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Research on Skeleton Plate Flatness Detection Method Based on Laser Sensor

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Abstract: The flatness of the seismic isolation support skeleton plate determines the seismic isolation performance of the seismic isolation support, and in view of the limitations of the traditional measurement method in the engineering field, the use of laser sensor and computer-related processing technology is proposed to solve the problem of flatness measurement of the seismic isolation support skeleton plate. The laser sensor measurement can obtain the data of the skeleton plate plane, and use the relevant tools to calculate the difference between the maximum offset value and the minimum offset value from each measurement point to the ideal plane to obtain the flatness value. The experimental results show that the flatness measurement method of seismic isolation support skeleton plate based on laser sensor can quickly and accurately complete the measurement of skeleton plate flatness, with low requirements for engineering application environment and good measurement stability.

Keywords: Seismic isolation support skeleton plate, Laser sensor, Flatness.

1. Introduction

Earthquakes happen every day on Earth. Earthquakes often cause serious casualties and disasters [1]. However, the current state of technology is not yet able to accurately predict the arrival of earthquakes. For earthquakes, what we should do is to improve the seismic resistance level of the building, not predict earthquakes. Therefore, the development prospects of seismic damping and anti-seismic products are broad, and the flatness value of the seismic isolation support skeleton plate affects the safety and reliability of its work, so in the production process of the skeleton plate, it is necessary to strictly control its flatness to ensure the reliability of its use process. In terms of detection, the current traditional methods are mainly tactile measurement methods [2-3]. However, contact measurement will cause tool wear and human influence, resulting in low measurement accuracy and large error, which cannot meet the requirements of fast and accurate flatness measurement. In contrast, foreign testing equipment has mature technology and high measurement accuracy, but the price is also relatively expensive. Therefore, it is of practical significance to study a laser scanning flatness measurement method for flatness detection. In addition, computer vision and image processing technology are developing rapidly, so with the help of computers, the post-processing of data has also become convenient, fast and accurate [4]. For the measurement of the flatness of the seismic isolation support skeleton plate, the laser sensor can be used to scan the seismic isolation support skeleton plate to complete the acquisition of the plane to be measured and a large number of data points, obtain the spatial position of the relevant points, and then obtain the corresponding space plane by least squares fitting, calculate the distance from the point to the fitting plane, and complete the flatness measurement [5].

2. Organization of the Text

Laser displacement sensors mainly use laser triangulation to accurately measure workpieces. The principle of laser triangulation is shown in Figure 1. After the laser beam is emitted, it is irradiated on the plane to be measured by the converging lens, and the plane reflected light is irradiated on the detector. After receiving the laser beam, the detector obtains the displacement of the measured object from the reference by comparing it with the position change of the reflected laser beam from the set datum, that is, by image shift. Its derivation formula is as follows [6].

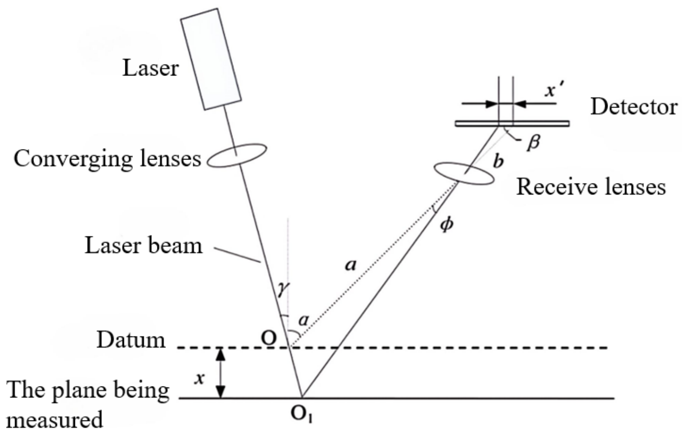

Figure 1. Schematic diagram of laser trigonometry

As can be obtained from Figure 1:

$$\frac{OO_1}{\sin\varphi}=\frac{a}{\sin(\alpha+\gamma-\varphi)} \tag{1}$$

$$\frac{x'}{\sin\varphi}=\frac{b}{\sin(\beta+\varphi)} \tag{2}$$

Comprehensive equations (1) and (2) yield:

$$\frac{x'\sin\beta}{OO_1\sin(\alpha+\gamma)}=\frac{b-x'\cos\beta}{a+OO_1\cos(\alpha+\gamma)} \tag{3}$$

As can be obtained from Figure 1:

$$x=OO_1\cos\gamma \tag{4}$$

Is available:

$$x=\frac{ax'\sin\beta\cos\gamma}{b\sin(\alpha+\gamma)-x'\sin(\alpha+\beta+\gamma)} \tag{5}$$

Among them, except for x', the other parameters are fixed constants of the sensor. Therefore, the image shift x' can be converted to the relative displacement of the measured surface x.

3. Algorithmic Analysis of Skeleton Plate Plane Measurement

The main methods for evaluating the flatness error of the skeleton plate of seismic isolation support are: three-point plane method, diagonal plane method, minimum area method and least squares method. [7] The ideal plane selected by the three-remote point method and the diagonal method does not comprehensively use the detected plane data, and the flatness error may cause a large evaluation difference according to the different reference data points selected each time, which is generally only suitable for flatness error measurement with a small number of plane distribution points and low plane accuracy requirements. [8] The minimum area method meets the minimum condition criteria formulated by national standards, and the calculated flatness error is the most accurate and unique, but its calculation process is complex and is mostly used for the operation of large and complex planar data points. The least squares fitting process makes full use of the sampled plane data points, the more accurate the number of accurate data points sampled, the more accurate the reference plane is fitted, and the calculation process is simple and fast, which can meet the requirements of real-time on-site detection. In summary, this paper uses the least squares method to calculate the flatness value of the skeleton plate [9-10].

