The application of GQJS in construction control analysis of the continuous box-girder bridge with corrugated steel webs

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In the past two decades, there has been increasing interest in the pre-stressed concrete girders with corrugated steel webs (PCGCSW) in bridge construction. Because of the existence of accordion effect and shear deformation, the classical Euler-Bernoulli and Timoshenko theories do not account for the bending behavior and vertical displacement of the PCGCSW perfectly (BARIANT, JEAN-FRANCOIS et al., 2006). Although 3-D FE modeling and analysis could provide accurate calculation results, it is always complicated and time-consuming. Therefore, the reasonable and effective simulation of these structures has been a challenge for bridge engineers.

This paper presents the results of construction monitoring and control of pre-stressed concrete continuous bridge with corrugated steel webs by Highway Bridge Design Analysis Software (Chinese name abbr.: GQJS). FEA with GQJS is conducted throughout the work of the construction control of Juancheng Yellow River Highway Bridge, which is an externally pre-stressed concrete continuous box-girder bridge with corrugated steel webs with the total length of 1460m and span arrangement of 70m+11*120m+70m. During the course of analysis, two element-modeling methods are adopted by GQJS and they are discussed in detail in the paper.

For the first element-modeling method (One-node Method for short), it is meant to make use of the principle of displacement compatibility of node through the rigid arm, i.e. multilayer beam elements with the same node number are utilized to model the composite section of bridge structure. In the process of modeling the concrete box-girders with corrugated steel webs, the whole section is divided into three layers of beam element, including the concrete roof and floor element and the middle steel webs element and the plane steel webs are used instead of corrugated webs for the convenience of solving the problem as shown in Figure 1.

Figure 1. Local FE model by the One-node Method.
In this case, the displacement compatibility of the three layers of beam element is ensured through rigid arm. If the sectional deformation of the three layers of beam element is in the same plane initially, it keeps in the same plane after deformation, which means the sectional deformation agrees with the assumption of plane section. In addition, two material properties are discussed in detail, namely the compressive and bend elastic modulus. With the adoption of the plane webs instead of the corrugated webs, the equivalent compressive elastic modulus of steel is substituted for the primary compressive elastic modulus (CHEN JIANBING et al., 2004) and it can be calculated using the recommended equation. The other important parameter of equivalent bend elastic modulus is obtained through the FEA. Firstly, a certain length of cantilever corrugated and plane steel webs subjected to concentrated force is modeled with the shell43 element of ANSYS software. Based on the fundamental theory of equivalent displacement in two structures with the same load and restrictions, the bend elastic modulus of the plane steel web is derived from the load-displacement relationship.

For the second element-modeling method (Two-node Method for short), the nodes of the top and bottom concrete slab element are independent relatively and the elements of corrugated steel web connect with those of top and bottom concrete slab. The section deformation does not agree with the assumption of plane section. Relative displacement exists between the top and bottom concrete slab element and it is restricted by the middle corrugated steel web element to a certain extent. More details are provided in the full paper.

Based on the two element-modeling methods, the FE models are established and the FE analyses are performed. Cantilever construction method is adopted in the Juancheng Yellow River Highway Bridge construction. The main beam is divided into twelve standard segments. The displacement increment of the twelve standard segments at maximum cantilever stage is mainly discussed. And it is found that the results from FEA are very close to the measured results.

There has been no work done to study the deformation of box-girders with corrugated steel webs with the above mentioned methods prior to the work presented in this paper. Two element-modeling methods were discussed firstly. And then corresponding finite element models were developed to simulate the cantilever construction. The natural closure of side and intermediate span indicates that the method employed in the deflection monitoring in cantilever construction of large span box-girder with corrugated steel web is reasonable.

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References

BARIANT, JEAN-FRANCOIS, UTSUNOMIYA, TOMOAKI, and WATANABE, EIICHI, 2006. Elasto-plastic analysis of PC girder with corrugated steel web by an efficient beam theory, Structural Engineering/Earthquake Engineering, 23(2), 257-268