Universe Scientific Publishing

ORIGINAL ARTICLE

Analysis of Tall Buildings Settlement Observation Process and Data Processing and Forecast

Yan Lv[1*] and Yi Zhu[2]

[1] College of Geometics Remote Sensing, Liaoning Technical University, Fuxin, Liaoning 123000, China

[2] Chinese Academy of Surveying and Mapping, Beijing 100039, China

ABSTRACT It is necessary to observe the deformation of buildings while they are constructed and utilized. Based on the practical requirements and combined with a real property, the thesis primarily discussed the processing researched for surveying of building settlement. Test and analysis of stability of the datum points. On the basis of the settlement difference calculated at intervals and the cumulative settlements, the curved p-t-s (pressure, time, settlement) diagram is plotted. For the buildings it is better with whole rigidity. By the analysis of settlement data, the mathematical model for the settlement, time and pressure is developed; some valuable results are obtained, which provide certain experiences for the practical projects.

KEYWORDS
Settlement observation
Processing method
Data analysis

1. Introduction

Building deformation observation project in China is still a relatively young science, in order to monitor the building during construction and use of safety, required in the course of the construction process and its deformation observation; on the other hand, in order to conduct scientific research and provide some empirical data for the foundation design in the future, but also the need for building deformation observation. The purpose of this study is based on real needs, high-rise buildings by the current settlement observation data obtained were processed and analyzed on the basis of prediction, provide the basis for a similar situation in the construction. This paper focuses on are: the deformation observation on the basis of the actual project by building settlement observation, thus calculated absolute settlement value of the building, with an average settlement value, the average sedimentation velocity of sedimentation value and time, the settlement value load analysis, which determined the relationship between the settlement value of the time, the settlement value of the load between on future projects have a certain significance [1,2]. In order to facilitate the guidance of actual work, now combined with internships in college faculty buildings.

doi: 10.18686/wcj.v4i2.3
Received: April 14, 2015; Accepted: May 23, 2015; Published online: June 27 2015

*Corresponding author: College of Geometics Remote Sensing, Liaoning Technical University, Fuxin, Liaoning 123000, China. E-mail: clsdau@126.com

2. Examples

2.1. Project Overview

College faculty is located on the 2nd floor of Jinan City, Shandong Swallow Road, it is the accumulation of the original slope foothills landscape units. Plant area undulating terrain, a ladder-like distribution, scarp more general southeast to northwest, the maximum height of about 7.28 m. Field area on the ground floor of the proposed faculty are 11 floors, basement. Frame-hear wall structure to be adopted, which corresponds to the underside of base load effect when standard combination of average pressure value 240 kPa, length of 41.50-69.50 m, width 16.50 m, the basic design of the bottom surface depth 121.51 m, intends to adopt pile foundation or raft foundation, site seismic fortification intensity is 6 degrees.

2.2. Engineering geological structure and foundation profile

The project site is remarkable period of 0.2194-0.2400 S, site soil is soft soil site, the venue for the class II construction site.

According to survey reports and regional geological data, the venue did not find faults and landslides, mudslides and other geological some adverse effects; rock layer present distribution is more continuous and stable region, its under-

lying bedrock is limestone, field area north of diorite rock intrusions, the space available for general construction.

According to site conditions and characteristics of the building, 12# building uses natural foundation, raft foundation, 11# building artificial digging pile group foundation.

2.3. Job execution specification

(1) "Building deformation measurement procedures" (JGJ / T 8-97)

(2) "Project measurement specifications" (GB 50026-91)

(3) "National one, second level measurement specifications" (GB 12897-91)

(4) "Building Foundation Design Code" (GB 50007-2002)

2.4. Detection alarm

Based on consideration of the safety of the building after the completion of construction and building security operations, according to engineering geology survey report data construction side, design and survey provided by the parties, combined with previous work experience, and with reference to the implementation of "building foundation design specifications "GB50007-2002 in 5.3.1, Article 5.3.2, Article 5.3.3, Article 5.3.4 provides that: building adjacent cylinder differential settlement should not exceed 0.002 L, foundations for buildings deformation characteristic value should not exceed an absolute settlement 200 mm, tilt ratio should not exceed 1/400, when it is judged likely to go beyond the "Building Foundation Design Code" deformation allowed value, it should be concerned parties early warning for timely analysis The reason, appropriate remedial measures [7,8].

