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Analysis of main beam of bridge crane based on ANSYS

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ABSTRACT*: In this paper, the beam of bridge crane is the research object. This paper introduced the main structure of the bridge crane. Four kinds of work conditions are studied, and a finite condition analysis is carried out based on ANSYS. According to the actual operating results and theoretical analysis on allowable bending and allowable stress this paper confirmed that the stiffness safety of beam meets the design requirements, and provided reliable basis and optimization of crane design.*

Keywords*: Bridge crane, Finite element analysis, ANSYS simulation, Rigidity*

I. INTRODUCE

With the increase of the domestic and foreign demand for bridge crane, the design of the domestic crane is a serious problem, such as the design ability and innovation ability. Traditional crane design usually adopts static design [1], according to the existing product design method and the traditional empirical formula to calculate and check, resulting in the long crane design cycle, the complicated design process and poor design accuracy. Unreasonable design makes the demand for steel increased, and the crane heavy, not conducive to the transport and installation of cranes, but also increase the energy consumption of users. Moreover, because of the bad working condition of crane, the dynamic performance of metal structure is affected by many factors, the actual performance and design performance are often different. So the product's safety is not guaranteed.

Because the design of the traditional semi-empirical and semi-theoretical design can't meet the actual work requirements, the dynamic simulation analysis and finite element analysis method are introduced to the crane design in recent years. The corresponding 3D simulation software is also emerging. The three-dimensional model of crane is built by computer, which imitates the actual working condition and the working environment. These software accurately analyze stiffness, strength and stability of crane at different time. These advanced technology methods largely promote the development of crane design technology and improve the safety and reliability of crane products.

Relied on the above ideas, this paper analyzed the crane beam in specific conditions by finite element analysis method. Through the use of computers to the crane beam operation, check and evaluate, to ensure the crane's safety performance, shorten the design cycle, reduce design risk and cost, optimize the product quality, provide strong guarantee for products functional, reliability, security, and other aspects.

II. STRUCTURE AND PARAMETERS OF BRIDGE CRANE

The structure of the bridge crane is divided into metal structure, mechanical transmission structure and electrical part [2]. Metal structure comprises a tray and trolley. The bridge beam, go Taiwan, guardrail and manipulating the composition of the room, the car is consists of a frame and a railing composition. The transmission mechanism is composed of a lifting mechanism and a large truck and a car running mechanism. Electrical part is composed of electrical equipment and electric line. This paper mainly studies the analysis of beam crane bridge structure; structure is no longer for other details. In this paper, QZ70333 Bridge crane Luoyang crane factory production as an example. Its overall structure is shown in Figure 1. The main performance parameters of the crane are shown in table 1.

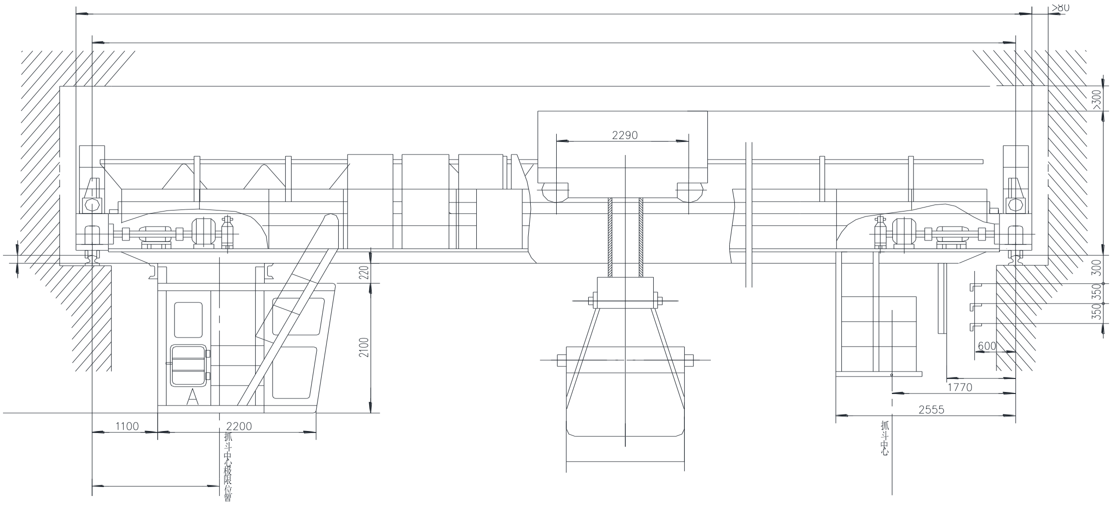

Figure 1 the structure of bridge crane

Table 1 main performance parameter table

performance data	hoisting mechanism	performance data	Mechanism of trolley	Mechanism of gantry
Rated load lifting capacity /t	5	Orbit distance /m	2	25.5
Maximum lift height /m	20	Running speed /(m•min^{-1})	44.5	60
Rising speed/(m•min^{-1})	37.8	Motor power /kw	3.7	7.5×2
Motor power /kw	30	Braking torque(N•m)	80~140	(112~225)×2
Braking torque (N•m)	(315~630)×2			
Work level	A3	Work level	A3	A3

