A Case of Construction Project Risk Management Analysis

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Abstract

Construction project risk management covers the risk identification, analysis and evaluation as well as to control the risk and to take measures, etc. On the analysis of construction project risk management process, describes in detail the identification, analysis and evaluation of risk and the last set of risk response measures. This article also analyzed the common countermeasures and control measures of construction engineering project risk factors. Combined with engineering example, finally, the fuzzy analytic hierarchy process (AHP) has been verified the applicability of the risk management in construction project.

Keywords

Risk Identification; Risk Analysis; Risk Strategy; Fuzzy Analytic Hierarchy.

1. Introduction

There are many characteristics among Construction project cycle such as period length, large investment and complicated technology, therefore in the process of its implementation hides a lot of risk factors. If we do better in construction engineering project risk management that can effectively avoid the construction engineering project risk. Thereby ensure the construction project carry out smoothly, finally obtained the expected comprehensive benefits about society, economy and environment Etc. Construction project risk management predict degree of influence after the risk and the risk probability of occurrence by risks identification and by risks analysis and evaluation to reduce the risk loss of the project. For the purpose of reducing the risk of the project and realizing the project goals, the risk level of the whole project are evaluated comprehensively .Finally, aim at all kinds of risk factors take the corresponding risk counter measures.

2. The concept of risk and the formation process

Risk is uncertain losses. Through risk analysis and assessment, we can predict probability of the occurrence and consequences. In terms of construction project, there are internal and external uncertain risk factors among the whole process of the project approval design, construction and completion in the project.

Risk factors induce the risk and determine the frequency and severity of the engineering project risk. Accidents of risk are caused by the risk factors so that are uncertainty, in which are the vehicle of the loss. Accidents of risk and factors of risk are not absolute, but relative. In terms of an event, if it makes any losses directly, call as risk accident; which it's just a potential, indirect loss, it is defined as the risk factors. Losses of risk are adverse unexpected economic value decrease to construction project target when the risk accident. The accident is not the same as risk loss. If the risk accident impact on construction target, thereby causing loss to the risk, which there is no effect, doing not risk loss. Therefore, the formation mechanism of the construction engineering project risk can be represented in figure 1:

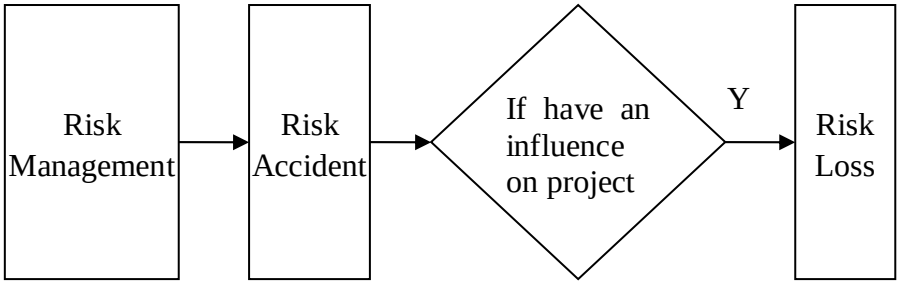

Figure 1. The formation mechanism of the construction engineering project risk

3. The management process of project risk

3.1 The risk identification of construction engineering project

A priority for the project risk management is identification to construction engineering project risk, and by providing the necessary information to make analysis and evaluation is more evidence. Identification to construction project risk is the foundation of the whole risk management, correctly of identification to construction project risk will directly determine the effect of risk analysis and evaluation. But the risk is concealment, invisibility, so that we identify risks is not so easy, there are very strong insight and sharp mind to risk managers. In identification phase of construction project risk, mainly we need list all risk factors that may affect the project objectives in the each stage. For different construction engineering project, we need to adopt corresponding, scientific and reasonable method to risk identification, to identify and analyze the key project risk, so as to prepare for the late risk analysis and evaluation. Can say, in the recognition stage has been identified risk factors is no longer a risk, but a management issue.

If risk factors identification is not accurate, will have a huge influence on the risk management of the follow-up work, and even lead to project risk management is invalid, so that to be comprehensively, accurately, continuously, systematically identify to project risk factors.

