

Civil Engineering and Surrounding Environment Risk Analysis Based on ALARP Principle

Yongjun Tang

Lanzhou Jiaotong University Engineering Consultation Co., Ltd. China

Abstract. This paper first describes the status quo of subway development in our country, analyzes the development trend of subway in our country, distinguishes the source of danger in civil engineering of subway from the perspective of unsafe behavior of people, the unsafe condition of material and environmental factors, And summarizes the existing methods of risk analysis. The safety checklist method and ALARP method are mainly selected to conduct risk analysis on the civil engineering works and the surrounding environment. At last, the risk control, management and monitoring measures of the subway construction are elaborated. The emergency plan for the civil engineering of the MTRC provides a safer guarantee for the construction of the MTRC.

1. Introduction

With the development of the national economy and the accelerating process of urbanization, urban traffic has increased dramatically. Urban traffic congestion is worsening. Therefore, the development of urban rail transit (subway) has become an inevitable choice. Subway in many bustling downtown, stratum conditions and the uncertainty of underground structures and the complexity of surrounding buildings increased the difficulty of construction technology, while increasing the safety risk of subway construction. And in recent years, a series of underground engineering accidents have also suffered heavy losses. Therefore, we must analyze and control all kinds of risks existing in the subway construction process. Taking subway project in our country as an example, this paper expounds the problems existing in the process of civil engineering in subway and puts forward some measures to control the risk.

With the continuous development of the world economy and science and technology, the subway project has been developing and maturing in terms of investment, construction, operation and management. The MTR plays an increasingly important role in the integrated transport system. With reference to China's "Tenth Five-Year Plan" and the national "Eleventh Five-Year Plan", the understanding of urban rail transit has been enhanced. The guidance of the national policy will make the subway construction have a better development prospect and will gradually shift from the construction of municipalities directly under the Central Government and capital cities to the second-tier cities. The development of metro in large and medium-sized cities in China is promising. China's mainland plans to build 55 lines recently (2014), the line mileage of about 1500km. In the short term, the newly built subways have been concentrated in the field. Experienced surveys, design and construction forces have been obviously inadequate, greatly increasing the risks in the construction of subway projects. Subway project related technical standards are not perfect, potential technical risks cannot be ignored. The implementation of an expert demonstration system for major security and



technical issues throughout the country, to a certain extent, avoided the mistakes in decision-making and the occurrence of security incidents. However, the expert argumentation is conducted at a certain point or in a period, and there has not yet been formed a comprehensive demonstration of "work-line-line network" and the mechanism of participation in the whole process. There is a lack of concepts and means to systematically solve the security issue.

The implementation of any project has engineering risk, it is an objective reality, and does not shift with the subjective human will. When the risk of engineering accumulation exceeds the threshold, it will break out in the form of an accident, and some will bring huge economic losses and even casualties. With the continuous deepening of the subway construction in the country and the continual emergence of various engineering accidents, how to correctly analyze and control the risk of subway construction projects has become a hot topic in engineering field.

The engineering risk of metro project has distinct characteristics. The engineering accident at a single work site not only causes the progress and economic loss but also causes difficulties and risks for subsequent construction.

2. Method introductions

2.1. ALARP evaluation method

Risk assessment is based on the principle of least acceptable risk (ALARP), which is the risk rationale for As Low as Reasonably Practicable. The Minimum Acceptable Risk Principle (ALARP) as shown in Figure 1, the ALARP model flow is shown in Figure 2.

