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Contribution of AHP method in prioritizing risk factors regarding tunnel project phases

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ABSTRACT

Tunnel projects are consistently regarded to be mostly a complex and risky engineering projects, owing to the features of the projects, since they increasingly achieve high risk and complexity during the execution of the project. this led to the fact that the necessity of risk management understanding and implementing is a crucial quest with the intention to obtain tunnel project objectives considering (time, cost, quality & safety) to avoid time and cost overruns and any other obstacles. it was observed the most affecting objective was Safety (47.3%) by AHP method in which it is actually reasonable as such project of tunnel need a great concern regarding that matter for many reasons for instance the closed construction area, ventilation considerations, blasting, and so on. the second major objective is quality (31.1%) in which as experts always say it has to be maintained as a high quality as possible.

Keywords: Tunnel projects, AHP, Project Objectives, Risk

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1. Introduction

Tunnels are considered as a multidisciplinary construction, to be more precise; it is one of the massive infrastructures. Regarding that kind of construction, the need of a good quality management is a must; in order to achieve the main outcomes as much as possible, among those as the most are; time, cost, quality and safety. Tunneling as project recognized as complex pursue since they are obviously different than the usual on-ground structures and accordingly the design conditions change from a case to another. In other words, it is not simple to conduct such construction(tunnels) with such sophisticated details in any land type profile without a high uncertainty and eventually risk with in different phases [1]. Tunneling regarding the complicity of construction process on the most carry risks that would eventually affect such enormous parts of project outcomes among those time, cost, quality, safety. There are many tools and methods that simplify risk examinations. There are tools that concerned in qualitative and other quantitative methods in which it depends basically on the details of that project, and according to those details a suitable method can be chosen. Many ways available for the mean to follow and options and as a result to create what is known as risk analysis through the phases of any construction project, the right kind of risk analyzing method must be chosen among many of different methods and tools such as; event trees, sensitivity analysis or even though Monte Carlo Simulation [2]; decision-making frameworks such as AHP (analytic hierarchy process). While there are diverse risk types during any project, some of those are more common and have a high probability of occurrence. Thus, the probability of occurrence and their impact of any risk factor in preliminary are assessed and the overall risk score is accumulative of those risk factors. The Analytic Hierarchy framework (AHP) can be used as a method for what can called complex environments for decision making, such as tunnel construction projects, according to [3] AHP process can help in the process of prioritize the risks during such project type beside that its simplicity comes from that it illustrates which element has more dominant effect by weight than the other factors.

1.1. Tunnel risk management

Tunnels are on the most underground space constructed to provide capacity for certain purposes such as underground transportation, storge, power plants, civil defense, mine development and any other activities that can be constructed in that kind of construction. Regarding that certain type of construction tunneling considered a massive infrastructure in which it imposes risks on the parties involved and beside that it affects even those who are indirectly involved in such project [4].

For any type of construction Projects those are covered by enormous risks; for instance, the ones related to human and so as environmental factors, an adequate risk management system procedure is becoming a pivotal demand. Particularly before the construction project starts, risk configuration should be conducted. Accordingly, management process regarding risk should take its action and develop a risk strategy, in which it includes any risk factor that would affect the project overwhelm. During the process of determination risks, project management system for tunnel projects can get benefits from some methods among those: checklists, brainstorming, experts judgment evaluation, etc. [5].

For engineering structures such as underground tunnels from the early life of such project the objectives, outcomes and their define functions should be clear and defined also care should be carry on in different phases of tunnel if it is regarding time for instance period of design needed, design process itself and accordingly construction must have an overall plan to ensure safety and economy considerations that bee hold through different conditions. Risk management though has been evaluated and totally in a favored for such demand to be achieved [6]. From the useful and dependable tools for risk analysis is AHP method in which it would help within the process of measures and evaluation by means of contributory technique in order to examine evaluated consistency regarding reducing mostly all the conflicts in need for decision making and prioritizing [7].

1.2. Analytical hierarchy process (AHP)

It can be considered as a powerful tool for the aim of decision-making technique and had been delivered by [8, 9] and conducted a decision technique for the purpose of measuring the priorities of all available and possible alternatives in accordance to the ratio scale. By considering how organizations would decide over which projects to be executed, we can observe such a constant desire in order to have explicit, objective and mathematical basis [10]. However, making decision is, in its wholeness, an awareness and rational process derived from the most viable adequate alternative based on tangible and intangible basis [11], which are arbitrarily selected by the ones who are responsible for decision making.

