Finite element static analysis of the main beam of mobile moulder grooving machine

Abstract: In this paper, the 1600t mobile moulded frame trenching machine is taken as the research object, firstly, the structural composition and operation flow of the trenching machine are introduced, and the finite element model of the trenching machine is established by using the parametric language of APDL in the ansys software. Since the main beam has a large self-weight and is the main load-bearing part of the machine, the analysis focuses on the stress and displacement maps of the main beam under the typical working conditions of pouring and over-holing. The stability of the main beam and the whole machine is studied under the dangerous working conditions of pouring and leg changing, which verifies the safety of the design of the main beam and provides theoretical basis for the subsequent study of whether there is any optimisation space for the main beam.
Keywords: mobile mould frame；main beam；finite element analysis

Introduction

Trough-making machine is a kind of special large-scale equipment for ferry with its own template, which can be moved forward automatically, developed by drawing on the experience of bridge moving mould frame bridge-making machine [1]. Trenching machine with simple, efficient, automatic, safe and other characteristics, in China has been used in Guangdong Dongjiang-Shenzhen Dongshen water supply and the South-to-North Water Diversion Middle Line Caohe ferry, Scott River ferry and other large-scale projects in the construction of the ferry [2]. In this paper, a company develops 1600t maximum span 42m ferry channel making machine as the research object. As one of the main load-bearing parts of the machine, especially under the condition that its own weight is also large, finite element analysis is of great significance to the overall equipment safety and subsequent optimisation of the machine.

1 Finite element analysis of slot-making machine

As a kind of large-scale water conservancy equipment, slot-making machine is mostly non-standard products. As one of the important components of the main beam, its design is extremely important to the overall safety and cost of the machine. Through finite element analysis, the first is to check whether the strength and stiffness of the main beam design meets the requirements, which is conducive to protecting the safety of construction personnel and equipment. Secondly, it is to analyse whether there is room for optimization of the design, which is conducive to saving the manufacturing cost for the enterprise and enhancing the competitive advantage.

1.1 Brief description of the structure of the groove making machine

The research object of this paper is the upstream 1600t slot-making machine, which is mainly composed of main beam, guide beam, pick beam, hanging outer rib, No.1 fixed outrigger, No.2, No.3, No.4 movable outrigger, outer mould system, hydraulic inner mould system, end mould system, electrical system and other parts. Among them, the main girder is a box girder structure with top and bottom two layers, and high strength bolts are used to connect the sections and sub-layers, and the guide girder is a truss structure, which is symmetrical in both longitudinal and transverse. In ANSYS firstly run the command flow in the main girder section file, so that the system saves the section data first, then run the main girder command flow file to get the main girder modelling entity and the right side section as shown in Fig. 1 Fig. 2:

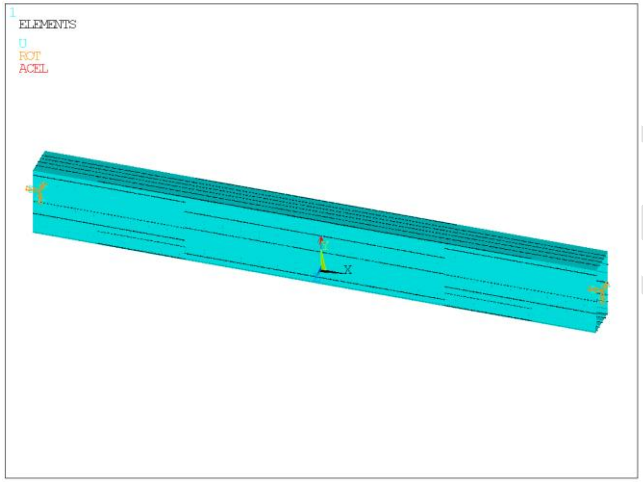

Fig. 1 Solid drawing for modelling of main beam (axonometric view)

