Rationality Analysis of Continual Improvement of a Simply Supported T Beam Bridge

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Abstract: A 40m prestressed concrete simply supported T beam in continuous transformation and reinforcement, because the T beams is thin, and there is no suitable T concrete diaphragm that can share the anchorage force, can not guarantee the reliability of prestressed anchoring system. This paper puts forward a new method to construct the pier top continuous transformation, and analyzes and discusses the rationality of the two construction schemes. Midspan construction loading and bearing pre-top construction reformation have not improved the T beam bearing capacity, which can improve the force of the structure, the calculation results show that the bending moment is close to the bending capacity of the middle span after the continuous transformation., and improve the effect is not obvious. In addition, the continuous structure and a new type of pier top continuous structure can not prevent the cracking of the pier top, and there is a risk of increasing the midspan deflection of T beams in the construction.

1. PROJECT OVERVIEW
The simple support and continuous construction techniques are widely used in the new built bridges. It is not uncommon for the bridges to be reinforced by the simple support and continuous method, mainly for the purpose of reducing the effect of load in the mid-span, improving the normal service performance, and the comfort of running, and some the practice of the bridge verified the feasibility and reinforcement effectiveness of the method. However, for certain bridges, it is still necessary to formulate a continuous plan based on its own characteristics and to fully demonstrate the feasibility and economy of the plan.

The superstructure of a bridge is a post-tensioned prestressed concrete simple-supported T-beam with multiple spans of 40m. The beam height is 2.30m, the main beam spacing is 2.20m, and the transverse section is composed of 8 beams. The original bridge width is 18.50m and the layout is 2.25m. The sidewalk +4×3.50m lane + 2.25m sidewalk, Figure 1 shows the original cross section of the bridge. In the longitudinal direction of the bridge, only transverse diaphragms are placed at the mid-span and at the end of the beam, as shown in Figure 1.
The bridge has an expansion joint every 40m. Due to the expansive devices, it reduces the ride comfort and increases the impact of the vehicle, causes local damage to the structure. It imposes a burden on the daily maintenance and is intended to adopt a structure.

2. RECONSTRUCTION PROGRAM

2.1 Deck layout
Dismantle the original concrete sidewalks and guardrails and replace them with lighter steel structure sidewalks and guardrails, as shown in Figure 2.

After the transformation, the layout of the cross section is 19.50m wide, and the layout is 1.75m sidewalks + 4×4.00m lanes + 1.75m sidewalks.

2.2 Pier Top Continuous Solution
For newly-built simple-supported and pre-stressed prestressed concrete T-beam bridges, generally, the prestressing force is applied to the pre-stressed concrete tooth plate by applying a prestress to the top section of the pier top to resist the negative bending moment of the section. Due to the influence of its own section size and structure, it is difficult to solve the anchorage problem of the negative bending beam at the top of the pier. Therefore, a new type of pier top continuous construction is proposed. That is, the top section of the pier top is connected to the top plate steel of the two span T beams only by welding, and the concrete in the transverse partitions on both sides of the adjacent two spans of the T beam is poured. A certain pre-force is applied to the threaded rod through the arrangement, and the pier is finally realized. The top structure is continuous and the detailed structure is shown in Figure 3 and Figure 4.
Fig. 3 Edge beam pier wing plate reinforcement connection layout
3. RATIONALITY ANALYSIS OF CONTINUOUS TRANSFORMATION

According to the above scheme analysis, it is found that the internal force distribution of the bridge state structure is related to the construction procedure, that is, the purpose of changing the internal force distribution of the final structure can be achieved by setting reasonable construction steps. This part will analyze and discuss the rationality of the two construction schemes for continuous transformation.

3.1 Rationality of Construction Schemes for Cross-Country Counterweights

The cross-neutral counterweight construction plan is to balance the cross-neutral weights before pouring the continuous sections on the top of the piers. After the concrete at the top of the pier reaches the design strength, the unloading of the cross-middle counterweights will cause the pre-compressive stress at the top edge of the pier to achieve OFFSET part of the car live load at the top of the pier to produce negative bending moment causes the upper edge of the tensile stress.

This scheme can increase the pre-compressive stress on the top edge of the pier by using the intermediate-neutral weight, but the larger cross-middle weight increases the mid-span bending moment combination of the dead load + vehicle live load, reducing the cross-center distance. Sectional bending moment safety reserve. The study of a reasonable cross-counterweight is to find a balance between the two, taking into account the negative moment of the pier and the positive mid-span moment. In addition, the influence of the cross-counterweight on the deflection of the T-beam structure also needs to be considered.

