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Discussion on Crack Resistance Technology Based on Long-Span Box Beam

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Abstract: According to engineering practice, the stress characteristics of long-span box girder are analyzed, especially the technical flaws in design and construction cause beam cracks. The theoretical basis and improvement measures are proposed, and the theoretical depth of optimization design is improved through the summary of breaks. And improve structural quality issues.

1. Introduction

China's transportation construction industry has built many large-span box beams in highway construction. This structure has large cross-section torsional stiffness, large span, resistance to alternating positive and negative bending moments, a combination of load-bearing systems and force transmission, and cross-sections. [1]High efficiency is suitable for the characteristics of structural space to ensure the prestressing degree, etc., and is often often used in key engineering design. Due to the extensive and complex structure design theory, it is found that the bridge body has different degrees of cracks in the operation practice after completion of the bridge. Therefore, it should be optimized and improved in terms of design depth and construction quality control.

2. Analysis of the Force Phenomenon of Long-Span Box Girder Section

The upper loads acting on the cross-section of a box beam are mainly live loads and dead loads. Live loads are generally eccentrically loaded. The eccentric load causes the section to have a torsional effect, and the load is symmetrical or nearly symmetrical:

(1) The downward deflection of the cross section under symmetrical load, the longitudinal bending stress δ_M and the longitudinal warping shear stress τ_M of the cross section under bending.

(2) Sections undergo rigid torsion under two conditions under non-nominal load, (a) When free torsion; under longitudinal free deformation, the section is warped but does not generate normal stress, and the thickness of the box beam relative to the section height To produce torsional torsional shear stress τ_k. (B) When constraining torsion; the stresses generated in the normal section are constrained torsional normal stress δ_W and constrained torsional shear stress τ_W.

(3) The cross-section dimensions of the beam web and roof are weak and the distance between the transverse beams is too large. Distortion stress δ_{dw} and distortion shear stress τ_{dt} occur on the beam section.

(4) Finally, the bending stress δ_C is generated due to the load acting on a certain position on the top plate.The total force state on the surface is:$\delta_{t.}$

(5) According to the section deformation and stress diagram analysis (Figure 1); the total force state on the box beam section is:

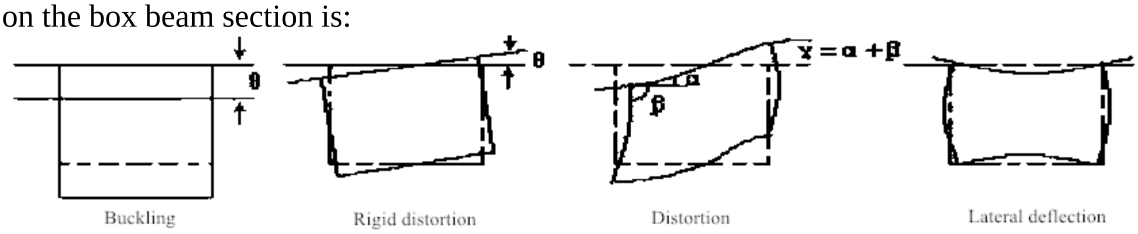

Fig.1 Section Deformation and Stress Diagram Analysis

Within the cross-section range; the longitudinal normal stress is $\delta_z = <\delta_m + \delta_w + \delta_{dw}$

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shear stress $\tau = \tau_k + \tau_m + \tau_k + \tau_{dw}$

Within the range of longitudinal section; transverse bending normal stress $\delta = \delta_{dt} + \delta_c$

3. Cracks and Causes of Long-Span Box Beams

The Institute of Highway Sciences of the Ministry of Transport has surveyed 180 bridges across the country's highway system with a span of more than 60m. The box beams in service have cracks to varying degrees, which are specifically manifested in the web, roof, floor, statistics (%) .

Table 1 Survey Statistics Of National Highway System More Than 60m Span

Web cracks				Roof crack			Floor cracks		
Fulcrum Oblique	L/4 Slant	Horizontal	Vertical	Direction	Broadwise	Slant	Direction	Broadwise	Slant
28.3	75.1	42.2	17.5	80.6	15.6	6.8	46.2	20.8	10.9

3.1 Causes of Cracks Caused by Design Work

The box-type girder bridge generally adopts the finite element calculation theory of the member system, and the error in the analysis and calculation of the spatial effect structure depth is large. If the spatial distribution of the temperature field and the eccentric torsion of the load are not considered; that is, the shear lag of the beam body Effects, torsional stress, distortion stress, etc. are miscalculated.[2]

Insufficient understanding of the principle of concrete shrinkage and creep, because it is theoretically difficult to accurately calculate the shrinkage and creep of concrete, it is difficult to judge and analyze the degree of bridge cracks and structure caused by concrete shrinkage and creep. The consequences of the analysis are as follows:

(1) The shrinkage and creep of concrete will increase the deflection of the component in the compression zone of the structure, and the prestressed component will cause the prestress loss.