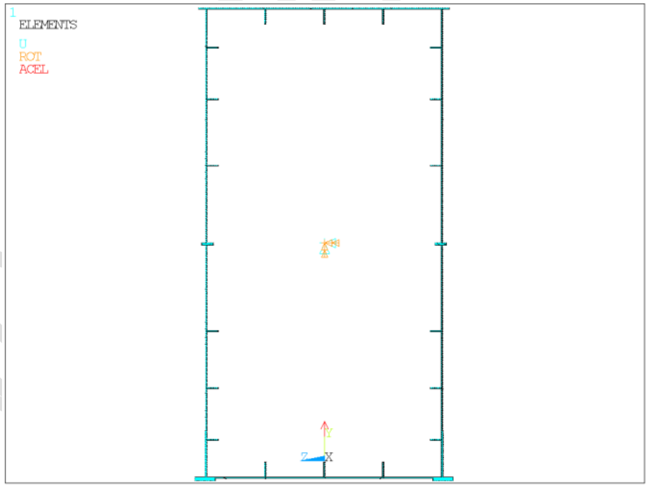

Fig. 2 Cross-section of the right side of the main beam

1.2 Trough-making machine operation process

(1) The whole machine is located at the top of the two piers, and the 2 and 3 legs are fixedly supported with the top of the pier in pouring mode;
(2) After completing the process of concrete raising, 2 and 3 legs drop down to demould, and the outer mould system rotates to open to prepare for over-hole;
(3) Start 2, 3 legs longitudinal shift cylinder machine forward 16m, at this time the No. 1 leg to the top of the pier in front of the support;
(4) No. 4 leg began to support, and at the same time release the No. 3 leg to lift off and move forward a span to the top of the pier in front of the drop to re-support;
(5) Loosen leg No. 2 and move forward one span to the front pier top support, the other No. 1 leg loosening lift-off;
(6) Start the longitudinal cylinder of No.2, No.3 and No.4 legs to move the whole machine forward by 7.5m, and release the No.4 leg;
(7) Start 2, 3 legs longitudinal cylinder, the whole machine moves forward 18.5m, No. 4 leg hanging forward 7.5m;
(8) Adjust the heavy load support mode of No.2 and No.3 legs to the end of one working cycle.

2 Finite element analysis results of main beam under different hazardous working conditions

The main working process of the groove making machine can be divided into two stages, one is the pouring construction process, and the second process of changing the leg over the hole after pouring one span.

2.1 Analysis of pouring operation of groove making machine

The finite element analysis is carried out when the stress and deformation of the main beam is the largest at level 8 wind, at this time, the groove maker carries out the casting operation under the action of the No.2 and No.3 outriggers, and the load received includes the weight of the concrete beam and the inner mould in addition to the machine's own weight and the wind load, and the overall load applied to the groove maker is as shown in Fig.3:

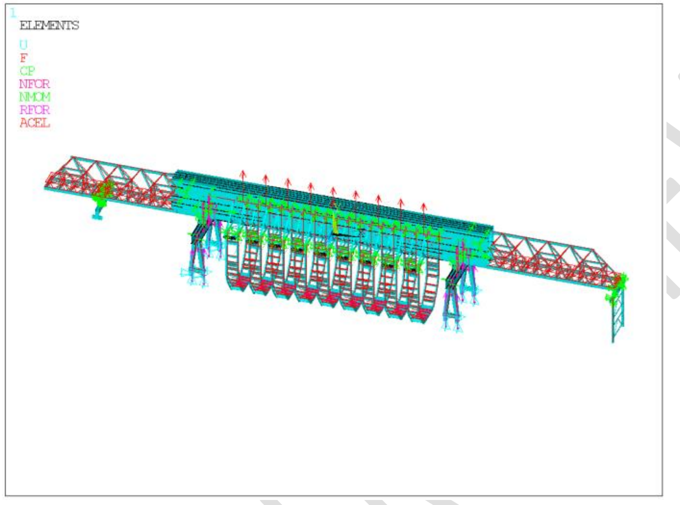

Fig. 3 Finite element model of channel builder under full load condition of class 8 winds

