Simulation and Result Analysis of Bridge Backfilling Process Based on ANSYS

Bin Cheng
Xinjiang Railway Survey & Design Institute Co.Ltd. China Railway First Survey & Design Institute Group Co.Ltd. Urumqi Xinjiang 830011, China

Abstract. The covered bridge of corrugated steel has many advantages, one of which has good adaptability to deformation. It should be noted that as a flexible arch structure, it is necessary to pay attention to the backfilling and expansion scheme. According to the available data, it is clear that modern researchers conduct analysis and research on experimental models and actual projects, and test the deformation and internal forces of the bridge and culvert structure of the backfilling project, but there is no impact on the backfill construction structure. Mechanics factors are studied and analyzed. In order to make up for this gap, this paper uses finite element software to build the model based on the actual engineering, and then calculates a variety of different backfilling schemes to study the influence of internal force and structural deformation of different backfilling schemes on structural mechanics. Researchers provide relevant references for research.

1. Introduction
Bridges and culverts with overlying corrugated steel sheets have many advantages, such as no pollution to the environment, low cost, wide application range, and rapid engineering progress. Therefore, many countries have analyzed and researched it, and now they have formed relatively mature construction techniques and specifications, thus replacing traditional building technology. In the analysis and research, this paper is based on the actual project. The finite element software is used to construct the relevant model, simulate various backfilling methods, analyze and study the structural stress generated during construction, and change its characteristics. To summarize, to make up for the blank of the research content in China, and to provide reference for other researchers to study the relevant content.

2. Establishment of finite element model
When carrying out the construction of the corrugated steel arch bridge, if it is analyzed from the structural angle, it can be found that the load is not simply and evenly distributed, because it is in close contact with the structure, so it will be subjected to the force together and will also deform together. Therefore, when carrying out the construction of the soil, it is necessary to analyze and study the influence of the structure and the soil. Because the problem was more complicated, there was no clear analytical tool at the time. With the development of science and technology and the continuous innovation of computer technology, researchers began to analyze and research using finite element numerical analysis. Now, when researchers are working on engineering, finite element software has become an indispensable tool. In the calculation of the results using the finite element model, the selected structural parameters and material parameters are very important, and different parameters will
affect the calculation results.

2.1. Preferences

In the calculation of the section characteristics of corrugated sheets, the calculation method chosen for use is the integral method. The calculation results are shown in Table 1.

| Waveform    | Bending stiffness (Unit: N•mm2/mm) | Area (Unit: mm2/mm) | Section moment of inertia (Unit: mm4/mm) |
|-------------|------------------------------------|---------------------|-----------------------------------------|
| 7mm×180×400mm | 7.027×10⁹                         | 9.7333              | 3.428×10⁴                               |

2.2. Establishment of a computational model

When researchers are designing and analyzing, the model that is often used is a planar model. The model has many advantages, such as faster running speed and simple modeling. For the corrugated steel bridge and culvert structure studied in this paper, because the axial length is much larger than the structural span, it is usually constructed by using the Saint-Venant principle when constructing this spatial structure, thus making the construction. The model can satisfy the basic assumption of plane strain. The model also has some shortcomings, such as the inability to load the live load form according to the actual situation, and the fact that the real waveform cannot be introduced into it.

(a) Selection unit

If you want to simplify the model, you need to base the principle of equal bending resistance to the bending stiffness, so that the steel plate with a certain waveform is equivalent to a flat steel plate. When researching and analyzing the actual steel plate stress, this paper chooses the beam3 two-dimensional beam element is simulated; as explained in the above, the mutual knot action needs to be considered when covering the soil. Therefore, when constructing the model, it is necessary to make the length of the soil on both sides meet certain conditions, that is, 2.5 times of the span. In this paper, when simulating the land, we chose to use the plane42 two-dimensional solid element for simulation.

(b) Structure and soil connection

According to relevant research data, the researchers divided the structure and soil contact into two types, one is to add contact units between soil and structure, and the other is node coupling. The second type of contact is that when the two structures are in contact with each other, there will be a common node through which the two structures can be closely connected, and when the force is transmitted, it is also carried out through this node. It is assumed that there is no slip between the structure and the soil in the backfilling project. On the basis of this, the interaction between the structure and the soil is studied and analyzed. It can be considered that the two structures are in contact through the second way. Of.

(c) Simulated construction

When backfilling, the backfill is not backfilled at one time, but backfilled layer by layer. Therefore, the model used in this paper for research and analysis also needs to be able to simulate the function of layered backfill. In the finite element software used in this article, if you want to simulate the function of layered backfill, you can do so by killing/activating the soil unit.

First, the soil unit, ie the two-dimensional solid element plane42, is killed/activated, leaving the simulated soil unit in an unactivated state, so that only the beam elements of the simulated arch are used in the calculation. In this case, the result of the calculation is the result of the arch in the self-weight state when there is no backfill.

Second, let the first layer backfill unit be activated, so that the unit that simulates the backfill can be calculated and then continue to load. In this case, the result of the calculation is the state result after the first layer backfill.

Third, let the second layer backfill unit be activated and continue the calculation.

