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Managing Geotechnıcal Rısks of Infrastructure Projects in Iraq

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Abstract:- The infrastructure project risks represent an essential areas in engineering field due to the importance of this types of project to the community. for that, the present research developed an approach to assess the geotechnical project risks in Iraq. the thesis specifies the north of Iraq as a case study and the risks were specified and evaluated through previous studies, questionnaires, and interviews with experts to build a geotechnical risks database for infrastructure projects. The geotechnical hazards were established using the Delphi technique, based on relevant research and expert views, in the first stage of this chapter, which was to designate the study region, which was the north of Iraq. In the second step, the researcher calculated the RII of dangers based on the region regions. In the third phase, the AHP was created which evaluates the collected data to discover and assess dangers as well as determine the risk rating. The RII and the AHP findings can be compared. The system performance was tested and the results were significant, and the risk prognosis was excellent, according to expert opinion

Keywords:- geotechnical risk assessment, AHP, RII, infrastructure projects,

INTRODUCTION

Early design stages for aircraft and spacecraft provide a fundamental grasp of physical events, allowing designers to forecast and analyze Risk monitoring is a continual process of risk management that involves tracking risk management execution and identifying and managing new risks. Risk monitoring allows for immediate action if a risk's likelihood, severity, or potential effect exceeds acceptable thresholds. It may have an impact on the workers' safety and health. These occurrences can have a negative impact on a construction project, such as income loss, schedule delays, or increased operational or maintenance expenses [1]. Because geotechnical hazards exist, numerous scholars have developed a project management statistic for geotechnical engineering projects that focuses on risks. A study presented by. Patil et al, in 2015 identify and categorize risks in infrastructure projects into eight categories: legal, physical, financial, political, construction, environmental, design, and contractual hazards, based on the nature of the effect. [2]. Kerim Koc et al, in 2020 conducted a study with the participation of 47 professionals from civil construction sector in Turkey. They used the correlation analysis based on index theory to estimate the rank of each risk in terms of cost and schedule. They found that "organic silts, soft clays, or peat" was the most significant risk factors [3].

GEOTECHNICAL RISK MANAGEMENT

Most ground engineering experts agree that managing geotechnical risk and the benefits that a comprehensive risk management framework can offer to a project are unquestionable (geologists, engineering geologists and geotechnical engineers). The usage of geotechnical risk registers throughout a Civil or Building Engineering project, as well as geotechnical risk management frameworks incorporated in the overall project risk management strategy, are viewed as beneficial steps in the construction sector. These benefits the construction team in terms of decreased design and construction risk, as well as the client in terms of total financial risk reduction[4]. It is critical to understand the features of geotechnical engineering projects in order to control geotechnical risk. Variable and challenging circumstances, extended project time schedules, major uncertainties, changing and distributed needs, vast and complex organizations, high technical levels, and a political, public, and environmental focus define many geotechnical engineering projects and situations. Many various players are involved in the building process, many of whom have competing interests and no experience working together. Many geotechnical engineering work activities, such as foundation work, excavations, and tunneling, may be classified as series systems. The order in which work activities are completed is determined by prior work processes and has an impact on subsequent work activities[5]. KOC et al, in 2020 investigated many advantages of deterministic risk assessment systems for mitigating geotechnical concerns. Furthermore, the geotechnical design codes for the entire structure meet the requirements for bearing capacity, durability, geometrical characteristics, and stability, as well as environmental effect and working conditions. The building process, the contract, the organization, and the economic arrangements are all key hazards in geotechnical engineering projects. Hazard, risk item, warning bells, starting event, damage event, and damage are all important terms in this process [3].

Sandip Deb and his colleagues give The effect of geotechnical risk is generally known by most ground engineering practitioners, but other construction professionals typically misunderstand or undervalue the problem and measures for mitigation[6].

A G Polyankin et al. investigated geotechnical concerns, focusing solely on economic consequences. Furthermore, for the development of complex multifunctional facilities, there is no comprehensive risk control technique. surrounding structures, topographical, engineering-geological, and hydrogeological aspects of the construction site region as possible geotechnical hazards that impact the development of emergencies during the construction of subterranean structures[7].

Evert Hoek et al. addressed the scenarios of risks by including various terms in contract papers, the difficulties continue. To avoid surprises, the best option is to characterize the geological conditions as early and precisely as possible[8].

