International Journal of Multiphysics
Volume 18, No. 3, 2024
ISSN: 1750-9548

Risk Assessment of Construction Projects in Full-process Engineering Consulting Using Analytic Hierarchy Process

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Abstract

Full-process engineering consulting is an essential path to promote the transformation and upgrading of China's engineering consulting industry, and it is also an inevitable choice for China's engineering consulting industry to integrate into the world economy and enhance its international competitiveness. In recent years, various risk events triggered by full-process engineering consulting construction projects have occurred frequently. These incidents have not only caused significant losses to the construction projects themselves, hampering the high-quality development of the full-process engineering consulting industry, but many of the risks from full-process engineering consulting construction projects have even threatened societal safety and stability. Through literature review, the Delphi method, brainstorming, and other methods, this article deeply analyzes the risk factors in the critical links of full-process engineering consulting construction projects, constructs a risk assessment index system, and uses the Analytic Hierarchy Process (AHP) for a comprehensive assessment of the risks. It gauges the risk level of the projects and seeks effective measures to control risks, thereby reducing risks in full-process engineering consulting construction projects and further promoting the high-quality development of China's full-process engineering consulting industry.

Keywords: Full-process engineering consulting, construction projects, risk assessment, index system, high-quality development, Analytic Hierarchy Process

1. Introduction

Full-process engineering consulting, a cornerstone of China's engineering consulting industry transformation and global competitiveness, has witnessed a surge in recent years. However, the increasing frequency of risk events associated with these projects has raised concerns about their impact on project outcomes, industry development, and even societal safety. To address this challenge, a robust risk assessment framework is imperative.

The Analytic Hierarchy Process (AHP), a well-established multi-criteria decision-making method, offers a structured approach for quantifying and prioritizing risks. By decomposing complex problems into hierarchical structures, AHP enables comprehensive evaluation and comparison of various risk factors. This study leverages AHP to assess risks in full-process engineering consulting projects.

The Chinese government has recognized the significance of full-process engineering consulting in promoting high-quality development. The issuance of relevant policies and standards, such as the "Guiding Opinions on Promoting the Development of Full-process Engineering Consulting Services" and the "Standards for Full-process Engineering Consulting of Construction Projects," underscores the nation's commitment to this sector. Moreover, the "Management Measures for the Engineering Consulting Industry" emphasizes the accountability of engineering consulting entities for project quality, highlighting the need for effective risk management strategies.

By applying AHP to identify, assess, and prioritize risks in full-process engineering consulting projects, this research aims to contribute to the development of risk mitigation strategies and ultimately enhance the overall quality and efficiency of these projects.

2. Current Status of Research on Construction Projects Based on Full-process Engineering Consulting

Internationally, research on full-process engineering consulting primarily focuses on consulting service models. The scientific methodology of risk control for construction projects emerged at the beginning of this century. International research on construction project risk control mainly focuses on the engineering quality, safety, progress, and cost of construction enterprises, using quantitative methods to assess risks associated with quality, safety, progress, and cost. However, from the perspective of full-process engineering consulting, there is limited research on how to effectively prevent and precisely control construction project risks and reduce risks for full-process engineering consulting entities.

Domestically, considering policy documents issued at the national level, published works, and publicly available academic papers, China's full-process engineering consulting is in its infancy. It's one of the research hotspots, with the main research content centered on full-process engineering consulting models and the transformation and upgrading of professional consulting institutions[1]. Emphasis on construction project risk control focuses on project progress and cost control. This mainly started with the introduction of foreign network planning technology. Overall, China's level is still in the stages of introduction, absorption, and digestion. Laws and regulations are not yet comprehensive, and both theoretical research and practical operation are still immature. There's limited research on controlling construction project risks from a full-process engineering consulting perspective.

