Study on Safety Environment of Highway High Slope Excavation Construction in Civil Engineering

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Abstract: Based on a large number of studies and engineering test, this paper proposes a two-stage evaluation technique for construction safety environment risk assessment of civil engineering slope excavation based on topographic geological conditions and construction environment in civil engineering. In terms of the assignment and practicality of indicators, the basic principles of simple and practical are followed, highlighting the key factors of geological conditions, emphasizing the dynamic supervision of the process, and adopting the height and stability correction coefficient of respecting the empirical model.

1. Introduction

According to the statistics of historical accidents, traffic engineering accidents have always occupied a considerable proportion in the total number of traffic accidents, exceeding 80% for three consecutive years, of which the proportion of collapse accidents is large, and the consequences of accidents are more serious. After analysis, the collapse and high-rise fall accidents are concentrated in the earthwork excavation, the edge, and the hole. In the construction of civil engineering, the work of high filling and deep excavation is huge. The excavation of high slope and deep foundation pit has always been the top priority of construction safety environment risk management.

China is a civil engineering areaous country. The civil engineering area accounts for about 70% of the country’s land area. The geological conditions and topography are different, and the impact on civil engineering construction is different. Take civil engineering area as an example. civil engineering area is in the transitional zone from the second step of China's terrain to the third step. The terrain can be divided into western civil engineering area, Hanjiang plain, low hills in northeastern civil engineering area, and low hills in southeastern civil engineering area. The characteristics of civil engineering area road construction risks are as follows:

(1) The valley is steep and steep, with high slope height and wide distribution.

The construction of highways in future civil engineering areas is mostly located in the Indaba civil engineering area, Puling civil engineering area, and Dong civil engineering area in eastern civil engineering area. Controlled by the regional tectonic line and the lithology of the stratum, the elevation of the gully varies greatly, the height difference of the terrain varies greatly, the civil engineering area is steep and steep, the slope height is high, and the distribution is wide[1].

(2) Karat development, there may be great water and mud in the excavation of foundation pits.

The karat land forms in southwestern civil engineering area are developed, and the exposed carbonate rocks are affected by the warm and rainy climate of the area. There is a great possibility of water inrush in the foundation pit excavation[2].

(3) The rock mass is broken, easy to weather, and the occurrence is changeable, which is easy to produce slip.
When the road is excavated, due to the metamorphic rocks and volcanic classic rocks, the rock mass is broken, easy to weather, the occurrence is variable, the stability is poor, and it is easy to cause slippage, which threatens the stability of the slope\(^3\).

(4) The rainfall is abundant, which directly affects the stability of the slope and the safety of the foundation pit.

The precipitation is abundant and the groundwater supply is sufficient. The most rainfall in summer, and heavy rain, it is easy to cause geological disasters such as civil engineering area torrents, directly affecting the stability of the slope and the safety of the foundation pit\(^4\).

(5) There are many bedding slopes, and the structural planes are easily cut to form unstable wedges. The Dang schist in the northwest of civil engineering area Province has extremely complicated geological conditions. There are many bedding slopes, and the structural planes are easily cut to form unstable wedges\(^5\).

(6) Expansive soil is an important cause of instability of slopes and foundation pits.

Expansive soil exists in some areas, which is prone to cliometric deformation, or forms cracks due to drying, which is an important cause of instability of slopes and foundation pits\(^6\).

2. Overview of the cause of related accidents

2.1 Overview of assessment methods

In recent decades, domestic and international research and application of engineering safety environment risks have been highly valued. The safety environment risk management techniques for tunnel construction in foreign countries are relatively mature 1~4. In the 1970s, Professor Einstein.HH of the Massachusetts Institute of Technology wrote a series of articles. The characteristics and concepts of tunnel engineering risk analysis are given. In 2004, the International Tunnel Association issued the Guideline for Risk Management of Tunnel Engineering Risk Management. Although China's research on engineering safety environment risk management is relatively late, it has also achieved great results in engineering risk management theory research and method innovation, such as analytic hierarchy process, fuzzy comprehensive evaluation method, Monte Carlo method, artificial neural network, factor analysis. The method and SWOT analysis method, the theoretical results have also been widely used in engineering practice. The construction safety environment risk assessment method has experienced four-step evaluation methods in the past ten years, but it has basically formed a four-step evaluation method of “discrimination, analysis, estimation and control”. However, in specific engineering applications, the selection of evaluation objects and the evaluation of evaluation indicators are evaluated. In other respects, the actuator's subjectivity is relatively large, and the pertinence is not strong, especially for the prevention and guidance of frequent and prone accidents due to differences in geological conditions, differences in the maturity of construction technology application, and differences in construction management and construction teams.

