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Advice on the implementation of risk management for the construction of tunnels and underground works

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1 INTRODUCTION

Compared with ordinary civil engineering works, the risk management of tunnels and underground works has the same meaning.

a. risk identification

It means the discovery of potential risks in the whole construction period.

b. risk analysis

Each risk may be predicted by the time, frequency and degree of harm.

c. risk assessment

The value of basic attitude or attention for each risk should be attained through mathematical calculation in this phase.

d. risk control

It is the destination of risk management. There are three ways to control risk.

- risk aversion

For example, we can bypass the serious adverse geological sites in the planning of tunnel location and direction.

- risk mitigation

proper measures should be taken to mitigate the risk. One measure is the application of assistant construction methods in the adverse geological conditions in the tunneling process, for example, improvement of geology, support-strengthening as a security. Another measure is adjusting the procedure of tunneling in order to transfer the time of risk happening. In this case, the risks, such as risk of pre-release of water or gas in the construction can be dispersed.

- risk transfer

There are many ways to transfer risks. The construction team could sub-contract the difficulty projects to the skilled professional team, or insure the project to get some payment from the insurance company in case that the risk accidents produce losses.

2 KEY POINTS

Because of reasons as follow, the risk management for the construction of tunnels and underground works is harder than other engineering projects.

a. The tunnels and underground works are located beneath the earth or water areas. The geological and hydrological conditions of the tunnels are vague by present investigation technology, which induces the uncertainty of the planning and construction. To some degree, it is an empirical work on tunnels and underground projects.

b. In reality, the planning of the underground projects should always be modified to fit the geological and hydrological conditions during construction period. Thus the planning of the projects has large variability. The planning team and the constructing team should cooperate with each other closely. It is strongly recommended to use the concept of information-design and information-construction derived from NATM.

c. Even the condition of geology and hydrology has been understood clearly, stratum media

physical and mechanical properties of mutant and discontinuity also cause the difficulty of design and construction. People only could copy with it by engineering analogy on the basis of the distribution of geology media.

d. For one design project, different construction contractors may choose different construction planning and methods because of diversity of knowledge, experience, capability and custom. We should admit that different construction planning and methods cause different results, and sometimes the difference is huge.

e. The construction of tunnels and underground works means small work shop, tight schedule, poor condition of humans and equipments. The security issues are very severe, especially in blasting. Once accidents happen, the losses are great.

f. The construction of tunnels and underground works means changing the original status of strata to form the architecture space. The force of strata and buildings is in great change and transforming. In order to achieve new balance and stabilization, the construction procedure is highly time-dependant. Otherwise, loss of opportunity may lead to big disasters, for example, beyond the limits of displacement, deformation, settlement, or even serious collapse.

Characteristics above determine the high risk of construction of tunnels and underground works, correspondingly, the risk management is difficult.

3 RISK CLASSIFICATION AND INFLUENCED FACTORS

From different points of view, the risks of tunnels and underground works cover the areas of profit, quality, time and security. But in one word, they will be presented by the form of economic risk.

3.1 Profit Risk

- project assessment

It means the engineering feasibility study and investment-benefit analysis. Compared with other projects, the investment of tunneling and underground works is big, the influence of geological and hydrological conditions is prominent. The change of policy can also affect the risk of benefit.

- design standards and technical precision

Actually, the design standards can not be decided by designer, but by the decision maker of the project, or the government official, or the leader in charge of the department. Design standards on such items, as depth of tunnel, its location, direction, longitudinal slop, lane number, section, attachment facilities affect the whole project greatly, usually on investment, function and benefits. While designer decides how precise the work should be. It usually means the quality of investigation. Too much changes on design cause investment risk.

- construction process

It means the construction planning, methods and procedure adopted by the construction contractor. Because of the complexity of geological and hydrological condition, the accidents happen easily if you do not choose the proper construction planning, method and procedure. We have some lessons in history.

- construction period

The lasting time of project has great relation with the cost and early benefits in the construction of tunnels and underground works. In the whole process, the variable costs, such as human forces, ventilation, lighting, transportation and machinery, are in high proportion of the total cost. All of the above is proportional to the extension period. The delay of delivery of project cause great economic losses.

- defects and disease treatment

After the delivery of project, people pay much on the governance of seepage, the repair of cracks and the modification of unlimited dimensions. It will cause bad effect on the operation of tunnels when the problems mentioned above are severe.