Regarding the study AHP process selected to aid the criteria for prioritizing project risk factors, and it demonstrates AHP in a step-by-step manner, where the resulting priorities are shown through the out puts and the possible inconsistencies are determined. The implementation of AHP starts with a problem being break down into a hierarchy of criteria in order to be analyzed with ease and compared in an unconstrained style Figure 1. After such reasonable hierarchy is conducted, the decision makers can in systematic manner assess the available alternatives by doing so what known as making pair-wise comparisons for each of available criteria. The step of comparison may use specific data from the alternatives or expert judgments as a way to input underlaying information required [12]. The stage of comparison between any two elements by using AHP can be done in different mechanism [13]. However, the relatively relevant weights between two alternatives proposed by [14-15] is the most commonly used. The related values vary in a scale from one to Nine and their reciprocals, the scale defines the relative Significance of an alternative whenever it is compared to another alternative, as illustrated in Table 1.

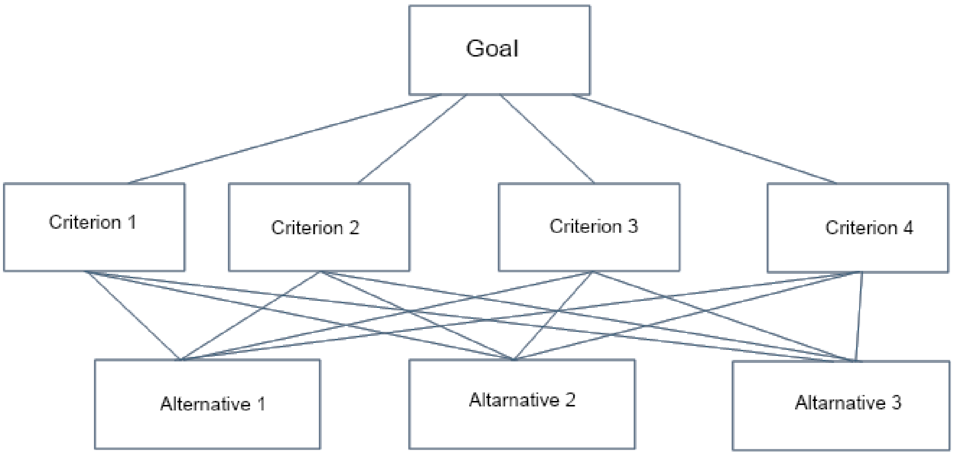

Figure 1. Example of analytical hierarchy process

Table 1 – Saaty's Scale of Relative Importance after [14]

Scale	Numerical Rating	Reciprocal
Extremely Preferred	9	1/9
Very strong to extremely	8	1/8
Very strongly preferred	7	1/7
Strongly to very strongly	6	1/6
Strongly preferred	5	1/5
Moderately to strongly	4	¼
Moderately preferred	3	1/3
Equally to moderately	2	½
Equally preferred	1	1

The method of AHP include generally the following steps to be applied:

1) A clear definition for the problem and what is the outcome to be achieved.
2) The structure of hierarchy is built up starting from the top which include the major outcome of project and getting down to the list of factors and choices.
3) Prepare a set of pair-wise comparison matrices (size n*n) Table 1. illustrate that step.
4) The AHP process tends to give what is known as eigenvectors by mean of weights with respect to each criterion and at the end the sum of that is taken as overall weighted eigenvector ingress Matching to the next lower level of the procedure.
5) Conducting the contrast matrices pair-wise, the consistency is found out by the usage of eigenvalue, λ max, in order to determine the consistency index, CI as follows: CI= (λ max-n)/(n-1)., where n is the matrix size. consistency ratio (CR) in the other hand is another check for the consistency index and is illustrated in table 2. (the value it meant to be (less than 0.1) for the purpose to achieve the consistency).
6) Steps from 3 to 5 are repeated and applied for all the steps in the procedure.

Table 2. Random consistency after [16]

Size of Matrix (n*n)	1	2	3	4	5	6	7	8	9	10
Random Consistency (RC)	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

2. Methodology

The methodology used for the study included site visit to some location with related type of construction (tunnel projects) Kurdistan-Region-Iraq, with preparation of list of selected factors recommended by experts regarding a pilot study with the ones close to that field of construction. The list of risk factors was caried out and delivered to (37) respondents. The list was divided into 13 categories in order to simplify the survey.

