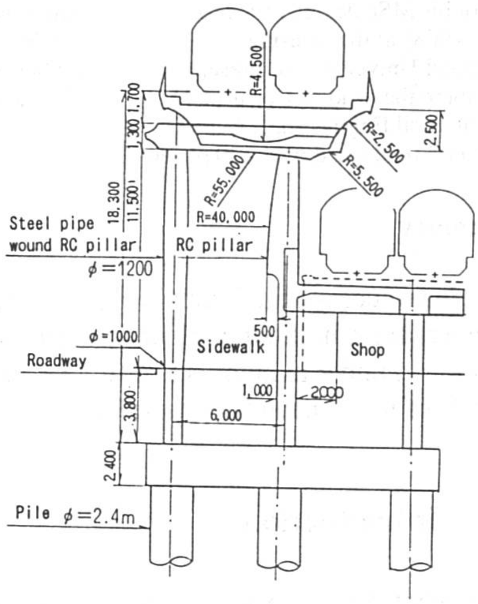

Figure-2 Cross section of viaduct
(unit:mm)

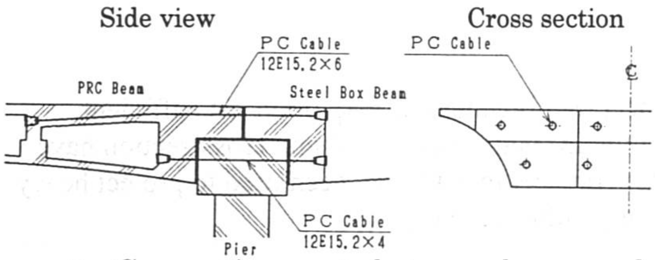

Figure-3 Connecting parts between beam and pier

4. Connections between steel pipe wound RC pillars and footings

As shown in Figure 1, the pillars of the viaduct on the left side were planned between the road and the footpath. Therefore, the pillar was to be made as thin as possible in order not to obstruct the passage of pedestrians. To cope with these demands, and considering the scenery, the pillars were made to a diameter of 1.0 meter on both ends and 1.2 meters in the center in the shape of an entasis (shaped like a cigar.) As for the constitution of the cross-sections of the pillars, steel pipes were used as Stirrup, and steel pipe wound RC pillar were constructed so as to allot the stretching forces to the iron bars in the concrete. In order to decide the arrangement of the iron bars at the connecting part of the upper crossway beam and steel pipe wound RC, experiments in horizontal load changing, using a 1/3-size model; results were applied to the actual design.

5. Postscript

Investigations were made in accordance with the above descriptions; the particular nature of each structure was determined, and the structure was erected. This viaduct was completed in November, 1996, and the train is currently in operation. The Hokuriku Super Express will begin operation starting in Autumn, 1997.