In summary, full-process engineering consulting is imperative and is an essential path for the transformation and upgrading of the construction industry. However, full-process engineering consulting in China's theoretical and practical fields is just starting. Theoretical research is not deep enough, and the comprehensive strength is strong, but the operability is relatively poor. From an engineering practice perspective, there are very few cases of full-process engineering consulting in the true sense. Therefore, how to effectively control the risks of full-process engineering consulting construction projects and promote the high-quality development of full-process engineering consulting has not only significant theoretical research value but also has profound practical significance in engineering.

3. Full-process Engineering Consulting

3.1 Definition of full-process engineering consulting

Full-process engineering consulting refers to the intellectual services provided by engineering consulting units by comprehensively applying knowledge from various disciplines, engineering practical experience, modern scientific technology, and economic management methods, adopting a combination of various service methods [1]. These services span across the entire life cycle of a construction project, covering the investment decision-making stage, the construction preparation phase, the construction implementation phase, and the operation and maintenance phase, offering solutions involving technology, economics, organization, and management. It includes both comprehensive consultation services and individual consultation services, with the latter comprising of basic and specialized consultation services, colloquially known as "WMC (Whole Management Consultation)" [2].

3.2 Main content of full-process engineering consulting

Engineering consultation industries abroad originated in the mid-19th century. Over the course of more than a century, the content of engineering consultation has continuously expanded, evolving from specialized consultation to comprehensive consultation throughout the process. Comprehensive consultation has further evolved from pure technical consultation to strategic and managerial consultations, with the consultation market expanding from domestic to international.

Domestic construction projects are just beginning to adopt full-process engineering consulting, primarily focusing on technical and managerial consultations. The main content includes management consultation services at various stages throughout the project's life cycle, such as investment decision-making, engineering survey and design consultation, engineering supervision consultation, tendering and procurement consultation, project cost consultation, project management consultation, operation, maintenance, and post-evaluation [2].

4. Construction Project Risk Assessment

4.1 Risk and construction project risk

Since the 18th century, there has been continuous exploration and research into the inherent laws of risk, leading to varied perceptions and hence varied definitions of risk. Generally speaking, risk can be broadly or narrowly defined. In its broad sense, risk refers to the uncertainty of an event's occurrence, which could be beneficial or harmful. In the narrow sense, risk pertains to the likelihood of an adverse event occurring. In this article, the term risk refers to the narrow definition, that is, the likelihood of an adverse event.

Construction project risk refers to the discrepancies between the actual outcomes of a project and its expected goals throughout its life cycle, including the decision-making, implementation, operation, and maintenance phases, and the likelihood of such discrepancies occurring.

4.2 Classification and characteristics of construction project risk

Construction project risks can be classified in various ways: by the source of risk as political, economic, natural, social, or legal risks; by the involved parties as risks to the owner, the contractor, or the consultant; or by the stage in the full-process engineering consulting process, such as risks in the investment decision phase, survey and design phase, tendering and procurement phase, supervision and project management phase, and operation and maintenance phase.

The characteristics of construction project risks include:

(1) Objectivity and unpredictability. Construction project risks are objective realities that are not influenced by human will. However, the timing and nature of their occurrence are unpredictable.

(2) Diversity and relativity. Construction projects have long cycles and face a myriad of risks throughout their life span. The intricate relationships between these risks and different entities' risk-bearing capacities also vary.

4.3 Construction project risk assessment

Construction projects, especially major infrastructure projects, generally involve large investments, longer construction periods, complex technologies, and significant societal impacts. They often pertain to national and public welfare, influencing the political, economic, cultural, social, and ecological environments for the local people, thus potentially leading to considerable risks. Risk assessment for construction projects involves identifying and analyzing these risks, then employing specific mathematical theories to construct a project risk assessment model. This model estimates the probability of risks occurring in the project, gauges the magnitude of various risk events, forecasts the potential consequences of these risk events, and identifies the key risk factors. The objective is to formulate risk response strategies and take measures to mitigate the project's risks [3]. Risk assessment for construction projects not only concerns the project's economic benefits but also has implications for the societal benefits in the affected area, directly impacting the welfare of the local people.

