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Study on the Risk Change Pre-control of Power Transmission and Transformation Based on Matter-element Analysis

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Abstract: The influencing factors of power transmission and transformation engineering are technology risk, natural risk, economic risk, contract conditions and the professional quality risk. According to a large number of references, an analysis model based on matter-element theory to evaluate the engineering change risk of power transmission project has been developed, aiming at China's current change management situation, and proposing the corresponding control measures.

Keywords: Engineering change, matter-element model, risk factors.

1. INTRODUCTION

In recent years, keeping the gradually deepening of lean management and refinement in the State Grid Corporation in view, Power Transmission Project Cost Management has been continuously strengthened, and the whole process of cost management and control has been regulated which makes the ontology engineering cost under effective control. But,in the process of constructing power transmission projects, the technical conditions , design depth, natural conditions and other conditions still make power transmission projects under great uncertainties. These uncertainties lead directly to the introduction of engineering changes which should increase cost control [1, 2] by analyzing and evaluating the risk factors of power transmission and transformation project engineering. It can scientifically help the construction units to establish early warning mechanism for engineering disasters and make corresponding preventive measures before the implementation of projects.

2. RISK FACTORS ANALYSIS OF POWER TRANSMISSION PROJECT CHANGE

2.1. The Technical Risk

Technical risk mainly refers to the possibility of engineering change caused by the technical uncertainty of power transmission project construction units. According to the research, technology risk classification can be divided into risk from the owner, designer, contractor and supervisor.

2.2. The Risk of Natural Conditions

The natural risk refers to the changes arising from natural environmental conditions and other risk factors in the projectconstruction process of the power transmission. For example, a series of factors such as the weather change, storm, typhoon, flood, fire, geological disasters are likely to bring influence and damage to project schedule, cost, and quality [3].

2.3. Economic Risk

Economic risk is mainly that the power transmission project is influenced by various factors in society making it risky for both the construction project cost control and schedule control. Economic risk results from the following reasons: unfavorable macroeconomic situation; large inflation rate , financing difficulties and so on.

2.4. The Risk of Contract Conditions

Conditions of Contract risk is the risk of change which is brought by the imperfect conditions of contract and poor execution during the process of construction. For example, the unclear definition of contract scope, confusion of project organization and management, lax cost control and other risk events which can supply lagging negative impact on contract management goals.

2.5. The Risk of Personnel Quality

The risk of personnel quality is the possibility of adverse influence which is caused by the lack of project technical quality and professional acumen among the main parties involved in the contract. For instance ,the low quality of main designers may lead to a large number of design errors and omissions; and the low personnel quality of construction management can result in reworking of the project. As a result, prolonged duration and costs rising may break out [4].

3. MATTER ELEMENT MODEL RISK EVALUATION OF POWER TRANSMISSION AND TRANSFORMATION PROJECT ON ENGINEERING CHANGE

3.1. Matter Element Analysis Model

Matter element analysis is a new subject that Professor Cai Wen founded in 1983. It is an interdisciplinary field of

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thinking science, system science and mathematics, and also a fuzzy discipline with wide application through natural science and social science. It uses formal tools to study the rules and methods of complex problems from quantitative point of view. The key points are: the thing is described with three elements, (things N, characteristic C, the magnitude V) namely ordered 3 elements R = [N, C, V] as the description of the basic element. These elements form the composition of matter element.

3.2. The Index System of Risk Evaluation

Based on the matter-element theory, the basic element of thing is described with three ordered elements "things N,features C, value V", which is so-called matter-element ,represented by R,R= { N, V, C}, The N stands for thing (refers to power transmission and transformation project engineering change risk level of security),C represents the characteristics of thing N (refers to classification of engineering change risks),V represents the magnitude of the thing characteristic C (in this case refers to the evaluation of engineering change risks).A thing has lots of features ,and if the thing N has n features c_1, c_2, c_3, …, c_n and the corresponding value v_1, v_2, v_3, …, v_n, the element R can be expressed as

$$R=\begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ R_4 \end{bmatrix}\begin{bmatrix} N & c_1 & v_1 \\ & c_2 & v_2 \\ & \vdots & \vdots \\ & c_4 & v_4 \end{bmatrix} \tag{1}$$

can be simply as R={N, V, C}.