Kevin McLain et al. The most effective strategy to mitigate pre-award risk is to do a full geotechnical evaluation before to awarding the contract. However, the federal government's desire to expedite project delivery, along with financial incentives to employ DB, makes it more likely that state DOTs will use DB to complete large-scale projects that face challenging geological obstacles[9].
The ongoing evolution of the conceptual ground model through all stages of the project was the major risk management tool, according to Koor, Nick. High pore pressures, low strength relict shear regions, and collapse features were all geological risks that posed a danger to the project's development and long-term performance[10].
Amadi Alolote investigates cost overruns and geotechnical risk factors. The study stated that the discovered gaps in practice might thus be used as a rational theoretical perspective for analyzing financial risk in highway projects owing to ground conditions. The research offers a kaleidoscopic picture of the numerous approaches to controlling hazards related to the ground throughout the preconstruction phases of highway projects, and how a lack thereof might lead to a pattern of high-cost overruns[11].
Mike Black outlines the scheme's overall geological background as well as the significant geotechnical dangers that were first identified. In order to remove or decrease these risks to reasonable levels, appropriate mitigation was devised both during design and delivery[12].
Crossrail [13]provide a wonderful chance to cooperate with academic and industry experts to further knowledge and understanding, and hence continue to decrease risk on the ground in future projects.
Raffaele De Risi et al. provide a technique for assessing the risk of a gas pipeline infrastructure in the aftermath of a seismic event at the regional level. Seismic intensity measurements (IMs), such as peak ground acceleration (PGA) and peak ground velocity (PGV), are determined at the position of each pipe using a simulation-based technique after earthquake parameters, such as magnitude and epicenter, are known. Damage maps help the prioritizing of inspections in the aftermath of an occurrence, whilst losses offer a rough estimate of repair costs[14].

Geological Hazards in Iraq

In Iraq, there have been 15 different types of geological hazards found. Because Iraqi soil is so diverse in terms of geography, morphology, and rock cover, 15 different types of geological hazards have evolved across the nation. Over the whole area, seven physiographic provinces could be recognized. The Mesopotamia Plain is created in the middle, stretching for around 730 kilometers from the Arabian Gulf in the south to Baiji, where it reaches a height of around 150 meters. It is made primarily of alluvial deposits from the Tigris and Euphrates Rivers, as well as its distributaries and the Shat Al-Arab, which are prone to floods, pipes, sabkhas, seawater intrusion, and depressions, among other geological hazards. To the west of this vast plain are the Iraqi Southern and Western Deserts, which occupy roughly a third of the nation and are covered in sedimentary rocks with rather rugged topography in certain places, such as the Ga'ara Depression. The surface topography climbs westwards to roughly 1000 meters near Jabal Anaza, revealing different geological hazards such as floods, mass movements, swelling clays, and depressions. A network of valleys that are prone to floods separates the two deserts. The karst phenomenon, which is particularly highly developed in the Southern Desert, is another type of geological hazard. Many geological hazards, such as mass movements, floods, movements, pollutants, earthquakes, mining catastrophes, and gypsum-induced hazards, may arise due to the diversity of rocks and geography[15]

INFRASTRUCTURE RISK FACTORS

The risk factors discovered in the study by Douglas et al. in [16] were adopted in this research since it covered a large body of literature on the subject and presented a holistic view of geotechnical concerns rather than focusing on individual ones. Experts have characterized and tested the 27 risk factors identified by Kerim Koc et al. in [3]. The next step in this investigation will be to enlist the help of specialists to identify the risks connected with transportation projects. Based on a literature review, a comprehensive list of 27 risk indicators was produced, and a questionnaire was designed to get comments from experts handling various infrastructure projects in Iraq. Table 1 lists these risk factors. .