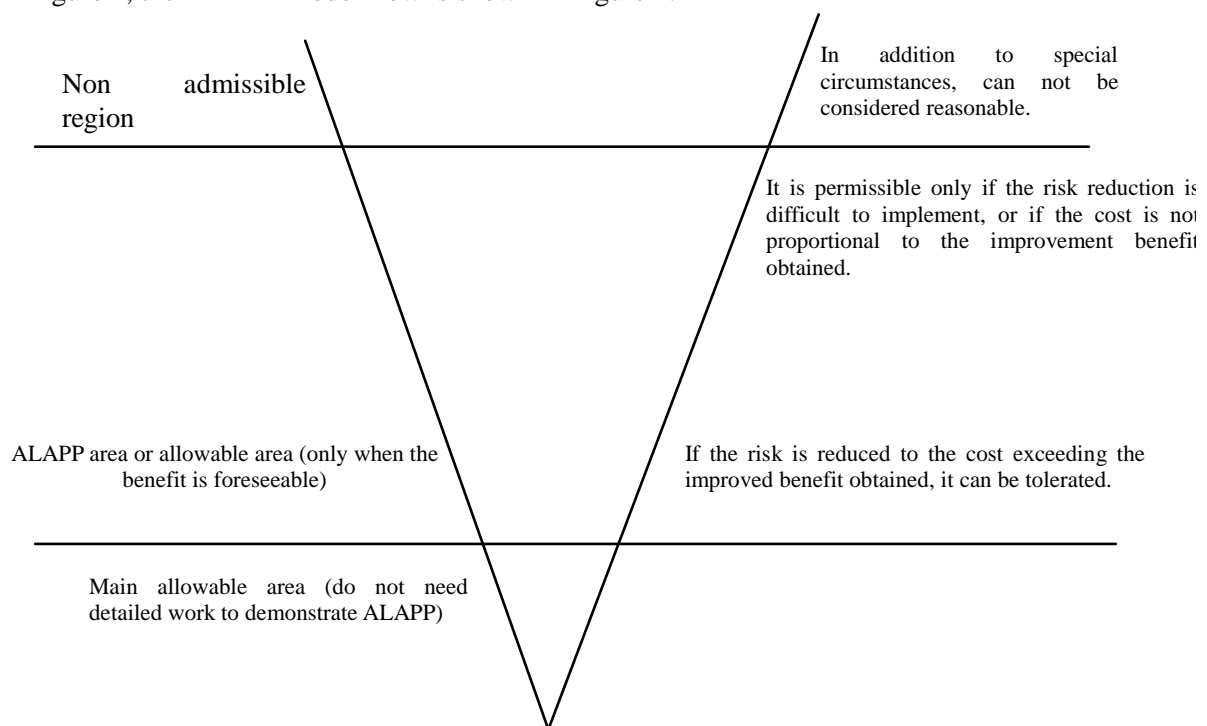
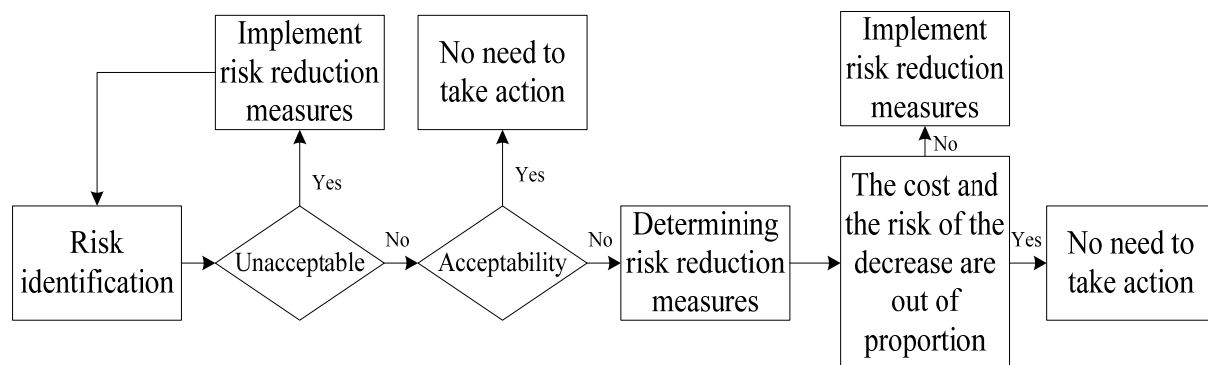


Figure 1. ALARP analysis diagram.

**Figure 2.** ALARP model.

The top range defines the level of permissibility that is not tolerated, the risks are high and the harm/damage outcomes that may be caused are almost unacceptable, so they are almost impermissible on any occasion. If the risk level cannot be reduced below this range cannot be implemented.

The lowermost range is defined as the main permissible area, and the risks in this area may be considered small without passing any proof of ALAPP criteria.

