Risk analysis using PROMETHEE method In Building Construction MANAGEMENT

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ABSTRACT: The building construction projects include a variety of risk factors due to uncertainties. To succeed in the projects, it is important how risks are managed. Risk management is composed of identification, analysis and response. Especially, the risk analysis is important to objectively calculate significance of risk factors. This paper evaluates a method to find priorities of risks using the AHP(Analytic Hierarchy Process). The method has some defects; (1) the consistency becomes weak as the number of pair-wise compared risks is large, and (2) the input and output procedures are complex when risks are added to or removed from a risk database. Thus the paper adopt the PROMETHEE(Preference Ranking Organization METHod Enrichment Evaluations) analysis process which is able to overcome the limitation of the AHP restricted to 9 risk factors. The PROMETHEE method makes the procedure of risk analysis simple, when the risk factors pull out and put in the risk database. The purpose of this study is to prove the possibility of the PROMETHEE analysis process by being compared with AHP.

Keywords: Risk Management, Risk Analysis, AHP, PROMETHEE

1. INTRODUCTION

1.1 Background and Object

Construction project contain various risk factors due to the characteristic of an uncertainty and complexity and this causes a result including delaying of terms of works, construction cost rising, and etc. Therefore in the construction project, risk management can remove various variants and lead a more successful project. Risk management is made through process of confirmation, analysis, and correspondence and accurate analysis of importance and priority of the risk factors can affect the success of the risk management.

Multiple criterion decision making techniques is used as the calculation method of risk importance. In the multiple criterion decision making, there are MAUTs (Multi-Attribute Utility Theory: Keeney and Raiffa, 1976) ,which find the utility function of each standards and convert the score of each alternatives to the utility, and the AHP(Analytic Hierarchy Process) proposed by Saaty as a weighed value establishing method of the evaluation component method by structuring and layering in consideration of difficult element to show with the metrical numerical value [3]

And there is the PROMETHEE (Preference Ranking Organization METHod Enrichment Evaluations) analysis method, and etc based on the concept of outranking.

As in the development of process risk management system, Yoon You-sang[6] drew the relative significance between each factors using AHP analysis technique as the analysis process about the process risk. In the case of the AHP analysis technique, it is considered as the most useful tool for the multiple criterion decision making. Researches about adaptability and benefit of AHP analysis technique have been accomplished enough and particularly in the case of selecting an alternative that the subjective judgment of an expert being selected by one numerical value or imposing the weighted value, it is used as the very powerful tool.

But in the AHP analysis technique, If the comparative object factor exceeds 9, it is difficult to maintain consistency of judgment and problem of reliability lowering may be occurred. It has to go through the complicated calculation procedure of the relative comparison, and etc. in the new factor occurrence.

In order to solve this kind of this disadvantage, we try to present the calculation method of risk importance through PROMETHEE analysis technique which comparison between factors is automatically made only by the setting up the evaluation function and parameter when adding or deleting factor.

1.2 Range and Method of research

In this study, investigation was progressed around the risk analysis among the confirmation of risk management, analysis, and the correspondence step. Risk range as analyzing objects is risk factor (below, process risk) which can be generated in the construction step of the construction project, and is limited to the risk factor which is possible to be controlled by a builder and to be

managed under the builder's responsibility among the process risk.

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As follows, this study is progressed with 3 steps.

1) Grasping about the method of importance calculation through the existing AHP analysis technique, and a feature and performance procedure of the PROMETHEE analysis technique.
2) Setting up the evaluation standard for the basic establishment for risk importance calculation using PROMETHEE analyzing technique and grasping features of the preference function by the type.
3) Presenting the process possible to be analyzed by process risk factor analysis using PROMETHEE analysis method

2. Analysis of the risk importance

2.1 AHP analyzing method

The AHP analysis was developed by the Thomas L. Saaty (1980) in the early 1970s for the first time and constituted of configuration and importance calculation of the hierarchical layer and deciding of priority[4]. In the domestic construction field, the various researches about the calculation method of the risk importance by the AHP techniques had been getting accomplished.