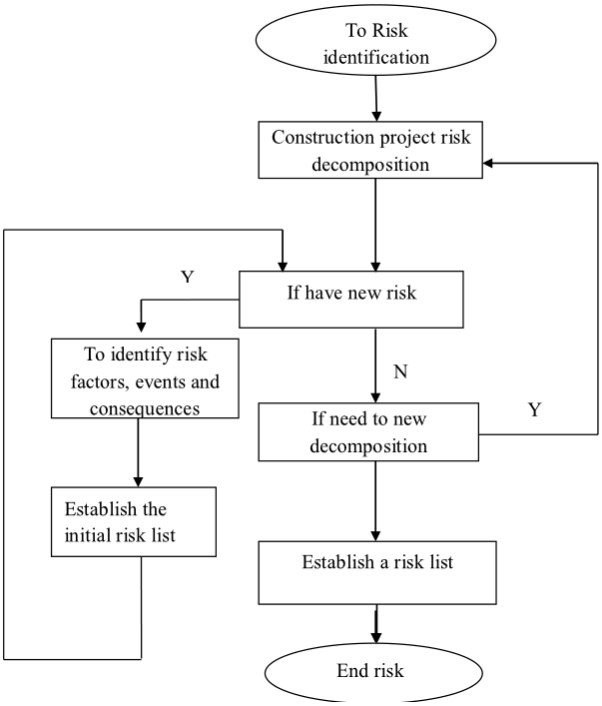

Figure 2. Construction engineering project risk identification process

The recognition of construction engineering project has two main important purpose:

1) By risk identification to select proper management countermeasure;

2) By the risk identification to analyze and evaluate influence degree of risks.

In terms of construction project, the ultimate goal aims at establishing a project risk list. Figure 2 shows the process available.

3.2 The risk analysis and evaluation of construction engineering project

Construction engineering project risk identification can solve the problem of the existence of the risk, the risk manager can clearly know the risk existing in the project, the risk which links, and when. Risk identification, however, did not answer the question: how much each risk occurrence probability, how much risk loss caused, how the relationship between different risks are, they can have what kind of comprehensive consequences for project or overall impact and can project principal can accept these risks. So on construction project risk analysis and evaluation aims to solve these problems, the works are On the basis of risk identification .There are a lot of method about Construction engineering project risk analysis, Generally speaking, research and expert scoring method, profit and loss balance method, mathematical statistics method, sensitivity analysis, extrapolation method and influence diagram method, etc. The whole process of construction engineering project risk analysis is shown in figure 3.

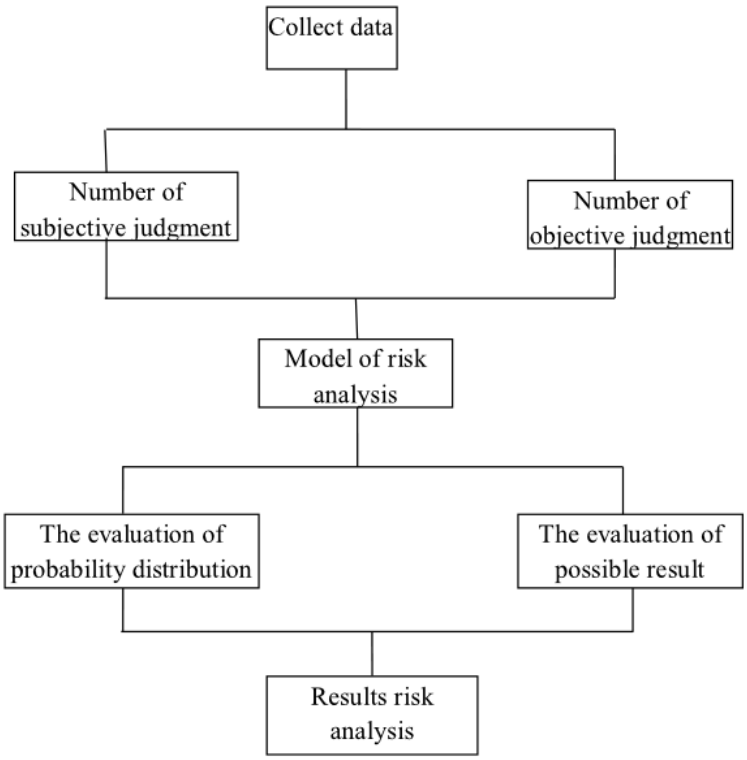

Figure 3. The construction of engineering project risk analysis process

3.3 Construction engineering project risk response

Risk response of construction engineering project is what take the risk identification, risk analysis and evaluation to the construction project, with the data and conclusions, and in the evaluation phase identified the risk of construction project in response to the measures that put forward on the basis of grade, and then to take corresponding measures according to different risk levels.