2.2 Introduction to evaluation methods

Set up an assessment team to collect relevant laws and standards at home and abroad, relevant systems for local transportation construction safety management, understand the accidents of collecting similar projects, and conduct in-depth research and analysis on the design, geological exploration and construction organization design of construction projects. Evaluation plan. Conduct on-site survey and collect basic data related to risk assessment.

The fish bone diagram, also known as the characteristic factor map, was developed by the Japanese management master Mr. Chi Cuchulain, hence the name Ashikaga. Fish bone diagrams are a way to discover the "root cause" of a problem. It can also be called a "cause and effect diagram." The characteristics of the problem are always influenced by a number of factors. We brainstorm these factors and combine them with the characteristic values. The layers are organized according to the correlation, and the figures are marked with important factors. Call the feature factor map. Because its shape is like
a fish bone, it is also called a fish thorn map (hereinafter referred to as a fish thorn map), which is an analysis method that sees the essence through the phenomenon, also called a causal analysis map.

The main steps of fish bone diagram analysis and manufacturing are as follows:

For the accidents of the evaluation unit, the risk factors of the evaluation unit are screened from the aspects of people, machine, material, law and ring (big bone); the factors that focus on people (operators, managers), construction procedures (plan), equipment factors, environmental factors and material factors and other risk factors combined with the project for analysis; according to the brainstorming method, according to the "Classification of Enterprise Workers’ Casualty Accidents" (GB6441-1986) on the unsafe behavior of people and the unsafe state of things, and "Classification and Code of Hazardous and Hazardous Factors in Production Process" (GBT_13861-2009) for human factors, physical factors, management factors and environmental factors, respectively identify all possible causes (factors) for each of the selected risk factors (Middle bone); classify and sort out the identified elements and write the analysis results into the risk analysis results.

Risk matrix method and indicator system method for risk assessment conduct dynamic risk estimation, and use qualitative or quantitative methods to estimate the probability and severity of risk accidents. Risk size = probability of accident × severity of accident. “×” indicates the combination of the possibility of accident and the severity of the accident.

According to the probability and severity level of the accident, the risk matrix method is used to determine the risk level of a certain major risk source in the high slope construction. The risk level is divided into four levels: smaller (I level), general (II level), larger (Level III), Major (Level IV).

The severity of the accident is divided into four levels. This Guide mainly considers casualties and direct economic losses. When multiple consequences are generated at the same time, the severity level of the accident should be determined on a high basis.

Personnel casualties refer to the casualties of personnel during the construction activities, according to the type and severity of casualties. The high slopes and deep foundation pits are relatively bridges and tunnels, with fewer operators and major accidents. Relatively less economic losses, based on actual engineering conditions and expert advice.

Direct economic loss refers to the sum of various expenses incurred in the project after the accident, including direct costs and various expenses required for accident handling (excluding recovery and reconstruction).

The main type of accidents for slope excavation and support operations is collapse accidents. The risk of collapse accidents runs through the excavation and support process of the entire high slope. The possibility of collapse accidents is mainly estimated from slope shape, rock mass conditions, slope monitoring, construction season rainfall, blast disturbance and other indicators.

The risk source control measures shall be clearly clarified one by one according to the three stages of ore-planning, early warning and prevention. Measures for construction activities or construction sections that have reached a high risk and above through special risk assessment shall take measures such as perfecting special construction plans and emergency plans, carrying out construction monitoring and early warning, improving on-site protection conditions, strengthening construction safety technology and risk notification, etc. A major danger or accident occurred. Different risk countermeasures can be taken depending on the different risk levels in the special assessment.

2.3 Dynamic assessment

The construction safety environment risk assessment of highway high slope engineering should be carried out throughout the construction process. The engineering risk status should be tracked and evaluated according to the tasks, geological conditions and construction process changes in different construction stages, and the unidentified risks should be discovered and dealt with in time. These include: changes in engineering risk levels, development trends in major risk sources, and recommendations for dynamic assessment of evasion measures.

Risk dynamic assessment The specific implementation phase time node, content and commitment unit can be found in the risk assessment life cycle table, as shown in Table 7-1 below. In the construction
phase, after the completion of the construction organization design documents, a special risk assessment is carried out to form a special risk assessment report at the initial stage; the construction unit prepares a corresponding special safety construction plan according to the major risk sources indicated in the special assessment report; During the construction phase, the construction operation characteristics, geological conditions and other changes are carried out to carry out dynamic risk assessment, and a phased dynamic assessment report is formed; after the construction is completed, the process assessment report data is archived.