Risk assessment should be combined with the frequency and consequences of the severity of the consequences of unsafe risk level, China's risk level according to the following table:

Table 1. Risk rating table

Probability level loss level	A	B	C	D	E
	Disastrous	Very serious	Serious	Need to consider	Ignorable
frequent (>10%)	I level	I level	I level	II level	IIIlevel
Possible (1%~10%)	I level	I level	II level	IIIlevel	IIIlevel
occasional (1%~1%)	I level	II level	IIIlevel	IIIlevel	IVlevel
Rare (0.1%~1%)	II level	IIIlevel	IIIlevel	IVlevel	IVlevel
Impossible (<0.1%)	IIIlevel	IIIlevel	IVlevel	IVlevel	IVlevel

Different levels of risk should be taken for different risk management principles and control programs;

Table 2. Risk Management and Control Program Table

level	Accepting guidelines	Principles of treatment	Control plan	Responsible (responsible) department
I level	Unacceptable or must be eliminated	Risk control measures must be taken to reduce the risk, at a minimum, to reduce the risk to acceptable or unacceptable levels	Risk warning and emergency preparedness plan should be prepared or revised or adjusted	Government departments, construction parties
II level	Unwilling to accept	Risk management should be implemented to reduce risk, and the cost of risk reduction should not be higher than the risk after the risk of loss	Risk prevention should be implemented in the monitoring, development of risk measures	
III level	Acceptable	Risk management should be implemented and risk management measures can be taken	Suitable for strengthening day-to-day management and monitoring	Project construction parties
IV level	Ignorable	Implement risk management	Conduct daily inspection	

2.2. ALARP Principle Based Security Control Early Warning Decision Making Method

The basic steps of early warning decision-making method of safety control based on cloud evidence theory are as follows:

a). Evaluation index eigenvalue acquisition. Evaluation and early warning on the status of safety control involve a series of quantitative indicators and qualitative indicators. Quantitative indicators are mainly based on monitoring values, while qualitative indicators mainly rely on experts to evaluate them.

b). Establish initial trust distribution based on cloud model. Build a model for each level of each indicator, calculate the membership degree of each indicator eigenvalue for each level cloud ALARP model, as the basic credibility allocation, and use the following formula to calculate the i-th

eigenvalue membership The degree of membership of the jth security level, ie:
$$\begin{cases} Ex = \frac{C_{\max} + C_{\min}}{2} \\ En = \frac{C_{\max} - C_{\min}}{6} \\ He = s \end{cases}$$

Where s is a constant; C_{\max} and C_{\min} are the maximum and minimum, respectively.

c). Weight of evidence calculation. Set the identification framework of two witnesses m_i and m_j respectively as $\{A_1, A_2, \dots, A_N\}$ and $\{B_1, B_2, \dots, B_N\}$. Based on the basic credibility distribution of evidence source and its coke element attributes, 'S distance function is used to calculate the distance

between m_i and m_j between two evidence bodies is $d_{ij} = |E_i - E_j| = \sqrt{\sum_{k=1}^n [m_i(A_k) - m_j(B_k)]^2}$. The

distance between the evidences forms a distance matrix. The similarity measure of defining the body of evidence m_i and m_j is $Sim(m_i \bullet m_j) = 1 - d_{ij}$. The support of the body of evidence m_i

is $Sup(m_i) = \sum_{j=1, j \neq i}^n Sim(m_i \bullet m_j)$ ($i, j = 1, 2, \dots, n$). m_i) Normalization is defined as the weight of evidence

$$m_i: W(m_i) = Sup(m_i) / \sum_{j=1}^n Sup(m_j) \quad (i, j = 1, 2, \dots, n)$$

d). Replace evidence. According to the formula to calculate the source of evidence of the weighted evaluation of evidence, replace non-conflicting evidence, calculate the average evidence to replace evidence of conflict; re-testing based on the formula combination.

e). Evidence fusion. Definition m is the coefficient of uncertainty, the smaller the m , the smaller the fusion uncertainty, the higher the credibility. If multi-layer fusion is involved, after one layer of fusion is completed, the fusion result is repeatedly allocated to multi-layer fusion as the basic credibility of the evidence. According to the above steps, we can draw a multi-layer fusion process based on ALARP evidence theory.

