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Design and Computer Analysis of a Road Load Detection Machine

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Abstract

In this paper, an experimental device is designed for measuring vehicle dynamic load,the structure and stress of the equipment are analyzed by computer technology. The device design mainly includes vehicle, road surface, vehicle transmission, and control [1]. The vehicle is designed based on a 2-DOF vehicle model, the road is designed based on the Pasternak foundation model, and the control mainly uses a single-chip microcomputer. The dynamic response of vehicles to the road at different speeds is analyzed through the experiment.

Keywords: Highway; Road Surface; Load, Vehicle; Dynamic Response

1. Introduction

The use of computer technology for detection and analysis is a common method and means in the field of engineering,In the research entitled Research on Optimization Design Method of Composite Roadbed Variable Stiffness under Highway Embankment Load published by Mr. Wang Ganlin, he mentions an optimization design of embankment, which uses a new flexible foundation laying method instead of a conventional foundation laying method. The traditional foundation laying is to adopt pile arrangement with equal support stiffness. This methodology cannot fundamentally eliminate the differential settlement of the foundation, which is still a problem in the construction of roadbed [3].

Road Load Detection Machine is a device that is used to measure the weight of vehicles that are passing through a particular road. It is an important tool for maintaining the integrity of the road and ensuring the safety of the drivers. There are several types of Road Load Detection Machines available in the market, and each one has its own unique features and capabilities. Some of these machines use sensors to measure the weight of the vehicle, while others rely on cameras or other imaging technologies to do the same. Regardless of the type of machine used, the primary aim is to accurately measure the weight of the vehicle and provide this information to the authorities. One of the main benefits of using Road Load Detection Machines is that they help to reduce the risk of road damage. When vehicles that are overloaded pass through a road, the additional weight puts undue stress on the surface, leading to potholes, cracks, and other types of damage. By detecting these overloaded vehicles, the authorities can prevent this damage from occurring and maintain the road in good condition for longer.

Another benefit of Road Load Detection Machines is that they can help to improve road safety. Overloaded vehicles are more prone to accidents and are more difficult to control. By identifying these vehicles and taking appropriate action, the authorities can reduce the risk of accidents and improve the overall safety of the road. In addition to these benefits, Road Load Detection Machines can also help to reduce the cost of road maintenance. By detecting overloaded vehicles and preventing damage, the authorities can save money on repairs and other maintenance costs. This can help to stretch the budget further and ensure that more resources are available for other important projects. In conclusion, Road Load Detection Machines are an essential tool for maintaining the integrity of the road and ensuring the safety of drivers. They help to reduce the risk of road damage, improve road safety, and reduce maintenance costs. As such, they play a vital role in keeping our roads safe and in good condition.

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This paper designs an experimental device in the laboratory to study the effects of different loads on the roadbed. The experimental device comprises three parts: a simulated vehicle system, a pressure detection system and a control system. The device is powered by direct current. When the power is on, the simulated vehicle structure starts to work. We artificially control the electric push rod and apply a pressure through the electric push rod. The pressure can be controlled to specific value, and applied by the electric push rod to the simulated vehicle structure [4]. Due to the constantly moves of the simulated car, the pressure is transmitted to the roadbed, where the pressure sensor in the roadbed reads the data and sends it to the computer so that we can see the real-time pressure reading. In the road load detection device, ANSYS and ADAMS are used. Some important parts of the device are subject to the finite element analysis. Through the device, the roadbed can be tested by alternately applying a load, and the stress and deformation profile of the road surface can be obtained. Through the simulation data analysis (using the method of finite element analysis), the road surface process under alternating load is simulated, and the analysis results are obtained. The results obtained from the experimental device can be used as a reference for roadbed construction and maintenance [5-6].

2. Experiment part

Structurally, this device as a traffic cyclic load simulator (Figure 1) is mainly composed of the 3-phase asynchronous motor, coupling, connecting disc, directional wheel, and casing. The load is applied by a hydraulic unit, and the 3-phase asynchronous motor is powered on to rotate. Through the coupling and the rotation of the three fixed directional wheels, the test data of different loads at different positions of the roadbed are obtained, and the influence of different loads on the roadbed is found. The theoretical parameters of the design are in the range between 1.5t and 2.5t. The minimum output pressure is 300N and the maximum output pressure is 600N.