Construction engineering project risk response measures of risk refers to on the basis of the risk identification, risk analysis and evaluation, to avoid or reduce the possibility of occurrence or all kinds of countermeasures of after risks loss. Generally speaking, construction engineering project risk countermeasures include risk transfer, risk avoidance, risk retention, risk control and risk using method, etc. Because of the complexity of the construction project itself, in the practical engineering application usually adopt a combination of a variety of coping strategies. That is to say, in terms of a project in the risk management, we may also use a variety of coping strategies. The same risk problems in different project may also need to what take different strategies.

4. Fuzzy hierarchy method in the application of the construction project risk management

4.1 Project profile

The paper introduces the construction project A that practices construction project in 2010, the project was established as estate project in April 2009. The country issued a series of preferential policies on real estate industry, such as bank lending rates of financial institutions greatly reduce delay charge, a number of real estate tax breaks even with the housing accumulation fund loan buys a house down payment and some to reward buyers such as government policy, the preferential policy, more or less to the located real estate industry development of A project, which become the momentum of the development of the real estate industry. At the time, due to the wide spread of the global financial crisis, the building materials market is not so lucky. The demand of building materials is caught in the downturn. Due to a supply glut, building materials prices are low. Project A take the preferential policies at the time and the development of building materials of low cost as A good time to implement, which realize expected economic benefits, social benefits and other comprehensive benefits.

4.1.1 The constructive environment of the project

A. Project geological conditions

Project A is located Anyang city in the north of Henan province. Due to the land surface is clay gravel layer and batholith structure is hard, which suitable build high-rise buildings. From the use of the existing buildings the early stage of Survey report, you can see the plot structure is stable and no phenomenon of landslides, mudslides, floods and other natural disasters nor the sudden earthquake in the history of signs.

B. The project conditions

Project is located transition region in the north subtropical and warm temperate zone. The four seasons climate, rain heat over the same period, annual average temperature 14.3 ℃, annual average frost-free period 210 days, annual average rainfall of 551.9 millimeters.

C. Public facilities

Project is located in a main street, which has the good power supply condition, so that can guarantee the use of water and electricity required for the production of life; The geographical position is very convenient traffic conditions, which the accumulate business, education, health care, finance, post Etc..Regional public facilities are also very perfect. There are characteristics among the project, such as obvious geographical advantages, big investment value and the large space of the appreciation.

4.1.2 Technical and economic indicators of the project

The main technical and economic indicators of project A as shown in table 1.

Table 1. The main technical and economic indicators of the project

Projects	Units	Values	Remarks
one. Total area of the land	m^2	40510	
1. Commercial housing	m^2	37190	
2. Market	m^2	3320	
two. Overall floorage	m^2	116015	
1. Commercial housing Area of dwelling structure	m^2	90485	
Stilt floor construction area	m^2	2160	
The area of garage and utility room	m^2	1420	
Realty and activity area	m^2	480	

building area of The underground garage	m^2	4854	not count Plot ratio
summation	m^2	99399	
2. business Commercial building area	m^2	12240	
building area of The underground garage	m^2	32776	not count Plot ratio
summation	m^2	15516	
three. plot ratio	/	2.86	
four. Building density	%	20.4	
five. greening rate	%	50.9	

4.2 The risk identification of the project

Construction project A is passed on-the-spot investigation, questionnaire and investigation (see appendix B) combination of a variety of methods by project risk management group in the process of risk identification. To summarizes all the risks associated with this project and carries on the classification, as shown in table 2.