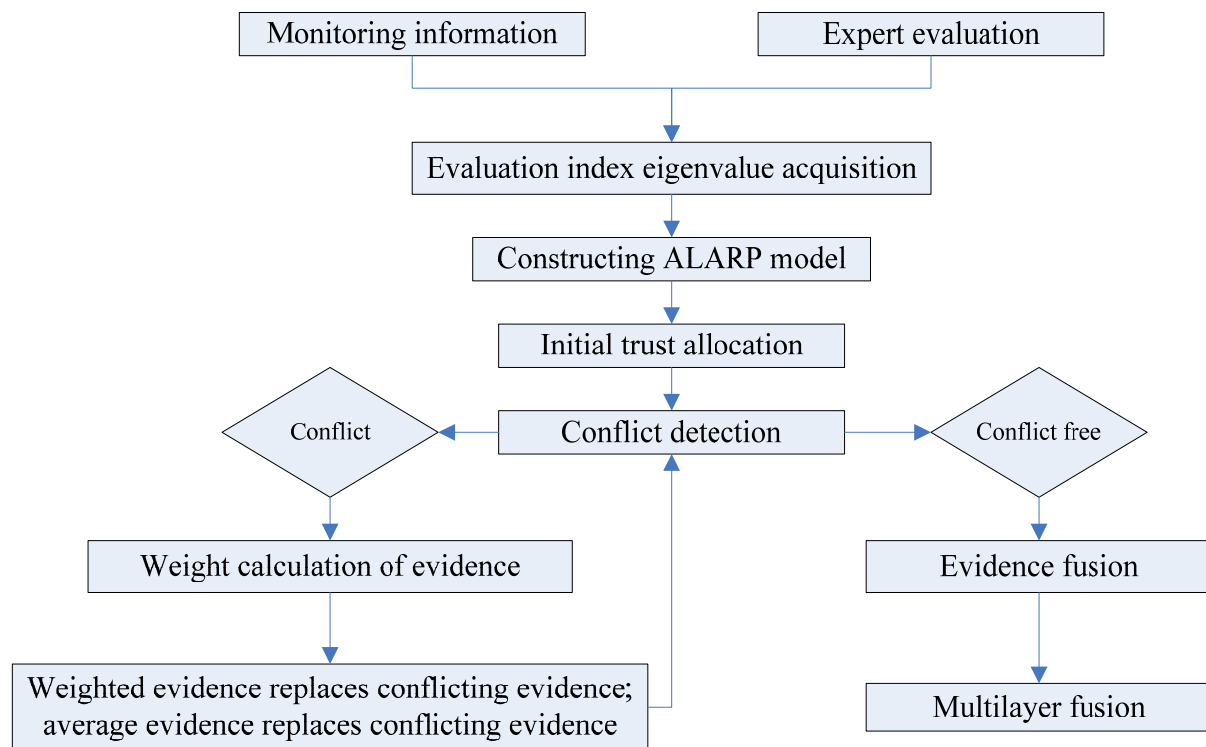


Figure 3. Based on ALARP theory of evidence for multi-level integration of the target process

3. The main risks and their prevention

3.1. Subway underground station risk impact of the main factors

The main factors that affect the risk of subway underground stations are extremely complicated and numerous, but the main factors that summarize and summarize the impact of subway underground engineering are as follows: a). Hydrogeology in which the project is located. b). Project itself characteristics. c). the impact of the surrounding environment. d). Construction technology, process and construction capabilities. e). Solar terms, the impact of climate on the project

3.2. Main Risks and Prevention of Tunnel Construction in Subway

a). Shield into and out of the affected area (ie, within 10m of the tunnel axis) If the distribution of sand, silt soil.

- b). Shield excavation section exists sand, silt soil.
- c). There are biogas layers, ancient river courses and dark Bangs in the affected area of shield tunneling.
- d). Underground shield along the tunnel along the complex obstacles, such as abandoned building (structure) buildings, piles and so on.