And by using the AHP techniques in "construction process based process risk management system", Yoon You-sang[6] selected risk to be prior managed by analyzing of the influences by the risk factors type.

The significance of risk is calculated by the execution process like figure 1 , in the AHP analysis.

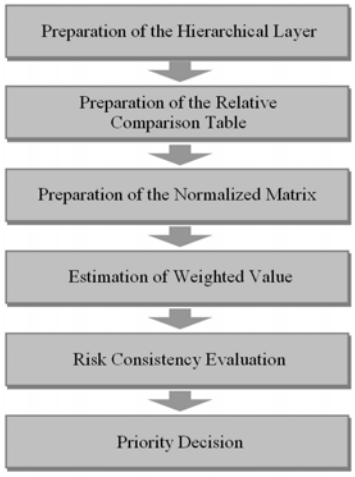


Figure 1. AHP Analysis Execution Process

AHP analysis is useful to the decision of priority by layering the decision making problem, particularly can quantitively evaluate qualitative factors and has an advantage that estimate consistency. But it is difficult to maintain the consistency of determination and deterioration of the reliability occurred if comparative object factors exceed 9.

Also there is a problem that has to go through the complicated calculation procedure of the significance such as relative comparison, and etc. when adding factor and new factor occurring.

2.2 PROMETHEE analyzing method

The Brans and Vincke[1] developed the PROMETHEE analysis method drawing the priority of alternatives by using the concept of preference leaving flow and preference entering flow based on the rank preference concept.

In PROMETHEE analysis, the relative comparison between the estimation items is automatically made through the inside analysis process if the evaluator (expert) sets evaluating functions and parameter (preference limit).

PROMETHEE has the execution process like figure 2 [3].

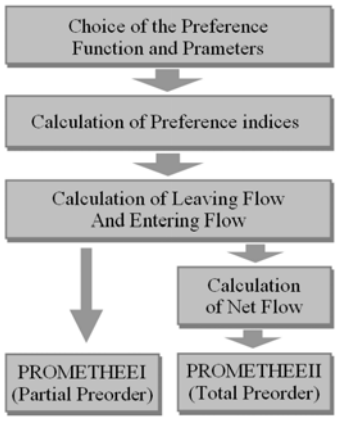


Figure 2. Execution Process of PROMETHEE Analysis

Establishment of the evaluation standard is needed, the preference function which most complies with the evaluation standard among the preference function of 6 should be selected and corresponding parameter is set in order to utilize the PROMETHEE analysis method.

Next, evaluate whether estimation items are important for the evaluation standard and or not by evaluator and calculate the quantifying value. Through this process, evaluation data like the table 1 is prepared and the preference index is calculated based on this.

Table 1. Example of the Evaluation Data for Risk Importance Calculation

Item / Criteria	max /min	Risk 1	Risk 2	Risk 3	Preference Function	Weight	Paramerer
C-1	max	0.10	0.25	0.15	V	0.33	m=0.2
C-2	max	0.35	0.07	0.22	V	0.33	m=0.2
C-3	max	0.45	0.25	0.03	V	0.33	m=0.2

By using the value which it calculates the preference index, leaving flow and entering flow of the preference are calculated. Here, it is PROMETHEEI that calculates the partial ranking by directly using the leaving flow and entering flow of the calculated preference. It says to be PROMETHEEII that finds the complete ranking through the calculation of net flow [3].

2.3 Comparison of AHP and PROMETHEE analysis technique

It is as the table 2, if the basic set up of AHP and PROMETHEE analysis techniques and axiom system is compared [5].

Table 2. Comparison of AHP and PROMETHEE Analysis Technique

classification	AHP	PROMETHEE
Preference	It depends on the subjective judgment of an evaluator.	It expresses as the mathematical function format.
Weighted value	By using the eigen value method based on the duality comparison matrices, it draws.	The evaluation fundamental star weighted value is determined through the study in advance and requirements gathering.
Of an alternative	The duality compare execution in which it depends on the subjective judgment of an evaluator.	The numerical duality compare execution by the internal algorithm.
using the method for preferring with rank	It determines as the weighted value of the evaluation standard and weighted sum size order of the evaluation fundamental star preference.	By using the method for preferring with rank, it is determined with ranking.
The stratification of the problem with decision making	The stratification of the evaluation standard.	It is not reflected in a model.
Basic assumption	The transitivity, the comparison possibility, and the division.	The sad fall season isomerism, a non-comparability, and the division.