2.5. Calculation and achievements within the industry consolidation

(1) Observation results of calculation, analysis, and statistical tests based on the principle of least squares principle to control network observation point adjustment calculation on the deformation measurement points were set analysis and the necessary physical explanation.

(2) The calculation and analysis of the measurement point observation results, in accordance with the following requirements [3,4]: if not contained in the observations overrun error, the observed value of the systematic errors reduced to a minimum; rational treatment of random error, correct distinction between measurement error and deformation information; the process more than the observed outcomes based on uniform reference; according to the different requirements of outlets, a reasonable estimate of the accuracy of observation results, the correct evaluation of the quality of results.

(3) The use of the tolerance test method to analyze the stability of the reference point, it is determined whether it is stable, to identify changes in point and amended.

(4) The adjustment leveling nets conditions while its height in the station each loop error is less than equal to the error in the value of the station elevation.

(5) calculated for each point of this settlement and the rate of change between the previous, while the cumulative settlement amount is calculated at each point in order to determine whether it is less than the daily settlement of 0.01-0.04 mm, and regression analysis and then hook painted points out settlement graphs to visually under-

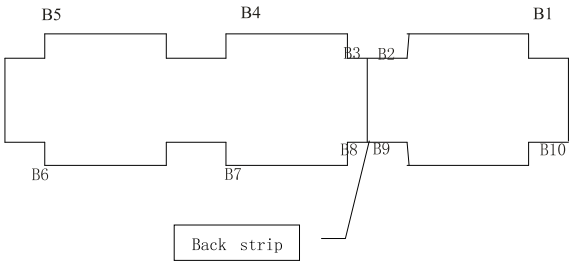

Figure 1. 11# Building pre-arranged points.

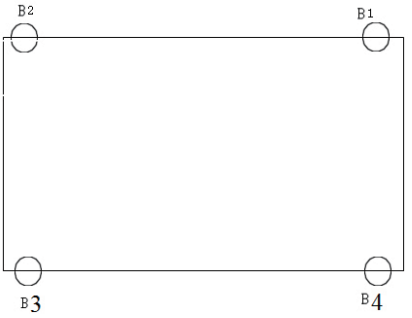

Figure 2. 11# Building late point arrangement.

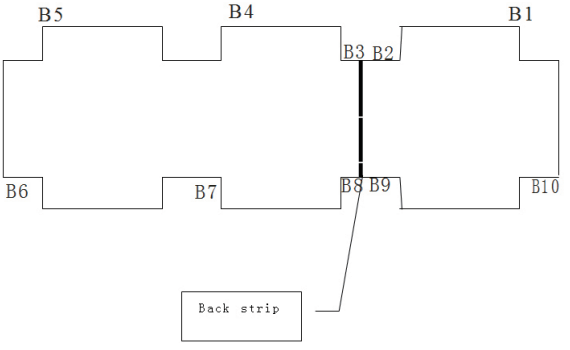

Figure 3. 12# Building pre-arranged points

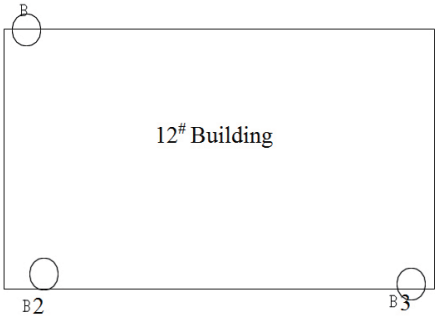

Figure 4. 12# Building late point arrangement.

stand the expected trends of each observation point, the development of a scientific basis for the subsequent settlement observations [5,13]. Settlement observation point floor plan as follows.

2.6. Settlement of Results Analysis

List all directions Wall poor poor list in each direction and tilt wall ratio was as follows [6]:

Table 1. Early works of 11# Building.