The Classical domain of risk can be defined as

$$R_j=\begin{bmatrix} N_j & c_1 & v_{j1} \\ & c_2 & v_{j2} \\ & \vdots & \vdots \\ & c_n & v_n \end{bmatrix}=\begin{bmatrix} N_j & c_1 & (a_{j1},b_{j1}) \\ & c_2 & (a_{j2},b_{j2}) \\ & \vdots & \vdots \\ & c_n & (a_{jn},b_{jn}) \end{bmatrix} \tag{2}$$

In the equation N_j—— risk level of evaluation objects (j = 1, 2, …, m) ;

c_i——Characteristics of risk level N_j (j = 1, 2, …, n), which is the sub index; c_{ji}= (a_{ji}, b_{ji}), indicates the magnitude range that risk level N_j represents on feature cj, namely the range that every risk level represents on each corresponding index taken,which is called the classic domain.

According to the general safety standards, power transmission and transformation project engineering change risk security levels can be divided into five risk grades(from R1 to R5). The lower the risk grade, the safer the power transmission and transformation. Technical level, natural conditions, economic conditions, contract conditions, personnel quality consist of the five primary safety indexes .15 secondary indexes such as the risk of the design depth, the risk of new technology in design, the risk of new technology in construction risk and so on are listed under the five primary indexes. And according to the advice of experts, each level of risk is given a corresponding score range [5, 6].

1) determine the segment domain of risk level

The following equation to calculate the change risk segment domain of power transmission project engineering can be evaluated.

$$R_j=(N_j,C_i,V_{pi})=\begin{bmatrix} N_p & c_1 & v_{p1} \\ & c_2 & v_{p2} \\ & \vdots & \vdots \\ & c_n & v_{pn} \end{bmatrix}=\begin{bmatrix} N_p & c_1 & (a_{p1},b_{p1}) \\ & c_2 & (a_{p2},b_{p2}) \\ & \vdots & \vdots \\ & c_n & (a_{pn},b_{pn}) \end{bmatrix} \tag{3}$$

In the equation, N_p———all the risk levels; V_{pi}= (a_{pi}, b_{pi}) ———the value range of N_p on characteristic C_i, obviously $V_{ji} \in V_{pi}$.

The segment domain of each index is shown in Table **1**.

2) determine the matter element evaluated

According to the risk level of power transmission projects, make each sub-index data or the analysis results are represented by matter-element. We can get a matter-element R_0 which can be evaluated.

$$R_0=(N_0,C_i,V_i)=\begin{bmatrix} N_0 & c_1 & v_1 \\ & c_2 & v_2 \\ & \vdots & \vdots \\ & c_n & v_n \end{bmatrix} \tag{4}$$

In the equation, N_0——power transmission project to be evaluated; V_i——the value that N_0 takes on C_i, namely, the actual value of power transmission and transformation project engineering change risk index.

3) Determine the correlation of evaluation index on the level of risk

① Calculate the distance

After the actual index data has been measured, we need to judge which risk grade interval that the data belongs to using the concept of distance. The distance between point x_o and the finite real interval X = (a, b) is as follow:

$$\rho(v_{ei},V_{0i})=\left|v_{ei}-(a_{0i}+b_{0i})/2\right|-(b_{0i}-a_{0i})/2 = \begin{cases} a_{0i}-x_0, v_{ei}\le(a_{0i}+b_{0i})/2 \\ x_0-b_{0i}, v_{ei}>(a_{0i}+b_{0i})/2 \end{cases} \tag{5}$$

In the equation, v_{ei}——the actual score of each index; v_{0i}——classical domain of each index , a_{0i}、b_{0i}——the lower bound, upper bound of the classical domain

$$\rho(v_{ei},V_{pi})=\left|v_{ei}-(a_{pi}+b_{pi})/2\right|-(b_{pi}-a_{pi})/2 \tag{6}$$

Table 1. Index score range and segment domain.