Since the relative comparison between alternatives is automatically performed by the internal algorithm if the decision maker determines the evaluation function and parameter, there are many numbers of comparative alternatives In case the new alternative is deleted or added, can efficiently than AHP [5].

3. Basic establishment for utilization of PROMETHEE

3.1 Evaluation standard Establishment

The establishment of the evaluation standard is needed in order to utilize the PROMETHEE analysis techniques. The standard has to be presented in performing the evaluation about that the estimation item has the significance of how much in the evaluation standard. The valuation basis setting up at the method of important calculation of the process risk sets based upon the result that the process risk reaches to the construction project.

As the process risk which control of a builder is possible, is the factor to be managed under the builder's responsibility, when process risk occurs it is connected to the delay of a term of works.

We studied a research toward the process risk factor of the reinforced concrete work. And as shown in Figure 3, we classified factors which cause the analyzed result of working term delay as 4 types such as cost-up, poor quality, safety accident, and operation delay.

In this paper, as follows, the analyzed 4-typed factors are defines. Cost-up is a factor which induces working term delay due to the occurrence of the additional expense. And poor quality is the working term delay factor due to a defect on the quality including the reconstruction due to a disqualification, and etc. Moreover, safety accident is the working term delay due to the number of lost work days occurrence due to the accident occurrence, the operation delay is the working term delay factor which gives an effect to the whole working term delay due to the operation delay of the corresponding working type.

The evaluation about which the process risk influences on the working term delay through the evaluation of this 4 type factor gets accomplished.

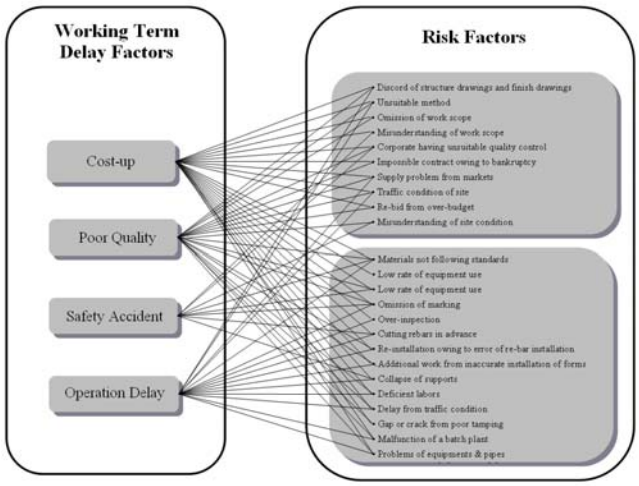


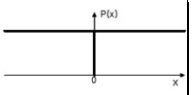
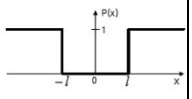
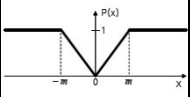
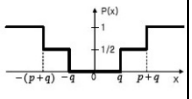
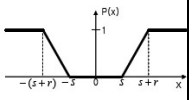
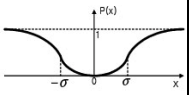
Figure 3. Analysis of Working Term Delay Factors

The presented reinforced concrete work process risk factor progressed a research toward the process risk of presenting in the research of the Yoon You-sang [6]

3.2 Features of preference function by the type

The preference function which matches the characteristic of the evaluation standard in order to utilize the PROMETHEE analysis techniques has to be selected. The preference at the PROMETHEE analysis techniques is defined as 6 type.