III. THE MAIN DESIGN LOADS OF BRIDGE CRANE

In the actual work of crane, it suffers many kinds of loads (normal load, accidental load, wind load, etc.) [3]. The normal load of crane is composed of dead load, load and load, and the acceleration load of a crane. The accidental load is a load that is caused by the wind, snow, ice, temperature change and deflection of the working state. The wind load is the static load of the crane which is working in the open air, and the wind load is usually assumed to be the most unfavorable horizontal direction of the crane. Special load is refers to occur in the crane in non normal working load, including by crane experimental and non normal working condition of wind load, collision buffer and crane (or the part of the tilting, crane, unplanned downtime, actuator failure or crane foundation under the load induced by the external excitation. Because of the length of this paper, we only analyze the conventional load.

According to different load combinations, the working condition of crane is divided into four working conditions:

Class Ⅰ condition: The gantry and the trolley are in a static state. The trolley is still in the middle of the main beam of the crane running mechanism. Lifting mechanism was carrying a static load. At this point, crane bridge beam by load combination: beam deadweight load (visual effects on the main beam of uniform load), trolley bridge static wheel load (visual effects on the main beam of concentrated load) and other metal structure of the additional load (such as the cab, go to Taiwan and handrails can be uniformly distributed load instead of, the self weight load multiplied by the load factor to represent).

Class Ⅱ condition: The gantry and the trolley remain stationary. The trolley is in the middle of the cart frame. The lifting mechanism is reduced and braking under the premise of bearing the weight of the crane. At this point of the crane bridge beam by load combination for beam deadweight load (visual effects on the main beam of uniform load) and (calculation should be considered dynamic load coefficient) and other metal structure of the additional load (such as the cab, go to Taiwan and handrails can be uniformly distributed load instead of car bridge wheel pressure, the self weight load multiplied by the load factor to represent).

Class Ⅲ condition: The crane running mechanism is still not moving, the trolley is located in the main beam of the crane running mechanism, the lifting mechanism is going down and braking under the premise of carrying heavy load. This combination of load conditions for: weight load, car bridge beam wheel pressure and other subsidiary body weight.

Class IV condition: The gantry is braking, the trolley is located in the main beam of the crane. The lifting mechanism is reduced and braking under the premise of bearing the weight of the crane. At this point, the crane bridge beam suffers load combination: run the cart brake inertia force, trolley wheel pressure and other ancillary structure weight.

IV. MAIN BEAM STRUCTURE ANALYSIS BASED ON ANSYS

4.1 Parts quality of crane

The load of bridge crane beam bearing consists of beam weight, vehicle weight load, lifting load, inertial load [4]. The quality of each part is shown in table 2.

Table 2 quality of parts

Components name	Quality /kg
Starting motor	500
Grab	2500
Retarder	800
Brake	90
Drum and appendages	1200

4.2 Calculating conditions

The common bridge crane work condition in the second part of the description, due to the length of the section II of the type of work on the crane for finite element analysis. Other condition analysis method likes this condition.

Because of the relatively time-consuming modeling and analysis of the whole crane, the performance of the computer has a higher requirement. This paper of crane model is simplified, the selection of a beam wake modeling analysis, when applied force were taken calculated main force generally applied to a single main beam.

4.3 Model loading force

The class II conditions, beam suffered main force for: beam deadweight load P_{G1} (uniformly distributed load), trolley heavy load P_{car}, grapnel and wire rope weight P_{zd}, hanging heavy load P_d and hanging weight reduction of decreasing acceleration load P_a. The trolley wheels l=1m.

$$P_{G1} = \rho g S L \quad (1)$$

$$P_{car} = 0.4 m_t g = 0.4 \times 5 \times 10^3 \times 9.8N = 1.96 \times 10^4 N \quad (2)$$

$$P_{zd} = m_{zd} g = 2.318 \times 9.8N = 22.7164 N \quad (3)$$

$$P_d = m_t g = 5 \times 10^3 \times 9.8N = 4.9 \times 10^4 N \quad (4)$$

$$P_a = \psi_5 (m_t + m_{zd}) a = 1.5 \times (5 \times 10^3 + 2.318) \times 0.12 N = 900.41724 N \quad (5)$$

The deadweight load P_{G1} is uniformly distributed load, according to the actual model of volume loading on the main beam by the ANSYS software. ρ、S、L respect beam density, cross-sectional area, span, m_t is crane rated load quality. m_{zd} is the quality of the grab bucket and rope. ψ_5 is dynamic load factor. Access to the crane design manual, ψ_5 =1.5 .

