Stiffness of a Car Body in White Test Analysis

Rongmin Li [a] , Jian Zhang [b], Shijie Su

Jiangsu University of Science and Technology, Jiangsu Zhangjiagang 215600, China

[a]rongmingli@sina.com, [b]zhjian127@163. com

Abstract

With the independent development car stiffness testing system for the platform ,the bending stiffness and torsion stiffness of the body-in-white's car is test and the loading position and pre-load on the bending stiffness of the car is studied. The results showed that :the perfect preload in the experiment was 200N, and bend rigidness of the car under concentrated condition was 68.5% of distributed condition. The torsion rigidness curve of clockwise condition changed slightly, compared with anticlockwise condition. The torsion rigidness of the car was 5460.5 $N \cdot m/°$.

Keywords

body-in-white ,bending stiffness ,torsion stiffness , pre-load , loading method

1. Introduction

Body stiffness test , an experiment which was used to evaluate stiffness properties of a car ,is to simulatethe actual use of the body under the process constraints and load conditions in a laboratory environment ,and using relevant instrument to measure various characteristics of the body parts of the deformation. Currently most car bodys are all-bearing structure , the body carries almost the process of twisting and bending loads ,when it was used . the static stiffness of the car body has obvious influence on the NVH performance durability and dynamic response performance of a car , so engineers should taken the body stiffness as the primary problem while designing the structure of a car.

Gui liang-jin had designed and developed the bending and torsion stiffness test systems in white body of the "changan star" minibus ,and had made theoretical analysis and experimental research on curved torsion stiffness of a body-in-white car ,which provided a basis and means for similar cars on modification and optimization .Sun zhuo had used the modern computer test and control technology to develop a new type of car body static stiffness measurement system ,taking the red car for example ,he had taken experiment on bending deformation and torsion deformation of a white car body . Wei jia-zeng had used the advanced computer test and control technology to develop a set of car body static stiffness measurement system, which could manually or automatically measure the static stiffness of a car body.Yuan li discussed the car body's static torsion stiffness test measurements ,including measuring method ,the determination of measuring load and measuring process. According to specific means , Zhong cui-xia measured the static stiffness of many model and the same model structures before and after revision by comparing the analysis ,she obtained the trends of the body bending stiffness and torsion stiffness .Zhang zhe-wei used the body stiffness test validate the correctness of the car body of the finite element analysis model established by him ,which laid the foundation for the future structure optimization .Chen jin-liang had established experiment model of the body and made the bodies of bending tests, and mastered the static characteristics of the body structure .however ,the constraints, loading position, data analysis, pre-load and other factors affect the result of a car body in white test ,very few articles are takenon these issues ,especially the load position and pre-load.

In this paper ,an automotive stiffness test system developed by our team would be used as a platform to test the bending stiffness and torsion stiffness of a car body in white . and we draw a conclusion on

the static stiffness of the body and discussed the effects of the location and pre-load on the bending stiffness of the car .

2. Car body stiffness test system

The test system included the stiffness of the test-bed body, sensors, signal conditioning, and optical isolation module, multi-function data acquisition card, computer, and so on(Fig. 1). Among them, the data acquisition card is NI PCI-6225,whose resolution is 16 bits and have a sampling rate of 250kS / s.It can be implemented in 80-channel analog signal acquisition; The displacement sensor is VOLFA of German, which has a stroke of 25 mm.Its linear precision is 0.1%, and the service life is 100 million times; force sensors is micro-pressure sensor, whose rated load is 2 t, comprehensive error is 0.2%. Sensors and conditioning circuits using separate program (Fig. 1(b)), the displacement sensor signal conditioning module provides a working voltage of 30V, the system measured the actual body deformation signal sampling error is less than 0.02 mm, signals the body to bear load the actual sampling error is less than 5 kg, to meet the test accuracy.

vehicle stiffness test site

signal conditioning box
Fig.1 Static rigidness measurement system of body-in-white car

The test system developed a stiffness test software with the help of Microsoft Visual Studio.Net 2003 and NI-DAQmx, it had the following four functions: 1) calibrate the displacement sensor and force sensor; 2) configure and manage different models of test parameters , test process and test report generation template;3)according to the predetermined testing , process to be automatic acquisition body each key point deformation data and record the testing process ;4)automatic generation of open format of the test results file and customizable test reports and documents .