Direction	Poor (mm)	Tilt ratio
B5—B1	25.04	1/1657
B6—B5	14.69	1/1123
B6—B10	3.96	1/10479
B10—B1	6.39	1/2582
Maximum: B5—B1	25.04	1/1657

Table 2. Post-construction work of 11# Building.

Direction	Poor (mm)	Tilt ratio
B2—B1	0.46	1/90217
B2—B3	0.76	1/21710
B3—B4	1.08	1/38425
B4—B1	0.14	1/117857
Maximum: B1—B3	1.22	1/36557

Table 3. Early works of 12# Building.

Direction	Poor (mm)	Tilt ratio
B5—B1	11.26	1/6172
B10—B1	4.51	1/3658
B6—B5	4.38	1/3767
B6—B10	7.71	1/9014
Maximum: B1—B7	12.22	1/4009

Table 4. Post-construction work of 12# Building.

Direction	Very poor (mm)	Tilt ratio
B1—B2	0.79	1/20886
B3—B2	0.48	1/144791
Maximum: B1—B2	0.79	1/20886

As can be seen from the X^{max}–X^{min} Table:

Early works of 11# Building:

(1) Maximum Range of 25.04 mm, far less than the alarm value: 0.002 × 41500 = 83 mm

(2) The maximum difference of 25.04 mm, the inclination ratio: H / L = 25.04 / 41500 = 1/1657, far less than the alarm value 1/400.

Post-construction work of 11# Building:

(1) Maximum Range of 1.22 mm, far less than the alarm value: 0.002 × 44600 = 89.2 mm

(2) The maximum difference of 1.22 mm, the inclination ratio: H / L = 1.22 / 44600 = 1/36557, far less than the alarm value 1/400.

Early works of 12# Building:

(1) Maximum Range of 12.22 mm, far less than the alarm value: 0.002 × 49000 = 98 mm

(2) The maximum difference of 12.22 mm, the inclination ratio: H / L = 12.22 / 49000 = 1/4009, far less than the alarm value 1/400.

Post-construction work of 11# Building:

(1) Maximum Range of 0.79 mm, far less than the alarm value: 0.002 × 16500 = 33 mm

(2) The maximum difference of 0.79 mm, the inclination ratio:

H / L = 0.79 / 16500 = 1/20886, far less than the alarm value 1/400.

Each of the settlement amount, time Line Analysis as follows:

Load, the total settlement amount, time Line Analysis as follows:

2.7. Conclusions and Recommendations

From each of the settlement amount, the time line chart can be drawn: During settlement building, the House majority point, most of the time the settlement rate is relatively small settlement within a relatively small range of floating, however, there are some few points relative settlement is obvious, especially in seventh, tenth, fifteenth period, sixteenth and eighteenth mutation magnitude of data is relatively large, the expert analysis, the vast majority of this phenomenon the soil freezing and thawing actions, of course, the touch point move is also part of the settling velocity impact calculated as follows [8]:

Table 5. Points sedimentation rate.

Point No.		Sediment	
		07.01.17 (mm/d)	07.03.07 (mm/d)
11#	B1	-0.10000	0.005306
	B2	-0.11083	0.002653
	B3	-0.08833	0.011224
	B4	-0.09417	0.008980
12#	B1	-0.04833	0.007551
	B2	-0.09917	0.013673
	B3	-0.12000	0.007551

As can be seen from the table [10,11], each building body, the daily average volume of each settlement observation points in the tolerance specification 0.01–0.04 mm/d within the allowable range, and therefore, it can be concluded: the House of the settlement has been stabilized, can be delivered.

