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Contents

Bearing Capacity of Concrete-filled Steel Tube Arch Bridge Summary of Factors

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Abstract: Many factors affect the bearing capacity of steel concrete arch bridge, rib void, the initial stress of steel, concrete Poisson's ratio, the lower rib torsion and other factors. By analyzing the principle and mechanism of these factors, and then puts forward the reasonable precautions, and summarizes the progress of the current research of concrete pipe Arch Bridge, as to provides a theoretical basis for the design and construction of the bridge.

Keywords: Concrete-filled steel tube; Baring capacity;Void; Initial stress

1. Introduction

In recent decades, concrete-filled steel tube arch bridge applications has been developing rapidly in our country ,especially in mountainous region and urban bridge construction, on the aspects of construction, concrete-filled steel tube can be used as a hollow steel skeleton and hoisting construction template, light weight, fast construction, steel consumption. At the same time, with the cable erection pull buckle used in concrete-filled steel tubular arch bridge without support, gradually mature, further promote the development of concrete-filled steel tube arch bridge. The steel tube concrete is a composite material [1], on the one hand, the use of steel pipe of concrete confinement effect, improve the concrete compressive strength and ductility, on the other hand, filled with concrete to improve the stability of steel compression, thereby improving tube corrosion resistance and durability. However, a large number of engineering practices shows that affected by different factors such as the bearing capacity of concrete filled steel tubular arch bridge. Arch rib slab and steel tube initial stress, concrete Poisson's ratio, arch rib deflection. Thus, concrete-filled steel tube arch bridge bearing force factors worthy of further in-depth study and discussion.

2. Arch Rib Slab

Concrete-filled steel tube arch bridge pavement main reasons are: construction process, material properties, concrete temperature, shrinkage and creep of concrete, the construction process is the primary cause [10].At present, mainly for the construction process of steel pipe concrete pouring concrete in steel pipe jacking method top to a certain height, the steel angle is less than the critical angle within the range of air escaping. When the concrete surface free from steel tube top surface is very near, the air is easy to concrete free surface waves or swell and sealed air cavity is formed; when the concrete pumping, concrete bleeding rise together, occupy the gas cavity and bleeding exhaust air bubbles continue to bring together movement to the vault direction, the space and space makes the cavity bleeding concrete filled steel tube cavity, which is the primary reason of construction technology leads to void.

Working state of concrete filled steel tube with three [2]:steel and concrete have radial extrusion, radial critical, radial void. Steel pipe concrete pavement, also known as debonding, in fact, is a steel and concrete in out of state or concrete empty and not dense. Arch rib slab is by the influence of all factors, such as concrete pump delivery of quality, the shrinkage and creep of concrete, temperature change, state under axial pressure, which may have arch rib entrainment phenomenon in concrete-filled steel tube arch bridge.

How to change the arch rib void on the working performance of concrete-filled steel tube arch bridge, there is no unified conclusions. When the concrete-filled steel tube void, the steel tube and the core concrete work alone and the two radial force P is 0, the deformation of the steel tube and the core concrete only meet the longitudinal strain compatibility, radial displacement compatibility condition is no longer satisfied. At this time steel tube and the core concrete separate force, stress of the steel tube and the core concrete, according to the elastic modulus K=Es/Ec distribution coefficient. If the steel pipe concrete axial pressures continue to increase. At the same time, the steel tube and the core concrete appear plastic by force, steel tube Poisson ratio changes, the core concrete Poisson change with the longitudinal force of growth, from low should stress state0.17 increases to more than 0.5, when the core concrete Poisson's ratio is more than steel tube Poisson's ratio, the core concrete and steel tube started hooping effect, void phenomenon of the steel tube and the core concrete disappeared.