3. Car stiffness test and its principles

This paper uses a total of 28 key parts of the body displacement sensors measuring the vertical displacement (Fig. 2), for the calculation of static stiffness to provide valid data. The bending and twisting modular, versatility , simple operation , time-saving and effort-saving ,was used to constraints the joints between the car body in white and front and rear suspension. Fig. 3 shows the bending stiffness of the test fixture assembly diagram, which could achieve the body of the "simple

beam" type of constraints ;pulled off the cylindrical pin in Fig. 3(a) then you could start white body torsion of the experiment .
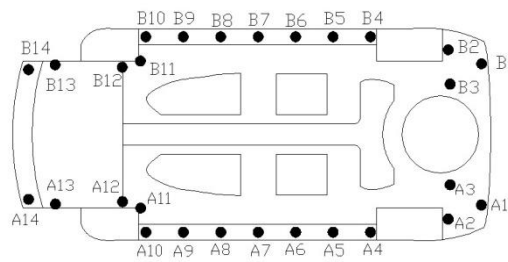

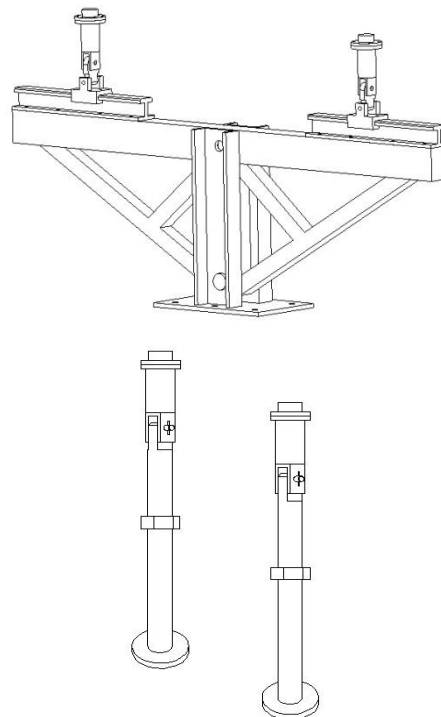Fig.2 Distribution of displacement sensors

Fig.3 Gripper stuctures of the car body

3.1 bending stiffness

Passenger vehicle of white body bending stiffness is measured by the ratio of F to the maximum bending deflection of the vehicle body load

$$W = \frac{F}{U_{max}}$$
(1)

Among them , W is the body of the bending stiffness (N / m), F is the body bending load (N), Umax is the maximum bending deflection (m).

3.2 torsion stiffness

Car body was assumed to a rod body with uniform torsion stiffness , the average car body torsion stiffness is calculated as :

$$GJ = \frac{M_T}{\Phi}$$
(2)

Among them : GJ is the torsion stiffness of car body (N · m / deg), MT is the car body of the torsion torque (N · m), Φ is the car body in reverse conditions between the front and rear shafts being relatively reverse Angle .

4. Results and discussion

First, making the bending stiffness of the experiment to study the effect of the load position and pre-load on the bending stiffness of the car, then go on torsion stiffness test according to a reasonable pre-load , finally draw the white body stiffness characteristics.

4.1 Analysis of bending stiffness

Loaded concentrated load in the body seat place(Fig. 4(a)), divided into 1500 N, 2200 N, 2800 N, 3550 N four grades. When the Pre-load is 200 N, the results shown in Fig. 5, where the abscissa is the relative position of the test measuring point, coordinate zero point before the suspension, front suspension points are moving back to negative, the vertical axis is the vertical displacement of the measuring point. Large parts of the deformation between the front and rear suspension and front load hanging around the front, which was related to the actual location of the binding site and load. The highest body in the vertical displacement of the maximum load is 0.17 mm, an analysis of its bending stiffness is 20882 N / mm.
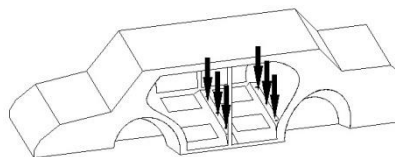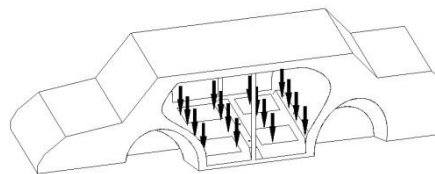