Table 1. Selected Geotechnical risk factors (from Kerim Koc et al.[3] and Sissakian et al, [15])

R1- mass of movement
R 2- Gypsum induced hazards
R 3- pollution
R4- Groundwater/water table
R 5- impacted Existing structures
R 6-Existing Contaminated material
R7- marshes (organic soil)
R 8- Sensitiveness of Landscape
R 9-Underground artificial debris
R10- Groundwater infiltration

The elements point to a connection between the Iraqi environment in the north and the Iraqi environment in the north. The type of soil around the foundation has a big influence. It's conceivable that the researcher home's construction was not designed for the type of soil beneath it. The moisture content of the soil has an impact as well. Near the foundation's perimeter, the dirt is drier. On the other side, too much moisture softens and weakens soil. The water leak will weaken the soil around the footing of the foundation, causing it to sag. Depending on the composition of the soil, hydrostatic pressure arises when it is either too dry or too wet[17][18]. Plants and trees within a short distance of the project have the potential to cause settling. Tree roots, in particular, will absorb water from the ground. During droughts and lengthy periods of dry weather, this is very prevalent. The soil shrinks when the weather is dry. Tree roots, which are always hunting for water and will grow around and beneath the foundation, are the most typical cause. Soil dryness is more common in shallow foundations that are closer to the surface. Basement-level foundations are particularly susceptible to earth disturbance since they reach deep into the ground [19].

METHODOLOGY OF PRESENT WORK

The study's main purpose is to assess the most important significant risk factors for infrastructure projects. The rating must be done by a professional team. For the researcher, the Delphi technique provides a diverse and adaptable tool for gathering and interpreting data. The Delphi method is utilized for the following reasons [20][21].The process of comprehending each of the identified hazards is known as the evaluation approach. It requires input to assess the risks that must be addressed and to determine the most cost-effective risk management techniques. It comprises the risk sources as well as the implications of those risks. The outcomes and likelihoods are frequently combined to evaluate and analyze risks. Risk assessments can be qualitative, quantitative, or semi-quantitative. The common risk evaluation techniques and analyses used in geotechnical engineering may be described as follows[22][1]:

i. Analysis of fault trees (FTA)
ii. Analysis of event trees (ETA)
iii. Cause-and-effect or cause-and-effect analysis

The kinds provided below can also be utilized to adjust the approaches used for assessing safety events, complicated hazards, and important controls:

i. PRA (probabilistic risk analysis) and decision analysis (decision analysis) are two types of risk analysis[23].
ii. Analytical hierarchy process (AHP) [24]

A quantitative analysis isn't always the best option if there are variations in data quality or data sources. In these circumstances, a thorough qualitative analysis with the same level of detail can be used. The documentation should include a description of the data quality and data sources used in the study, regardless of the method used. A description and discussion of the system and problem definition, identified risk sources and hazards, starting events, and so on should also be provided. This study presented a practical and effective method for assessing the significance of geotechnical concerns. According to a common rule in risk management, risks are best handled by the party having the best capabilities and qualifications to manage them. As a result, some risks can be assigned to a single party, ensuring that the project is protected or that the risks' repercussions are avoided. The geotechnical hazards were established using the Delphi technique, based on relevant research and expert views, in the first stage of this chapter, which was to designate the study region, which was the north of Iraq. In the second step, the researcher calculated the RII of dangers based on the region regions. In the third phase, the AHP was created using MICROSOFT EXCEL software, which evaluates the collected data to discover and assess dangers as well as determine the risk rating. The RII and the AHP findings can be compared. Finally, the affecting variables of infrastructure projects were identified and tested based on the risk assessment.

RESULTS AND DISCUSSION

The percentage scoring approach mentioned earlier in this study was used to determine the importance of the hazards. To identify all hazards associated with infrastructure project operations, a thorough methodology is required. Table 2 shows the results for the top 14 most important hazards.

Table 2: the selected geotechnical risk factors

The researcher split the geotechnical risks factor effect into three regions in this study due to the various geotechnical properties of these locations. There are just a few urban and archaeological sites on the island. The city of Kirkuk, as seen in Figure 1, is notable for its large muddy grounds, as well as having a port with views of the Arabian Gulf and a plethora of urban structures. We can better recognize threats as a result of zoning. The geological structure and the character of the land influence geotechnical hazards.