3. Summary

In the building design stage, should follow the require-

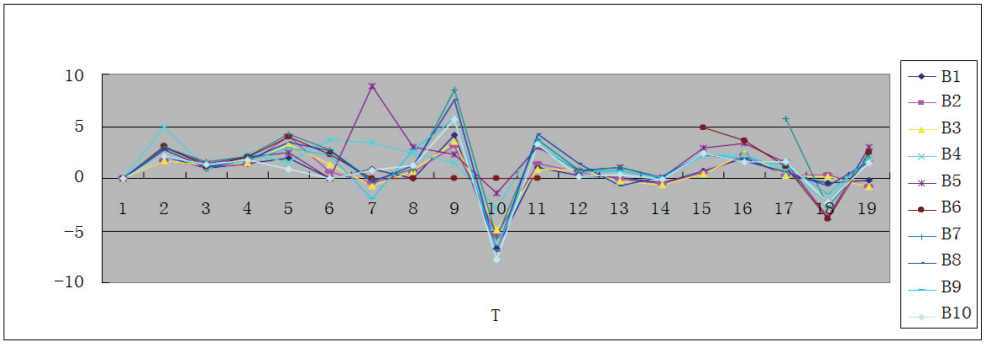

Figure 5. 11# Building pre-settlement time line chart.

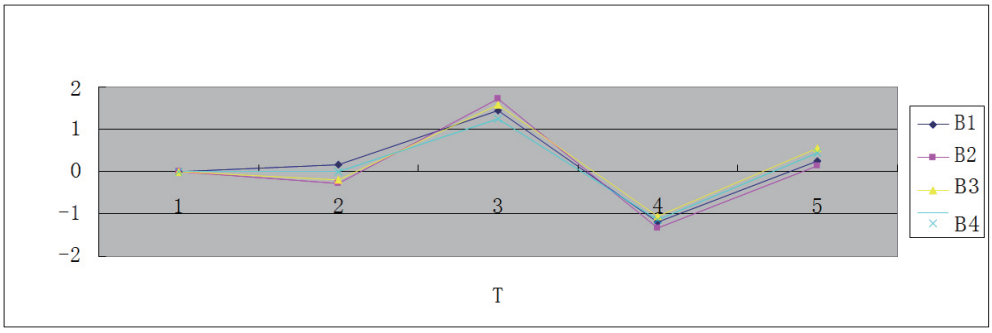

Figure 6. 11# Building late settlement time line chart.

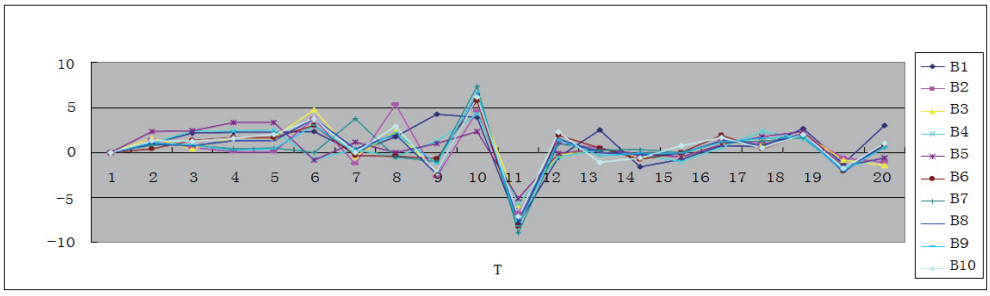

Figure 7. 12# Building pre-settlement time line chart.

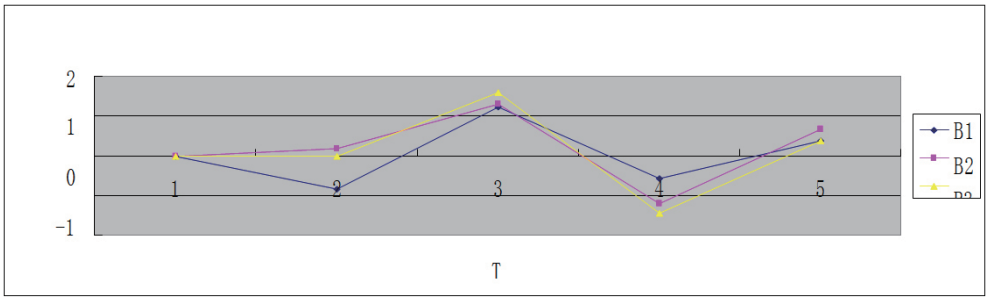

Figure 8. 12# Building late settlement time line chart.