Table 2. The project classification of associated Construction project risk factors

Risk type	Risk factor
Policy	Imperfect laws and policies, changes, etc
Economy	Market risk, finance risk
Design	Unreasonable designing scheme, unadvanced design
Construction	project delay, quality dissatisfaction, improper security measures
Management	Low level of management, Coordination between the various stakeholders
Contract	The contract signing and the performance ability is not enough, disputes of Claims and contract
Nature and the environment	The environmental pollution of Earthquake, flood, fire, rain, such as bad weather, complex engineering geological conditions

4.3 The risk factor analysis construction engineering project

4.3.1 The design risk factors

construction project A in the design phase, as there is no crime scene investigation to designers, no carefully analysis to the exploration design report , no enough in-depth understanding of the specific conditions of construction project A, no enough knowledge level for the designers and limited personal ability, which design factors are more likely to the unreasonable design. Furthermore, build enterprise want to long-term develop in local and want to enjoy certain reputation. In order to achieve the "different" effect with the surrounding project, there are certain risks project A on the design concept and model innovation and so on; Moreover, we must be make some violation of construction design specifications and standards because of the request of the owner in the process of design, especially the compulsory requirements standards in some countries, place, or the industry. Thus brings to the construction engineering project design.

4.3.2 Economic risk factors

The methods such as expert investigation can be concluded that construction project A facing the main economic risk cover the influence of market changes and the impact of project financing.

A. Market Risk

There is good real estate development situation on Location of Project A in 2009. Commercial housing sales increased by 172% compared with a year; Sales area is also very optimistic, with the previous year increased by 183%; Commercial housing sales price rose 8.6% from a year with that

of last year. Construction project A is located in the downtown area, which is the center of the county. The geographical position has great advantages compared with those of other buildings, market competitiveness must be stronger than other buildings and the appreciation space of the product is relatively large, so that the market risk is relatively small.

B. The financing risk

Construction project A is divided into two parts, which shopping mall at the underground and commodity house at the ground. Full funding of the underground shopping malls self-raised capital contribution by the enterprise. Project construction is one year, over the course of project construction period, enterprise need to borrow from the bank about a $ and loan interest rate calculated at 6.31%. During the construction period, the bank loan interest rate is expected change. Therefore, in terms of construction project A, project financing is likely to bring certain influence to project goals.

4.3.3 Risk management factors

The major management risk factors for construction project A is how to make the various project participants achieve "win-win" situation in the process of the implementation of the project and good coordination between the parties. Although in the early stage of the project, management measures of construction project A have been taken some coordination in various aspects. Due to construction projects have particularity, such as long construction cycle, complexly constructions, there are conflict for all the stakeholders.

4.3.4 Construction risk factors

For general construction project, a variety of risks exist in the construction process of the construction. Construction project A is considerate comprehensive Come to the main risk of construction that risk of construction quality, construction period and construction safety risk.

A. Uncertainty analysis of Construction project A during construction period:

1) In the construction organization design, schedule is improper for cross each job;

2) labor productivity, such as the rationality of the labor employment form a complete set, the construction team quality, labor employment dynamics, etc.;

3) Material supply condition and transportation condition, project A is located in the center of the county, which transportation is convenient, the transportation is convenient.

4) Due to construction work of building project A has special environment, including aerial work and the outdoor work. So the climate has a great influence on construction period.

B. Uncertainty analysis of construction project a construction quality:

In construction process, constructors lose sight of tracking on quality management, especially those key positions and key process of tracking and processing.

C. Uncertainty analysis of construction project a construction safety:

1) There is unsafe state for machinery and equipment, such as construction equipment and tools do not normally operate and use.

2) Personal unsafe factors, such as tower crane error cause of the casualties, etc.

4.3.5 Natural and environmental risk factors

From geological investigation report of the construction project A can be concluded that geological structure of the construction project A is stable and clear four seasons. However, there are common floods in local, so the risk of construction project A is the flood. Construction project A building high quality residential quarters in the process, though some protective measures have been taken to reduce the impact on the surrounding environment, but the influence is inevitable.

4.3.6 Contract risk factors

Major contract is a contract for construction project A risk. In the course of construction, number of participants involved, capability and credibility could bring some risk to the project contract, bring loss to the project.