Table 3. Features of Preference Function by the Type

Preference function.		Feature.
(1) usual		The working term delay is generated in the risk occurrence irrelative of the intensity of risk.
(2) U-shape		When it is unable to reach any affect in the risk occurrence according to the risk intensity to the certain intensity (l) to the working term delay but it exceeds the certain intensity, the working term, delay according to risk is generated.
(3) V-shape		The affect that the certain intensity (m) reaches to the working term delay in the risk occurrence according to the increment of the risk intensity consistently increases.
(4) Level		When the certain intensity (p) exceeds as risk increases in the risk occurrence of the intensity, the affect that it reaches to a primary to the working term delay is appeared, and when the certain insensity (p+q) exceeds, the working term delay is generated.
(5) Linear		The certain intensity (s) doesn't influence on the working term delay in the risk occurrence, the second certain intensity (s+r) consistently influences on the working term delay in this intensity (s).
(6) Gaussian		When it is gentle and the effect that it reaches to the working term delay in the risk occurrence according to the risk increase the certain intensity (σ) exceeds this intensity (σ), it has an effect to be rapid in the working term delay.

The preference function for each type feature can be organized like the table 3. And through this, the basic set up about a calculation the importance of the process risk of utilizing the PROMETHEE analysis techniques is made if the establishment of the preference function about the evaluation standard and parameter are set up.

4. The process risk importance produces

4.1 Preference function selection and setting up parameter

The preference function matched the characteristic of each evaluation standard is selected.

The preference function corresponding to the evaluation standard presented in chapter 3.1 is selected and the parameter required in the preference function is set. The evaluation index of 4 evaluation standards, Cost-up, poor quality, safety accident, and the operation delay produce of 0~5 based on the evaluation index calculating table of the table 4 by evaluator.

Table 4. Evaluation Index Calculating Table

index	evaluation standard
0	No working term delay factor occurs.
1	The potential of working term delay factor is low if it occurs then there are no schedule of construction delay.
2	The potential of working term delay factor is low and the schedule of construction days are few.
3	The potential of working Term delay factor is high but the schedule of construction days are few.
4	The potential of working term delay factor is high and the schedule of construction days are many.
5	The potential of working term delay factor is 100% and it influence a huge affects to the schedule of construction.

According to the process risk intensity, since the whole schedule of construction is together delayed, each is determined that the preference function of V-type is suitable.

Since evaluation index of each estimation item is more dangerous as a value is large, it is defined as the problem of the maximum, and evaluation data is prepared for the process risk importance calculation based on the described in the above like the table 5.

In order to analyze the process risk importance utilizing the PROMEHTEE analysis techniques, the process was shown using the arbitrary index of evaluation.

Table 5. Evaluation Data for Risk Importance Calculation

Item / Criteria	max /min	Risk 1	Risk 2	Risk 3	Risk 4	Risk 5	Preference Function	Weight	Paramerer
Cost-up	max	5	3	3	2	4	V	0.25	m=5
poor quality	max	2	1	2	5	3	V	0.25	m=5
safety accident	max	1	1	3	3	4	V	0.25	m=5
operation delay	max	2	3	1	4	2	V	0.25	m=5

4.2 Preference index calculation

If evaluation data are calculated based on the content that it prepares through the method (1), the preference index can be found like table 6.

$$\pi(a,b) = \sum_{h=1}^{4} w_h p_h(a,b) \qquad (1)$$

Table 6. Preference Index

$\pi(a,b)$	Risk 1	Risk 2	Risk 3	Risk 4	Risk 5
Risk 1	-	0.15	0.15	0.15	0.05
Risk 2	0.05	-	0.10	0.05	0.05
Risk 3	0.10	0.15	-	0.05	0
Risk 4	0.35	0.35	0.30	-	0.20
Risk 5	0.20	0.30	0.20	0.15	-

In this (1), the evaluation standard is cost-up, poor quality, safety accident, and the operation delay and w_h shows the weighted value of the evaluation standard, p_h (a,b) is the function reflecting the preference inclination of the decision maker about the evaluation data difference of an alternative 'a' and 'b'[3].

4.3 Calculation of the leaving low and Entering flow of preference.

Leaving flow(Φ^+)of preference is the numerical value which shows the extent of dominating or preferring other alternatives. Entering flow(Φ^-)of preference is the numerical value which shows the dominated or preferred extent from the other alternatives [3].

$$\Phi^+(a) = \sum_{x \in k} \pi(a, x) \qquad (2)$$

$$\Phi^-(a) = \sum_{x \in k} \pi(x, a) \qquad (3)$$

By using the method (2) and method (3) based on the preference index which use the method (1), calculated values of Leaving Flow of a preference and Entering Flow are found like table 7.