ments of the relevant technical specifications and engineering in the perimeter and interior of the building should be a laying points. Geological factors, the structure and shape of the building, load and other factors, the overall consideration, rational layout, the first design and then implement. In particular observations, we must adhere to the "five-set" principle, so that during the measurement, always strictly comply with regulatory requirements, strict operating procedures, so that you can reduce the gross errors in the data. Reasonable choice of continuous observation period, blindly increasing the number of observations and shorten the period of observation, in order to avoid wasting manpower and resources. In data processing, the combination of these circumstances to keep abreast of settlement deformation of the building, if there are unusual circumstances, it shall promptly report to the authorities,

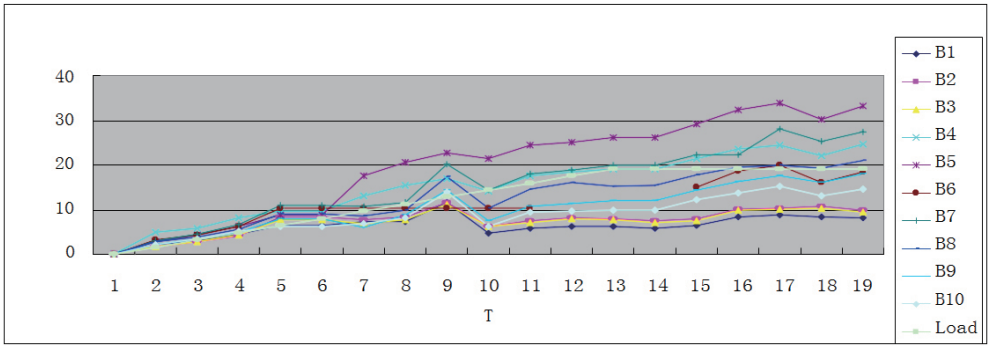

Figure 9. 11# Building pre-load, the total settlement amount, time line chart.

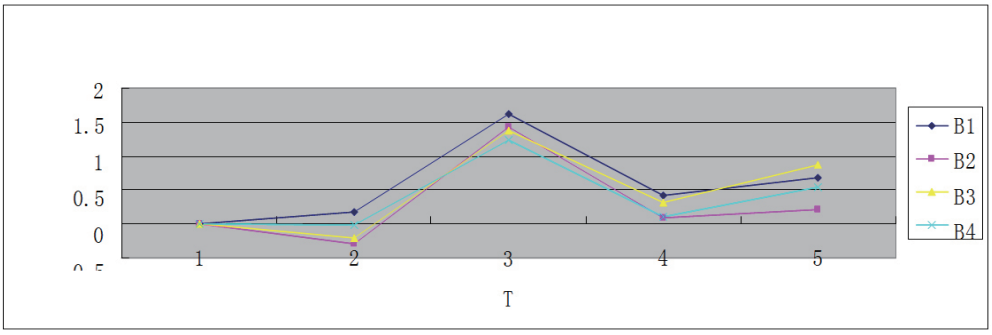

Figure 10. 11# Building late load, the total settlement amount, time line chart.