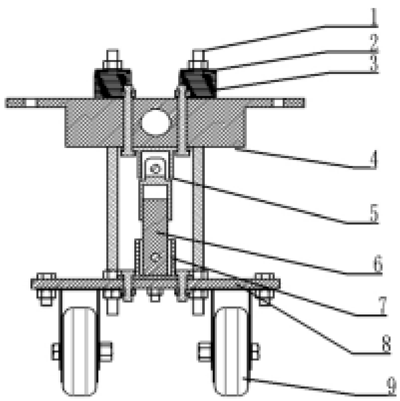

Figure. 1. Simulated vehicle structure

1-fixed screw rod 2-spring pressure plate 3-pressure spring 4-power transmission plate 5-electric push rod fixing flange 6-electric push rod 7-flange 8-directional wheel fixing plate 9-directional wheel.

The pressure plate is made of Q235 steel and the thickness is 5mm. Via direct type selection and search, the pressure sensor is determined to be 0-1T (Φ 56/Φ 25). The unidirectional movement distance of the device is 1000 mm, and the pressure is applied by an electric push rod.

The actual vehicle movement is a very complicated vibration system, so it is difficult to establish a model that can completely reflect the actual vibration in reality. In this paper, the vehicle model is simplified accordingly. To fully reflect the operating conditions of a vehicle, at least an 8-DOF model needs to be established. This paper simplifies it into a 2-DOF model, as shown in Figure 2. Assume that the vehicle moves in a straight line and only has vertical vibration.

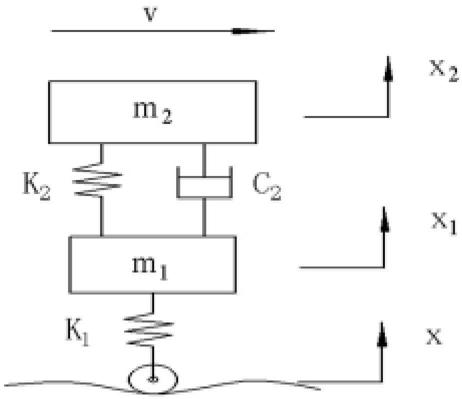

Figure. 2. The 2-DOF model of simulated vehicle

In the design of the vehicle device, four directional wheels are fixed for the movement. The 5 mm thick steel plate is used for simulating the vehicle body. The middle of the steel plate is connected to the vehicle with the electric push rod through the flange. The load is applied by the electric push rod to achieve the purpose of outputting different loads. The electric push rod has a minimum output of 300N and a maximum output of 600N. The vehicle's power output is by the driving screw rod of the motor, and the four screws are used to connect the vehicle to the screw rod slider, as shown in Figure 2. The spring is applied to the top to reduce vehicle vibration [7].

In order to ensure the strength of the simulated vehicle, a 5mm thick steel plate is used to simulate the vehicle body, and a flange is used to connect the vehicle and the electric push rod in the middle of the steel plate. The load applied by the electric push rod can output different loads, which has the advantages of stable load output and more compact structure. According to the pavement mechanics model can be divided into three categories: rigid pavement, flexible pavement and semi-rigid pavement. The rigid pavement model can be considered as an infinite rectangular damping plate supported by an elastic Pasternak foundation 9,10. The Pasternak roadbed model includes the mutual shear between elastic elements, which is regulated by the road surface installed on the spring, and the spring can only be deformed by the transverse shear force. So, in the Pasternak model, the shear deformation and the compressive deformation of the pavement are properly approximated [8-10].

3. Results and analysis

After 3D modeling, the device is analyzed in ANSYS. In this paper, a force of 600N is applied to the device. It can be seen that the position with the greatest stress is at the screw hole, and the position with the largest deformation is in the middle. All the stress values and deformation values are within the design range.