4.4 Fuzzy analytic hierarchy process (AHP) to evaluation of project risks

4.4.1 To establish hierarchical model of the system

For construction project A risk factor identification and analysis, classification analysis of key factors and establishing a risk factor analytic hierarchy model of construction project, Figure 4 is a risk stratification analysis model for construction projects.

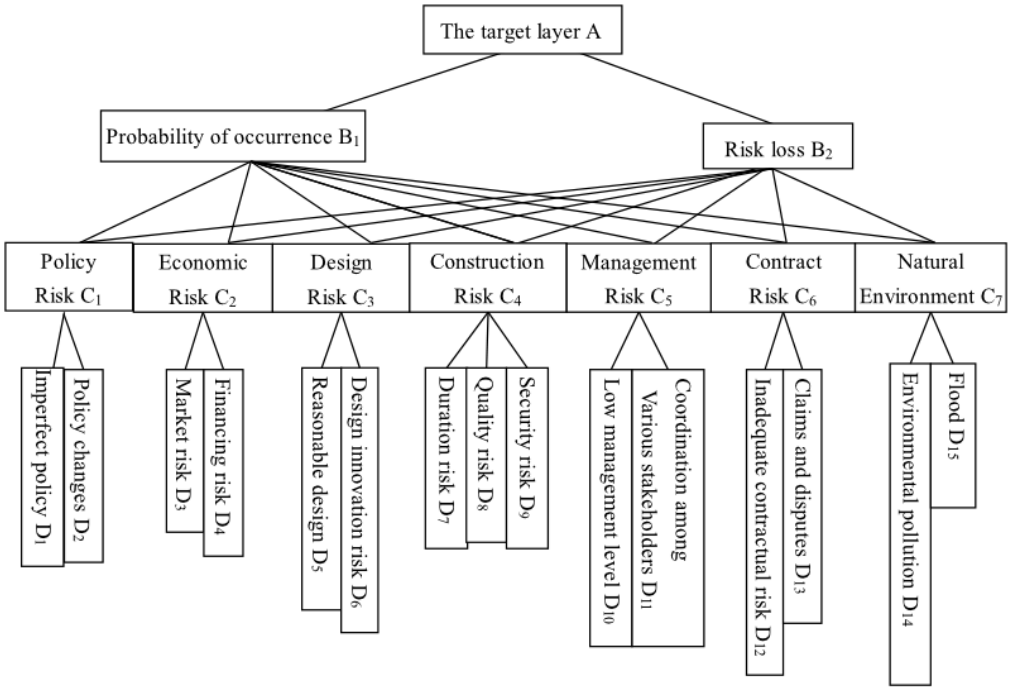

Figure 4. Hierarchical analysis model of Construction project a risk factors

4.4.2 Consistency and test its structural fuzzy complementary judgement matrix

With respect to the probability of B1 and B2 risk loss, according to (0.1-0.9 number table) scoring methods, expert analysis 7 risk factors of c and 22 factor comparison, finally got the fuzzy complementary judgement matrices B1 and B2.

$$\text{Assumption } B_1=\begin{pmatrix} 0.5 & 0.4 & 0.4 & 0.3 & 0.2 & 0.3 & 0.7 \\ 0.6 & 0.5 & 0.6 & 0.2 & 0.1 & 0.2 & 0.5 \\ 0.6 & 0.6 & 0.5 & 0.4 & 0.6 & 0.5 & 0.9 \\ 0.7 & 0.8 & 0.6 & 0.5 & 0.8 & 0.8 & 0.9 \\ 0.8 & 0.9 & 0.4 & 0.2 & 0.5 & 0.5 & 0.9 \\ 0.7 & 0.8 & 0.5 & 0.2 & 0.5 & 0.5 & 0.8 \\ 0.3 & 0.5 & 0.1 & 0.1 & 0.1 & 0.2 & 0.5 \end{pmatrix}$$

$$\text{Assumption } B_1=\begin{pmatrix} 0.5 & 0.6 & 0.4 & 0.3 & 0.7 & 0.6 & 0.4 \\ 0.4 & 0.5 & 0.5 & 0.2 & 0.8 & 0.7 & 0.6 \\ 0.6 & 0.5 & 0.5 & 0.4 & 0.7 & 0.5 & 0.3 \\ 0.7 & 0.8 & 0.6 & 0.5 & 0.9 & 0.8 & 0.7 \\ 0.3 & 0.2 & 0.3 & 0.1 & 0.5 & 0.2 & 0.3 \\ 0.4 & 0.3 & 0.5 & 0.2 & 0.8 & 0.5 & 0.4 \\ 0.6 & 0.4 & 0.7 & 0.3 & 0.7 & 0.6 & 0.5 \end{pmatrix}$$