The categories include:

1-Pre-Study Risks. 2- Bidding Risks. 3- Risks due to Design Stage. 4- External risks. 5- Environmental risks. 6- Organizational risks. 7-Project management risks. 8- Right of way risks (legal). 9- Construction risks. 10- Financial Risks. 11- Physical and Logistic Risks. 12-Operational Risks. 13-Safety & Health Risks.

Accordingly, those categories were divided into sub categories including the risk factors related to each category mentioned. Based on the comparison step by AHP process used in order to show the most considerable and effective risk for each category. Through the study another comparison was conducted through selecting the factors with most risk from all categories based on the expert's judgment. As to keep on the study a critical comparison was made among five main factors in which those are Time, Quality, Cost, Safety and technical part including site investigation and test. The ease of use and flexibility of AHP process was the significant to assess and find the prioritizing risk factors included in the study.

3. Results and discussion

Analytical Hierarchy Process or as abbreviated (AHP) is such a technique that developed by Thomas L. Saaty in (1980) as a Multi Criteria Decision Making method, where the input data can be obtained accordingly through some personal opinion such as satisfaction, or even through real measurements such as prices and weights [17],[18]. The AHP procedure involves four stages: first build up the decision hierarchy, second determine the relative significant of related factors, third evaluate the suggested alternative and finally calculate the overall weight regarding those attributes, and the crucial part is to check the consistency of the subjective evaluations [19]. In this study relative weights of factors were considered by mean of test importance and source of error that would cross the test during execution and implementation, simply by conducting pairwise comparing the factors with respect to the goal of study; AHP process were conducted by means of Microsoft excel to simplify the process. The process for the matrices that would take place can be explained as follows:
Model for calculations;

A- Normalization:

Matrix pair- wise
$$\begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \end{bmatrix} \quad (1)$$

1- Sum the values in each column of the pair-wise matrix

$$C_{ij} = \sum_{i=1}^{n} C_{ij} \quad (2)$$

2- Divide each element in the matrix by its column total to generate a normalized Pair-wise matrix

$$X_{ij} = \frac{C_{ij}}{\sum_{i=1}^{n} C_{ij}} = \begin{bmatrix} X_{11} & X_{12} & X_{13} \\ X_{21} & X_{22} & X_{23} \\ X_{31} & X_{32} & X_{33} \end{bmatrix} \quad (3)$$

3- Divide the sum of the normalized column of matrix by the number of criteria used (n) to generate weighted matrix

$$W_{ij} = \frac{\sum_{j=1}^{n} X_{ij}}{n} \begin{bmatrix} W_{11} \\ W_{12} \\ W_{13} \end{bmatrix} \quad (4)$$

B- Consistency Analysis:

1- Consistency matrix is calculated by multiplying the pair-wise matrix by the weight vector.

$$\begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \end{bmatrix} * \begin{bmatrix} W_{11} \\ W_{21} \\ W_{31} \end{bmatrix} = \begin{bmatrix} Cv_{11} \\ Cv_{21} \\ Cv_{31} \end{bmatrix} \quad (5)$$

2- Then it is accomplished by dividing the weighted sum vector with criterion weight

$$Cv_{11} = \frac{1}{W_{11}} [C_{11} * W_{11} + C_{12} * W_{21} + C_{13} * W_{31}]$$

$$Cv_{21} = \frac{1}{W_{21}} [C_{21} * W_{11} + C_{22} * W_{21} + C_{23} * W_{31}]$$

$$Cv_{31} = \frac{1}{W_{31}} [C_{31} * W_{11} + C_{32} * W_{21} + C_{33} * W_{31}]$$

3- To find max. eigen value λ, where λ is calculated by the value of the consistency vector

$$\lambda = \sum_{i=1}^{n} Cv_{ij} \quad (6)$$

4- Find the consistency index (CI)

$$CI = \frac{\lambda - n}{n - 1} \quad (7)$$

5- Calculate the consistency ratio $C_r = \frac{CI}{RI}$ where (RI) can be found from table of Satty Table 2.

Based on the expert judgment factors were nominated to be used for the compression on the base of nine factors as a maximum. First as illustrated in table 4. to table 16. list of total factors under each category that was established based on pilot study conducted by expert respondents as follows:
As mentioned earlier maximum number of factors under any categories taken as nine to simplify the AHP matrices based on the expert's judgment. For each category rank of risk factors related to that category were found and prioritized based on the weight.

