# Calculation for Hard Measured Loads on the Travelling Mechanism of Bridge Inspection Vehicle

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**Abstract.** In allusion to the recently problem of some loads to be calculated and hard measured of travel mechanism of bridge inspection vehicle, based on the principle of superposition in the elastic mechanics, the FEA simulation and test methods have been used to research the hard-measured loads on the travel mechanism of bridge inspection vehicle. The calculation case of the driving force in the driving case and the side load in the turning case of traveling mechanism of bridge inspection vehicle have been solved with this method, the results are used to be applied reference for the property optimization and model selection of mechanical bearing inside of travel mechanism of the bridge inspection vehicle. The research method is of well-reference value for the calculation of the unknown loads of whole machine and parts of construction machinery.

## 1 Introduction

In recent years, with the fast construction of bridge and the development of the urban viaduct construction in the world [1], the bridge inspection trade is of the well development potentiality, and the bridge inspection vehicle will be of the well market prospect, but it will be of the hard market competition at the same time [2], so it is very important to improve the performance and technology research of the bridge inspection vehicle.

**Figure 1.** The bridge inspection vehicle.

The travel mechanism is the key bearing component of bridge inspection vehicle [3]. When the bridge is inspected, the travel mechanism not only is used to kept the whole machine stable, but also it takes the important responsibility to keep travelling. So whether the strength calculation of parts and components and the driving force were correct, not only it would influence its performance, but also it would impact the safety of the inspectors.

For the strength calculation of the travel mechanism, the calculation method has been very professional, it is widely used to calculate the stress of parts and components with FEA simulation, and based on the results, the structure will be improved, in order to make the mechanism be satisfied with the strength and stiffness and standards.

Recently, the research methods of the driving force, turning force and friction which is very peculiar, but it is very unrealized to measure them [4-7], it is widely used to calculate and design with the analog method, but because of which results are very conservative, it is easily caused by wasting the resource and increasing the cost.

The test and FEA simulation are combined with together in this paper, the driving force and turning force of the driving mechanism has been calculated, and the results would be used to be applied reference for the optimization of driving mechanism.

## 2 Method of calculation

The model of hydraulic reducer of bridge inspection vehicle used to be selected with experience after generally calculated, when the bridge is inspected, the driving force is hard to be measured which is exported by hydraulic reducer of driving mechanism, so it is not easy to be judged whether the selected model is correct or not，at the same time, when the bridge is inspected on the curve bridge, it is unrealized to measure the turning force and the research of which is very peculiar.

Recently, the research of driving force and turning force of driving mechanism of bridge inspection vehicle is very peculiar. In allusion to the characteristic of driving

mechanism of bridge inspection vehicle, the calculation method of unknown force has been summarized in this paper： based on the principle of superposition in the elastic mechanics, through the straightly driving test and the turning test, the stress of driving mechanism had been collected, and all of the FEA simulation model of driving mechanism in all of the case, and the force was loaded in order to be calculated the stress of driving mechanism parts, then the value of loaded force was adjusted to reduce the error between the test stress and the simulation stress, when the error would be controlled in the scope of 10% of the design , the loaded force would be regarded as the force which hardly to be measured.

### 2.1 Principle of superposition [8-12]

Principle of superposition means that the stress、strain and displacement of the elastic structure loaded complex force could be added through the stress、strain and displacement of the elastic structure loaded simple force under the precondition of infinitesimal deformation and linear strain.

### 2.2 Driving case force solution of bridge inspection vehicle

When the bridge inspection vehicle is worked, the driving mechanism supports on the ground, which bears the supporting force $F_y$ from the ground; when the driving mechanism is worked in the straightly driving case ,which bears the supporting force $F_y$ from ground, the driving force $F_x$ from the hydraulic reducer and the friction force $f$ from ground; when the driving mechanism is worked in the turning case, which bears the centripetal force $F_R$ which caused by the factor such as turning centrifugal case and the relative displacement(Fig.2).

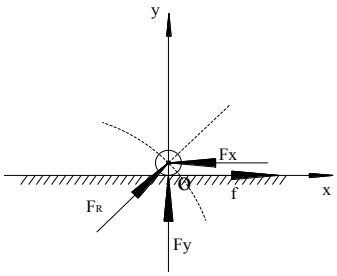



**Figure 2.** The loads of bridge inspection vehicle.

The parts of driving mechanism is in the elastic transformation scope, according to the principle of superposition in the elastic mechanics, one stress state is $\vec{\sigma}_{CASE1} = \vec{\sigma}_y$ in the static supporting case, one stress state is $\vec{\sigma}_{CASE2} = \vec{\sigma}_y + \vec{\sigma}_{F_x}$ in the straightly driving case and the other stress state is $\vec{\sigma}_{CASE3} = \vec{\sigma}_y + \vec{\sigma}_{Fx} + \vec{\sigma}_{F_R}$ in the turning case. So the driving force $F_x$ and centripetal force $F_R$ of outrigger can be calculated according to the three different cases.

