Anomaly Analysis of Safety Monitoring Data of Shield Method Construction

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Abstract. Monitoring data is the important signal for safety situation decision of shield method construction. This paper analyzes the abnormal types appearing in safety monitoring data of shield method construction, and points out its caused by the environmental quantity anomaly, structure form change, misreading mistake, instrument error, and human negligence. Based on the test and analysis of the abnormal monitoring data, it considers the monitoring data as abnormal value if the monitoring data beyond the confidence interval. And then uses the theoretical model to eliminate the observation error and systematic error. Furthermore, this paper analyzes the reasons of abnormal of the shield method construction settlement monitoring data, displacement monitoring data, shaft force monitoring data, deep horizontal displacement monitoring data, the water level monitoring data according to theory above.

Monitoring data is an important signal of determine the shield method construction safety situation, its accuracy directly affect the evaluation result [1]. The abnormal of the subsidence, horizontal displacement monitoring, deep horizontal displacement monitoring, axial force monitoring and water monitoring data are all attribute to narrow and complicated of the shield subway construction site. It should analyzed according to the data types and anomaly genesis as well as its surrounding environment change and construction progress, because the abnormal values are not all gross error or human error, so as to ensure the safety of shield construction method.

Safety Monitoring Data Exception Type

Abnormal environment quantity, morphology changes, misreading mistake, instrument error and human negligence are all reasons to cause abnormal monitoring data [2, 3]. Therefore, it requires a combination of construction environment and other factors on the systematic analysis of outliers. And eliminates the error, identifies human errors and so on, pays close attention to changes caused by the abnormal structure form. Usually, monitoring abnormal value of deep subsidence, horizontal displacement, axial force, horizontal displacement, water level monitoring project are divided into the following several.

Abnormal Subsidence Monitoring Data Types

(1)Subsidence data mutates while external environment exists no abnormalities;

(2)Settlement data presents the phenomenon of when liters down while external environment exists no abnormalities;

(3)Settlement deformation mutates while external environment exists abnormalities.

Abnormal Displacement Monitoring Data Types

(1) Displacement data mutates which show the monitoring stations appear larger displacement while external environment existing no abnormalities;

(2) Displacement data presents the phenomenon of when liters down while external environment exists no abnormalities;

(3) Shaft deformation amount mutates while external environment exists abnormalities.

Abnormal Axial Force Monitoring Data Types

(1) Axis force data mutates which show the monitoring stations appear larger displacement while external environment exists no abnormalities;

(2) Axis force data presents the phenomenon of when liters down while external environment exists no abnormalities;

(3) Shaft deformation amount mutates while external environment exists abnormalities.

Unusually deep horizontal displacement monitoring data types

(1) Deep horizontal displacement data mutates which show the monitoring stations appear larger displacement while external environment exists no abnormalities;

(2) Deep horizontal displacement data presents the phenomenon of when liters down while external environment exists no abnormalities;

(3) Deformation of deep horizontal displacement mutates while external environment exists abnormalities.

Abnormal Water Level Monitoring Data Types

(1) Deep horizontal displacement data mutates while water monitoring data shows greater change when pit exists no abnormalities;

(2) The amount of change in water level upheavals while pit existing no abnormalities.

Monitoring Data of Abnormal Cause Analysis

If the measurement data beyond the confidence interval, it thought to be outliers, and outliers should contact the surrounding environment and construction conditions further concrete analysis. Observation error and systematic error related theoretical model can be used to eliminate the error, to get accurate value.

Subsidence Data Anomaly Genesis Analysis

(1) External environment without exception, the monitoring data of mutation. First we should analyze deformation surrounding the construction environment change, Add and subtract inside the support in the foundation pit, precipitation is normal, Can analyze the work basis points or the stability of the monitoring points, if the work of subsidence sink or work basis points rate is faster than monitoring leads to monitoring the overall rise phenomenon, secondly, when Initial monitoring error is bigger may cause abnormal monitoring data next time; May also man-made destruction spot, or the instrument itself, if these conditions do not exist, we should set foot is not straight, human touch dynamic instrument factors such as looking for reason

(2) The successive data curve wave fluctuates while external environment existing no abnormalities. First we should analyze the instrument, if the data changes gently, it may be affected by system error, atmospheric refraction, earth curvature, they prominent in summer commonly, observed in a timely manner to the instrument protection measures; Secondly, its monitoring with mulch not keep clear of in time, makes the monitoring data bigger than last time, it appears rise phenomenon, while mulch is cleared in later monitoring, lead monitoring data rising and down at time [4]. Again, its deformation is less than the measurement error, usually at the beginning of the observations and stand out late. In addition, But also from should stand feet is not straight, human touch instruments as factor analysis.

