Trial Design on Concrete Arch Bridge with Corrugated Steel Webs

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Summary

Because arch works essentially in compression, thanks to the greater compression strength of concrete, it is reasonable to use concrete in arch bridge. In order to increase the span capacity of concrete arch bridge, a new type of concrete arch with corrugated steel webs is proposed, in order to decrease the heavy dead load of the arch ring and make its possible and economic. Taken Wanxian Yangtze River Bridge with the longest span of 420m in the world as a proto type, a trial design of such a new concrete arch bridge is carried out. Comparing to the built bridge, the self-weight of the arch ring in the trial design was decreased by 27%. Meanwhile, the construction time for cast in-situ of the concrete in the arch ring in the trial design is shortened by 70 days. The trial design research shows that this new type bridge is a potential bridge type for super-long span concrete arch bridge.

Keywords: Arch bridge; concrete; corrugated web; new type; trial design.

1. Introduction

Thanks to the greater compression strength of concrete, it is reasonable to use it in arch bridge because arch works essentially in compression. Wanxian Yangtze River Bridge with span of 420m in China is the longest concrete arch bridge in the world. It was built by embedded formwork comprising a latticework structure of concrete-filled steel tubes (CFST). The scaffolding was erected by cantilever cable-stayed method [1]. The Krk I Bridge in Croatia with a second longest span of 390m was constructed by temporary truss method. However, theoretical studies show that limit spans for concrete arches will not exceed these two already built bridges, especially if complicated construction of these bridges is accounted for, unless the weight of the superstructure is reduced [2]. In order to increase the span capacity of concrete arch bridge, a new type of concrete arch with corrugated steel webs is proposed, which substitute the concrete web in arch ring for corrugated steel web. Taken Wanxian Yangtze River Bridge as a proto type, a trial design of such a new concrete arch bridge was carried out and will be introduced in this paper.

2. Trail Design for Concrete Arch Bridge with Corrugated Steel Webs

In this trial design, except substituting the concrete webs of the arch ring for 10mm thick corrugated steel webs, the dimensions and material of the bridge structure are the same with Wanxian Yangtze River Bridge. The corrugated steel web is disposed perpendicularly to arch axis and connects the upper and lower steel tubes by welding which embedded in the extrados and intrados slabs of the arch box ring. Fig. 1 show the arch ring cross section of the trial design.

In order to enhance the global performance for arch ring and protect corrugated steel webs from local buckling, 25cm thick transversal diaphragms are set at every 15m interval along the arch.

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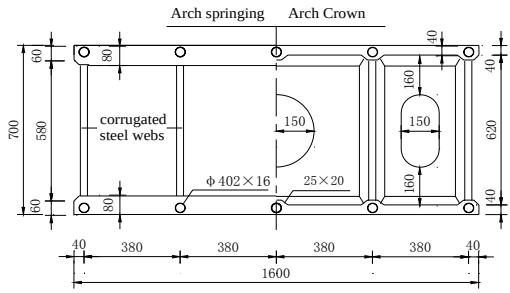

Fig.1: Arch cross section of trial designed bridge (unit: cm)

The construction method of the trial design is still the embedded CFST scaffolding method used in Wanxian Yangtze River Bridge. Therefore, the corrugated steel webs in the trial designed bridge do not only replace the concrete web but also the web tubular members of the embedded scaffolding in the prototype bridge.

The concrete weight in arch ring in this trial design bridge is decreased by 31% by using corrugated steel web, while the steel weight for embedded scaffolding is increased by 19%. But in a whole, it should highlight that the self-weight of arch ring in the trial designed bridge is decreased by 27%

It is proposed to use the embedded scaffolding method to construct the trial design bridge, similar to Wanxian Yangtze River Bridge. The steel tube-corrugated steel web scaffolding is only 9t per unit heavier than that used in Wanxian Yangtze River Bridge, but still under the capacity of the cable crane of 70 tons and can be erected by cantilever method with cable crane. After the closure, concrete will filled into steel tubular chords to from a CFST arch with corrugated steel web. Then, the top and bottom slabs of arch ring and transversal diaphragms are concreted in situ to form the concrete arch ring. It is worth to point out that 70 days in concreting the webs as in construction of Wanxian Yangtze River Bridge will be saved in construction of the trial designed bridge, because the corrugated steel webs are used instead of the concrete webs in the arch ring.

3. Analysis of Trial Designed Bridge

Using FE method, the performance of the arch ring under dead loads after closure and during construction, and the arch bridge under dead load and live load as well as seismic load of the arch bridges were analyzed. It was found that the trial design bridge were satisfied to the requirements of the Chinese Code for Design of Highway Reinforced Concrete and Prestressed Concrete Bridges and Culverts (JTJ D21-89) [3].

4. Conclusions

A new type of concrete arch bridge with corrugated steel webs is proposed in this paper. A trial design, took the Wanxian Yangtze River Bridge as prototype, shows that self-weight of arch ring is decrease by 27% and 70 days are saved for concreting.

Preliminary analyses by FE method confirm that the trial design of this new bridge type can meet general design requirement during construction and after it completed under both normal and earthquake loading. It is expected that this new type of concrete arch bridge will be applied to mountainous area of China in the near future.

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