According to the theorem 4.1, if a fuzzy complementary judgment matrix $A=(a_{ij})_{n\times n}$, for matrix $A=(a_{ij})_{n\times n}$ in sum $r_i=\sum_k^n a_{ik}$ (i=1,2,3,…,n).As a mathematical transformation $r_{ij}=\frac{r_i-r_j}{2(n-1)}+0.5$,get fuzzy consistent matrix $R=(r_{ij})_{n\times n}$,to the normalized processing of R, get factors sorting vector $W=(W_1, W_2, \ldots, W_n)^T$,in which the W vector satisfy

$W_i=\frac{\sum_{j=}^{n} a_{ij}-1+\frac{n}{2}}{n(n-1)}$(i=1,2,…,n).

Get weight vector WB_1 and WB_2 of B_1 and B_2.

WB_1 =(0.126, 0.124, 0.157, 0.181, 0.160, 0.151, 0.101)

WB_2 =(0.143, 0.148, 0.143, 0.179, 0.105, 0.132, 0.150)

By the definition of 4.2, get calculation results of B_1 and B_2's characteristic matrix:

$$WB_1=\begin{pmatrix} 0.5 & 0.504 & 0.445 & 0.410 & 0.441 & 0.455 & 0.555 \\ 0.496 & 0.5 & 0.441 & 0.407 & 0.437 & 0.451 & 0.551 \\ 0.555 & 0.559 & 0.5 & 0.464 & 0.495 & 0.509 & 0.609 \\ 0.590 & 0.593 & 0.536 & 0.5 & 0.531 & 0.545 & 0.642 \\ 0.559 & 0.563 & 0.505 & 0.464 & 0.5 & 0.514 & 0.613 \\ 0.545 & 0.549 & 0.490 & 0.455 & 0.486 & 0.5 & 0.599 \\ 0.445 & 0.449 & 0.391 & 0.358 & 0.387 & 0.401 & 0.5 \end{pmatrix}$$

$$WB_2=\begin{pmatrix} 0.5 & 0.491 & 0.500 & 0.444 & 0.577 & 0.520 & 0.489 \\ 0.509 & 0.5 & 0.509 & 0.453 & 0.585 & 0.529 & 0.497 \\ 0.500 & 0.491 & 0.5 & 0.444 & 0.577 & 0.520 & 0.488 \\ 0.555 & 0.547 & 0.555 & 0.5 & 0.630 & 0.576 & 0.544 \\ 0.423 & 0.415 & 0.423 & 0.369 & 0.5 & 0.443 & 0.412 \\ 0.480 & 0.471 & 0.480 & 0.424 & 0.557 & 0.5 & 0.468 \\ 0.512 & 0.503 & 0.512 & 0.456 & 0.588 & 0.532 & 0.5 \end{pmatrix}$$

According to definition 1: Assuming matrix $A=(a_{ij})_{n\times n}$ and $B=(a_{ij})_{n\times n}$ are fuzzy judgment matrix, we call $I(A,B)=\frac{1}{n^2}\sum_{j=1}^{n}\sum_{i=1}^{n}|a_{ij}+b_{ij}-1|$ are the compatibility of A and B.

Respectively, to calculate compatibility about the fuzzy complementary judgment matrix B1 and B2 and its characteristic matrix $WB_1^*$and WB_2^*,get $I(B_1,WB_1^*)=0.089<0.1$,$I(B_2,WB_2^*)=0.076<0.1$,Due to its compatibility are less than the attitude of decision-makers α（usually α=0.1）, so fuzz y judgment matrix B1 and B2 are satisfied with the consistent, Thereby confirming distribution of the weight rationality its weight set WB_1 and WB_2.