Each layer of backfill units is continuously activated until the backfill units of all layers are activated and the state after each backfill is calculated.
3. Backfilling process simulation and results analysis

In order to make the design research described in this paper more elaborate, this paper chooses to divide the process of backfilling into a total of 14 stages. The filling height of different backfilling stages is shown in Table 2. By using the model constructed in this paper, the backfilling stratification process can be simulated. The method used is the life and death unit method. Firstly, the stress and displacement of the backfill should be calculated according to the state of the backfill of different layers, and then the state of the backfill of different layers is analyzed. After comparing and finding the most unfavorable stage, study the effect of this stage on the structural performance of the structure.

Table 2. Summary of construction backfilling at different stages

| Construction stage | 14 | 13 | 12 | 11 | 10 | 9  | 8  | 7  | 6  | 5  | 4  | 3  | 2  | 1  |
|--------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Filling height (unit: m) | 4.3 | 4.0 | 3.7 | 3.4 | 3.1 | 2.8 | 2.5 | 2.2 | 1.9 | 1.6 | 1.3 | 1.0 | 0.7 | 0.4 |

When performing the symmetrical backfilling project, not only the load is symmetrical, but also the structure is symmetrical. Therefore, when calculating, only the half arch ring can be calculated, so as to obtain the internal force and displacement generated by the backfill state in different stages. In this paper, several construction stages are selected on the basis of Table 1. The radial absolute displacement of the arch ring from the arch to the dome is calculated. The results are shown in Figure 1.

Figure 1. Displacement diagram of symmetric backfill construction structure at different stages

In-depth study and analysis of Figure 1 can be made clear that in the 1/8 span structure, when the fill height is less than 2.5m, the displacement and the fill height are positively correlated. When the fill height continues to increase, the displacement is negatively correlated with the fill height at 4.3 m; in the dome structure, the displacement change is the same as the 1/8 span, but the displacement direction is different, and the fill height is increased. At the time of the displacement, the resulting displacement is upward, that is, the reverse arch phenomenon occurs. Fig. 2(a) shows the structural state when the fill height is 2.5 m; Fig. 2(b) shows the structural state when the fill height is 4.3 m. In-depth study and analysis of Figure 2 (b) can be made clear that the deformation trend that occurs at this time is that the sides of the arch are not convex outward, and the dome is concave. The reason for this is that when using finite element software to build the model, the software will consider the structure and soil function, backfill distribution, so that the deformation is restricted. When backfilling is carried out, the maximum displacement occurs when the backfill height is 2.5 m, and the displacement value is about 0.9 mm.
It can be clarified from the above discussion that in the case of backfilling construction, the state in which the stress changes greatly is near the vault. If the structure is a concrete structure or a completed structure, cracking is likely to occur under this stress, and corrugated steel is used. It is possible to better adapt to such stress changes while having the same tensile strength, thereby avoiding cracking.

Through the research and analysis of the symmetrical backfill construction, it can be clarified that when the maximum stress and displacement appear in the structure, it is the time when the backfill is filled into the vault. Now this paper will study and analyze a special case, that is, the backfilling of the dome is asymmetric backfilling, and analyze and study the structural stress and displacement changes in this case. At the time of analysis, the height of the backfill was 2.2m and 2.5m. The height of the backfill on one side is increased by 40 cm and the other side by 20 cm. See Figure 3 for details.

In-depth study and analysis of the above two figures makes it clear that the structural displacement is greatly affected by asymmetric backfilling. At the 1/8 span of the higher side of the backfill, the maximum displacement occurs, as shown in Figure 4. In-depth study and analysis of Figure 4 can be clear, compared with the previous calculation results, the deformation trend of Figure 4 is basically the same, is also a convex ring on the side of the small load, concave on the side with large load Arch circle. However, compared with the calculation results before this article, there are still differences, the difference is the constraint of the finite element model on structural deformation.

4. Conclusion
In the research and analysis, this paper uses finite element software to study the structural force performance of the two backfill construction methods. The conclusions obtained through experiments are as follows:
a) For the structural stress performance, compared with the symmetrical backfill construction method, the asymmetric backfill construction has obvious influence on it. On the higher side of the backfill, both the stress change and the deformation are obvious;
b) The displacement maximum occurs at the 1/8 span of the higher side of the asymmetric backfill. As the soil layer increases, the displacement on the higher side increases, and the displacement on the lower side decreases.
c) The stress on the higher side of the asymmetric backfill has the largest stress at 1/8 span and the top of the vault. Compared with the lower side, the stress on the higher side is more obvious, and the maximum stress is from the higher side. The movement of the lower side occurs;

When backfilling the corrugated steel arch, the arch is prone to arching at the initial stage of backfilling. This is due to the extrusion of the soil. When the backfill is applied to the vault, the maximum displacement occurs. The corrugated steel plate material has strong deformation adaptability, but during the construction, the deformation from the construction to the vault and the 1/8 span is still strictly monitored, especially at the vault, because the whole structure is here. The weakest part, so it is easier to deform due to stress.

References
[1] Flenere. B. Testing the Response of Box-type Soil-steel Structures under Static Service Loads [J]. Journal of Bridge Engineering, VOL. 15 (2017), P.90-97.
[2] Damian Beben. Zbigniew Manko. Static Tests on a Soil-steel Bridge Structure with a Relieving Slab [J]. Structure and Infrastructure Engineering. 2010
[3] Kells J.A. Hydraulic Performance of Damaged-End CSP Culverts [A]. Annual Conference of the Canadian Society for Civil Engineering [C], Canada, 2012: 483-491