(3) The SETTLEMENT exists abnormal values change while external environment exists abnormalities. If the work basis points and the monitoring stations in good: when rains outside and the previous period data is correct, monitoring data than the previous rise within 1~2 mm can think is right. Due to soil and water pressure, make the earth's surface. Artificial support strengthening, causing them to monitor data changes, such as steel support after excavation, the tunnel roof support, the springback amount within 1 mm can think right[5, 6]. Tunnel and foundation pit during unloading, monitoring will send smaller sink, generally within 2 mm. If the above several are not

consistent, the analysis should be human factors or instrument.

Displacement Data Anomaly Genesis Analysis

The environment without exception, the displacement data mutation, mainly reflected in the large displacement monitoring points presented. Firstly, we should calibration the work basis points and the stability of the datum, if work basis points and the datum are not stable, it will produce a great impact on the monitoring results, then the monitoring data of mutations, general integrity of variability. Secondly, it should patrol monitoring points, for the construction site of the foundation pit is narrow and complicated, so the monitoring is easy to be impacted, causing the monitoring data to be abnormal. Geological conditions, generally great mobility of sand soil, the excavation unloading, and the stress release is rapid, makes the palisade structure produce different degree of moving into the foundation pit, because of the influence of foundation pit supporting, the horizontal displacement of pile head is commonly move outside the foundation pit, and the bottom of the retaining structure deformation direction. On the other hand, if by retaining structure dorsal XuTu or silt soil, the displacement of deep all outward migration, at the bottom of the top displacement and displacement are consistent, the top or the cumulative displacement deformation rate were greater than the bottom deformation rate and cumulative changes generally[7, 8]. If the geological condition is good, middle deformation is often larger than other side, by continuous wall at the bottom of foundation pit to move into the foundation pit generally smaller, top moving outside the foundation pit, with deep displacement monitoring of mutual authentication.

(2) No abnormal situation of environment, data of the displacement mutation the monitoring accidental error and system error are all the reasons that cause this kind of situation.

①The instrument error (error system).

②The instrument of the error

$$M_{中}=\frac{\rho\times e\times S_{AB}}{S_1\times S_2} \tag{1}$$

In the formula

e——Eccentric distance.

S1——To view direction after between the length of the test site;

S2——Test site to the maximum distance monitoring regulations.

③Target eccentric error

$$m_{偏}=\frac{\rho\sqrt{(\frac{e_1}{S_1})^2+(\frac{e_2}{S_2})^2}}{2} \tag{2}$$

Accurate expression is abbreviated as:

$$M_D=\pm(A+B\times D) \tag{3}$$

In the formula,

D——Measured distance,km;

A——Fixed error,mm;

B——Percentage error coefficient,mm/km.

① Establish a fixed point (X, Y) and Angle (beta), distance (D) of the several relation between:

$$X=D\times\cos\beta \tag{4}$$

$$Y=D\times\sin\beta \tag{5}$$

② The above several relation between total differential, the true error equation：

$$\Delta X = \cos\beta \times \Delta D - D \times \sin\beta(\Delta\beta) \tag{6}$$

$$\Delta Y = \sin\beta \times \Delta D + D \times \sin\beta(\Delta\beta) \tag{7}$$

③ According to the law of error propagation of error square equation:

$$M_X{}^2 = M_D{}^2 \cos 2\beta + D \times 2\sin(2\beta) \times M_\beta \times \beta \tag{8}$$

$$M_Y{}^2 = M_D{}^2 \sin 2\beta + D \times 2\cos(2\beta) \times M_\beta \times \beta \tag{9}$$

(3) Displacement data will mutation while external environment existing abnormalities compared with previous data. Abnormal situation general foundation pit appear dangerous, In general, displacement monitoring will produce larger deformation, generally reflect subsidence in small area, Reasons include the foundation pit is leaking, excavation speed too fast, supporting not in time.