3.3. The main risk of surrounding environment and its prevention

In the control of the surrounding environment, it is necessary to strengthen the control over internal pressure pipes, such as houses and confluence sewers, and other key facilities that endanger the safe operation of cities. The situation should be detailed before row Pao touch, at the same time need to strengthen the identification of civil authority's in advance authoritative department, meticulous construction. And from the Shield into and out of the foundation reinforcement to the entire section of tunneling, well joint construction, melting and other sidewalks pouring slurry throughout the construction process to implement engineering risk prevention measures.

Particular attention should be paid in the environmental protection work to the effect of trenchless technology, that is, the pipeline buried by directional drilling technology on the tunnels, especially for the buried depth, so as to avoid unnecessary or difficult disposal consequences.

3.4. Construction risk, construction procedure, construction ability and other engineering risks and their prevention

Foundation reinforcement has been described in detail in the chapter of deep foundation pit. This chapter mainly emphasizes the influence of foundation reinforcement process on the surrounding pipeline. The selection of foundation reinforcement process must be matched with the depth of reinforcement and the location of adjacent peripheral pipelines. In the difficult conditions, new technologies and new technologies such as MJS can be adopted.

Before shield construction, it is necessary to know in detail the construction conditions of the end-head wells, especially the situation of collapsing holes in shallow sandy soil, the construction condition of the lock-mouth pipe, the seepage in the excavation of the foundation pit and its disposal status, Channels (including precipitation wells, observation wells, exploration holes, etc.) and the tunnel between the adjacent relationship and the blocking situation, etc., in order to formulate and improve various precautionary measures to avoid all kinds of risks.

For shield tunneling under the condition that the end hole is hoisted and closed, it is necessary to strengthen the management of measurement work and at the same time reserve a reference point before sealing the station.

3.5. Operation and Social Risks and Their Prevention

The key to operational safety is the comprehensive treatment of seepage water and fragmentation of tunnels. The stacking and transportation of on-site pipe pieces need corresponding protection and protection measures, that is to say, the standardized "tire frame" should be made and the proper safety distance should be set for the on-site pipe pile stacking. In the process of tunneling, the shield and the adjacent profile of the segment should be strictly controlled. The unit of each shield must be based on the length of the shield tail shield selected by the currently used segments and tunnels. Integrated anti-seepage measures on seepage prevention of embedded well grouting pipes at shield well joints. Thin tube patch repair technical requirements. Section tunnel leakage plugging must be used in the form of grouting, non-use of caulking and other methods. Acceptance of post-construction acceptance of the tunnel, that is, the subway opened to traffic test operation three months or six months before acceptance.

The key to social risks is the implementation of various engineering and technical measures through the private houses. Residential housing protection is a technical issue, but also a political issue. It is required to carry out the crossing across the houses according to the major cross sections, that is, to set up the simulation section before crossing. At the same time, the overloading of residential

houses should be considered according to the different structures and basic forms of residential houses. The parameters of shield tunneling should be optimized to ensure the residential safety and use.

Summary

This paper firstly elaborates the status quo and trend of the subway in our country, collects various types of accidents and environmental hazards in the subway civil engineering process, analyzes the typical accident cases and analyzes the risk analysis and control of the civil engineering works and the surrounding environment. The importance of From the perspective of unsafe behavior of people, unsafe condition of materials and environmental factors, the dangerous sources in subway civil engineering are discerned, and the dangerous sources are classified. The internal and external causes of each dangerous source are analyzed. The existing risk analysis methods are summarized, such as safety checklist method, fault type and impact analysis method, brainstorming method, hazard and operability analysis method, fault tree analysis method and ALARP evaluation method. The evaluation model is established to carry out the risk analysis on the civil engineering and the surrounding environment of the subway.

References

- [1] Sun Cheng, Zhang Changming. Discussion on risk management of subway civil engineering [J]. *Mechanics Management Research*, 2012 (2): 127-129.
- [2] Liu Xiaowei, Chen Yingcai. Metro construction project risk management and related issues of thinking [J]. *Building Materials and Decoration*, 2012 (3): 43-43.
- [3] Huang Weidong. Common diseases and analysis of civil engineering [J]. *Urban Construction Theory Research: Electronic*, 2013 (1).
- [4] Xiao ZI Wei. Subway civil engineering construction project safety management [J]. *Chinese Journal*, 2014 (5): 58-58.