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Application of Close-range Photogrammetry in Foundation Pit Monitoring

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Abstract:*I*n this paper, the deformation monitoring problem of subway pit construction is studied. And the feasibility of close-range photogrammetry method in foundation pit monitoring is studied.Through the simulation experiment to get the parameter index.This paper is based on the Shijiazhuang Metro Line 3 XI Sanzhuang station pit site measured, and then through the processing and measured data for comparison.The test show that: the error is less than ±2mm.The application of close-range photogrammetry in foundation pit monitoring is feasible.

1 Introduction

During the excavation and foundation construction of the deep foundation pit.It is necessary to monitor the deformation of the supporting structure to ensure the safety of the surrounding buildings and construction. The traditional geodetic method has many shortcomings: The measurement speed is slow[1-4].It can not be completed in a short time a number of deformation points of the measurement, and followed by the limitations of the site conditions.In addition, the use of the total station to implement high-precision measurement operations need to set up prism, which in many cases difficult to achieve, and cost a lot of manpower and resources. Close-range photogrammetryhas the ability to quickly obtain a large amount of physical information and geometric information of the measured object. It does not touch the measurement target when monitoring,and not affect the natural state of the measured object[5-6]. It can be carried out under relatively harsh conditions Measurem-ent operations.

Multi-baseline close-range photogrammetry Lensphoto v2.0, photoscan image post-processing software system, use ordinary camera obtain area of the image[7-8]. We can get images for 3D modeling, in principle, with four control points can be completed by the precise measurement of the shooting area and modeling[9]. At present, there are many applications in the slope deformation monitoring, large scale mapping and so on. And there are some studies in the foundation pit deformation monitoring[10-12]. Post-processing system based on Multi-baseline close-range photogrammetry software in the application of deformation monitoring as an example. Through simulation experiment to determine monitoring method, experimental measurements are taken at the scene of the foundation pit, combining the actual measurement data post-processing and comparison. To study the feasibility of its application and its accuracy.

2 Simulation experiment

2.1Camera calibration

Before the experiment, the camera should be calibrated. Camera calibration use the computer screen settings software given the grid. It s easy to operate. The purpose of the camera calibration is to calculate the camera's azimuthal elements: the main point coordinates x0, y0, camera focal length"f", distortion parameters k1, k2, p1, p2.

This paper checks the focal length of 28mm, 50mm lens. The camera used for canon ds126201.The camera to obtain the camera parameters shown in Tab.1.

Tab.1 Camera parameters

Focal length f(mm)	**Like the main point**		**Distortion coefficient**			
	x0	y0	k1	k2	p1	p2
31.522800	3.4905	0.8194	-1.212e-004	6.125e-008	4.183e-00	6.072e-00
51.296700	0.2837	-1.4383	-5.222e-005	1.421e-008	1.132e-00	6.529e-00

2.2 Control signs and control points

The canon ds126201 digital camera is used to simulate the outside of the building. The feasibility of the scheme is determined by changing the focal length of the lens and the number of control points and the number of factors.

The relationship between the correlation coefficient and the control point is shown in Tab.2, by changing the number of control points and the number of control points.

Tab.2 Comparison of results

Shooting distance	**Logo size**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Close distance (<3m)	3×3	0.735	0.811	0.810	0.811	0.815	0.814	0.813	0.813
	6×6	0.723	0.789	0.790	0.790	0.791	0.791	0.790	0.790
	10×10	0.712	0.790	0.789	0.791	0.791	0.792	0.790	0.789
	20×20	0.699	0.754	0.755	0.756	0.757	0.756	0.754	0.754
Long distance (20m)	3×3	0.584	0.611	0.612	0.613	0.613	0.614	0.612	0.610
	6×6	0.609	0.693	0.694	0.694	0.695	0.696	0.695	0.963
	10×10	0.690	0.725	0.725	0.726	0.727	0.727	0.727	0.725
	20×20	0.751	0.809	0.811	0.812	0.814	0.815	0.815	0.813

Through the simulation experiment: the foundation pit pile deformation monitoring long distance shooting selected 50mm focal length of the lens. The pit select 20×20 signs to meet the use of requirements. The road settlement， around the pit,use close-up shooting and the 28mm focal length wide-angle lens. Selecting 3×3 reflective film as a monitoring mark. When the control point is more than four, the correlation coefficient does not change much. In order to facilitate the operation, using the minimum number of control points is four.

3 Based on Lensphoto foundation pit deformation monitoring experiment

Project background: XI Sanzhuang station is located in Shijiazhuang City, South China Street, along the South China South Street is arranged north and south. The main length of the station is 219.50m.Width is 21.1m.The shield section is 25.3m wide. The thickness of the top center of the station center is 3.3m.