5. Risk Analysis for Full-process Engineering Consulting in Construction Projects

5.1 Risk identification in full-process engineering consulting

The primary task of risk identification is to assess the impact of both internal and external factors on the project's anticipated objectives, determining whether risks exist in the full-process engineering consulting process and what those risks might be [4]. Risk identification must adhere to principles of comprehensiveness, scientific approach, criticality, and relevance, ensuring logical and evidence-based decisions. Risk identification can employ both qualitative and quantitative analysis methods. Currently popular risk identification techniques include literature reviews, expert surveys, the Delphi method, brainstorming, fault tree analysis, work breakdown structure (WBS), and direct surveys [5].

5.2 Key risk analysis in full-process engineering consulting

By conducting full-process engineering consulting case studies, combined with literature reviews, expert panel discussions, field investigations, and visits for communication [6], risk factors at various stages of full-process engineering consulting have been identified, as shown in Table 1.

Table 1 Risk Analysis of Key Stages in Full-Process Engineering Consulting

Serial No.	**Division of Full-Process Engineering Consulting Stages**	**Main Content of Full-Process Engineering Consulting**	**Major Risk Factors in Full-Process Engineering Consulting**
1	Investment Decision Consulting Stage	Project Planning and Strategy	Political risks such as government policy changes, war and riots, industry changes, alignment of project planning with regional development
		Project Proposal	Economic risks such as investment estimation, project financing, economic benefits, social benefits, inflation
		Feasibility Study	Legal risks like changes in laws and regulations, project violations
		Construction Condition Consulting	Technical consulting risks like construction scheme selection, construction conditions, technical feasibility
		Environmental Impact Assessment	Ecological risks such as ecological impact, environmental protection measures, economic losses and benefits from environmental impacts, implementation of environmental monitoring, force majeure
		Social Stability Risk Assessment	Social stability risks such as resettlement, demolition of illegal buildings, safe and civilized construction, surrounding public security
2	Survey and Design Consulting Stage	Construction Project Survey Consulting	Technical and management consulting risks such as construction project survey quality, cost, safety, progress, and internal management
		Construction Project Design Consulting	
3	Bidding and Procurement Consulting Stage	Bidding Agent Consulting	Technical and management consulting risks such as bidding documents, bidder review, bidding failure, prolonged bidding time, bidding control price, material prices, material quality, equipment prices, equipment quality, contract management
		Engineering Procurement Consulting	
4	Engineering Supervision and Project Management Consulting Stage	Engineering Supervision Consulting	Technical and management consulting risks such as supervision quality, engineering quality, investment control, supervision team, project progress, contract management
		Project Management Consulting	
5	Operation and Maintenance Consulting Stage	Operation and Maintenance Consulting	Technical and management consulting risks such as operating costs, engineering maintenance, investment promotion, public accidents, operational management, market competition

6. Risk Assessment of Construction Projects in Full-Process Engineering Consulting

6.1 Main methods of risk assessment

Even if the event has occurred, before it concludes, to judge, predict, and estimate the potential adverse impacts and losses caused by the event. Currently, risk assessment often combines quantitative and qualitative analysis methods[7].

(1) Quantitative Risk Assessment Analysis. Whenever opinions from expert surveys or public polling can statistically and quantifiably reflect the acceptance level of a significant engineering project by relevant groups, social risk reference indicators and grading standards can be set based on the proportion of opposing opinions. For those conditions that allow multiple social risk reference indicators, an integrated score can be derived using expert scoring to set weights, and risk levels are determined based on the scoring results[8]. Commonly used

quantitative analysis methods mainly include the comprehensive scoring method, hierarchical analysis method, and subjective probability method.

(2) Qualitative Risk Assessment Analysis. For situations difficult to directly quantify the acceptance level of relevant groups, a detailed multi-factor social risk analysis and assessment system can be formulated based on actual conditions, and risk levels are determined through comprehensive judgment. Common qualitative analysis methods mainly include the subjective probability expert estimation method, risk factor comparison method, public opinion surveys, questionnaires, conducting symposiums, hearings, consultations, seminars, etc[9].