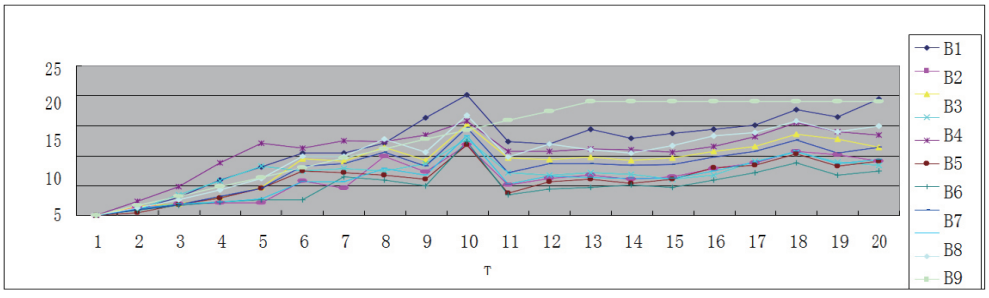

Figure 11. 12# Building pre-load, the total settlement amount, time line chart

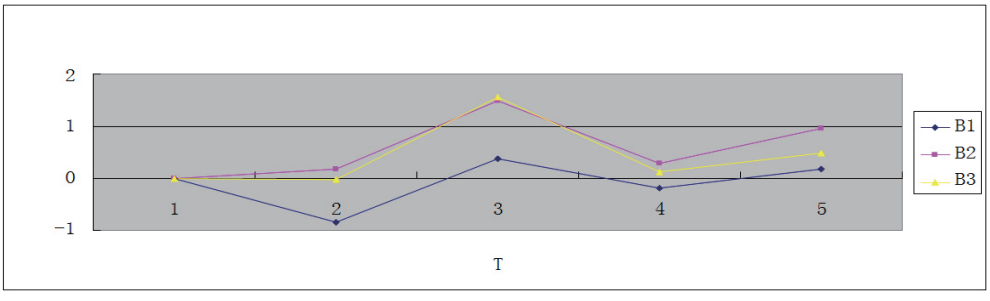

Figure 12. 12# Building 12 late load, the total settlement amount, time line chart.

should the construction units, supervision units and construction units to submit information on intermediate outcomes and final outcomes .

4. Problems and solutions on settlement observation often encountered

In the settlement observation often encounter some paradoxes, and manifested from the settlement versus time curve. For these problems, we must analyze the causes, treatment to be reasonable; common are the following phenomena [7].

4.1. Curve rebound phenomenon occurs after the first observation

The reason for this phenomenon, one may be the beginning of the measurement accuracy is not high; on the

other hand it may be caused by precipitation changes in the region's construction; construction area if it is caused by precipitation changes, this is normal. If it is because the initial test accuracy is not caused by high curves rise more than 5 mm, it should set aside the results of the first observation, while the use of the second observation results as the first test results, such as the curve of the rise in the 5 mm, can be adjusted at the beginning measuring elevation level consistent with the second observation

4.2. The curve in the middle of a sudden pick-up point

When this behavior occurs, mostly because the standard point or observation point was hit due to move, but was hit only when the movable front elevation and observation points lower than the standard point touch move was hit before being hit motion move higher. When the elevation, will rebound phenomenon may occur. Since the standard point or observation point is to disturb, damage its appearance must be relatively easy to find. As the standard point is to disturb, you can use other standard point to continue observation. Such as observation points move after being hit loose, you must separate laying of new points; if touch is still firmly fixed after point, you can continue to use, but because of elevation change on this issue must be a reasonable treatment, the approach is: Choose structure, load and geological conditions are the same observation point near another settlement, the settlement to take the points in the same period as the observation point is to disturb the settlement amount. Although this method does not truly reflect the settlement observation point, it is appropriate you select obtained results closer to the actual situation.

4.3. The curve gradually rebounded from a certain point

This phenomenon is generally due to produce the standard point of sinking due to such use provided in the standard point on the building, because the building is not yet stable and sink; or the new embedded standard point, due to the laying of improper place, time is not long, so as to cause subsidence phenomenon. When the level points are gradually sinking, and the settlement is small, but the initial building settlement amount is large, that is, when the building settlement amount is greater than the standard point, the curve does not rise occurs at a later stage, building sinking gradually stabilized, As standard point continues to sink, the curve will occur gradually rebound phenomenon. Therefore, when selecting or embedded standard point, especially when setting the standard point in the building, should ensure the stability of its points, as has been standard point for ascertaining the reasons sinking line should measure the subsidence level points to amend the observation point elevation.

4.4. Waves undulating curve phenomenon

In the late presentation undulating curve phenomenon, this phenomenon is most commonly encountered in the settlement observation. The reason for this is often not the building caused the sinking, but often is caused by measurement error. So in the early undulating curve is not obvious, because it is more than a building sinking of measurement errors, but by the late, since the building is minimal or sinking close to stable, so the curve on measurement error of the more prominent phenomenon . When dealing with this phenomenon, the whole situation should be analyzed according to the decision from a certain point onwards, the wavy curve into a horizontal line.