Evaluation System	Index of Evaluation	Segment Domain	R1	R2	R3	R4	R5
Technical level	risk of design depth	0-100	100-90	90-70	70-40	40-10	10-0
	design risk of new technology	0-100	100-90	90-70	70-40	40-10	10-0
	risk of new technology in construction	0-100	100-90	90-70	70-40	40-10	10-0
	risk of change control	0-100	100-90	90-70	70-40	40-10	10-0
	Risk of investigation in consruction	0-100	100-90	90-70	70-40	40-10	10-0
Natural conditions	change of geological conditions	0-100	0-10	10-40	40-70	70-90	90-100
	Climate change	0-100	0-10	10-40	40-70	70-90	90-100
Economic conditions	risk of inflation	0-1	0.0-0.3	0.3-0.6	0.6-0.8	0.8-0.9	0.9-1.0
	Financing risk	0-1	0.0-0.3	0.3-0.6	0.6-0.8	0.8-0.9	0.9-1.0
Contract Conditions	risk of default of the contractor	0-1	0.0-0.3	0.3-0.6	0.6-0.8	0.8-0.9	0.9-1.0
	risk of default of the material supplier	0-1	0.0-0.3	0.3-0.6	0.6-0.8	0.8-0.9	0.9-1.0
	risk of project claim	0-1	0.0-0.3	0.3-0.6	0.6-0.8	0.8-0.9	0.9-1.0
Quality of personnel	personality of designer	0-100	100-90	90-70	70-40	40-10	10-0
	personality of supervisor	0-100	100-85	85-70	70-40	40-10	10-0
	personality of Owner	0-100	100-85	85-70	70-40	40-10	10-0

Table 2. Distance fo each Index.

Evaluation System	Index of Evaluation	Actual Value of Indexes	P (v_{ei}, V_{pi})	$\rho(v_{e1}, V_{o1})$	$\rho(v_{e2}, V_{o2})$	$\rho(v_{e3}, V_{o3})$	$\rho(v_{e4}, V_{o4})$	$\rho(v_{e5}, V_{o5})$
Technical level	risk of design depth	73	-27	63	33	3	-3	17
	design risk of new technology	65	-35	55	25	-5	5	25
	risk of new technology in construction	39	-39	29	-1	1	31	51
	risk of change control	30	-30	20	-10	10	40	60
	risk of investigation in consruction	35	-35	25	-5	5	35	55
Natural conditions	change of geological conditions	72	-28	62	32	2	-2	18
	Climate change	60	-40	50	20	-10	10	30

Table 2. contd…

Evaluation System	Index of Evaluation	Actual Value of Indexes	P (v_{ei}, V_{pi})	ρ(v_{e1}, V_{o1})	ρ(v_{e2}, V_{o2})	ρ(v_{e3}, V_{o3})	ρ(v_{e4}, V_{o4})	ρ(v_{e5}, V_{o5})
Economic conditions	risk of inflation	0.75	-0.25	0.45	0.15	-0.05	0.05	0.15
	Financing risk	0.63	-0.37	0.33	0.03	-0.03	0.17	0.27
Contract Conditions	risk of default from contractors	0.75	-0.25	0.45	0.15	-0.05	0.05	0.15
	risk of default from material suppliers	0.7	-0.3	0.2	0.1	-0.1	0.1	0.4
	risk of project claim	0.65	-0.35	0.35	0.05	-0.05	0.15	0.25
Quality of personnel	personality of designer	45	-45	45	25	-5	5	35
	personality of supervisors	37	-37	48	33	3	-3	27
	personality of Owners	30	-30	55	40	10	-10	20

Results are shown in Table **2**, according to the equations above.

②Calculation of correlation function K v_{ei}）

According to the calculated value of table 2-2, use the formula (7) to calculate the correlation function values of each index.

$$K(v_{ei}) = \begin{cases} \rho(v_{ei}, V_{0i}) / \{\rho(v_{ei}, V_{pi}) - \rho(v_{ei}, V_{0i})\}, v_{ei} \notin V_{0i} \\ -\rho(v_{ei}, V_{0i}) / |V_{0i}|, v_{ei} \in V_{0i} \end{cases} \quad (7)$$

4) determine the weights

According to the actual data collected in the project, use AHP to determine the weights of the various features based on expert advice and relevant information documents. All the weights (w_1, w_2⋯ w_n) must satisfy the condition that $\sum_{i=1}^{n} w_i = 1$， and each index is scored according to the actual situation.

5) Calculate the correlation of power transmission and transformation project change on each category of risk.

According to the weight of each index, calculate correlation of power transmission and transformation project change which is to be evaluated, on grade j as follows:

$$K(p) = \sum_{i=1}^{n} w_i K(v_{ei}) \quad (8)$$

6) the principles of evaluation

$$K_j = \max K_j(p_e), j = 1, 2, m \quad (9)$$

In the equation, K_i—the correlation of power transmission and transformation project change which is to be evaluated on each category of risk level.