6.2 Indicator system for risk assessment in full-process engineering consulting

Through expert surveys, case analysis, and conducting discussions, the following indicator system for risk assessment in full-process engineering consulting has been constructed.

Table 2 Indicator System for Risk Assessment in Full-Process Engineering Consulting

Serial No.	Full-Process Engineering Consulting Risk Stage	Full-Process Engineering Consulting Risk Category	Full-Process Engineering Consulting Risk Assessment Indicator System	Explanation of Full-Process Engineering Consulting Risk Assessment Indicator System
1	Investment Decision Consulting Risk (A)	Political Risk (A1)	Government Policy Change Risk (A11) War and Riot Risk (A12) Industry Change Risk (A13) Project Planning and Regional Development Fit Risk (A14)	1. Government policy change risk is calculated using the frequency of policy changes. 2. The other indicators are calculated using expert scoring.
		Economic Risk (A2)	Investment Estimation Risk (A21) Project Financing Risk (A22) Economic Benefit Risk (A23) Social Benefit Risk (A24) Inflation Risk (A25)	1. Investment estimation risk is calculated using the investment estimation deviation rate. 2. Economic benefit risk evaluation can use indicators such as sales profitability rate, capital return rate, debt to asset ratio, liquidity ratio, quick ratio, and total asset return rate. 3. The other indicators are calculated using expert scoring.
		Legal Risk (A3)	Legal and Regulatory Change Risk (A31) Project Violation Risk (A32)	Calculated using expert scoring
		Technical Consulting Risk (A4)	Construction Plan Selection Risk (A41) Construction Condition Risk (A42) Technical Feasibility Risk (A43)	Calculated using expert scoring
		Ecological and Environmental Risk (A5)	Ecological Impact Risk (A51) Environmental Protection Measures Risk (A52) Economic Impact of Environmental Risk (A53) Environmental Monitoring Implementation Risk (A54) Force Majeure Risk (A55)	Calculated using expert scoring
		Social Stability Risk (A6)	Land Expropriation and Relocation Risk (A61) Demolition and Relocation Risk (A62) Illegal Building Demolition Risk (A63) Safety and Civil Construction Risk (A64) Surrounding Social Security Risk (A65)	1. Land expropriation and relocation risk is calculated using compensation for land expropriation and relocation. 2. Demolition and relocation risk is calculated using the satisfaction rate of the public with the demolition and relocation plan. 3. Illegal building demolition risk is calculated using the illegal building demolition rate. 4. Surrounding social security risk is calculated using the criminal case crime rate. 5. Safety and civil construction risk is calculated using expert scoring.
2	Survey and Design Consulting Risk (B)	Technical Consulting Risk (B1)	Construction Project Survey Quality Risk (B11) Construction Project Design Quality Risk (B12) Construction Project Material Risk (B13) Construction Project Design Budget Risk (B14)	Calculated using expert scoring
		Management Consulting Risk	Construction Project Survey Cost Risk (B21) Construction Project Survey Progress Risk (B22)	Calculated using expert scoring

		(B2)	Construction Project Survey Safety Risk (B23) Construction Project In-house Management Risk (B24) Construction Project Design Cost Risk (B25) Construction Project Design Progress Risk (B26) Construction Project Design Safety Risk (B27)	
3	Bidding and Procurement Consulting Risk (C)	Technical Consulting Risk (C1)	Tender Document Risk (C11) Bidding Object Review Risk (C12) Tender No Bid Risk (C13) Tender Duration Risk (C14) Tender Control Price Risk (C15)	Calculated using expert scoring
		Management Consulting Risk (C2)	Material Price Risk (C21) Material Quality Risk (C22) Equipment Price Risk (C23) Equipment Quality Risk (C24) Contract Management Risk (C25)	Calculated using expert scoring
4	Engineering Supervision and Project Management Consulting Risk (D)	Technical Consulting Risk (D1)	Supervision Quality Risk (D11) Engineering Quality Risk (D12) Investment Control Risk (D13)	Calculated using expert scoring
		Management Consulting Risk (D2)	Supervision Team Risk (D21) Engineering Progress Risk (D22) Contract Management Risk (D23)	Calculated using expert scoring
5	Operation and Maintenance Consulting Risk (E)	Technical Consulting Risk (E1)	Operation Cost Risk (E11) Engineering Maintenance Risk (E12)	Calculated using expert scoring
		Management Consulting Risk (E2)	Investment Attraction Risk (E21) Public Accident Risk (E22) Operational Management Risk (E23) Market Competition Risk (E24)	Calculated using expert scoring