Table 4. Pre-Study risk factors

Categories	
1	Pre-Study Risks
Code	Risk Factor
PS1	Insufficient estimation for funds
PS2	Lack of technical documents and reports
PS3	Unreasonable estimate for a proper location for the tunnel project
PS4	Insufficient assumption of length of tunnel at proposed Location
PS5	Delay in solving disputes with local residence at the proposed location

Table5. Bidding risk factors

Categories	
2	Bidding Risks
Code	Risk Factor
B1	Black listed competitive bidders(contractors)
B2	Unexperienced & misunderstanding biddings
B3	Insufficient selection for the Bidders
B4	Lack of full information of the bidder including financially, technical and equipment
B5	Fake information Provided by The Bidders
B6	Prequalification stage for the bidders not qualified as it should be
B7	Misunderstanding of task of work completely by the bidders
B8	Awarding the bid to certain bidders (Corruption)
B9	Nepotism and Collusion

Table6. Design stage risk factors

Categories	
3	Risks due to Design Stage
Code	Risk Factor
D1	Design errors and omissions
D2	Design process takes longer than anticipated
D3	Stakeholders request late changes
D4	Failure to carry out the works in accordance with the contract
D5	Unqualified Designer teams
D6	Design not according to the National Standards
D7	Lack of Design recheck(review)

Table 7. External risk factors

Categories	
4	External risks
Code	Risk Factor
Ex1	New stakeholders emerge and request changes
Ex2	Public objections
Ex3	Laws and local standards change
Ex4	War & natural hazards
Ex5	Politics
EX6	Forced to apply workers from neighborhood residents of project location (rather than skilled ones)
Ex7	Effect of influenced Hidden Hands

Table 8. Environmental risk factors

Categories	
5	Environmental risks
Code	Risk Factor
En1	Environmental analysis incomplete
En2	New alternatives required to avoid, mitigate or minimize environmental impact
En3	Difficulty to access the site (very far, ………. etc.)
En4	Geophysical and geological Impact
En5	Pollution (Contamination)
En6	Effect of raw materials and storage

Table 9. Organizational risk factors

Categories	
6	Organizational risks
Code	Risk Factor
O1	Inexperienced workforce and staff turnover
O2	Delayed deliveries
O3	Lack of protection on a construction site
O4	Financial including insufficient funding
O5	Renew of Insurance Clause
O6	Routine

Table 10. Project management risk factors

Categories	
7	Project Management Risks
Code	Risk Factor
PM1	Failure to comply with contractual quality requirements
PM2	Scheduling errors, contractor delays
PM3	Project team conflicts
PM4	Change in Management ways (including change of project manager)
PM5	Information Un availability (include uncertainty)
PM6	Lack of qualified and professional management companies to manage the tunnel project
PM7	Unexperienced and unqualified Project Manager

Table 11. Right of way risk factors

Categories	
8	Right of Way Risks (legal)
Code	Risk Factor
R1	Expired temporary construction permits
R2	Contradictions (conflict) in the construction documents
R3	Existence of old buildings
R4	Acquisition & Compensation
R5	Delayed Disputes resolutions
R6	Agriculture lands (not suitable for building)
R7	Non-authentic approvals
R8	Existence of previous project units (equipment, buildings, materials, etc.)
R9	Existence of Utilities (electric power cables, internet cables, water pipes, sewers, etc.)

Table 12. Financial risk factors

Categories	
9	Financial Risks
Code	Risk Factor
F1	Inflation
F2	Delayed payment on Contracts
F3	Financial failure of Contractor
F4	Price Adjustment
F5	Fluctuation in currency exchange rate
F6	Change of economic condition of the state

Table 13. Operational risk factors

Categories	
10	Operational Risks
Code	Risk Factor
OP1	Ventilation System (jet fans, connections, etc.)
OP2	Lightning System
OP3	Fire Control System
OP4	Traffic Control System
OP5	Drainage & flood system control
OP6	Air monitoring System (oxygen rate, methane and other flammable gases rates, Co & Co2 rates, etc.)