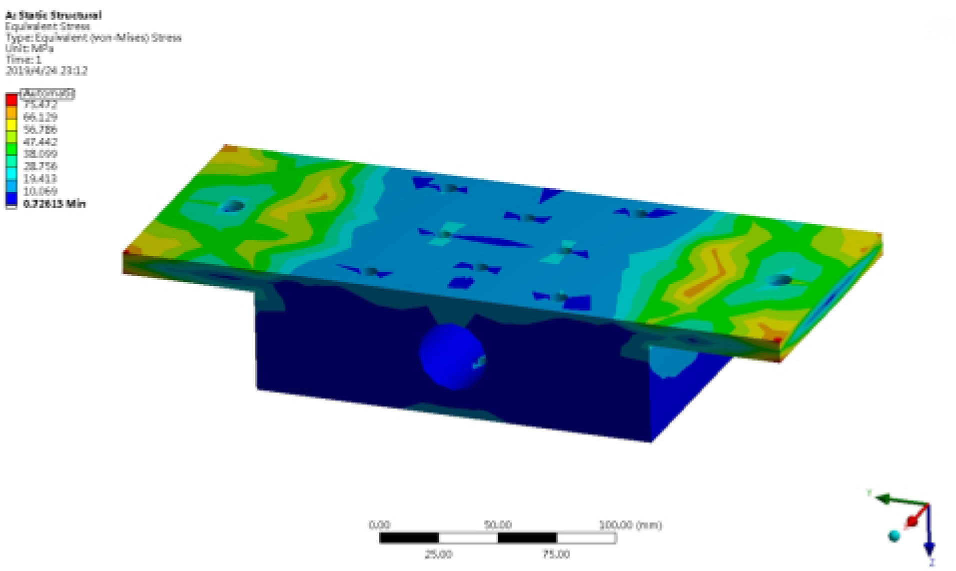

Figure. 3. Equivalent stress analysis

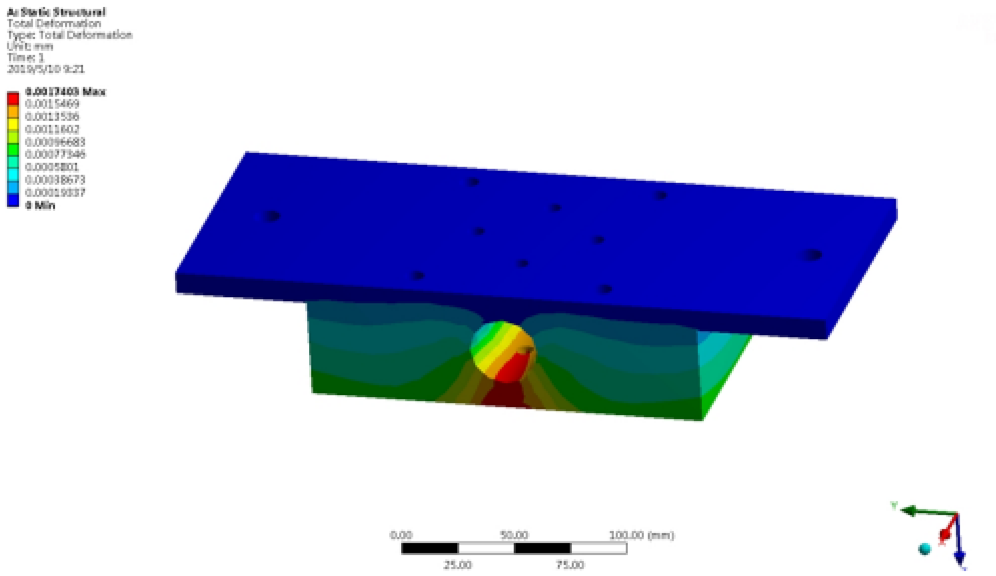

Figure. 4. Overall deformation analysis

A static analysis of the power transmission plate is performed while applying a force of 600 N. Figure 3 and Figure 4 show the stress and the deformation, respectively. It can be seen from the figure that in the case of 600N, the most stressed position is on both sides, the structural walls on both sides are thinner, and the most deformed position is in the flange connection hole. Here, the point of force applied by the electric push rod is below. All stress values and deformation values are within the design range.