3. Accident probability assessment index design

In the construction of the indicator system, in the face of the actual needs of engineering construction, the following principles are followed:

- Contact engineering practice: the method is simple, efficient and practical
- Control factors: the standard system is the top priority of the guide
- Features: How to consider the stability of the slope itself
- Solve the outstanding problem: how to consider the scale effect of the project scale (height, depth) on risk. Dynamic assessment: how to combine monitoring measurements.

On the one hand, the evaluation technology relies on the summary of the evaluation work. The project has summed up the 455km expressway bridge tunnel, high slope and high embankment in the west of the 10th, Enlarge, Envy, Li wan, Bao bab, Mazama and Guiyang sections. As well as the risk assessment of deep foundation pits, 450 assessment sites were completed, including 98 high slopes, 58 high embankments and 4 deep foundation pits, see Table 11. On the other hand, through the expert questionnaire survey, 100 engineering test were designed and distributed, of which 89 were effectively recovered.

According to statistical analysis, 69% of the accidents are caused by engineering geological conditions, 24% of the causes are from the scale of the slope, and the height is in the engineering geological conditions, 35% of the rock stratum structure surface, that is, whether there is a bedding slope and other factors. According to the frequency of occurrence, from the largest to the smallest: the first gear (prone to occur, the average probability of 38%) is collapse, high altitude fall, shot, object strike; second gear (occasionally, average probability 9%) is mechanical Damage, electric shock, lifting damage, vehicle damage.

The assessment of key risk sources is not only the main work of the special initial evaluation, but also the only work of the dynamic evaluation. The evaluation system highlights the following characteristics:

1. Major risk source accidents
2. The possibility of major risk source accidents highlights the process characteristics
3. Integrate management of people in it

Evaluation indicators (Table 5) The indicators are considered in terms of dynamics, construction methods and management.

The consequences of falling and object impact damage in high places are related to height and depth. According to the space theory of dangerous sources, the correction coefficient of the influence of slope excavation height on the results is proposed, which reflects the amplification effect of accident risk of different scale projects; Through the stability factor correction, the risk due to the stability of the slope itself is solved.

4. Case application

The geological condition of the slope is special, the tendency of the rock stratum is close to that of the slope, and there is a smooth layering, forming a large wedge body, the slope stability is poor, and it is easy to collapse. The risk simulation evaluation flow chart is Figure 1.
Figure 1 Risk Assessment Simulation Program
1. A large security threat to various machinery and construction personnel working on slope construction.

2. During the slope protection construction, there are many wedge-shaped sliders on the slope body, which poses a large safety hazard to the construction workers below, which is easy to cause object impact damage.

3. In addition, the slope excavation height is very large, and there are cross-operations. How to prevent high-level fall and object strikes during construction should be noted. The stability of the slope is the safety control factor in the construction process. How to control its stability is the most difficult point of slope construction. The slope is unstable and does not dig. The dangerous rock body is not treated and not excavated.

Using the fish bone diagram analysis method in the system safety engineering to determine the risk factors that may cause accidents in the various sub-items of the slope, that is, the causes of accidents that may occur during the construction process. The risk factors of typical accidents were obtained from five aspects: human unsafe behavior, unsafe state of materials, environmental insecurity factors, materials and management defects.

After discussion by the project evaluation team, the on-site investigation and expert opinions were mainly based on accidents such as slope collapse, high-level fall, object strike, gunpowder explosion, etc., and the evaluation result of the accident possibility index was “probable”.

In combination with on-site investigations and expert consultations, if the slope is excavated, heavy rain or support is not timely, and long-term exposure will cause a large-scale collapse accident. At the same time, due to the disturbance of the slope by the stone blasting, it also increases the possibility of causing the collapse accident. The level of casualties caused by accidents is level 2 (larger), and the level of direct economic loss is level 2 (larger). According to the principle of high, the severity level caused by the accident is level 2 (larger).

5. Conclusion
There are other risk sources for slope construction of civil engineering area roads. Applying the technical ideas and index construction principles of this paper, we can further study and establish an evaluation index system such as anti-slide pile construction. The impact of “human” unsafe behavior on construction safety has always been a difficult point and focus of risk assessment. This study has not entered into in-depth research, and adopts relevant standard guidelines, which should be further studied in the future.

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