For the risk of construction projects throughout the whole process of engineering consultation, an evaluation index system is constructed as shown in Table 2. The meanings of some evaluation indicators are as follows:

(1) Government policy change frequency. $A_{11} = \frac{\sum B_i}{T} \times 100\%$. T represents the total number of policy documents issued within the year, and B represents the number of times the policy documents change within the year.

(2) Investment estimation deviation rate. $A_{21} = \frac{G_1 - G_2}{G_1} \times 100\%$, G_1 represents the construction project investment estimation, and G_2 represents the construction project design estimation.

(3) Sales profit margin. $L = \frac{S - C}{S} \times 100\%$. S represents sales revenue, and C represents the total cost.

(4) Return on capital $Q = \frac{S - C}{Z} \times 100\%$. Z represents the actual capital used.

(5) Debt-to-asset ratio $F = \frac{F_{\text{total}}}{Z_{\text{total}}} \times 100\%$. F_{total} represents the total liabilities, and Z_{total} represents the total assets.

(6) Current ratio $D = \frac{Z_{\text{flow}}}{F_{\text{flow}}} \times 100\%$. Z_{flow} represents current assets, and F_{flow} represents current liabilities.

(7) Quick ratio $B = \frac{Z_{\text{flow}} - Z_{\text{inventory}}}{F_{\text{flow}}} \times 100\%$. $Z_{\text{inventory}}$ represents inventory.

(8) Total asset return rate $M = \frac{R+T}{Z_{\text{total}}} \times 100\%$ .R represents the total profit, and T represents interest expenses.

(9) Land requisition and demolition compensation $A_{61} = \frac{L}{F}$. L represents per capita compensation income, and F represents the local per capita GDP.

(10) Public satisfaction rate with the resettlement plan $A_{62} = \frac{P_1}{P_0} \times 100\%$. P_0 represents the total number of people affected, and P_1 represents the number of people satisfied with the resettlement plan within the affected range.

(11) Illegal building demolition $A_{63} = \frac{Y}{H} \times 100\%$. Y represents the number of illegally constructed buildings that have been demolished, and H represents the total number of illegally constructed buildings.

(12) Criminal case crime rate $A_{65} = \frac{K_1}{K_0} \times 100\%$. K_0 represents the total number of criminal cases, and K_1 represents the number of criminal cases.

6.3 Comprehensive evaluation of risks in the whole process of engineering consultation for construction projects

(1) Constructing a hierarchical structure of indicators. In order to evaluate the risk of the whole process of engineering consultation for construction projects, a four-level structure [10] is constructed: The first level is the objective layer, that is, the risk of the whole process of engineering consultation for construction projects. The second level is the sub-objective layer, namely the risks of investment decision consulting (A), survey and design consulting (B), bidding and procurement consulting (C), engineering supervision and project management consulting (D), and operation and maintenance consulting (E). The third level is the criterion layer, indicating the risk categories at each stage { Ai, Bi, Ci, Di, Ei, i=1, 2, 3... }. The fourth level is the scheme layer, including specific risk assessment indicators { Aij, Bij, Cij, Dij, Eij, i=1, 2, 3... , j=1, 2, 3... }.