In the field monitoring, the camera is used to take pictures of the foundation pit wall. And the camera mode is rotated multi-baseline photography. Lensphoto v2.0 is used for data processing. The shooting distance is 20 m. There are four control points in the survey area and six monitoring points in the middle. Which the middle of the two monitoring points "2"and"5"arer the envelope of the bored pile. The deformation monitoring point of the foundation pit is shown in Fig. 1.With the ZT80 total station in the rear rendezvous way to measure the coordinates of the control point. Use Lensphoto to post-process the picture and enter the control point coordinates. The point cloud is obtained by qualitative processing. The processing of the generated point cloud can be measuredt,then get the coordinates of the point of we need. Use photoscan to process the resulting point cloud, as shown in Fig.2 .

Fig. 1 Deformation monitoring point

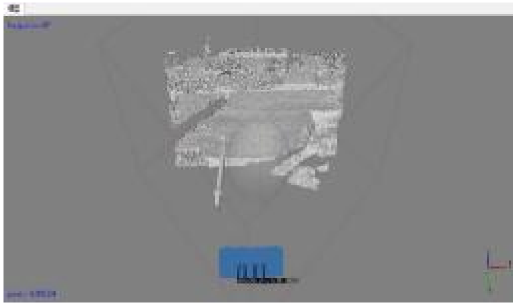

Fig.2 Foundation pit cloud

The subsidence monitoring of the surface around the pit is carried out using the same camera using the parallel shooting method for data acquisition. And then the same processing steps to process the data.

The deformation data of the foundation pit measured by the close-range photography method are compared with the measured data, as shown in Tab.3 and Fig.3.The comparison of the surrounding surface data with the measured data using the close-range photography method is shown in Tab.4 and Fig.4.

Tab.3 Comparison of pit deformation ratio table

Monitoring position	First deformation value (m)			Second deformation value (m)		
	Δx	Δy	Δz	Δx	Δy	Δz
C2 Pile top	-0.0012	-0.0008	-0.0017	0.0002	-0.0010	-0.0009
C5	-0.0002	0.0001	-0.0005	0.0009	-0.0006	-0.0001
Measured pile top	-0.0013	-0.0006	-0.0014	0.0011	-0.0023	-0.0002

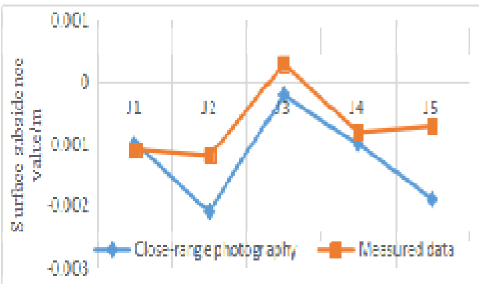

Fig.3 Comparison of pit deformation ratio

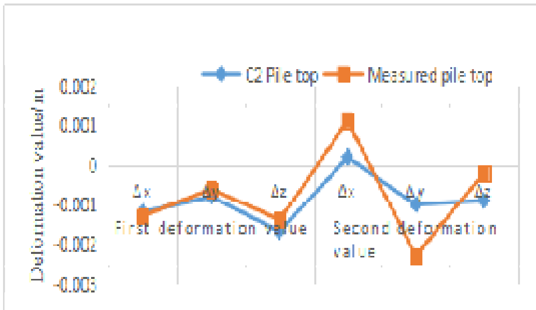

Fig.4 Surface Comparison

Tab.4 Surface Comparison Table

Monitoring method	J1(m)	J2(m)	J3(m)	J4(m)	J5(m)
Close-range photography	-0.0010	-0.0021	-0.0002	-0.0010	-0.0019
Measured data	-0.0011	-0.0012	0.0003	-0.0008	-0.0007

It can be seen from the comparison chart that the horizontal displacement, vertical displacement and the settlement of the surrounding surface measured by the close-range photogrammetry method are very different from the measured data. The maximum error is 1.3mm and the precision is satisfactory. And the use of close-range photogrammetry can be measured in the shooting area of any point of deformation such as point C5.And the measurement time is short. Consume less manpower and material resources. These are reflected through the experiment its outstanding advantages.

4 Conclusion

In this paper, it is proved that the close-range photogrammetric method is feasible for the deformation monitoring of the foundation pit and achieves high precision. Compared with the conventional foundation pit deformation monitoring method, this method has the characteristics of high automation, high precision and high efficiency.

Acknowledgments

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