## 3 Calculation case

### 3.1 Force calculation in the straightly driving case

#### *3.1.1 Test in the straightly driving case*

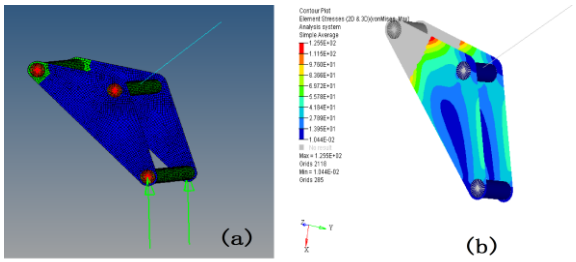
**Figure 3.** The strain sensors arrangement of travelling mechanism of bridge inspection vehicle.

The strain sensors are pasted on the parts of driving mechanism of bridge inspection vehicle, in order to monitor the stress of driving mechanism in the straightly driving case, when the outrigger is out of the ground, the values of sensors are cleared to zero, then it is supported and worked, the sensors are controlled to collect the stress.


**Figure 4.** (a) load collecting test in the supporting case (b) strain collecting test in the straightly driving case

#### *3.1.2 Simulation in supporting case and in straightly driving case*

The FEA simulation model of driving mechanism has been established, and the driving force has been loaded, then the solved results are contacted with the test results, the loaded driving force would be adjusted according to the error between the solved stress and the test stress, it would be controlled in the scope of 10%, then the loaded driving force would be thought as the force output from the vehicle. After contacted, the error is in the 10% scope of the results, and the driving force is 30kN, which being considered as the practical driving force value.



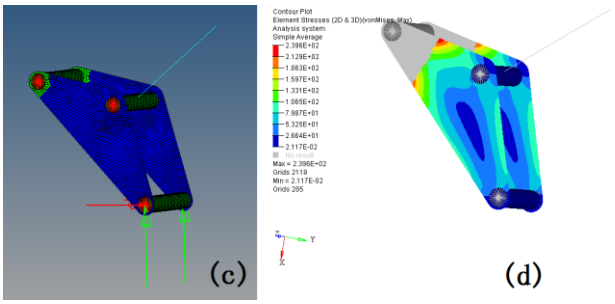



**Figure 5.** (a) simulation model in the supporting case (b) simulation results in the supporting case (c) simulation model in the straightly driving case (d) simulation results in the straightly driving case

### 3.2 Force calculation in the turning case

When the bridge inspection vehicle is worked on the turning case, it causes the side force and changes the bearing force situation, the selected bearing model is decided from side force FR 、driving force FX and vertical force FY together. The vertical force FY could be collected by being assigned sensor under the driving mechanism, the driving force FX has been solved with the above-mentioned method. According to the above-mentioned method, the side force FR would be solved in this paper, it can supply some data for the model selected of driving mechanism later.

#### *3.2.1 Test of turning force*

**Figure 6.** The strain test in turning case.

According to the above-mentioned method, in order to calculate the turning force of driving force, it is necessary to establish the FEA simulation model of turning case, the side force should be load, according to the actual stress, the side force should be adopted to keep the error between the test stress and the solved stress being in the scope of 10%, then the turning force satisfy requested is the force needed to solved.

#### *3.2.2 Simulation in turning case*

The simulation model of side force of driving mechanism has been established, the side force has been loaded, the parts stress of driving mechanism has been calculated, and the result has been compared with test stress, then the loaded force value has been adjusted to keep the error between them being in the scope of 10%, then the side force should be solved is 21.7kN, it is considered as the actual side force.

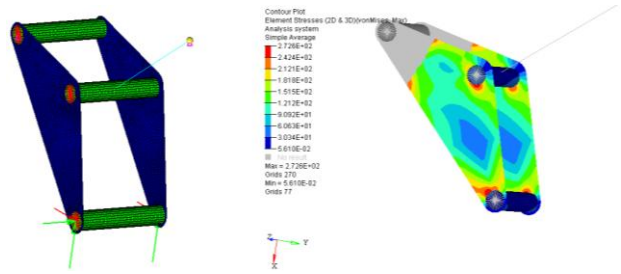


**Figure 7.** The simulation model in turming case.

The test results of driving mechanism in the all case as follows:

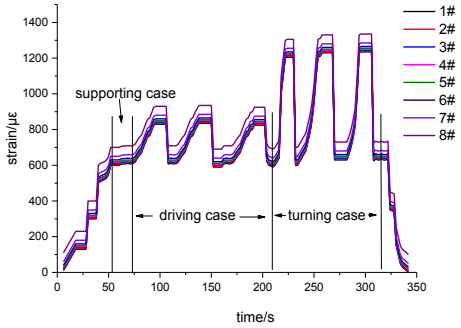



**Figure 8.** The curves between time and strain of travelling mechanism of bridge inspection vehicle

## 4 Conclusion

(1)Based on the principle of superposition in the elastic mechanics, it forms a force solved method by combined the simulation with test, and the driving force and side force has been solved of driving mechanism of bridge inspection vehicle, the results are used to be applied reference for the property optimization and model selection of mechanical bearing inside of travel mechanism of the bridge inspection vehicle;

(2)The calculation method combined the FEA simulation with test can be used to solve other hard measured loads of the construction machine , and it can be widely used in the force calculation of the other parts , so it is of very important value in the project.

## Acknowledgement

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