Preliminary Discussion on Monitoring of Steel Support Axis Force in Metro Engineering

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Abstract. Axial force monitoring of steel support is one of the important factors for foundation pit safety monitoring. In the monitoring of steel support, there are many problems, such as unreasonable installation of axonometer, irregular monitoring behavior of axonometer, incomplete analysis of axial force and imperfect early warning system. Collecting many engineering cases, and in-depth analysis and research on the problems and irregular behavior of steel support axial force monitoring in every link. The influencing factors and control measures of steel support axial force are discussed in detail, and some useful conclusions are obtained. It has been applied in the actual monitoring work and achieved good results. It is of great significance to guide subway safety construction and promote the development of axle force monitoring industry.

1 Introduction

Steel support has the advantages of rapid installation, disassembly and support, so it is widely used in the support system of subway foundation pit construction. However, how to effectively and accurately monitor the axial force of steel support has always been the focus and difficulty in the field of deformation monitoring. The steel support axial force monitoring generally uses a vibrating string axial force meter and a frequency reading instrument, and the technology has been relatively mature. Actually, in the actual on-site monitoring of axial force, due to insufficient safety awareness of construction units, incomplete professional knowledge of monitoring units and confusion of management work, the monitoring of axial force often fails to achieve the desired results. Therefore, in the deep foundation pit steel support axial force monitoring, how to ensure the accuracy and reliability of the monitoring data is very important.

2 Significance of Axis Force Monitoring

The foundation pit excavation, along with the large amount of earthwork transported abroad, the whole supporting system will be deformed under the action of external comprehensive force. Since the steel support acts directly on the enclosure structure, therefore, the magnitude of the axial force on steel support is one of the most direct forms of deformation of the retaining structure; it is also one of the characteristics reflecting whether the calculation results of the supporting structure and the construction conditions meet the relevant technical standards. By monitoring the axial force of steel support, the stress of the steel support can be known in time, so as to judge the stability and safety of the foundation pit and ensure the safety of the foundation pit construction. When the axial force monitoring data is too large, take effective control measures in time to avoid safety accidents and the axial force data is too small, the prestress is added in time to make the steel support play its supporting function at the fastest and maximum extent, so as to avoid the falling of the steel support and the excessive deformation of the foundation pit. In addition, the axial force monitoring results are fed back to the design unit to provide the data basis more in line with the actual situation of the project, so as to adjust and improve the adverse situation of the site construction.

3 Existing problems and control measures

3.1 Axial Force Meter Installation

Due to the lack of safety awareness and the lack of attention paid to the monitoring work, the installation of field axial force meter is often not standard, leaving hidden trouble for the follow-up monitoring work.

(1) Installation of steel purlin...
After backfilling, the compactness of concrete is not up to the standard, which can easily lead to the loss of steel support axial force too fast, resulting in insufficient pre-loading force; the quality of steel purlin is not up to the requirements, and the steel purlin will be greatly deformed in the process of strengthening.

Steel purlin should be installed strictly in accordance with the requirements. After the installation is completed, the concrete should be backfilled to ensure that the steel enclosing purlin is closely connected with the foundation pit structure. Strictly control the quality of steel purlin, add a piece of steel plate (specification 250mm * 250mm * 25mm) between the axial force meter and the steel purlin to prevent the steel purlin from large deformation in the process of steel support force.

(2) Apparatus for exerting force

The jack device applying the force is not regularly verified or calibrated, and the jack is not matched with the oil meter, resulting in a big difference between the steel support axial force calculated by oil meter reading and the actual monitoring axial force value. Large axle force loss occurs after the jack is disassembled [1]. The axial force booster is regularly checked and maintained, and the booster must be used together, and should not be assembled and mixed without authorization. When applying the force, the law of axial force loss after the jack disassembly should be summarized, and the prestress should be appropriately increased to ensure that the axial force meets the design requirements.

(3) Axis Force Meter Range

The range of the axial force meter is often ignored during the installation of the axial force meter, and the axis force meter is chosen randomly to install, which results in the measuring range of axial force meter in the later period does not meet the actual monitoring requirements.

The measuring range of the axial force should be 1.25 times of the designed value of the axial force meter. If the design value of the axial force of a steel support is 800 kN, the measuring range of 1000 kN should be selected. It is not appropriate to measure the axial force too large or too small. Therefore, in the purchase of axial force meter and site installation selection should be strictly in accordance with the requirements of the design documents, and do a good job of technical disclosure.

(4) Installation position is unreasonable

Installers selfishly adjust the installation position of the axiometer or forget to install the axiometer, which results in the lack of data in some key parts or the failure to form a monitoring section with other monitoring points. After the installation of the axle force meter, the axes are not aligned with the axes of the centre of the steel support, which easily causes additional bending moments and other problems.