A and C layer each risk factors, In a similar way, Calculate their respective weight vector. Assumes fuzzy complementary judgment matrix of the factor A, C1, C2, C3, C4, C5, C6, C7 is:

$$C_1=\begin{pmatrix} 0.5 & 0.3 \\ 0.7 & 0.5 \end{pmatrix},\ C_2=\begin{pmatrix} 0.5 & 0.6 \\ 4.7 & 0.5 \end{pmatrix},\ C_3=\begin{pmatrix} 0.5 & 0.8 \\ 0.2 & 0.5 \end{pmatrix},$$

$$C_4=\begin{pmatrix} 0.5 & 0.4 & 0.3 \\ 0.6 & 0.5 & 0.4 \\ 0.7 & 0.6 & 0.5 \end{pmatrix},\ C_5=\begin{pmatrix} 0.5 & 0.3 \\ 0.7 & 0.5 \end{pmatrix},\ C_6=C_7=A=\begin{pmatrix} 0.5 & 0.5 \\ 0.5 & 0.5 \end{pmatrix}$$

So its the weight vectors are calculated:

WC_1= (0.4, 0.6), WC_2 = (0.55, 0.45), WC_3= (0.65, 0.35),

WC_4 = (0.283, 0.333, 0.384), WC_5= (0.4, 0.6),

WC_6= WC_7= WA= (0.5, 0.5)

According to 1, by the calculation, compatibility are less than the attitude of decision-makers α（usually α=0.1）, so fuzz y judgment matrix B1 and B2 are satisfied with the consistent, Thereby confirming distribution of the weight rationality its weight set WB_1 and WB_2.

4.4.3 Sorting

In the last section, calculated weights are the relative to the top level in the hierarchy of elements related to the relative weight hierarchy corresponding to each weight marked on the chart in Figure 5. From Figure 5, you can clearly see on the relative weight of each element.

4.5 Measures of construction project risk

After a construction project risk assessment, clearly different standards should be the focus of construction project under the control of the key risk factors, then is to be done according to the risk

probability, risk, loss severity and tradeoff to get the final risk rating, should adopt different strategies for different risks.

Risk response measures, for construction projects in General, may, in accordance with the following table 3lai risk. Building a risk management phase of the project schedule during the implementation as shown in table 3.