(2) Determine the weights of the indicators at each level. The Analytic Hierarchy Process (AHP) is used to determine the weights of the indicators at each level. Experts are invited to use a 1-9 scale method to construct pairwise judgment matrices for each level of indicators.

$$X = \begin{bmatrix} a_{11} & a_{12} \cdots a_{1n} \\ a_{21} & a_{22} \cdots a_{2n} \\ \vdots & \vdots \quad \vdots \\ a_{n1} & a_{n2} \cdots a_{nn} \end{bmatrix} \tag{1}$$

In the matrix, $a_{ii} = 1$ and $a_{ji} = \frac{1}{a_{ij}}$, where i=1, 2, 3... , j=1, 2, 3... , a_{ij} represents the judgment of the relative importance of factor a_i compared to a_j.

Based on the judgment matrix, the weight of the investment decision consultation scheme layer indicator is determined:

$$W_{A1} = \left(W_{A11}, W_{A12}, W_{A13}, W_{A14}\right)$$

$W_{A2} = (W_{A21}, W_{A22}, W_{A23}, W_{A24}, W_{A25})$

$W_{A3} = (W_{A31}, W_{A32})$

$W_{A4} = (W_{A41}, W_{A42}, W_{A43})$

$W_{A5} = (W_{A51}, W_{A52}, W_{A53}, W_{A54}, W_{A55})$

$W_{A6} = (W_{A61}, W_{A62}, W_{A63}, W_{A64}, W_{A65})$;

Weights of the Indicator for the Scheme Layer of Survey and Design Consulting:

$W_{B1} = (W_{B11}, W_{B12}, W_{B13}, W_{B14})$

$W_{B2} = (W_{B21}, W_{B22}, W_{B23}, W_{B24}, W_{B25}, W_{B26}, W_{B27})$;

Weights of the Indicator for the Scheme Layer of Bidding and Procurement Consulting:

$W_{C1} = (W_{C11}, W_{C12}, W_{C13}, W_{C14}, W_{C15})$

$W_{C2} = (W_{C21}, W_{C22}, W_{C23}, W_{C24}, W_{C25})$;

Weights of the Indicator for the Scheme Layer of Engineering Supervision and Project Management Consulting:

$W_{D1} = (W_{D11}, W_{D12}, W_{D13})$

$W_{D2} = (W_{D21}, W_{D22}, W_{D23})$;

Weights of the Indicator for the Scheme Layer of Operation and Maintenance Consulting:

$W_{E1} = (W_{E11}, W_{E12})$

$W_{E2} = (W_{E21}, W_{E22}, W_{E23}, W_{E24})$.

Based on the judgment matrix, the weights of the criteria layer indicators for investment decision consulting are determined as: $W_A = (W_{A1}, W_{A2}, \cdots W_{A6})$, the weight for survey and design consulting is $W_B = (W_{B1}, W_{B2})$, the weight for bidding and procurement consulting is $W_C = (W_{C1}, W_{C2})$, the weight for engineering supervision and project management consulting is $W_D = (W_{D1}, W_{D2})$, and the weight for operation and maintenance consulting is $W_E = (W_{E1}, W_{E2})$.

$W = (W_A, W_B, W_C, W_D, W_E)$。Based on the judgment matrix, the weights of the sub-objective layer indicators for investment decision consulting are determined as: $W = (W_A, W_B, W_C, W_D, W_E)$.

After obtaining the weights of the indicators for each stage, a consistency test is required.

Comprehensive weight of risk factor indicator W' = Scheme layer weight × Criteria layer weight × Sub-objective layer weight. (2)

(3) Determination of the Membership Degree Matrix

For a comprehensive risk assessment of the engineering consultation process, evaluation indicators are categorized based on the magnitude of the risk they induce into five levels[11]: no risk, minor risk, moderate risk, major risk, and huge risk. The determination of the membership degree matrix employs the expert scoring method. An evaluation team consisting of several experts scores the risk levels of evaluation indicators. The membership degree of the evaluation indicators is the proportion of experts who give a certain score to the total number of experts. The scores given by the experts are then statistically compiled to derive the membership degree matrix.