3.1.1 Cross-weight construction process

Taking the four-span and one-link as an example to illustrate the construction plan of the cross-weight. The following table 1 shows the construction process of the bridge.

| No | Program                                      | Remarks                                      |
|----|----------------------------------------------|----------------------------------------------|
| 1  | Simple-supported structure operates for 1,000 days | before renovation                           |
| 2  | Bearing replacement                          | Original cast steel bearing replaced with rubber bearing |
| 3  | Demolition of sidewalks, railings, bridge decking | Within a 13m radius of the middle pier of a continuous section of the |
4 Applying load
The load is set within 20m of each span in the load as an external force and applied in accordance with the uniform load.

5 Structural continuous construction, de-stuffing stowage
After the concrete strength reaches 95%, the stowage is removed and the structure is transformed into a continuous system.

6 Elimination of the remaining deck pavement (Phase II construction)
Eradication of deck surfacing and surfacing in areas outside the 13 m of the pier piers.

7 After the transformation of the second phase of the dead load
The installation of steel walkways, paving bridge decking and other surface.

3.1.2 The reasonable range of loading weights across the mid-span
In order to study the influence of the cross-weight on the structural stress, the internal forces of other construction processes are combined and defined as the structural dead-load bending moment combination Mg, and the additional bending moment generated by the counterweight is Mp. The internal force generated by the weight loading and unloading of the four-span one-span cross-span is calculated according to Figure 5.

![Fig.5 Internal force calculation diagram for mid-span loading](image)

According to the calculation, the bearing capacity of the T-beam is controlled by the side beam. The bending capacity of the T-beam mid-section of the side beam is 13148.9 kN•m, and the bending capacity of the pier section is 4764.2 kN•m.

![Fig.6 Bending moment envelope under bearing capacity limit state](image)
Fig. 7 Bending moment $M_p$ distribution map generated by loading 100t across the middle

From Fig. 6 and Fig. 7, the maximum positive moment of the four-span one-span joint occurs at 0.8m from the mid-span side of the 0# pier. The cross-section reinforcement and the mid-span section are the same, that is, the cross-section bending capacity and the mid-span cross section. The maximum negative bending moment appears on the left side of the 1# pier. Loaded in the mid-span and pier top have a positive moment, the largest left bearing at the top of Pier #1. Table 2 below lists the combinations of bending moments for several key sections.

| Table 2  Cross-loading effect of 100t counterweight |
|-----------------------------------------------|
| program section                               | Side spans | 1# pier tops | secondary side spans | 2# pier tops |
| Bending moment combination value $M_G$ (kN·m) |            |             |                    |             |
| 100t counterweight generates bending moment $M_p$ (kN·m) | 378.3 | 719.6 | 613.2 | 486.2 |
| Consider the combination of bending moments of 100t counterweight $M_G+M_p$ | 13349.7 | -3629.0 | 13358.7 | -3117.4 |
| Cross section bending capacity $(kN·m)$ | 13148.9 | -4764.2 | 13148.9 | -4764.2 |
| whether the bearing capacity meets the specification requirements after loading | no | yes | no | yes |
| Unmatched safety reserves /% | 1.926 | 8.725 | 4.001 | 24.361 |
| The weight can change the range /t | 66.93 | -57.77 | 85.78 | -238.72 |

It can be seen from Table 2 that the four-span one-piece 100t counterweight produces a positive bending moment of 719kN·m at the top of the 1# pier, and a positive bending moment of 378.3 kN·m in the side span. If construction is carried out according to the procedures in Table 1, the load-carrying capacity structure can be satisfied if the load is not required, and the load-carrying capacity cannot meet the specification requirements if the load-carrying is carried out. The reason why the unloading is not required is that the second-stage dead load of the original bridge except the 6.5m left and right of the pier top is reserved at the beginning of construction, and the concrete structure of the pouring pier top is continuously removed, and the structural weight is separately. The same principle. If it must be loaded, the loading capacity is controlled by the side span, and the maximum can only be 66.9t.

4. CONCLUSION

(1) At the beginning of construction, the dead load of the original bridge in the second phase except the 6.5m range from the top of the pier shall be retained at the beginning of construction. The concrete structure of the pouring pier top should be removed after it is continuously constructed. This is the same effect as if the structural counterweight is used alone. The calculation shows that Need to load, you can make the bearing capacity structure to meet the requirements. It is possible to reduce the negative bending moment at the pier top through the mid-span loading, with a maximum of 66.9 tons.

(2) After the transformation, the flexural bearing capacity of the mid-span section and pier top section satisfies the requirements of class I of the highway, but the safety reserve is not large.
(3) Calculations show that the use of the pre-clamped approach is not suitable for this type of structure, and it is not possible to achieve the goal of producing a pre-compressive stress at the upper edge of the pier top section.

(4) For the two methods of continuous transformation in the text, the T-beam's own bearing capacity has not been improved after the transformation, and the structural stress is improved. From the calculation results, the mid-span bending moment is close to its own resistance after continuous transformation. Bending capacity, the improvement effect is not obvious. In addition, the continuous structure and a new type of pier-top continuous construction method can not prevent the cracking of the pier top, and there is also the risk that the mid-span deflection of the T-beam will increase during the construction.

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