(a) concentrated load

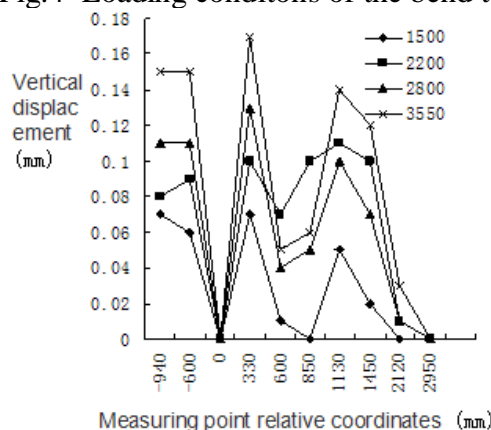Fig.4 Loading conditons of the bend test

Fig.5 Deformation profiles of the car body under bend test

Table 1   Experimental results under different preload conditions

Item	Scheme 1	Scheme 2	Scheme 3	Scheme 4
Pre-load(N)	1000	1500	2000	2500
Stiffness(N/mm)	16579	17292	20882	20000

Pre-load bending stiffness of the body affect the dialogue

In order to study the pre-load test results on body effects of bending stiffness, respectively, 1000 N, 1500 N, 2000 N, 2500 N four kinds of bending stiffness of the pre-load test, the results of the bending stiffness was shown in Table 1, which showed that when the pre-load was too small, body bending rigidity test results were not accurate, while the pre-load were 2000 N and 2500N, the test results trended to stable, so when doing the body torsion stiffness test, using 2000 N preload.

White body bending stiffness of the load position effects

For white body stiffness test load each enterprise has its own index, there is no accepted standard load. For this, our team had taken the concentrated load and uniform load two ways of bending stiffness test. And the results showed the analyses the uniform loading white body for bending stiffness was 22500N/mm, concentrated loads were only uniform load of 88.9%.

4.2 Analysis of torsion stiffness

when torsion stiffness of the body for testing, the pre-load at 2000 N, respectively, 1000 N · m, 2000 N · m, 3000 N · m, 4000 N · m torque for four levels of loading, loading method for the left side loading (clockwise) four times, the right load (counterclockwise) four times (Fig. 6).

Fig.6 Loading conditions of torsion test

Table 2 shows the two loading directions, the front and rear axle relative reverse angle of the test results under four torque levels, thus for the torsion stiffness analysis, the results shown in Fig. 7, visibly, clockwise and counterclockwise load stiffness curve change little in the average two test results, the torsion stiffness of the body is (5492 +5429) / 2 = 5460.5 N · m / °

Table 2 Experiment results of torsion test

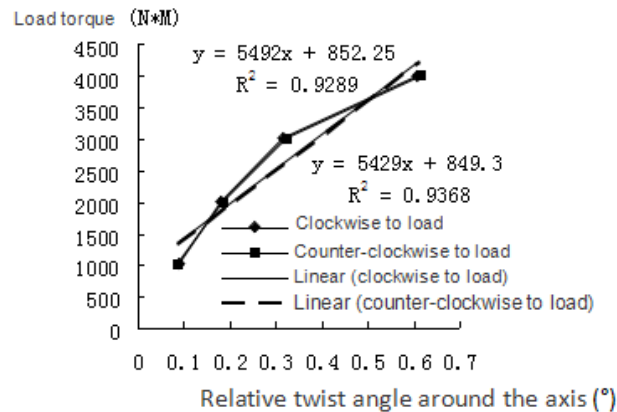| Torsion loading(N·m)	Clockwise twist angle load(°)	Load counterclockwise twist angle(°)
1000	0.0909	0.0888
2000	0.1829	0.1845
3000	0.3160	0.3261
4000	0.6103	0.6168

Fig.7   Torsion rigidness curves

5.   Conclusion

Based on self-developed car stiffness test platform, our team made a research on the static stiffness of a car body in white, the conclusions were as follows:

The test system is high accuracy, full-featured, using modular fixture body with front and rear suspension dialogue junction for binding, versatility, easy operation, saving time and effort;

(2) pre-load and load way had a great influence on result of the static stiffness of a car body in white, a reasonable pre-load White body stiffness test for White body stiffness test was 2000N, concentrated load of the bending stiffness of Bucharest are contained 88.9%;

(3) clockwise and counterclockwise load of the torsion stiffness curve has a good consistency, the body's torsion stiffness is 5460.5 N · m / º;

(4) In this paper, The research method used in this paper can also be extended to the static stiffness test analysis of other white body, which can provide reliable test data for the development of automobile body.

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