$$R_A = \begin{bmatrix} r_{11} & r_{12} \cdots r_{15} \\ r_{21} & r_{22} \cdots r_{25} \\ \vdots & \vdots \quad \vdots \\ r_{k1} & r_{k2} \cdots r_{k5} \end{bmatrix} \quad k = 1,2,\cdots 24 \qquad R_B = \begin{bmatrix} r_{11} & r_{12} \cdots r_{15} \\ r_{21} & r_{22} \cdots r_{25} \\ \vdots & \vdots \quad \vdots \\ r_{k1} & r_{k2} \cdots r_{k5} \end{bmatrix} \quad k = 1,2\cdots 11$$

$$R_C = \begin{bmatrix} r_{11} & r_{12} \cdots r_{15} \\ r_{21} & r_{22} \cdots r_{25} \\ \vdots & \vdots \quad \vdots \\ r_{k1} & r_{k2} \cdots r_{k5} \end{bmatrix} \quad k = 1,2\cdots 10 \qquad R_D = \begin{bmatrix} r_{11} & r_{12} \cdots r_{15} \\ r_{21} & r_{22} \cdots r_{25} \\ \vdots & \vdots \quad \vdots \\ r_{k1} & r_{k2} \cdots r_{k5} \end{bmatrix} \quad k = 1,2\cdots 6$$

$$R_E = \begin{bmatrix} r_{11} & r_{12} \cdots r_{15} \\ r_{21} & r_{22} \cdots r_{25} \\ \vdots & \vdots \quad \vdots \\ r_{k1} & r_{k2} \cdots r_{k5} \end{bmatrix} \quad k = 1,2\cdots 6$$

k represents the number of risk assessment indicators.

(4) Comprehensive Risk Assessment of the Full-Process Engineering Consultation

$$G = W' \times \left(W_A \times R_A \quad W_B \times R_B \quad W_C \times R_C \quad W_D \times R_D \quad W_E \times R_E \right) \tag{3}$$

Through the comprehensive risk assessment formula of the full-process engineering consultation, the risk level of the full-process engineering consulting construction project can be clearly calculated, providing a basis for risk control of the full-process engineering consulting construction project[12], thereby reducing the risk of the full-process engineering consultation and further promoting the high-quality development of the full-process engineering consultation industry.

7. Risk Control of Full-Process Engineering Consulting Construction Projects

7.1 Risk control during the investment decision consulting stage

During the investment decision consulting stage, a comprehensive analysis and evaluation of the potential risks of the project, such as technical risks, market risks, and policy risks, should be conducted. Establish measures for risk identification, risk assessment, and risk responses, and define risk-responsible personnel and timelines. Thoroughly investigate and research the market prospects and technical and economic feasibility of the project[13]. Determine the required funding sources and fundraising methods rationally and carry out financial risk assessments. Formulate clear contract terms and legal protection measures to ensure the project's legitimate rights and legality. Regularly audit and evaluate the project's risk status and investment returns and report to investors promptly. Thus, through comprehensive project evaluations, establishing risk management plans, conducting technical and market surveys, formulating reasonable fundraising plans, establishing effective contracts and legal protections[14], as well as regular supervision and project progress reporting, investment decision consulting stage risks can be effectively reduced.

7.2 Risk control during the survey and design consulting stage

During the survey and design consulting stage of the full-process engineering consulting construction project, sufficient communication and understanding with the client are crucial to clarify project objectives, scope, and requirements, thereby reducing risks due to misunderstandings or omissions. Conduct a detailed investigation of the project location's geology, topography, and environment to understand potential risk factors. Take into full consideration project requirements and real-world situations, formulate design plans that comply with technical specifications and laws and regulations to reduce design risks and subsequent construction risks. Involve engineers, designers, technical experts, and other professionals with expertise and experience to provide specialized opinions and recommendations. Regularly audit design plans, survey results, and progress to ensure the project progresses as expected and meets quality requirements. Proactively communicate and coordinate with clients, relevant departments, and suppliers to address issues and risks encountered promptly[15]. Thus, by fully understanding project needs, conducting in-depth investigations and research, formulating rational design plans, incorporating professional expertise and personnel, performing regular reviews and evaluations, and establishing effective communication and coordination mechanisms, risks during the survey and design consulting stage can be effectively reduced.