5. Curve interruptions

The reason for this phenomenon is that some observation points in the field do not have the viewing conditions, and produce leakage test cases, resulting in a settlement of this observation points no value, leaving the settlement curve interruption. In order to make continuous curve connecting together, in accordance with the processing curve point in the middle of a sudden rebound phenomenon approach, the estimated amount of the settlement is not obtained for the observation period.

In addition to the required content, the need to pay attention to the problem [12]: absolute distortion engineering buildings, is relative to a reference point in terms, but the observation point is determined by the point of work, working point and the reference point by absolute net (from the reference point and work together constituting point network called absolute net) linked, which produces the following problems: First, the reference point should be stable without moving, if not all does not move, there should be at least one group (a little vertical displacement observation, while the horizontal displacement observation is two points) is stable immobile, since the number of reference points are usually planted more than this number, which resulted in selection Which group is stable point of the problem; on the other hand, if the working point is stable, then the absolute distortion observation point is relative to the working point, then measured by the absolute networking point of the "displacement" is from the measurement errors cause, it is not necessary to calculate the correct value because the "displacement" of the observation point shift work basis points, but if proven to work by the inspection point is unstable, it is necessary to carry out this correction, which requires an inspection of the work by point It is stable and then make conclusions. The reference point setting, in addition to setting the bedrock of the impact layer and the expansion of land area, even if the reference point buried very deep, it is difficult to believe that they are stable. The need for a reference point stability testing and analysis. Not much to do described here.

Acknowledgements

In this paper, under the guidance of fellow teachers completed, give a lot of support and help in terms of data collection, access to literature. Sincerely thank in this process,

teachers and students to help guide. In academic research and personal life we got a lot of people on the guidance, support and friendship. Without their help, this paper will not be completed. Thanks also to the strong support in this data collection process, internships and teacher respect given.

Conflicts of interest

These authors have no conflicts of interest to declare.

Authors' contributions

These authors contributed equally to this work.

References

1. Hua, Z. Z. (1988). "Chinese-English dictionary of science and technology". *Nanchang: Jiangxi Science and Technology Press*.
2. Wu, L. D., & Deng, X. C. (1997). "Construction measurements handbook". *Beijing: China Building Industry Press*.
3. Tao, B. Z. (1984). Free network adjustment and deformation analysis. *Beijing: Surveying and Mapping Press*.
4. Measurement Adjustment Basis. (1996). *Wuhan: Wuhan University Press*.
5. Guan, Y. N., & Wang, Y. B. (2000). Probability theory and mathematical statistics, *Shenyang: Northeastern University Press*.
6. Li, Q. H., & Tao, B. Y. (1982). Probability and statistics theory and applications in measurement. *Beijing: Surveying and Mapping Press*.
7. Zou, S. L. (1991). Architectural engineering survey. *Wuhan: Wuhan University Press*.
8. Zheng, Z. S. (1995). Architectural engineering survey. *Beijing: China Building Industry Press*, *2*.
9. Bai, Y. L., & Lin, F. M. (1996). Architectural engineering survey. *Wuhan: Wuhan University Press*, *2*.
10. Rüther, H., Martine, H. M., & Mtalo, E. G. (2002). Application of snakes and dynamic programming optimisation technique in modeling of buildings in informal settlement areas. *Journal of Photogrammetry and Remote Sensing*, *56*(4), 269–282.
11. Akiyama, T., Ohsawa, K., & Watanabe, M. (1997). Compaction grouting for buildings suffering uneven settlement. *Geomechanics*, *2*, 95.
12. Sakai, M., & Muto, H. (1998). A novel deformation process in an aggregate. *A Candidate for Superplastic Deformation Scripta Materialia, 38*(6), 909-915.
13. Zhong, J. S., & Yang, S. C. (1995). A test of optimization of structures of buildings against ground deformations due to mining (in Chinese). *International Journal of Rock Mechanics and Mining Sciences & Geomechanics, 32*(5), 246.