3.2 Quality Risk

- design quality

Generally speaking, China civil engineering design specification standards are low. The tunnels and

underground works are in no exception. For example, the standards of choosing of early support in tunnels, the index of concrete strength and grade of impermeability, the location of water-proof and drainage and so on. Construction deviation makes the quality stability and reliability difficult to guarantee.

- construction quality

Different construction teams, with different ideological qualities and professional qualities, make different product qualities.

- construction supervision

The quantity and quality of construction supervision members should meet the need of projects. There are many unpredicted factors, complex procedures in underground works, so the supervisor should take charge of the whole project. They should check the planning files, the raw materials, test on-site, the operation of machinery, setting of equipment, and so on in case of hidden quality problems.

- project management

The construction part should organize the management team, combining the design part, construction part and supervision part together, in order to transit the information efficiently. We did not have the effective management team and the proper rules, and it is a shortcoming of China engineering field.

3.3 Time Risk

- design change

It is very common to change the former design drawings in the underground projects. Big change will postpone the project.

- construction mistakes

The possible reasons are improper construction planning, improper construction methods, improper construction organization. As soon as the mistakes make effect on the whole project, the time risk will happen.

- natural disasters

It means earthquakes, floods, mud-rock flows, landslides, mountain collapse, et al. They all interfere with the project period.

- great policy adjustment and war

The project has to be ended because of war or great policy adjustment.

The latter two kinds can only be predicted and prevented, but can not be the controllable risk factors.

3.4 Safety Risk

- personal safety

We can reduce the frequency of accidents by educational training and behavior management. As soon as accident happens, we can only handle the aftermath through insurance payment.

- machinery and equipment safety

It can also be controlled through management. Once the accident happens, the risk can only be transferred or partial transferred through prior insurance.

- engineering safety

It includes the project equipment safety and surrounding environmental safety. These may be types of insurance to be explored. For projects which need the enormous amount of payment, we can reduce the payment by united insurance. Environmental safety, which is regarded as “third party” insurance, includes insurance on others, and insurance on the nature and society as well.

4 SEVERAL IMPORTANT ASPECTS

Engineering construction is the combination of humans, technology, materials and the nature. Its risk management should involve all aspects in construction. The important aspects are demonstrated as follows.

- g. In the feasibility study stage, the risk from the high-level should be paid much attention to.

In the feasibility study stage, the will of government officials and the opinion of advanced consultants may be decisive. The former reflects social political risk. The latter reflects technical authority risk. The success of major construction project and its merits are often doomed by a few words of the technical leaders and authorities. Such cases are not uncommon.

The way to overcome the poor decisions which have led to major risks is democracy. In the feasibility study stage, we should organize all kinds of consultation and assessment activities for major issues.

h. In the implementation phase, we should pay attention to the potential risks which is induced by bidding and invitation for bidding.

Because of our great population, there are plenty of design groups, construction groups and supervision groups. The investing part is easy to find the suitable construction group by inviting public bidding. However, the severe competition in construction field, difficulty in implement the bidding system, difference on ideological quality and technical quality make the bidder unreliable. Many subcontracts have very poor quality, including design part, construction part and supervision part. And these facts are responsible for accidents happening.

So, we should pay much attention to the risk in bidding and inviting public bidding. The rules and disciplines should be made as soon as possible. In the project risk management, the performance of design staff, construction staff and supervision staff should be included in the risk assessment.

i. Insurance and risk-controlled manner can be designed according to features of tunnels and underground works in engineering insurance industry.

Such as the United Kingdom, insurers' losses in the tunnels and underground works may be much bigger than other risks, with a significant difference to 4.5 times. The insurers advance three plans. They are cancelling the insurance on tunnels and underground works, raising the insurance rate and allying with the tunnel engineering. At last, they choose the allying plan, and the rule on allying action in tunnel engineering risk management of Britain was published in September 2003. The rule is fit for the problems in the construction period and the relative maintenance, but not for the problems in the operation period. We can draw on the British insurance industry, and gradually find out the suitable risk-controlled manner for China.

The insurance should be diversity to satisfy the needs of insured objects. It may be "all-risk" insurance, or an individual insurance against one subject or "third-party". This setting is helpful for the development of insurance industry.