7.3 Bidding and procurement consultation phase risk control

In the bidding and procurement consultation phase of the whole process engineering consulting construction project, it's imperative to strictly adhere to the bidding laws and related regulations, reducing legal and non-compliance risks. Establish clear bidding and procurement procedures, standardized documents, and strict evaluation and procurement processes. Thoroughly assess suppliers in terms of credibility, quality, technical capability, and pricing to select appropriate suppliers. Draft clear contract terms and conditions, ensuring contract execution and fulfillment. Monitor and accept the suppliers' performance, ensuring they fulfill their responsibilities as per the contract. Maintain close communication with suppliers, clients, and related departments, timely resolving issues and risks, minimizing risks arising from miscommunication and information asymmetry. Therefore, by strictly adhering to laws and regulations, establishing a robust bidding and procurement system, rigorous supplier assessment and selection, strict contract management, efficient supervision and acceptance mechanisms, and enhanced communication and coordination, risks in the bidding and procurement consultation phase can be effectively reduced.

7.4 Engineering supervision and project management consultation phase risk control

During the engineering supervision and project management consultation phase of the whole process engineering consulting construction project, it's essential to establish clear objectives, scope, and plans, ensuring the project is completed on time, to standard, and within budget. Develop supervision plans, procedures, and reports to ensure construction adheres to design specifications and contract requirements. Regularly inspect and evaluate construction progress, quality, and safety to identify potential problems and risks promptly. Engage supervision engineers and project managers with professional expertise to offer specialized supervision and project management services. Maintain close communication and coordination with owners, construction teams, designers, and relevant departments to timely address problems and risks[16]. Therefore, by establishing an effective project management system, comprehensive supervision mechanisms, regular engineering inspections and evaluations, engaging professional supervisors and project managers, and fostering efficient communication and coordination, risks in the engineering supervision and project management consultation phase can be effectively reduced.

7.5 Operation and maintenance consultation phase risk control

During the operation and maintenance consultation phase of the whole process engineering consulting construction project, it's vital to establish clear operation objectives, plans, and processes to ensure equipment and system functionality, reducing equipment malfunction and operational risks. Regularly check, maintain, and repair equipment to prevent failures and extend equipment life while reducing maintenance costs. Establish safety regulations, conduct safety training, and draft emergency plans to safeguard personnel and equipment, mitigating accident and safety risks. Engage operation managers and maintenance engineers with professional expertise to offer specialized operation and maintenance services. Monitor and analyze equipment performance, energy consumption, and maintenance records to promptly identify potential problems and risks, reducing operational risks and energy wastage. Therefore, by establishing a robust operational management system, effective preventive maintenance plans, comprehensive safety management systems, engaging professional operation and maintenance personnel, and fostering efficient monitoring and feedback mechanisms, risks in the operation and maintenance consultation phase can be effectively reduced.

8. Conclusion

The full-process engineering consultation industry has been rapidly evolving. While whole-process engineering consultation has been in its infancy in many regions, there has been a shift from individual operations to collaborative operations. However, the true strength of whole-process engineering consultation enterprises is still far from sufficient, and their international competitiveness is not strong, with the integration of surveying, design, costing, and supervision being relatively slow. Risks in full-process engineering consultation construction projects are becoming increasingly prominent, hindering the healthy development of the industry. This paper, centered on the business process of whole-process engineering consultation, delves deep into the risk factors of crucial stages of full-process engineering consultation construction projects. The risk assessment indicator system constructed considers societal risks such as political, economic, and legal risks, as well as project risks like technical and managerial risks. This system can be employed to identify, evaluate, and comprehensively assess risks arising from whole-process engineering consultation construction projects. Based on the evaluation, one can judge the risk level of a project and devise precise control measures. This approach holds significant theoretical value and practical implications in preventing and reducing risks in full-process engineering consultation construction projects, promoting high-quality development in the industry, and enhancing the international competitiveness of industry enterprises.

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