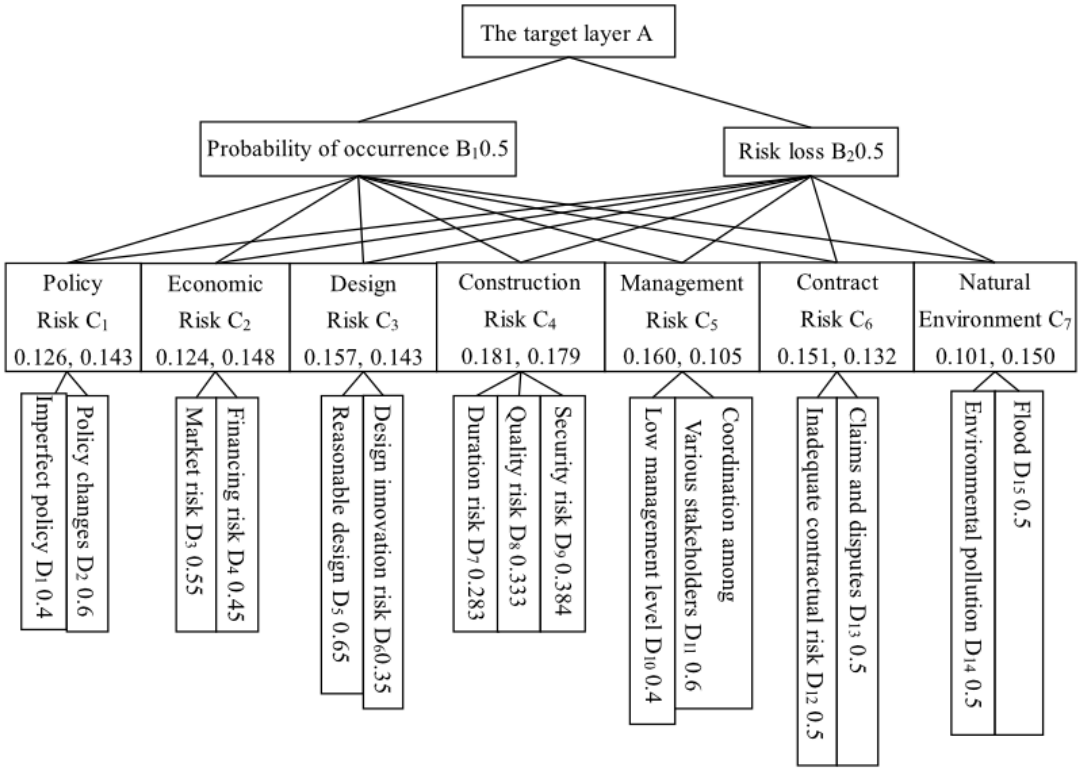

Figure 5. The relative weight of each element of the hierarchical structure

Table 3. Implementation phase of the project risk management plan

Risk categories	Probability of occurrence (high/medium/low)	influence (high/medium/low)	Risk strategy
Policy risk	medium	medium	Risk aversion, Risk mitigation
Economic risks	medium	high	Risk aversion
Design risks	high	medium	Risk mitigation, End of the risk
Construction risks	high	high	Risk aversion
Management risks	high	low	Risk aversion, Risk mitigation
Contract risks	medium	low	Risk mitigation
natural environment	low	medium	Risk aversion

4.6 Construction project risk monitoring

With the early stage of the risk identification, risk analysis and assessment and develop risk response plan, you can make decisions based on the specific circumstances and implemented. On risk should plans of implementation never is step by step so easy, because project risk management of environment in variable, risk factors also in occurred various of changes (as increased, and reduced,

and disappeared, and new risk appeared,), this may will makes originally developed of should plans has not adapted, then if not added modifications to implementation plans, not plans made adjustment, on will makes risk management of effect big discount. In addition, in the implementation process will also exist to perform or execute wide of the mark.

Risk monitoring is designed to examine risk response measures implementation and expected results are consistent if there are deviations, to find the corrective measures, and resolved in a timely manner. With the progress of the construction project, the uncertainty of the project factor is reduced. Progress with the implementation of construction projects, information that relating to the construction project itself will show it, risk management of construction project risk is more and more confident.

In order to effectively control construction project risks, project management organization must strengthen the implementation of precautionary measures. Mainly the following points:

A.Scientific risk management awareness. First, the participation party of the project set up consciousness of full risk management, which is ensured implement to the whole project construction process; Second, because construction project construction cycle is long, which is ensured implement to project implementation of full process; Finally, in the process of risk management, we need to establish the legal awareness of risk management. To the extent possible, through legal means to protect themselves legitimate rights and interests and the losses to a minimum.

B. Establish a sound risk management system. Framework of the market economy system is later in China and many systems are still immature and incomplete. In particular laws and regulations and risk management in modern construction projects are not suited and lack of insurance-related regulations and rules is serious. Therefore, we should refer to the international practice to the insurance and guarantee system that match the status quo of construction engineering projects in China in process of implementation.

C. Enterprise risk management system. Establishment of responsibility system of construction project risk management is a prerequisite for improving the anti-risk ability. Therefore, we establish an enterprise risk management system as soon as possible, scientific risk management of the project to minimize risk of loss.

D. Marketing and information management. In all walks of life in various fields, the timeliness of market information is indispensable key factors. The development of construction projects are no exception, construction companies only focus on information management, risk management can be achieved qualitative leap. On the market and the market supply and demand, enterprises should understand; in addition, our new policies and new trends to timely control. In short, businesses to close contact with the market get effective ways to strengthen information management risk control.

5. Conclusion

Construction project risk management is an important content of Construction project management, in which determines success of the project. First, we need to make analysis of theory for construction project risk management. Based on risk identification, analysis and evaluation of construction project, responding to and monitoring for construction project A, and theory combined with the actual, established structure model of risk factors level. Fuzzy analytic hierarchy process to risk analysis and evaluation of construction project A, so that get key factors of construction project A. Prevention of key factors are took the measures, and to strengthen risk control requirements is proposed.

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