Application of 3D Laser Scanning Technology in Monitoring Deformation of Port Trail

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Abstract: Qinhuangdao Port, as the main hub port for coal transportation from north to south, has become an important coal, oil and other energy export port in China. The port facilities are in continuous operation all the year round, especially in the peak period of coal transportation in the south. The maintenance and monitoring of the equipment are faced with such problems as heavy work tasks, poor working environment, many construction disturbances, and the influence of monitoring on port production. This paper mainly introduces the application of ground 3D laser scanner in building deformation measurement based on the deformation measurement project of positioning car cable track in the unloading department of coal terminal of Qinhuangdao Port. Through actual results illustrate using the ground three-dimensional laser scanner for high-risk, complex structure deformation monitoring operation is of field operation is simple, short construction period, small impact on the continuity of production equipment, complete data and reliable advantages of accuracy, which is the ground three-dimensional laser scanner in Qinhuangdao port for the first time application, for the future of 3 d laser scanning technology in the port risk measuring project and digital 3 d modeling and so on has certain reference value.

1. Introduction

Qinhuangdao Port, as one of the largest coal export ports in the world, is the terminal hub of Daqin Line. Coal is continuously transported to Qinhuangdao Port through Daqin Railway Line, and then unloaded by dumper and transferred to Marine freighters. The cable car track of the coal transport and unloading department plays such an important role in the whole coal transport. Therefore, it is necessary to regularly monitor the deformation of the cable car track of the coal transport and unloading department. The monitoring content includes four items: tilt of the supporting beam body, track gauge, superelevation and straightness. If using traditional measurement scheme of four kinds of deformation need to be measured, and measuring using prism and level ruler must be stationed in direct line in orbit, positioning hang rope track from the ground 5.5 meters, on-site construction vehicle cannot enter, can only use ladder finish the erecting of prism and level ruler, personnel fluctuation track will need about 1200 times, not only inefficient, affect the coal loading production arrangement, but also a serious threat to aerial work and high voltage cable operations personnel safety. Based on the above reasons, 3D laser scanning technology is introduced to monitor the track deformation of cable car in unloading department of port area.

2. Measurement data acquisition

Leica HDS6200 3D laser scanning system is used to monitor the track deformation of cable car in the
unloading department. According to the operation method of the whole field data acquisition, the basic steps of scanning at sub-stations first and then stitching in the internal industry are used. In order to ensure the monitoring accuracy, black and white target is used for stitching.

2.1. Establish local coordinate system and obtain target coordinates with high accuracy
In order to ensure the stitching accuracy of point cloud data, a total station should be used to establish a local coordinate system and measure the central coordinates of the target with high accuracy (Figure 1). When the total station is measuring the center point coordinates of the target, the distance between the center of the total station and the center of the target is generally 5~75m, and the maximum distance should not be more than 100m. The prism-free mode is adopted to measure the center point coordinates of the target. The cross wire in the eyepiece of the total station is used to aim at the center of the target and verify that the laser point is at the center of the target. When the total station measures the coordinate of the center point of the target, it measures in the set order, such as clockwise or counterclockwise, in the order of self-increasing. The starting point is selected as a specified point, such as the No. 1 point on the target board, for the convenience of marking the target. Each target was measured three times. If the difference was less than 2mm, the average value was taken. If the difference was more than 2mm, the measurement was taken again.

2.2. Free station laser scanning
Due to the restriction of the observation condition of the positioning vehicle, the laser incident Angle of the scanner is larger, and the intensity of the reflected light is relatively low. The reflectivity of one side is within 20 meters to meet the needs of the track deformation measurement. Combined with the 5 meter interval of the cable car track supporting beam body, the distance between the scanner set stations is controlled at 20 meters, that is, the interval of the 4 supporting columns. In this way, the scanning distance of one side of the scanner can be controlled within 20 meters, and the scanner only needs to be leveled. The target is generally set up in the middle of two scanning stations within a range of 20 meters from the scanner. The target does not need to be leveled and centering, but only needs to select an appropriate position to be placed steadily. In this way, the target can not only meet the requirements of the target Mosaic model, but also clearly observe and select the center point of the target on the 3D laser point cloud. After the total station observes the central point coordinates of no less than 3 targets of the station, the scanner can be used for scanning. High-density scanning is adopted during scanning. After the total station measures the target center, the target shall not be moved. If the target center is moved, it is necessary to re-observe the moved target center and then re-scan it. After the scan is completed, the scanner can be moved to the next station for scanning.