The main beam is extracted individually by APDL command to view the stress cloud and displacement cloud of the main beam. The command flow is as follows:

esel,s,sec,,33154,33157 ! Main beam

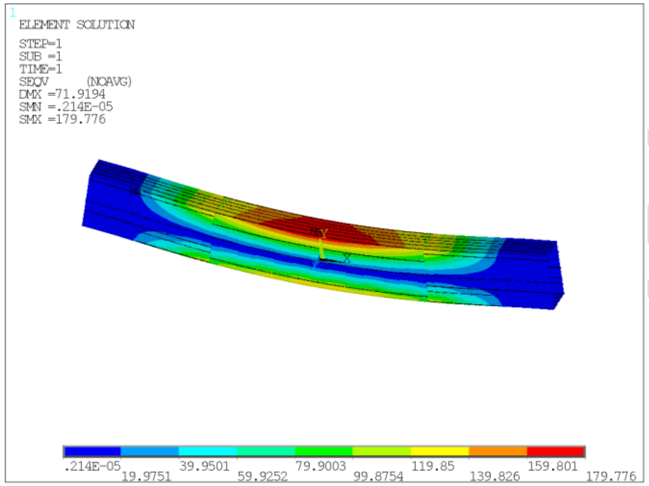

Fig. 4 Equivalent force cloud diagram of the main beam of the groove maker under full load of force 8 winds

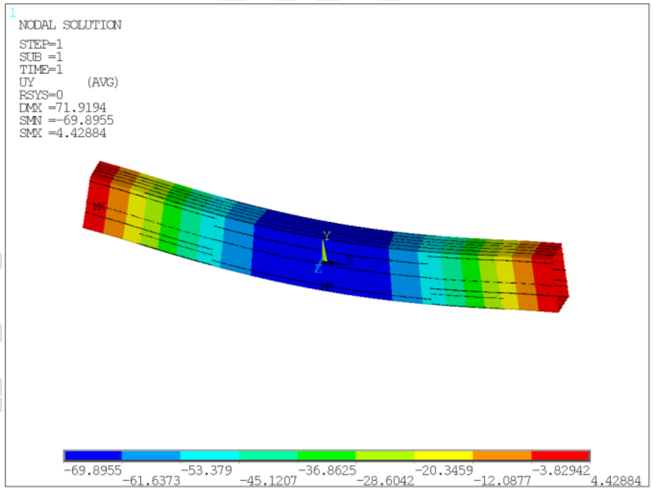

Fig. 5 Displacement of the main beam of the groove maker under full load of force 8 winds

The permissible stress method is used to check the strength of the main beam[3,4,5].

$$\sigma \le [\sigma] = \frac{\sigma_s}{n}$$

Where: is the yield limit of the material; is the safety factor of the material; is the permissible stress of the material.

By the main beam equivalent stress map Figure 5 can be seen at this time the maximum value of stress is 179.78MPa, occurring in the middle position of the main beam. The material of the main beam is Q355B, and the permissible stress is 236.7MPa, so the strength of the main beam meets the use requirements.

From the main girder displacement and deformation cloud diagram Figure 6, it can be seen that the maximum deformation of the main girder in the Y direction is -69.90mm, which occurs at the two ends of the main girder. Considering the influence of the deformation of the outrigger, the maximum deformation of the main girder in the middle of the span is 69.90mm-11.58mm=58.32mm, of which 11.58mm is the maximum deformation of the Y direction of the outrigger 3, and taking into account the deformation of the main girder under no-load, the maximum deflection in the middle of the span is: 69.90mm-11.58mm=58.32mm. Considering the deformation caused by the self-weight of the main girder when it is unloaded, the maximum deflection of the main girder at mid-span is 58.32mm-20.55mm=37.76mm, of which 20.55 is the maximum deformation of the main girder in the Y direction when it is unloaded by the wind of class 8. The permissible deflection is 45mm, so the stiffness of the main girder meets the use requirements.

Four important working conditions are selected to analyse the stress and deformation of the main beam when the groove-making machine is working, and the results are shown in Table I:

Table 1 Stress and deformation of main beam under different working conditions

working condition		main beam	
		maximum stress/Mpa	Maximum deformation in Y direction/mm
pouring operation	At full load in force 8 winds	179.78	−69.90
	Force 11 winds unloaded	81.45	−26.16
perforation	Force 6 winds through the hole 16m	53.82	-17.76
	Force 6 winds over the hole 33m	40.07	-15.9

In summary, it can be seen from the chart that the stresses at the two ends of the main girder and the displacement at the middle of the main girder are much smaller than the permitted values, leaving a large margin of safety, taking into account the different wind loads of the casting and over-hole conditions.