4. Experiment

4.1. Experimental flow

The experiment first builds the skeleton plate flatness detection test platform, collects the skeleton plate plane image and the data of all measurement points through laser sensor scanning, and then preprocesses the data by the computer, selects and determines the ideal reference plane through data analysis, and finally calculates the data results of the measurement point and the ideal reference plane. In this experiment, the KEYENCE linear laser sensor was used to verify the feasibility of measuring the flatness of the skeleton plate of the seismic isolation support. In order to ensure the accuracy of the flatness measurement of the skeleton plate, two sensor detection heads are used for separate experiments, and the machine and main parameters are shown in Table 1. The hardware structure composition and function diagram are shown in Figure 2.

Table 1. Using machines and main parameters

	Option 1	Option 2
Sensor head	LJ-X8900	LJ-X8400
controller	LJ-8000	LJ-8000
Z-direction detection range	400mm	60mm
Line direction resolution	0.225mm/pixel	0.075mm/pixel

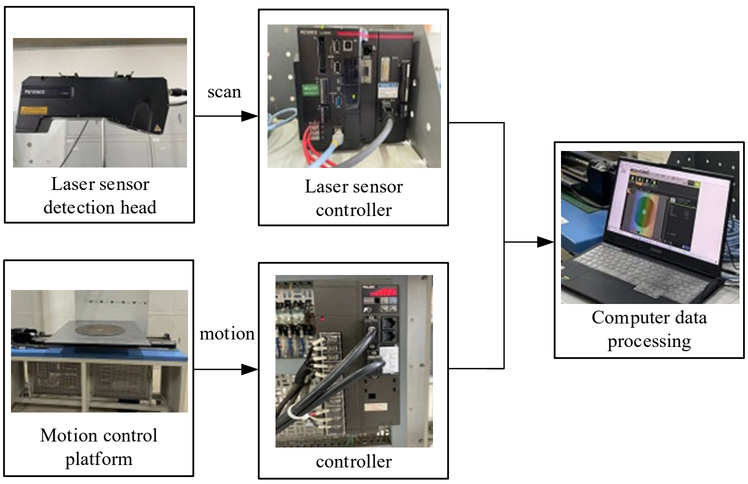

Figure 2. Structural composition and function diagram

4.2. Experimental results and analysis

The mounting erection of the seismic isolation support skeleton plate and its laser sensor in the experiment is shown in Figure 3. After scanning by the laser sensor, the scanned skeleton plate image and related data need to be processed, the detection image is shown in Figure 4, and the image analysis uses its own plane to simulate a reasonable plane, measure the maximum and minimum heights, and subtract to obtain flatness.

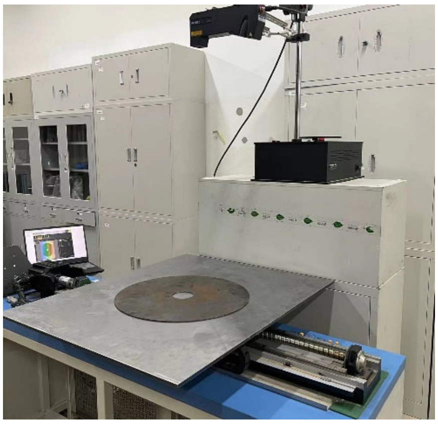

Figure 3. Skeleton plate flatness detection installation erection diagram

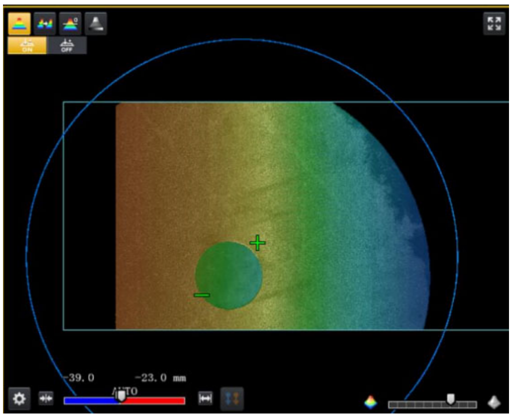

Figure 4. Skeleton plate flatness detection image

The experimental results are shown in Table 2. The average flatness of scheme 1 is 3.2683mm, the maximum value is 3.295mm, the minimum value is 3.222mm, and the repeatability is 0.073mm; the average flatness of scheme 2 is 2.8762mm, the maximum value is 2.895mm, the minimum value is 2.851mm, and the repeatability is 0.044mm. Therefore, the laser sensor can well realize the flatness detection of the skeleton plate. In addition, the laser sensor detection has the characteristics of fast measurement speed, high accuracy, large measurement range and low environmental impact, and can complete the flatness detection task of the predetermined function.

Table 2. Experimental test results

serial number	Scheme 1 detects flatness values	Scheme 2 detects flatness values
1	3.295	2.889
2	3.271	2.895
3	3.271	2.889
4	3.246	2.859
5	3.271	2.885
6	3.246	2.871
7	3.295	2.884
8	3.295	2.876
9	3.271	2.851
10	3.222	2.863
repeatability	0.073	0.044

5. Conclusion

According to the characteristics of the seismic isolation support skeleton plate, the data information of the skeleton plate plane is obtained by laser sensor scanning, and then the flatness value is accurately calculated. Since computers and related programs are widely used and can be calculated quickly, especially when measuring large planes, the number of data points is large enough, and the advantages of this algorithm will be further reflected. The flatness of the skeleton plate is closely related to the safety assessment of seismic isolation support, and has a certain degree of social value and practical significance.

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