3. Measurement data processing
3.1. Point cloud data processing
After resampling and black and white target annotation of point cloud data, point cloud splicing is carried out. The splicing is to unify the point cloud scanned by field single station into a single coordinate system with target as control condition. After the splicing, the laser-point cloud data was homogenized to complete the preliminary data preparation, as shown in Figure 1.
3.2. Support beam tilt Angle extraction
The tilt Angle measurement of the supporting beam is to detect its tilt. It is assumed that the supporting beam is a rigid body structure without bending in geometric processing. A plane near the ground track of the beam body was selected as the detection plane, and the tilt of the whole supporting beam was reflected through the tilt of this plane. The specific method is to select a point on the column as the seed point, and use the method of regional growth to fit a plane on this side, and show the tilt Angle of the supporting beam through the Z-axis normal vector of this plane. It is stipulated that the tilt Angle to the south is positive and the tilt Angle to the north is negative. The small mileage is defined as close to the rollover (west side) and the large mileage is defined as far away from the rollover (east side). The observed data are shown in Table 1, and the statistical results are shown in Figure 2.

![Figure 2. Statistic Chart of Inclination Angle Deformation of Supporting Beam Body (Part)](image)

| Post code | Angle of inclination | Inclination Angle of Supporting Beam Body | Post code | Angle of inclination | Inclination Angle of Supporting Beam Body |
|-----------|----------------------|-------------------------------------------|-----------|----------------------|-------------------------------------------|
| 1-1       | 0.0002               | 0.0115                                    | 1-6       | 0.0039               | 0.2235                                    |
| 1-2       | 0.0001               | 0.0057                                    | 1-7       | 0.0044               | 0.2521                                    |
| 1-3       | 0.0003               | 0.0172                                    | 1-8       | 0.0061               | 0.3495                                    |
| 1-4       | 0.0009               | 0.0516                                    | 1-9       | 0.0023               | 0.1318                                    |
| 1-5       | 0.0041               | 0.2349                                    | 1-10      | 0.0087               | 0.4985                                    |

3.3. Gauge extract
The small-area growth method is used to fit a track side every 1 meter. The gauge value can be obtained by calculating the side distance of the same side of the I-shaped track of the cable car through software, as shown in Figure 3. The observed data are shown in Table 2, and the statistical results are shown in Figure 4.

![Figure 3. Gauge extract](image)

| The mileage | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|-------------|----|----|----|----|----|----|----|----|----|----|----|
| Gauge (mm)  | 796| 794| 794| 799| 800| 801| 801| 802| 803| 802| 796|
3.4. **Orbit ultra high extraction**

The bottom surface of the I-shaped track was selected as the detection surface, and the bottom elevation of the left and right sides of the track was measured at an interval of 1 meter. The method of small area growth was used to fit a track base, and the difference in elevation of two tracks was calculated. The right line of a pair of tracks is the benchmark, the left line is positive when it is higher than the right line, and the opposite is negative. Calculate the difference in elevation between the two orbits. The observed data are shown in Table 3, and the statistical results are shown in Figure 5.

| The mileage | 10  | 11  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ultra high (mm) | -2  | -2  | -3  | -2  | 2   | 9   | 2   | 4   | 5   | 5   | 3   |

![Ultra high orbital statistics](image)

3.5. **Track straightness extraction**

Track straightness is the measure of deviation from the straight line of the side points of the track with an interval of 1 meter, and is the measure of straightness deviation of three adjacent detection points. The straightness can be calculated by sampling the center coordinates of the orbit every 1 meter from the point cloud data. The observed data are shown in Table 4, and the statistical results are shown in Figure 6.

| The mileage | 10  | 11  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Orbit straightness (mm) | 11  | 5   | 1   | 2   | 1   | 2   | 11  | 7   | 12  | 6   | 3   |

![Track straightness extraction data](image)
4. Conclusion
In coal transport port operation environment, construction interference, monitoring more conflict with production operation environment, using 3d laser scanner to port key facilities, building deformation monitoring, field survey work is very simple, just in the unloading interval between two trains RACES mounted instrument for automatic scanning, auxiliary by total station instrument accurately measuring the target coordinates all the field work is completed. The construction period of the traditional survey scheme is about 10 days, and the unloading operation must be completely stopped during the survey operation, which has a serious adverse effect on the operation of the coal dumper on the Daqin Line. The 3D laser scanner was used to measure all the field work in one day without affecting the normal unloading operation of the unloading department of 9 company. 3d laser scanner for millimeter precision, point cloud data is huge amounts of data, improve the reliability of the deformation measurement results, the accuracy is better than the traditional measurement methods, which is the ground three-dimensional laser scanner in Qinhuangdao port for the first time application of 3d laser scanning technology for the future in the port risk measuring project and digital 3d modeling and so on has certain reference value.

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