2.2 Stress analysis at the joint between the main beam and box guide beam when the groove-making machine passes through the hole

Since the connection between the main beam and the box guide beam is weak when the slotter passes through the hole, the local stresses at this position are analysed separately. The stress results are shown in the figure below:

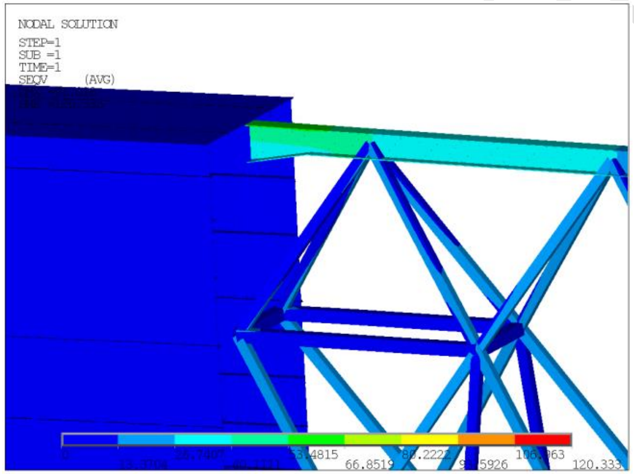

Fig. 6 Local stress cloud of 0m over the hole for class 6 winds

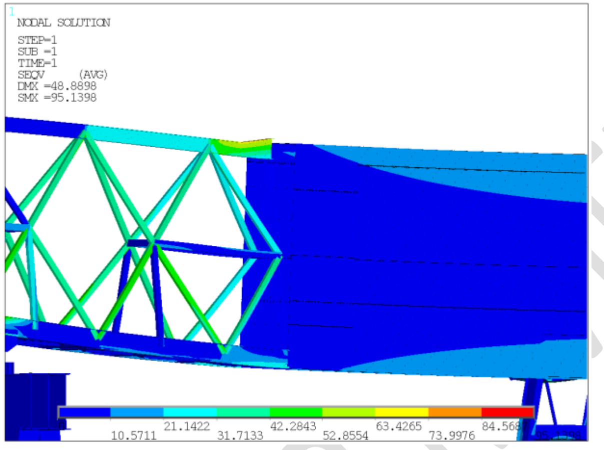

Fig. 7 Local stress cloud at 10m over the hole for class 6 winds

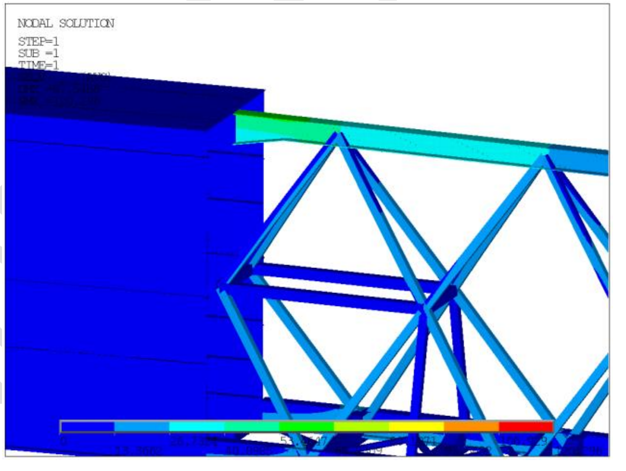

Fig. 8 Local stress cloud at 16m over the hole in force 6 wind (2 and 3 outrigger supports)

Conclusion

In this paper, using ansys finite element software, the strength and stiffness of the main beam of 1600t trough making machine under dangerous working conditions such as pouring and over-hole were checked and calculated, and the results were all within the permitted range, which verified the safety and reasonableness of the design of the main beam. From the charts of main beam stress and displacement deformation results in the paper, it can be seen that there is still more room for optimisation of the main beam, which provides a reference basis for further research on the optimisation of the main beam.

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