The insurance rate may be adjusted by the size of project, the complexity of construction, the insurance type and the credibility of the insured object. It needs stimulation and lead of the government.

j. Technically, we should make research and innovation on the risk analysis and assessment.

From a technical point of view, the theory of engineering risk management is mature all over the world, while in the practical application, there are many problems to be solve in tunnels and underground works construction.

Risk assessment is based on the risk identification and risk analysis, relying on the mathematic tools to get the qualitative, quantitative and semi-quantitative results. Because of the uncertainty of tunnels and underground works, it is a big question whether the results based on the probability is reliable or not in the application.

In fact, they do. Severe accident may happen in the neglected places. The time-based monitoring system and risk control system should be established to enhance risk information collection, processing and feedback work.

In a word, the research on the risk management theory and methods needs to be continued, so that it will be refined and improved.

5 ORGANIZATION FORMS

The risk management on tunnels and underground works construction should adopt the combining method, that is the way combining the professionals with the supporters of engineering.

Risk management on tunnels and underground works construction is a systematic and professional work, which can only be done by specially trained staff. The man only with the knowledge of risk, or

the knowledge of engineering can't do this job. The cooperation of risk management professionals and well-experienced engineers can help finishing the tasks of risk identification and control.

-Engineering companies should set up tunnels and underground engineering insurance division, in charge of the insurance business. For every project, the insurance company should send out 1 to 3 risk management professional, according to the size of project, to take charge of daily risk management. The works include risk monitoring, organizing the professionals to inspect or guide on-site, filling out the statistic statements and risk reports.

-Insurance company may have a certain number of tunnels and underground works professionals work for the insured projects. Also the manager can adopt another method, that is cooperating with the professional divisions of Civil Engineering Society or other professional consultative companies. Make sure to understand both parts' responsibilities. The latter method is more suitable at present. In the tunnels and underground works division of China Civil Engineering Society, more than twenty members are the experts in design, construction and research. They are good at dealing with specific projects.

-It should be noted and discussed the issue on confliction between project risk management staff and the project supervision. From the point of view of nature of business, the two are different.

Project supervision is commissioned by the investing group, and to fulfill the contract to do inspection and supervision on contractors. The rules of their work are Industry technical standards, inspection standards, design drawings and contractual terms. While, risk management staff is sent out by the insurance company directly. Their work is to prevent and control the potential risk which may be transferred to their company from the insured company. The rules of their work are risk management discipline and contract of engineering insurance.

There is something in common for the two kinds of work. That is the supervision on the engineering quality. But they have different methods, different objectives, different targets. Generally speaking, the content of risk management is wider than supervision.

6 ADVICES

k. Although the risk of tunnels and underground works is much higher than other engineering projects, it can be controlled. There are many successful cases in foreign countries. Risk management is feasible in China.

It is a social progress to reduce the engineering construction risk to the minimum extent through implementation of risk management. In China the tunnels and underground construction projects will be more and more ambitious, and the prospects are enticing, so the implementation of risk management in the engineering field is inevitable. The state legislature should be clear.

l. In recent years, we have begun construction risk management theory and technology introduction and research work. But there is a large distance to apply them to the actual tunnels and underground works. Departments in charge of professional groups should set tunnels and underground construction risk management approach and application rules as soon as possible to promote risk management's rapid and healthy development.

m. Engineering construction risk management needs the support of insurance industry. Internationally, the insurance industry has the name of "social stability tool". The implementation of engineering risk is helpful for the performance of construction contract. The state should give some policy support on the engineering risk.

The insurance rate should be fair and reasonable. Engineering risk should be paid by rules. The insurance pay should be included in the budget. The bidding file should conclude the value of insurance rate.

n. The government figures out the trial spot in implementation of engineering risk management. For example the major urban tunnel program or the subway construction program may be chosen as the trial for implementation of risk management so that we can get more experience on risk management.

REFERENCES

Mao ru. New trend of insurance for tunnel projects. Tunnel Construction[J]. 2006.2.Vol 26(1).

Mao Ru. Risk assessment on tunnel projects. Tunnel Construction[J]. 2003.5.Vol 23(2).

Huang Hongwei. Guidelines of Risk Management for Metro Tunnelling and Underground Engineering Works[M]. Tongji University. 2006.5.