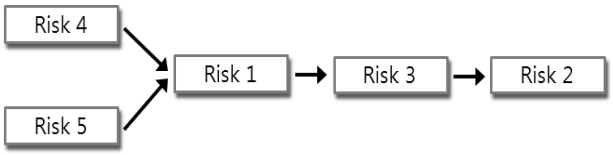
Table 7. Leaving Flow and Entering Flow

	Risk 1	Risk 2	Risk 3	Risk 4	Risk 5
Leaving Flow(Φ^+)	0.125	0.063	0.075	0.300	0.213
Entering Flow(Φ^-)	0.175	0.238	0.188	0.100	0.075

4.4. PROMETHEE Ⅰ

If the calculation value of table 5 is used, the partial ranking like figure 4 can be shown.

Figure 4. Partial PROMETHEE Ⅰ Relation



In figure 4, the items in the left side are higher as the risk factor in the priority than the items in the right.

Because PROMETHEE Ⅰ shows partial ranking, risk needless Risk 4 and Risk 5 are impossible with comparison.

4.5 Net flow calculation

In the method (4), Net flow($\Phi(a)$)shows the difference of leaving flow aand entering flow of preference[3]

$$\Phi(a) = \Phi^+(a) - \Phi^-(a) \qquad (4)$$

Net flow can be calculated if the leaving flow and entering flow of the preference are calculated by the method (4).

The table 8 is the value calculated net flow and become data for applying PROMETHEEII.

Table 8. Net Flow

	Risk 1	Risk 2	Risk 3	Risk 4	Risk 5
Net Flow(Φ)	-0.050	-0.175	-0.113	0.200	0.138

4.6 PROMETHEE Ⅱ

If the calculation value of the table 6 is used, complete ranking like figure 5 can be shown.

Figure 5. Total PROMETHEE Ⅱ Relation

Like as partial ranking, moreover in complete ranking, Risk 4 which is the initial point of an arrow becomes also the process risk acting highest process risk factor, Risk 2 is the process risk which has the smallest risk factor.

In PROMETHEE ii, the priority of Risk 4 and Risk 5, showed up being incapable with comparison through the calculation of net flow in PROMETHEEI, is determined and the priority of whole process risk is determined

4.7 Adding and deleting of Schedule risk

After the execution process of the PROMEHTEE analysis method is completed, in case the new process risk is added, if only the index of evaluation of the additional process risk about the evaluation standard inputs, the relative comparison between the estimation item is automatically made through the inside analysis process. And in case existing process risk is deleted, the inside analysis process automatically gets accomplished the deleted process risk.

Therefore if the new procedure risk addition and process risk omission are generated in PROMETHEE analysis, Analysis need not be gone through complicated importance calculation procedure such as the relative comparison, and etc. generated in the AHP analysis technique and can be performed effectively.

5. Conclusion

In this study, problem of the AHP analysis techniques used as the calculation method of process risk importance in the existing research is grasped, and as the alternative of this method, we proposed PROMETHEE analysis technique that if the preference function and parameter were set up by an evaluator, then the relative comparison analysis of the process risk factor is automatically possible by the inside analysis process so that there were many number of process risk factors. And presented PROMETHEE analysis can make more effective analyzing when new process risks addition or omission.

In this study, in order to utilize PROMETHEE analysis techniques, we established the evaluation standard and presented the process of the calculation method of process risk importance using PROMETHEE analysis.

And then we identified applicability of PROMETHEE analysis technique in the calculation method of process risk importance.

It should be continuously complemented through the requirements gathering of many experts in the setting up of the selection of the valuation basis and preference function and parameter in the future so that the process risk importance of utilizing the PROMETHEE analysis techniques can secure the reliability of the method of calculation.

Moreover, further studies should be progressed together for presenting the plan for reaction to users as any form through the analysis process and the process risk importance of utilizing the PROMETHEE techniques.

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