Table 14. Construction risk factors

Categories	
11	Construction risks
Code	Risk Factor
C1	Construction cost overruns
C2	Technology changes
C3	Quality control
C4	Testing (field + laboratory)
C5	Extending project time
C6	Rush Bidding
C7	Efficiency of equipment
C8	Lack of good quality row materials
C9	Inaccurate Site Survey
C10	Unavailable enough area for Construction debris
C11	The appearance of groundwater during excavation work
C12	Excessive deformations causing failure of the lining

Table 15. Safety and health risk factors categories

12	Safety & Health Risks
Code	Risk Factor
S1	Blasting (improper Implantation, usage & storage for blasting materials (explosives))
S2	Improper Installation & Usage of Equipment
S3	Inadequate Carry out and delivery of materials and equipment
S4	Unforeseen site condition
S5	Improper ventilation during construction
S6	Severe Weather Conditions
S7	Improper and inadequate safety instruments and guidelines
S8	Vandalism
S9	Inadequate Emergency Passages
S10	Inadequate Excavation & drilling (face collapse)
S11	Improper Support Systems
S12	failure of sprayed concrete due to insufficient strength
S13	Fall from heights + Falling objects
S14	Poor Visibility and Lighting
S15	Surface and underground fueling

Table 16. Physical and logistic risk factors

Categories	
13	Physical and Logistic Risks
Code	Risk Factor
PL1	Occurrence of accidents because of poor safety procedures
PL2	Unavailable Labor, materials and equipment
PL3	Poor communication between parties

Results regarding Risk factors prioritizing by means of AHP, Sample of calculations illustrated in table 17. and Table 18.

Table 17. Pair wise matrix regarding pre-study

	PS1	PS2	PS3	PS4	PS5	sum	average
PS1	1.000	2.000	2.000	3.000	4.000	12.000	2.400
PS2	0.500	1.000	0.167	0.333	2.000	4.000	0.800
PS3	0.500	6.000	1.000	2.000	4.000	13.500	2.700
PS4	0.333	3.000	0.500	1.000	4.000	8.833	1.767
PS5	0.250	0.500	0.250	0.250	1.000	2.250	0.450
sum	2.583	12.500	3.917	6.583	15.000		

Table 18. Normalized pair wise matrix regarding pre-study for the weight calculation

	PS1	PS2	PS3	PS4	PS5	sum	Average weight	consistency
PS1	0.387	0.160	0.511	0.456	0.267	1.780	0.356	5.475
PS2	0.194	0.080	0.043	0.051	0.133	0.500	0.100	5.110
PS3	0.194	0.480	0.255	0.304	0.267	1.499	0.300	5.630
PS4	0.129	0.240	0.128	0.152	0.267	0.915	0.183	5.441
PS5	0.097	0.040	0.064	0.038	0.067	0.305	0.061	5.255
sum	1.000	1.000	1.000	1.000	1.000		1.000	
							CI	
							RI	1.12
							CR	0.085/accepted

The highest ranked factor was (PS1) Insufficient estimation for funds (35.6%) Followed by (PS3) Unreasonable estimate for a proper location for the tunnel project (30%) and (PS4) Insufficient assumption of length of tunnel at proposed Location (18.3%), The results showed the main risk is regarding fund and improper location and length proposed.

For other categories, Table 19 illustrates the highest 3 factors regarding that category

Table 19. Top 3 factors regarding each category by the weight calculated through AHP

S.N.	Categories	Top 3 Risk Factors	Percentage by weight
1	Pre-Study Risks	PS1	35.6
		PS3	30
		PS4	18.3
2	Bidding Risks	B4	25.35
		B9	16.08
		B3	13.7
3	Risks due to Design Stage	D7	46.9
		D4	19.6
		D5	10.8
4	External Risks	EX7	41.9
		EX4	25.3
		EX5	9.7
5	Environmental Risks	EN4	37.3
		EN5	18.6

		EN3	18.5
6	Organizational Risks	O4	38.4
		O6	19.7
		O5	15.5
7	Project Management Risks	PM5	27.1
		PM6	23.5
		PM7	14.7
8	Right of Way Risks (Legal)	R7	25.5
		R5	16
		R4	15.3

Table 19. Continued top 3 factors regarding each category by the weight calculated through AHP

S.N.	Categories	Top 3 Risk Factors	Percentage by weight
9	Construction Risks	C5	40.6
		C4	13.8
		C3	10.6
10	Financial Risks	F6	38.3
		F2	26.6
		F5	11.3
11	Physical and Logistic Risks	PL3	63.3
		PL2	26
		PL1	10.6
12	Operational Risks	OP6	27.6
		OP5	21.7
		OP3	15.6
13	Safety & Health Risks	S1	18.6
		S5	15.8
		S14	12.5