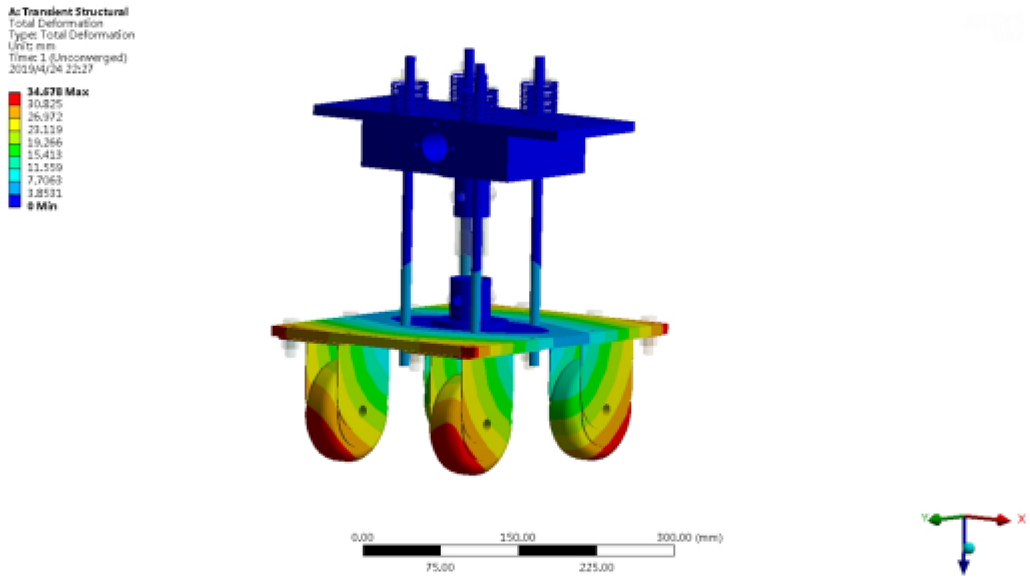

Figure. 5. Analysis on overall structure of simulated vehicle

The overall static analysis is made on the simulated vehicle structure subject to a 600N bidirectional radial force. It can be seen that in the case of 600N, the most stressed position is below the four directional wheels and the most deformed position is in the directional wheel fixing plate as shown in Figure 5.

The pressure test structure uses a 1t pressure sensor which is fixed on the frame. The top of the pressure sensor is connected with a 4mm thick steel plate. The 4mm steel plate is fixed with 4 springs and bolts to make the steel plate under pressure able to quickly reset as shown in Figure 6 and Figure 7.

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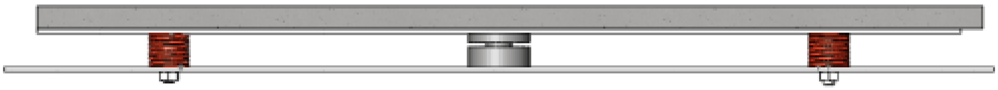
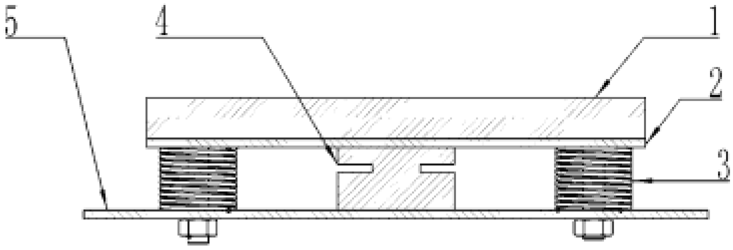


Figure. 6. Front view of pressure test system



1--Roadbed 2--Pressure system upper plate 3--Pressure spring 4--Pressure sensor 5--Pressure system lower plate
Figure. 7. pressure test system

The above two formulas can be used as a mathematical model for simulating the road surface in this paper. In the design, a 4mm thick steel plate is used to simulate the shear plate. Springs are installed under the steel plate to simulate the roadbed damping. A sensor is attached in the middle of the steel plate to collect experimental data.

