Experimental Study on Loading Features of Continuous Rigid-Frame Bridge with Corrugated Steel Webs

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ABSTRACT

Two comparison models of single cell box variable cross-section continuous rigid frame bridge with corrugated steel webs and the equivalent ordinary concrete continuous rigid frame bridge were designed and constructed. The loading features are contrastively researched. The results show that with same loading condition, strain of roof and floor of box girder with corrugated steel webs is increased when the load is increased, while the strain value of corrugated steel web is very low and nearly unchanged when the load is increased. The bending stiffness of box girder with corrugated steel webs was main supply with roof and floor and the bending stiffness is lower than box girder with concrete webs.1

Continuous rigid-frame bridge with corrugated steel webs box girder integrated the advantages of rigid-frame bridge and box girder with corrugated steel webs. This new structure has larger span capacity; lighter self-weight, excellent seismic performance and higher effective prestressing system, etc, which is suitable for large span bridge in high seismic intensity[1]. Static characteristics of box girder with corrugated steel webs have been further researched with theory and test method by foreign scholars[2-4]. On the aspect of bending performance, the damage characteristics of simply supported box girder bridge with corrugated steel webs have been researched[5]. Three simply supported box girder bridge with corrugated steel webs have been designed and constructed to research it’s static effect[6]. The applicability of “Quasi plane assumption” has been verified with FEA method and model test of simply supported box girder bridge with corrugated steel webs[7]. Ignoring the bending contributions of corrugated steel web, the calculation formula of ultimate bearing capacity of box beam is deduced[8]. Combined with the

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model test and the FEA method, the calculation formula of normal stress and shear stress of box girder bridge with corrugated steel webs are deduced\[9\]. Considered the shear slip of shear key between the corrugated steel webs and the roof and floor concrete, the formulas of the ultimate flexural capacity of the externally prestressed box girder with corrugated steel webs were derived\[10\]. On the aspect of inner lining concrete research, the method of shear calculation of steel concrete composite segment is researched with contrasting of shear distribution method of steel concrete combination\[11\]. The impact of the thickness of concrete lining to the shear bearing capacity of the corrugated webs was analyzed via theoretical calculation and finite element analysis\[12\].

In summary, a large number of theory and experimental research on prestressed concrete box girder with corrugated steel webs at home and abroad, but most of model test are simply supported box girder bridge, very few are continuous box girder. In this paper, the loading features are contrastively researched depend on the model of continuous rigid frame bridge with corrugated steel webs and the equivalent ordinary concrete continuous rigid frame bridge.

Test Model

The test model is single cell box variable cross-section continuous rigid frame bridge with span of 2.4m+3.6m+2.4m. The height of box girder cross-section is range from 33cm to 49cm, the height of side pier is 95cm, middle pier is 80cm. 1# bridge represent the model of continuous rigid frame bridge with corrugated steel webs, 2# bridge represent the model of equivalent ordinary concrete continuous rigid frame bridge. C40 concrete and HRB335 steel bar (12mm,10mm) were used in the test, the diameter of constructional reinforcement is 8mm, R235. Prestressed steel strand is φj15.2. The material of steel web is Q235. The general structure diagram and cross section diagram as shown in Fig. 1 to Fig. 3.

![Figure 1. 1/2 Elevation drawing of girder(mm).](image1)

![Figure 2. Section of girder of 1# bridge (mm).](image2)
The design principle to construct the ordinary concrete continuous rigid frame bridge is equivalent shear capacity of box girder with 1# bridge, the thickness of the concrete web is 70 mm, the rest size is consistent with the box girder with corrugated steel webs as shown in Fig.4.

**Arrangement of Measuring Points**

The measured device of strain is static data acquisition system DH3815 and DH3816. The longitudinal strain gauge is pasted on the roof, floor and web of concrete box girder. The longitudinal strain gauge is pasted on the roof and floor of steel web box girder, 45° strain rosette is pasted on the steel web of box girder. The strain points on cross section were numbered 1~16# along clockwise as shown in Fig.5 to Fig.8.
The Program of Test Loading

Loading method of the test are four points symmetrical load as shown in Fig. 9.

The load was controlled via pressure sensor, pressure sensor was calibrated before use. The load compress on the steel support via a distributive girder, the steel support get in touch with top surface of the test model, the stiffness of the distributive girder meets the test requirements. Load of test divided into 8 grades with every step incensement 10kN and stop at 80kN. Measure the value of strain and deflection in different conditions under different load effects of the model.
Analysis of Test Results

Longitudinal strain distribution along height of mid-span section of 1# and 2# bridge under the symmetrical load is shown in Fig.10 and Fig.11. Longitudinal strain distribution along height of 1/4 span section of 1# and 2# bridge under the symmetrical load is shown in Fig.12 and Fig.13.

As shown in Fig.10 to Fig.13, strain of roof and floor of 1# model bridge is increased when the load is increased. While the strain value of corrugated steel web is very low, which is nearly 0 and unchanged when the load is increased. This shows that bending stiffness of box girder with corrugated steel webs was main supply with roof and floor, and the strain change of section accord with “Quasi plane assumption”. Strain distribution along height of 2# bridge is nearly a line, the strain value of roof and wed and floor is increased when load increased, fitting ordinary “plane assumption”.

Contrasting the strain value of 1# bridge and 2# bridge, the strain of the box girder with corrugated steel webs is much larger than the box girder with concrete webs. So the bending stiffness of box girder with corrugated steel webs is lower than box girder with concrete webs.
CONCLUSIONS

With same loading condition, strain of roof and floor of box girder with corrugated steel webs is increased when the load is increased, while the strain value of corrugated steel web is very low and nearly unchanged when the load is increased, bending stiffness of box girder with corrugated steel webs was mainly supplied with roof and floor, and the strain change of section accord with “Quasi plane assumption”. Strain distribution along height of box girder with concrete web is nearly a line, the strain value of roof and web and floor is increased when load increased, fitting ordinary “plane assumption”. The bending stiffness of box girder with corrugated steel web is lower than box girder with concrete webs.

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