Regarding the results for highest top three factors for each category the following were noticed:

- Pre-study risks: as main concern was about estimated funds and a part of geometric requirements including location and proper estimated length (83.9% for all three factors from total) these are with great concern and affects the total cost, time, and safety for the project of tunnel as a whole.
- Bidding Risks: factors such lack of full information of the bidder as 25.35% represent a critical point that no clear and enough information about the side of contractor affect majorly on the whole process of construction in all the outlined objectives (time, cost, quality and safety). Other two factors are somehow in the same line regarding the lack of information about the bidder or let say a forced bidder (55.13% out of total) is something to be put into consideration and establish a more expert and isolated committee regarding the bidding process.
- Risk factors regarding Design Stage: the top ranked factor was Lack of Design recheck(review) by 46.9% that was a serious issue in the projects of tunnel in Kurdistan Region that come from the low experience regarding tunnel design and beside the companies did the design didn't give a clear idea about the design procedure. Other two factors regarding design stage will as a combined (77.3% from total) that is considered as a serious issue and requested from the authorized parties to find a solution to this matter, as it eventually will affect the objectives for the whole project.
- External Risks: effect of influenced hidden hand was the highest score with 41.9% followed by politics 25.3% and war and natural hazards third 9.7%, with a combination of (76.9% from total).

- Environmental Risks: geophysical and geological impacts were on the top of 37.3% as these factors affect the progress of the project from the beginning so it must be reduced as much as possible. All three factors as a combined (74.4% from total).
- Organizational Risks: again, most concerned factor was regarding finance 38.4% and routine as followed with 19.7% and those will eventually affect mostly on time and accordingly cost. For combined all top three factors (73.6% from total).
- Project Management Risks: the highest three factors all regarding the quality and experience of management staff beside that tunnel projects mostly are considered aa one of the highest infrastructures with great uncertainties. Due to that highly experienced and qualified team of management for such project type is a must in order to low the risk and reduce the effects on project objectives (time, cost, money and safety). As combined percentage for those three (65.3%).
- Right of Way Risks: all the top three factors affect directly on duration of project and cost with emphasizing on the fact it affect's on safety of the project and the staff if it was not dissolved as it should be, for the three factors as combined percentage (56.8% from total).
- Construction Risks: at the top sits extending project time factor with 40.6% even though most of infrastructure projects won't be done at proposed time but the high percentage was most likely due to the fact most of the tunnel projects in Kurdistan reign stopped actually due to the war against ISIS and that gave that percentage. As for other 2 factors both are considered a part of quality control issues. For the three factors as a combine (65% from total).
- Financial Risks; Change of economic condition of the state with 38.3% as mentioned earlier the war with ISIS and what followed affected the economy situation for the country and that also clear from the percentage calculated. As for the all three factors combined (76.2% from total).
- Physical and Logistic Risks: the highest factor was poor communication between parties (63.3%) that is with a great concern since such issue will affect all the parts of the project as it might lead in some how to stop the project to solve that issue.
- Operational Risks: the highest factors were all picked up due to the fact tunnels as an enclosed structure and with a highly concerns about the air quality, drainage systems and fire safety to maintain as much as possible a safe transportation for the public, those factors as a combine (64.9%).
- Safety and Health Risk: again, the highest scored factors also were related to the fact of tunnel is enclosed construction and the method used for the construction in Kurdistan region included blasting materials those definitely should be done with great care to avoid any incidents and accidents. For the three factors as a combine (46.9% from total).

Figure 2. The compression of top three factors compared by the rest factors of category

Top 3 Risk Factors Compared to the rest	WEIGHT %
PS1,PS2,PS3	0.84
REST	0.16
B4,B9,B3	0.55
REST	0.45
D7,D4,D5	0.77
REST	0.23
EX7,EX4,EX5	0.77
REST	0.23
EN4,EN5,EN3	0.74
REST	0.26
O4,O6,O5	0.74
REST	0.26
PM5,PM6,PM7	0.65
REST	0.35
R7,R5,R4	0.57
REST	0.43
C5,C4,C3	0.65
REST	0.35
F6,F2,F5	0.76
REST	0.24
PL3,PL2,PL1	1.00
REST	0.00
OP6,OP5,OP3	0.65
REST	0.35
S1,S5,S14	0.47
REST	0.53

Figure 2. Compassion top three factors and the rest by percentage weights

Results regarding Risk factors prioritizing by means of AHP divided based on effect on (Time, Cost, Quality and safety). To establish this a pilot study conducted and based on the expert's judgment the factors been divide and nine factors nominated from the previous risk factors for each main project objectives as illustrated in Figure 3.