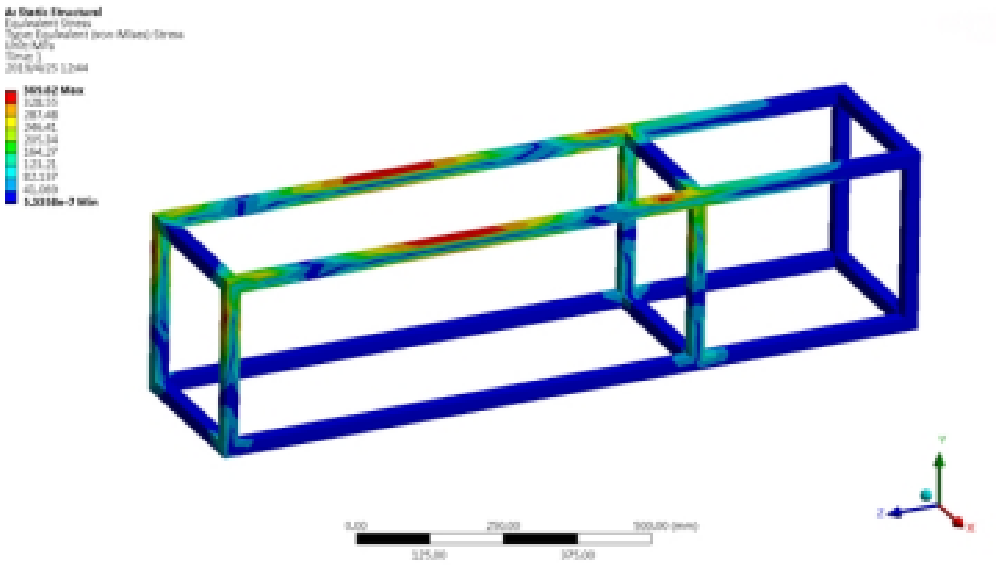


Figure. 8. Equivalent stress analysis

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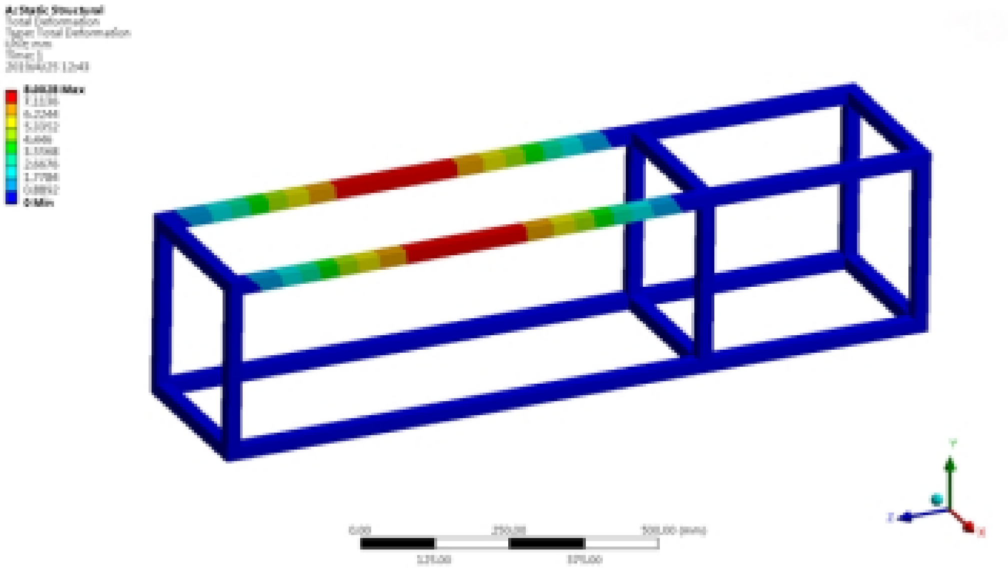

Figure. 9. Total deformation analysis

The frame is subjected to static analysis under a force of 600 N. Figures 8 and 9 show the stress and deformation, respectively. It can be seen that in the case of 600N, the position with the most stress is the middle of the frame and the position with the largest deformation is also the middle of the frame. Therefore, the middle of the frame should be strengthened [11].

The design of the device can make the vehicle move at a constant speed in the range of 0 ~ 1m / S, and the limited position switch can make the car move back and forth. The vehicle load is defined as 300N, 400N and 500N by electric push rod, and the dynamic load of road surface is analyzed when the vehicle is 0.1 m / s, 0.5 m / s and 1 m / S, As shown in table 1.

Table. 1. Different loads and vehicle speeds

load	300N	400N	500N
vehicle	0.1m/s	0.1m/s	0.1m/s
	0.5m/s	0.5m/s	0.5m/s
	1m/s	1m/s	1m/s

According to the collected data, the dynamic load on the road surface when the vehicle is moving is obviously more than that under the static load, and the higher the speed, the more obvious the dynamic load increase. The maximum dynamic load increased by about 3.2% under 300N load and 4.2% under 500N load. The maximum dynamic load at 1 m / s velocity and 0.1 m / s velocity increased by about 3% [12-13].

4. Conclusion

The above experiment and the data analysis show that the experimental data reflects the dynamic response to the road at different speeds, indicating that in addition to the vehicle's own load, increasing the speed of the vehicle will increase the load of the vehicle on the road surface, and thus indirectly provides a reference for the design of the road surface. In this paper, an experimental device is designed mainly based on the 2-DOF vehicle model and the Pasternak roadbed model. At present, there are not many results for such experimental devices in China, which are mainly used in static experiments.

In the field of modern engineering, computer technology is used more and more. Especially in the simulation and analysis, it plays a very important role.

In this paper, an experimental device is designed to simulate the dynamic load of vehicle road in laboratory. The model is based on 2-dof vehicle model and Pasternak Foundation model. The device tests the dynamic load of the vehicle on the road surface when the vehicle under different loads passes the road surface at different speeds. According to the experimental data, the following conclusions can be drawn: (1) vehicle speed is an important factor which affects the coupling effect of vehicle and road, and the dynamic load can exceed the static load by more than 50% when the vehicle is running in the actual condition. Therefore, you should avoid speeding to prevent road damage. (2) vehicle load will also aggravate the coupling effect between vehicle and road. Overloading of vehicles should be prevented.

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