Axial Force Data Anomaly Genesis Analysis

(1) The surrounding or other monitoring project has no obvious change, axial force meter or strain gauge is abnormal. Concrete support: Lack of concrete support the age, condensation of concrete hardening process can produce contraction deformation, lead to the strain gauge reading increases, the strain gauge reading all considered in the process of calculating concrete strut axial forces increase(the increase of the actual axial force is less than calculated on strain and axial force). In addition, the influence of temperature has great influence on concrete strut axial forces, especially on support benchmark, the ability after must be stable, and monitoring of every period under the condition of constant temperature as far as possible.

(2) The axial force meter or strain gauge is abnormal while the surrounding or other monitoring projects have changed. General situation is mainly due to the excavation of earthwork excavation unloading speed too fast, the phenomenon such as severe overbreak, lateral earth pressure increasing, the support system supporting, not in time lead to deformation of foundation pit system is too large, axial force changes.

Deep Horizontal Displacement Data Anomaly Genesis Analysis

Inclinometer is divided into activity type and fixed type. It consists of the probe, reading meter, cable, dip tubes.

(1) Deep horizontal displacement data when liters down while the external environment existing abnormalities. Various monitoring instrument its precision, generally if the foundation pit is in a state of stability, due to monitor the calculation principle of the clinometer from each measuring point error accumulation at the bottom of the bore to the orifice, so the error is greater than the deformation value, lead to monitoring data back and forth, different precision instruments, general control in less than 1 mm.

(2) The deep horizontal displacement deformation and runs counter to the conventional when the outside world without exception. First of all, according to the principle of the survey, the accumulation of each point offset, from the bottom of the hole accumulation plan or from the orifice, monitoring error, at some point if it leads to the various points on all can produce human error, generally can only from the data analysis, the mutation point of each measuring point above produce consistent large change, mutation point all of the following all have small changes [9, 10]. Secondly, a dip hole, its a lot of monitoring points, general monitoring of the deformation in a continuous change, Curve is a gradient curve. Again, if the monitoring data, in contrast to the previous data symbols, if the dip hole are not ideal vertical state, monitoring can be thought of as positive and negative direction wrong.so analysis data is the reasons should be considered.

(3) The deep horizontal displacement deformation upheaval while the outside world have abnormal situation. Firstly, we should analysis the geological conditions through the engineering practice, the different geological conditions lead to deep horizontal displacement change value,

especially the sand soil, gathered force is small, The excavation-unloading, the stress release, retaining structure deformation time shorter[11], if not to support in time, in a short period of time beyond the alarm value of the deformation and the structure of foundation pit and surrounding, general unloading deformation in one or two days more than 10 mm. Earthwork excavation speed too fast, support is not timely, especially in Yang angular position, the deformation is more obvious. For retaining structure is leaking, causing soil and water around the pressure decreases, break the balance, foundation pit supporting system to produce corresponding outside the foundation pit deformation of retaining structures and corresponding supporting axial force decreases, generally if the leaks are not blocked in time, the retaining structure has been outward migration, in general, variable range 1 ~ 4 mm.

Water Level Anomaly Genesis and Data Analysis

(1) The water level data mutation while foundation pit has no anomalies, the water level data mutation, Performance for monitoring large movements. Firstly, analyzing whether the weather do effect, such as the influence of monitoring before the heavy rain. Secondly, analyzing whether precipitation around the site constructed, or artificial mass collection of groundwater, etc. Additionally, analyzing the water pipe again, or drainage pipes or pipe burst, drowning in underground water level. Finally, analyzing whether or not to clean the construction site, using high pressure water cleaning, this also one of the main reasons that the construction site often lead to the sharp rise or fall of the underground water.

(2) The change of the water level deformation is bigger while the foundation pit have abnormal situation. When excavation site visits, we should observe whether the pit is leaking, foundation pit water results in the decreasing of groundwater level drawdown is ever one of the main reasons.

Conclusion

According to engineering practice, monitoring data often appears abnormal situation, putting forward the type of outliers occur: (1) The observation data mutates while the external environment exists abnormalities compared with previous data, characterized by the observation data of the monitoring stations have bigger rise or fall; (2) Monitoring data exists when liters down in few of the continuous data and change trend with the waves while the external environment exists no abnormalities. (3) The amount of deformation is contrary to the conventional while the external environment existing abnormalities. The ways of analyzing the routine surveillance of shield method construction project, including the vertical displacement and horizontal displacement of deep horizontal displacement, strut axial forces, the cause of the underground water level monitoring data exceptions, which shield to ensure construction safety is of great significance.

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