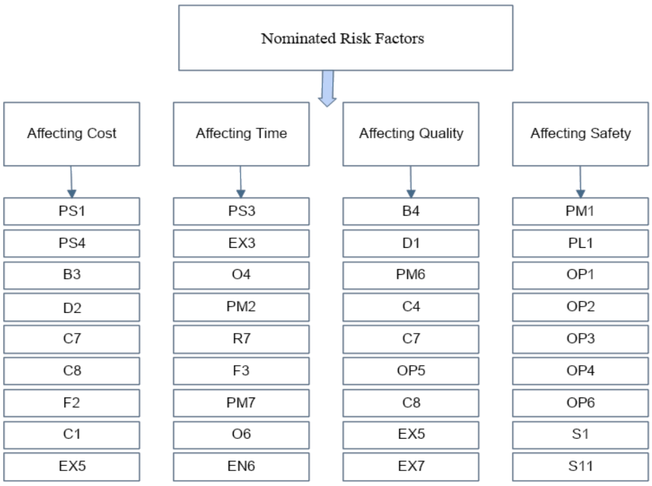

Figure 3. Nominated risk factors affecting project objectives

Regarding cost factors it was observed the main three factors affecting the cost were: F2 delayed payments on contracts (22.11%) C1 construction cost overruns (20.38%), EX5 politics (20.25%) and those were the main factors affecting cost objective.
As for time it was observed that the main three factors affecting the time were: R7 Non-authentic approvals (18.98%) O6 Routine (17.49%), EX3 War & natural hazards (14.1%) and those were the main factors affecting time objective.
As for quality it was observed the main three factors affecting the quality were: EX5 Politics (34.45%), EX7 Effect of influenced Hidden Hands (21.26%), D1 Design errors and omissions (9.48%) and those were the main factors affecting quality objective. As noticed, there are two external factors in which it is something to be concerned about.
Regarding safety it was observed the main three factors affecting the quality were: OP3 Fire Control System (20.51%), OP4 Traffic Control System (18.94%), OP6 Air monitoring System (oxygen rate, methane and other flammable gases rates, Co & Co2 rates, etc.) (16.72%) and those were the main factors affecting safety objective.
Accordingly, the need for a comparison between the main project objects and see what are most important objective regarding the project from the opinion of experts. From Table 20, it was observed the most affecting objective was Safety (47.3%) in which it is actually reasonable as such project of tunnel need a great concern regarding that matter for many reasons for instance the closed construction area, ventilation considerations, blasting, and so on. the second major objective is quality (31.1%) in which as experts always say it has to be maintained as a high quality as possible.

Table 20. Normalized pair wise matrices regarding main project objectives

	Quality	Time	cost	safety	sum	average
Quality	1.000	3.000	4.000	0.500	8.500	2.125
Time	0.333	1.000	2.000	0.250	3.583	0.896
cost	0.250	0.500	1.000	0.250	2.000	0.500
safety	2.000	4.000	4.000	1.000	11.000	2.750
sum	3.583	8.500	11.000	2.000		

Normalized matrix						weight			
	Quality	Time	cost	safety	sum	average	consistency	average	
Quality	0.279	0.353	0.364	0.250	1.246	0.311	4.112		
Time	0.093	0.118	0.182	0.125	0.517	0.129	4.048		
cost	0.070	0.059	0.091	0.125	0.345	0.086	4.028		
safety	0.558	0.471	0.364	0.500	1.892	0.473	4.139	4.082	
sum	1.000	1.000	1.000	1.000		1.000			
						CI		0.0273	
						RI	0.9		
						CR		0.030	accepted

4. Conclusions

Any tunnel project is a risk domain due to the uncertainty regarding all the phases of construction, regarding those factors would be elected as much as possible to be included in a way that all affecting the project objective during the life cycle of the project (time, cost, quality and safety) those are with great concern and should be solved to reduce such effect. Main factors most likely depending on the expert judgment and that mean different selection from a project to another with same title, and that would be a great concern also; this would push to the fact that a need for a convenient and systematic approach to be established in such projects regarding risk is a must to if not possible to avoid at least to reduce such effect on project outcomes

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