Through a series of experiments and research, concrete filled steel tube void under axial pressure, literature [3]is given for the whole process of the analytical description: concrete filled steel tubular (CFST) be separated at the beginning, axial force increase slowly, gap increase rapidly; with the increase of axial force the voids reach a peak, voids also decreases slowly, until void disappeared. The effect of arch void of axial pressure generated is very little on the bearing capacity of concrete-filled steel tube arch bridge.

In construction, the concrete-filled steel tube arch bridge void main irrigation concrete cavity or not dense, such as literature [4] ,by comparing the experimental data illustrate: concrete filled steel tubular column bearing measured values are very close to the limit calculated values , the difference is very small; when concrete-filled steel tube column exist void, void ratio is big, the more the carrying capacity reduce, and the column slenderness ratio (L / D) increase, the faster magnitude of bearing capacity decrease. Visible, steel and concrete exist empty or not dense, concrete filled steel tubular arch bridge bearing force influence is serious, which influence the concrete filled steel tube arch bridge service life, so in the construction, concrete filled steel tube arch bridge should ensure the filling compactness of concrete or with self-compacting concrete, at the same time, we should also use ultrasonic technology which was used to detect the steel pipe.

Concrete filled steel tube arch bridge in the construction avoid void phenomenon, vacuum assisted pouring construction technology can be taken. Literature[11]: Hejiang Yangtze River Bridge (the largest span steel pipe concrete arch bridge) in the construction use the vacuum assisted pouring construction technology. Tap test and ultrasonic wave test, borehole survey and other means, which prove the compactness of tube concrete pouring stage.

3. Initial Stress of Steel Tube

Concrete-filled steel tube arch bridge at first set up the hollow steel tube, and pour concrete, when the concrete has not reached the design strength, empty steel tube withstand the weight of self and the concrete gravity. Therefore, before steel and concrete as a composite structure bear the load together, hollow steel tubes have been produced force and initial strain at the beginning, which is steel tube initial force question. The initial stress of the steel tube causes the steel pipe to enter the elastic-plastic stage in advance, and affect the bearing capacity of the concrete filled steel tube arch bridge [12]. Due to the diversity of the section form of steel pipe concrete arch bridge, the influence of initial stress on bearing capacity of concrete filled steel tube arch bridge is different, such as single limb round pipe, dumbbell and four limbs latticed configuration section arch bridge.

3.1. Single round tube

The influence of initial stress on bearing capacity of concrete filled steel tube arch bridge with single leg is analyzed. Based on the literature [5], the influence coefficient curve of bearing capacity is analyzed, and the curve equation is obtained:

$$K_p = f_1(\lambda)\beta + f_2(\lambda)\beta^2$$

Type:

$$f_1(\lambda) = 0.1\frac{\lambda}{120} + 0.3(\frac{\lambda}{120})^2$$

$$f_2(\lambda) = -0.19\frac{\lambda}{120} + 0.15(\frac{\lambda}{120})^2$$

K_P - bearing capacity influence coefficient

λ— ratio of length and width

β— initial stress coefficient

Through a series of data analysis, the larger concrete filled steel tube arch bridge ratio of length and widthλis, the smaller the value of the influence factor of main arch bearing capacity; from the analysis of the parameters in practical engineering, and the bearing capacity is less than 10%, which is bounded, the single limb steel pipe concrete arch bridge initial stress coefficient is less than 0.35.

3.2. Dumbbell type

With the chang of initial stress coefficient and ratio of length and width, the dumbbell shaped concrete-filled steel tube arch bridge bearing capacity influence coefficient get the rule, fitting coefficient expression of bearing capacity:

$$K_p = 1 - 0.14\beta(L \le 200)$$

$$K_p = 1 - 0.17\beta(L > 200)$$

Type show that under the condition of ratio of length and width, the influence coefficient of bearing capacity and initial stress coefficient show a linear relationship, the initial stress force coefficient (the initial stress of steel tube arch rib and the yield strength ratio, namely β=σ0/*f*s, σ0is magnitude of initial stress, *f*sis Steel yield strength) becomes larger, bearing force influence coefficient value is smaller. From the analysis of parameters in practical engineering, and the decrease of bearing capacity is not more than 10%,suggest that the single limb concrete filled steel tube arch bridge initial stress coefficient is controlled within 0.6.