(2) Increasing the eccentric pressure to cause bending, so increasing the initial eccentricity and reducing the bearing capacity.

(3) Concrete shrinkage causes cracks on the surface of thicker members. This phenomenon belongs to the fact that shrinkage generally starts on the surface and is simultaneously hindered by the interior, which causes structural cracks caused by shrinkage tensile stress.

(4) The stress of the members with different concrete components is redistributed by the superstatic structure, which results in the secondary stress of the structure Cracks.

Temperature stress is a typical cause of cracks in bridge structures. According to the requirements of the code; China's machinery uses a certain theoretical value. Due to the large differences in climatic and geographical environments in different regions, it is not possible to accurately analyze the box theoretically. The inherent distribution of the cross section of the beam and the predictability of cracks. In the high temperature season, due to the strong sunlight shining on the top of the box beam, the temperature stress exceeds the prescribed value and the temperature stress is generated in the beam. [3]Therefore, the box beam is in the process of construction The roof cracks appeared earlier, which was caused by lateral warpage.

3.2 Cracks and Causes Caused by Construction

(1) Large-span box beams are generally designed to use high-strength concrete above C50, but during the construction process, ordinary silicate 42.5MPa is the most typical.The contractor emphasized unilaterally that the strength index of concrete must reduce the water-cement ratio and increase the amount of cement At the same time, the use of high-efficiency water-reducing agents for the auxiliary mix composition design, therefore, the shrinkage, creep, alkali content and chloride ion of the concrete are increased, and the elastic modulus that matches the strength of the concrete is reduced, so the structure is lost. Durability reaches fatigue and cracks.

(2) For box girder bridges constructed by cantilever hanging baskets, high-strength hot-rolled ribbed steel bars are often embedded in the web of box girder as vertical prestressing tendons of the

bridge structure, due to its anchoring and anchoring process. The stress loss cannot be effectively controlled, which causes the vertical prestress to fail to function and fails, which is also the main reason for cracks in the web of the box beam prestressed structure.

(3) The general design documents do not elaborate on the tensioning of the vertical prestressed tendons, and the construction specifications do not specify them.The current common construction practice is to perform the vertical prestressed tendons to be stretched in sections at the same time, which is easy to be carried inside the web. Interval stress blanks are generated, making the internal stress of the web uneven and causing tensile stress cracks.

(4) At present, the prestressed tensile construction is only to control the tensile force and elongation value.After reaching the theoretical requirements, it is then grouted to maintain health, but the problem of tensile aging of the prestressed tendons is ignored, based on the complex stress of the box beam and internal force cracks.

(5) The large-span box girder No. 0 of the cantilever method is first positioned to pour the concrete from the top of the pier.The concrete volume at this part is large and the shrinkage and deformation are large.In addition, the internal hydration heat reaction is strong and internal tensile stress cracks are generated.

4. Technical Countermeasures to Prevent Cracks in Box Girder

(1) First, strengthen the theoretical depth from the aspect of design to analyze the force characteristics of box girder. Through the generalization of structural mechanics (about simple beams, shear lag effects, beam comparison method for elastic foundations, frame analysis method, finite element method, finite strip) Method, finite segment method, influence surface method, beam torsion theory, thin shell theory) and other structural mechanics principles, to improve the calculation of the stress characteristics and inevitable connections of various parts of the box beam, through targeted and quantitative analysis of section selection and reinforcement Calculation is a necessary prerequisite to ensure box beams to avoid cracks and durability.[4]

(2) To prevent the shrinkage and creep of concrete during construction is a necessary technical measure to prevent cracks in the structure.It should be from the production of form-work, optimization of the composition design of the mix, the solid stability of the hanging basket construction, and the foundation bearing of the cast-in-situ support. Forces should be strictly controlled.

(3) The corrugated pipe coordinates of the prestressed tendons must be accurate, otherwise it will affect the error judgment of the elongation of the force tendons; at the same time, it will affect the uneven secondary stress generated in the structure and cause cracks. The design of box beams using 3D prestressed tendons, Vertical tension bars must be spaced symmetrically to ensure tensile stress.

5. Conclusion

Large-span box beams are inherently complex and subject to complex stresses, which can easily cause cracks and erosion during the use of the bridge to reduce durability. Therefore, the rationality of structural design can be achieved by increasing the theoretical depth and comprehensive analysis and calculation in terms of design. At the same time, during the construction process, strictly enforce technical specifications and strengthen technical management according to local conditions, to minimize the shrinkage and creep of concrete, and avoid structural cracks.

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