Axial force monitoring points should be placed on the same monitoring section as horizontal displacement of pile or wall, surface settlement and other monitoring points. Each support in the vertical plane should be equipped with measuring points to provide data support for the later analysis. When installing the axial force gauge, use the mounting bracket to ensure that the axis of the axial force gauge and the centre line of the steel support coincide, ensuring that the contact surfaces are flat, so that the steel support can transmit force through the axial force gauge [2].

(5) Operation process

When the axial force gauge is tested after installation, there is a phenomenon that the axial force gauge is damaged. Carrying axle force meter gently and heavy pressure is strictly prohibited. Before installing the axial force meter, check whether the components of the axial force meter are working properly. The installation of the axial force meter should be carried out by hooking the mounting bracket with a wire, and it is forbidden to directly pull the axial force cable to move. When applying the axial force preload, the prestressing force should be graded strictly according to the design requirements, so as to avoid the damage of the monitoring element caused by one-time preload, and make a detailed record of in the process of the preload.

3.2 Axial force monitoring process

The non-standard operation behavior of monitoring units will also have a great impact on the accuracy of monitoring results. How to effectively implement control measures to improve the accuracy of monitoring data is the top priority of monitoring work.

(1) Selection of Monitoring Instruments

The performance of the frequency reader is unstable, and the frequency reader was not used within the calibration time range. When purchasing the frequency reader, we should select the instrument which can meet the requirements of monitoring accuracy and measuring range and has stable and reliable performance. In the process of monitoring, an instrument manager should be set up to take charge of the custody, maintenance and check of the instrument and equipment. At the same time, the instrument management account is established, including the instrument specifications, performance, accuracy verification, use, repair and transfer of acceptance records. Ensure the performance of monitoring instruments meet the requirements of field monitoring.

(2) Determine the initial frequency

There are drawbacks in using the zero load frequency reading on the quality inspection certificate of axial force meter as the initial frequency [3]. Because of the interference of such factors as the faulty certificate of the axial force meter, the damage of the axial force meter in the transportation process, the high or low temperature on the spot, the axial force meter must be tested before it is installed. When the difference between the monitoring frequency and the calibration frequency of the verification certificate is <±20Hz, the initial frequency of the axial force monitoring can be either the calibration frequency of the qualified certificate or the on-site test frequency. If the difference between the two is large, the axial force meter needs to be re-calibrated or the axial force meter that meets the requirements needs to be selected.

(3) Monitoring component performance
Monitoring element performance instability leads to abnormal data and other conditions. When it is found that the reading of the frequency meter is flickering constantly or the axial force data is unstable, or the data of the axle force measuring value is abnormal, the axle force component may have been destroyed and the calculation model of the axle force has changed. The monitoring unit should report in time and hold the data abnormal analysis meeting urgently to find out the cause of the abnormal data. After confirming the damage of the axial force meter, a steel support should be added to the adjacent position and an axial force meter should be installed for normal monitoring.

(4) Monitoring frequency

The problem of insufficient monitoring frequency exists in pure manual axial force monitoring.

Axis force monitoring frequency is usually 1/d or 2/d. Manual data acquisition is instantaneous and random. The collected data is easily affected by the complex construction environment on site, which brings difficulties to data analysis and judgment. Therefore, it is necessary to increase the monitoring frequency, and actively develop and promote the automatic real-time monitoring system of steel support axial force under the condition of conditions, so as to obtain massive data in real time and provide effective evidence for data analysis, steel support and safety state assessment of foundation pit [4].

(5) The environment temperature

The axial force varies greatly at different temperatures.

The monitoring of steel support axial force should be carried out in the same time period of temperature, and the temperature measurement results should be recorded at each reading, so as to avoid the large influence of temperature difference on the support axial force results. If the span time of axial force monitoring is long and the temperature change interval is large, a function model of the relationship between temperature and axial force should be established to modify the temperature of axial force data [5].

3.3 Processing and analysis of monitoring data

In the process of axial force data processing and analysis, it is necessary to fully consider the influence of various factors on the monitoring results, comprehensively judge and give scientific and correct conclusions and benign construction suggestions.

(1) Artificial interference factors

Human factors lead to errors in data recording and calculation, and incomplete data analysis. In the steel support stress system, the steel support only has the compression state, does not have the tension condition. When the final axial force is tension, the axial force value is obviously wrong and does not conform to the actual situation of the project. All monitors must be certified, and the company should regularly carry out technical training and assessment. At the same time, the project department should strengthen the audit of original data, calculation process and results report to avoid human errors.