3.3. Limbs lattice configuration

With the change of initial stress coefficient, the influence coefficient of the concrete filled steel tube arch bridge bearing capacity is obtained, and the expression of the influence coefficient of the bearing capacity is obtained:

$$K_p = 1 - 0.14\beta(L \le 200)$$
$$K_p = 1 - 0.17\beta(L > 200)$$

The formula shows that the influence coefficient of bearing capacity and initial stress coefficient is linear, and if the bearing capacity decline no more than 10%, the bearing capacity of arch bridge is maintained at 0.9, and the initial stress coefficient is less than 0.6.

A large number of calculations show that the steel tube concrete arch bridge is subjected to a large load, and the load of the vehicle is smaller. Therefore, the bearing capacity is calculated according to the formula:

$$P_j = \lambda P_o$$

In the formula, P_j is the maximum bearing capacity, and the Po is the internal force of the arch, and λ is the stability coefficient.

Literature [13], calculation of single leg, dumbbell shape, and limb lattice arch bridge draw: With the increase of initial stress coefficient, the influence coefficient of bearing capacity is reduced, and the load capacity of steel tube concrete arch bridge is reduced.

4. Concrete Poisson's Ratio

According to the literature [6] calculation formula of steel tube arch core concrete Poisson's ratio in u_c :

$$u_c = \begin{cases} 0.173, \dfrac{\sigma_c}{\sigma_o} \le 0.221 \\ -0.323 + 0.82\left(\dfrac{\sigma_c}{\sigma_o}\right)^{\frac{1}{2}}, \dfrac{\sigma_c}{\sigma_o} > 0.221 \end{cases}$$

Type: σ_c is longitudinal stress of core concrete, σ_o is the core concrete ultimate compressive stress.

Literature [7] analysis that structure reaches ultimate bearing capacity, to consider the core concrete Poisson variation and does not consider the core concrete Poisson ratio changes were compared and found that the arch angle crushing of concrete is different, which considered the core concrete Poisson ratio changes in the crushing of concrete more, mainly due to the concrete Poisson's ratio change, and made the stress redistribution. Therefore, the ultimate bearing capacity of concrete filled steel tube arch bridge without considering the change of concrete Poisson's ratio is low.

5. Rrch Rib Deflection

In the operation stage, the steel tube concrete arch bridge may appear disease of the arch rib deflection. Due to temperature change, concrete shrinkage and creep, live load and other factors, arch rib deflection is caused by synthetic action. Arch rib deflection deviated from its reasonable arch axis, micro deflection and large arch axial force interaction, which result in greater bending moment, so that the mechanical properties of the arch have great changes.

Literature [8]:through Three Shanxi bridge and Yajisha bridge arch rib measurement, when the arch rid height was measured at the time of completion, The results reveal that the mid span deflect largely, a parabola traits. Three Shanxi bridge and Yajisha bridge are considered arch rib deflection and does not take into account the arch rib deflection, Which calculate ultimate bearing capacity, the analysis of the results showed that: the arch rib deflection will reduce the limit of concrete filled steel tube arch bridge bearing capacity, but the magnitude of the effect is not large, mainly because the span of arch rib is too small.

6. Conclusion

Concrete filled steel tubular arch bridge occupies an important position in the bridge, and the bearing capacity of the concrete-filled steel tube arch bridge is also a concern. Several factors affecting the bearing capacity are described in this paper: the arch rib cavity, the initial stress of steel tube and concrete Poisson ratio, arch rib deflection. Different aspects illustrate that concrete filled steel tube arch bridge bearing capacity influence degree. We further understand that should be paid attention to in the construction and maintenance.

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