Combining correlation and weight of indicators listed above, use equation (8) and (9) to calculate the correlation that each index belongs to the risk level of power transmission projects in the sample .The result is shown in Table **3**.

According to the results in Table **2**, **3**, obviously K (V_{e3})= 0.065 is the maximum, conclusion can be drawn that the risk level of this power transmission project change belongs to R2, which is safer than normal. This result is consistent with the basic practical engineering, as the low level of security can be seen in design depth risk, geological conditions change and the quality of the supervising engineer. Corresponding prevention measures should be formulated to solve the problems above, and strengthen control and management of the daily risks to prevent the hidden danger.

4. TRANSMISSION PROJECT CHANGE PRE-CONTROL MEASURES

Most of the changes in the project construction are caused by many hidden factors of pre-design and tendering. Taking preventive measures for project change before construction can will help in achieving significant economic benefits.

1) Increase the accuracy of early exploration:

At early stage of power transmission project investigation, regular check-ups and detailed measurements should be implemented on substation construction sites and the path of project line to guarantee that the data provided is credible.

2) Preparation of tender documents should be accurate:

Strive to achieve a comprehensive and accurate reflection on the tender of power transmission project when the tender documents are prepared. Comprehensive and accurate tender documents can avoid unnecessary engineering changes.

3) take limit control measures in the design:

In the pre-construction process of power transmission project, the project designer should strive to make the difference between the design budgetary estimate of preliminary

Table 3. Risk distribution table of the index level.

Evaluation System	Index of Evaluation	Weight	R1	R2	R3	R4	R5
			$K(v_{e1})$	$K(v_{e2})$	$K(v_{e3})$	$K(v_{e4})$	$K(v_{e5})$
Technical level	risk of design depth	0.225	-0.7	-1.1	-0.1	0.125	-0.386
	design risk of new technology	0.037	-0.611	-0.833	0.167	-0.125	-0.417
	risk of new technology in construction	0.075	-0.426	0.033	-0.025	-0.443	-0.567
	risk of change control	0.056	-0.4	0.5	-0.333	-0.571	-0.667
	risk of investigation in construction	0.045	-0.417	0.167	-0.125	-0.5	-0.611
Natural conditions	change of geological conditions	0.073	-0.689	-1.067	-0.067	0.077	-0.391
	climate change	0.036	-0.556	-0.333	0.333	-0.2	-0.429
Economic conditions	risk of inflation	0.037	-0.643	-0.375	0.25	-0.167	-0.375
	financing risk	0.11	-0.471	-0.075	0.15	-0.315	-0.422
Contract Conditions	risk of default of the contractor	0.037	-0.643	-0.375	0.25	-0.167	-0.375
	risk of default of the material supplier	0.073	-0.4	-1	0.5	-0.25	-0.571
	risk of project claim	0.109	-0.5	-0.125	0.25	-0.3	-0.417
quality of personnel	personality of designer	0.057	-0.5	-1.25	0.125	-0.1	-0.438
	personality of supervisor	0.019	-0.565	-2.2	-0.075	0.088	-0.422
	personality of owner	0.011	-0.647	-0.571	-0.333	0.5	-0.4
Comprehensive evaluation of risk		1	-0.553	-0.572	0.065	-0.162	-0.452

design and that of construction drawing design controlled within a certain percentage. This constraint condition puts forward higher requirements for the construction units, thereby reducing the possibility of major changes in the process of construction.

4) Strict implementation of drawing system:

The owner shall entrust a professional institution plan for conducting the pre-trial review of the drawings, optimize the design, supervise the design units for revising and improving the design drawings, and try to reduce the defects caused by changes in the design documents.

CONCLUSION

In this paper, we have proposed the matter element model for analyzing the power transmission project engineering changes and have conducted comprehensive evaluation of the risk grade of project changes. In addition, there are also some other methods, such as analytic hierarchy process and grey correlation method for risk evaluation of engineering changes. Based on the analysis and evaluation of the engineering change data of power transmission and transformation project, we have put forward control measures for engineering change, which helps to improve the risk prevention awareness on engineering changes for participating parties. These control measures contribute to reducing the occurrence of engineering changes and are significant for the construction of power transmission projects.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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