4.4 The model establishment and analysis of main beam

Box beam cross section of bridge crane is shown in figure 2. Refer to the crane design manual: $b \times \delta_1 \times \delta_2 \times h_0 \times \delta_0 = 500 \times 8 \times 6 \times 1300 \times 6(mm)$, $b_0 = b - (40 \sim 60)mm \geq 300\,mm$

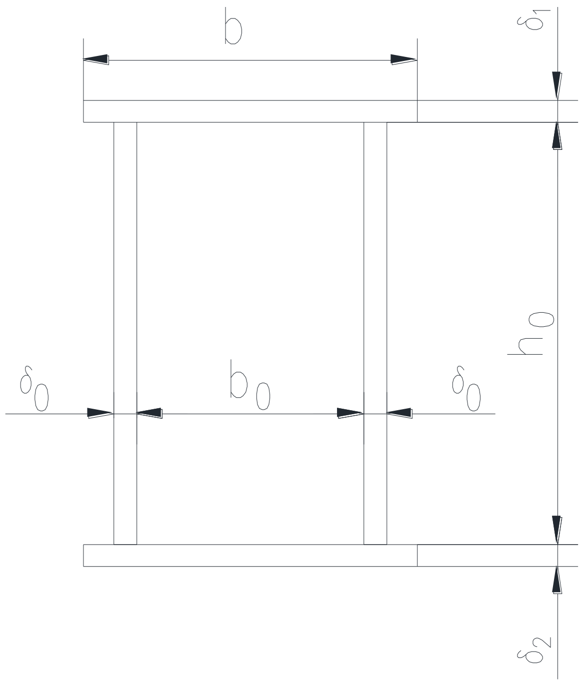

Figure 2 size of box beam of the bridge crane interface [5]

4.5 Analysis results

For mode II, the Figure 3 and figure 4[6] are equivalent (vov-Mises) stress and total deformation of the beam.

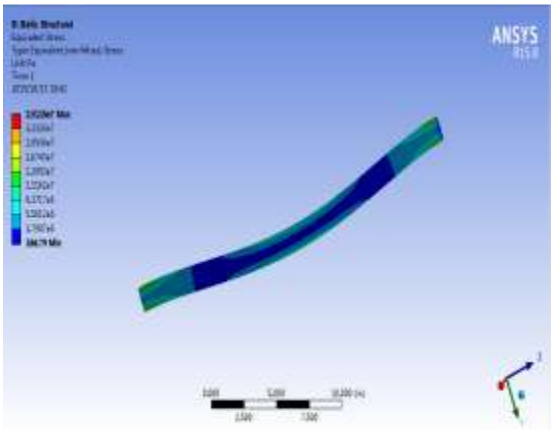

Figure 3 Equivalent (vov-Mises) stress

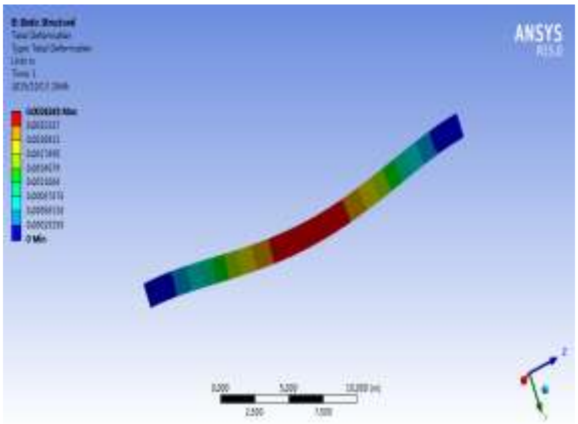

Figure 4 Total deformation

V. CONCLUSIONS

As is shown in Fig 3, beam of concentrated stress appear at the both ends of the main beam with fixed ends, so on both ends of the main beam should add just the right amount of web, on both ends of the main beam hole position should pay attention to the occurrence of stress fracture, when it is necessary to open hole position compensation structure strength. From Figure 4, the maximum deformation of the girder occurred in the middle of the beam. Bridge crane's allowable deflection of beam is 1 / 700 ~ 1 / 400 of the beam's length, and the research object of this paper analysis results show that of the beam meets the safety requirements under this condition.

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