(2) Environmental load interference

The uncertain dynamic and static loads around the foundation pit will produce a large additional force on the foundation pit, which will have a great impact on the monitoring results of steel support axial force. Monitoring personnel should conduct axial force monitoring when the impact of external environment is relatively small, as far as possible to avoid large vehicles and other uncertain dynamic load interference. When it is really inevitable, patrol records should be made according to the on-site situation, and used as a reference in data analysis, so as not to affect the judgment of the data result to the conclusion.

(3) Effect of Soil and Water Pressure

The change of ground water level around the foundation pit will directly affect the change of steel support axial force. Most cities will have a rainy season. The rainy season has a large amount of rainfall. Continuous rainfall leads to a sudden increase in soil moisture, which directly increases the water and soil pressure on the foundation pit. Therefore, the change of surrounding water level and the alternations of rainy season and dry season should be fully considered in the analysis of steel support axial force data.

(4) Special support design

For the consideration of multi-elements in construction, design units often adjust some steel support to concrete support, and concrete support to steel support or encrypted steel support in original concrete support [6]. Concrete support strength is large, steel support strength is relatively small, concrete support and steel support have the "force transfer" phenomenon of force, resulting in the measured value of this kind of steel support is smaller than the normal situation. In the analysis of axle force data, it is necessary to refer to other supporting axle force data and discuss them together with other monitoring items of the monitoring section, to draw reasonable data conclusions.

3.4 Implementation of early warning mechanism

The monitoring and early warning mechanism of steel support axial force is generally formulated by the construction units according to the technical requirements of national standards, and combined with the characteristics of local engineering construction and long-term accumulated management experience.

(1) Uniformity of Management Standards

The management standards of administrative departments such as urban safety supervision units, construction units, and supervision units are not uniform. Especially in the inspections of national units such as the Ministry of Housing and Urban-Rural Development, The problem of inconsistent management is often caused by different management standards of axial force monitoring and warning. When formulating management standards, the metro construction department should fully refer to the management documents of the state, province, city and other cities, and try to achieve uniform
technical standards. At the same time, do a good job in the dissemination of technical documents and disclosure. Participating units at all levels should strictly abide by and implement the early warning system to avoid the phenomenon that management technology standards are not uniform.

(2) Single warning index

The axial force control value is a double control index. The maximum index of the steel support axial force control value is 60% to 70% of the design value of the bearing capacity, and the minimum index is 80% to 100% of the design value of the supporting prestress. However, construction units often adopt the maximum warning of axial force and neglect the insufficient preloaded axial force of steel support [7]. Monitoring units should make a good technical presentation in advance. When the monitoring ring value of steel support axial force does not meet any one index, monitoring units should strictly follow the early warning mechanism to carry out the early warning of steel support axial force, send early warning documents, supervise units organize early warning analysis meeting, and construction units take effective control measures to ensure the safety of foundation pit.

4 Monitoring precautions

(1) Purchase of monitoring components must be completed before excavation of the foundation pit. The measurement range of the components must be determined according to the requirements of the final design document. The length of the component cable should be calculated according to the installation position to avoid insufficient length or waste of resources.

(2) Installation of monitoring elements should be carried out synchronously with erection of steel support. It is strictly forbidden to dismantle and install axial force meter after the erection of steel support which may causes major safety accidents.

(3) The design unit should fully consider the engineering characteristics, geological and hydrological conditions to ensure the rationality of the pre-loading axial force for support and the rationality of the design of the support structure.

(4) Strengthen the protection of monitoring points to ensure the continuity of monitoring data. All units must take safety protection measures when working on site, pay attention to the safety of personnel and instruments.

5 Conclusion

(1) Axial force monitoring components should choose a brand with good comprehensive performance to ensure that in the follow-up monitoring process, the axial force meter has high sensitivity, good linearity, good repeatability, stable and reliable performance, drift, small lag error, good waterproof, strong anti-interference ability.

(2) Give full play to the management role of the construction unit and the supervision unit, strengthen the safety awareness of the construction unit, standardize the installation process of the axial force meter, and strengthen the control over the monitoring process of the monitoring unit.

(3) In the data analysis, the monitoring unit should fully consider other monitoring data of the same monitoring section around the foundation pit, the site construction conditions and environmental impact factors, and comprehensively analyze the axial force monitoring data to correctly judge whether the foundation pit is safe.

(4) Strengthen the research on steel support theory system, further improve the monitoring and early warning system of steel support axial force, achieve scientific early warning, standardize early warning, ensure the safety of foundation pit construction, and make monitoring play a real role.

(5) Promote the development and application of the axial force real-time monitoring system and the steel support axial force automatic compensation system, reduce the influence of environmental factors and personal error, and make efforts for the safety monitoring of deep foundation pits.

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