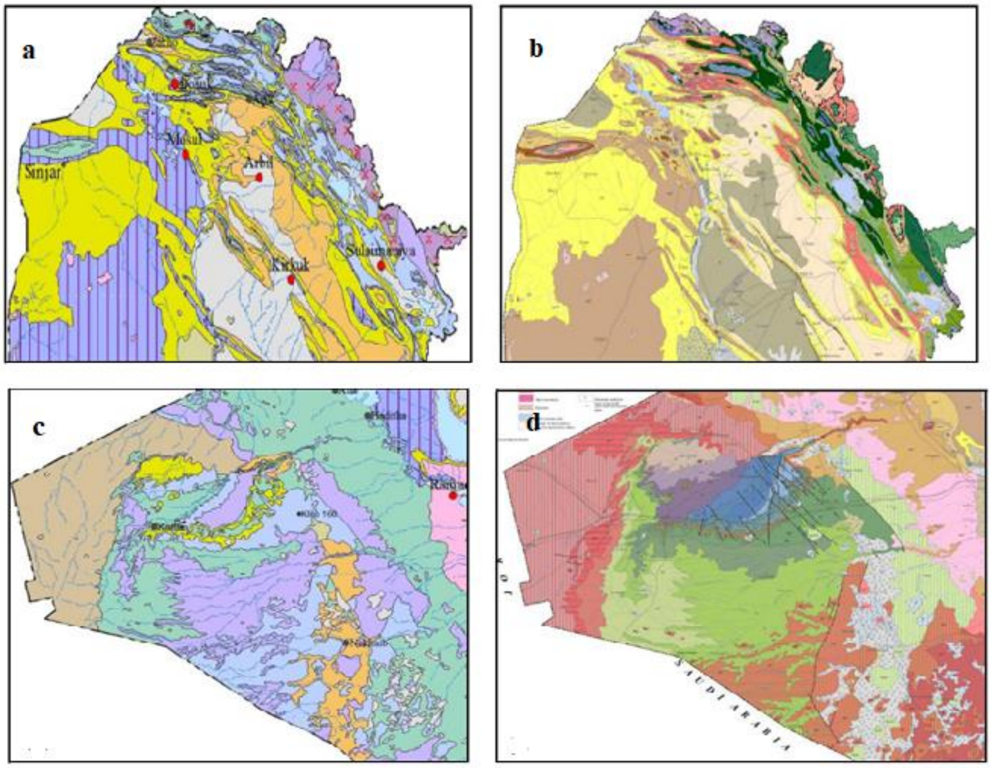

Figure 1: the selected regions in Iraq

Based on the expert's opinions, the working factors have been specified and the evaluation of each risk specified in the tables below.

RII RESULTS

Relative importance index analysis is a technique for prioritizing indicators assessed on Likert-type scales that allows for the identification of the majority of important criteria based on participant replies. To establish their relative significance, the criteria were sorted using a relative index analysis. The relative index analysis ranking findings for each region are provided in the tables in the following sections. As a consequence of these ranking results, 14 threats were recognized as having high priority levels in the risk assessment of infrastructure projects based on geotechnical impacts.

The relative importance index, or RII, was created for each problem to detect risk variables in geotechnical infrastructure projects. The obtained RII values were used to rank these factors.

Table 2: RII of Risk factors respond scoring in region 1

factor	total values	samples summation	RII
R1- mass of movement	67	20	0.67
R 2- Gypsum induced hazards	79	20	0.79
R 3- pollution	66	20	0.66
R4- Groundwater/water table	68	20	0.68
R 5- impacted Existing structures	73	20	0.73
R 6-Existing Contaminated material	65	20	0.65
R7- marshes (organic soil)	68	20	0.68
R 8- Sensitiveness of Landscape	66	20	0.66
R 9-Underground artificial debris	67	20	0.67
R10- Groundwater infiltration	73	20	0.73

The R2 rank came up on top, as can be shown (79 percent). Gypsum induced hazards of geotechnical problems was the most important component that generated risk difficulties. It is quite easy for a gypsum induced hazards when it is exposed to a mechanical

load. Gypsum is a source of inorganic pollutants, as well as geological formations that grow especially in karstic environments. Furthermore, gypsum regions are hazardous geological conditions where natural hazards can arise if settlement areas or human-made structures (buildings, roads, and substructure systems, for example) are present. As a result, gypsum is an essential evaporating unit that should be considered in terms of natural disasters, environmental issues, and urbanization.
In this section, the results of relative importance index, RII, was computed for each factor to identify the risk factors in geotechnical infrastructure projects in region 2. According to the computed RII values, these factors were ranked.

Table 3: RII of Risk factors respond scoring in region 2

Factor	total values	samples summation	RII
R1- mass of movement	67	20	0.67
R 2- Gypsum induced hazards	70	20	0.7
R 3- pollution	63	20	0.63
R4- Groundwater/water table	68	20	0.68
R 5- impacted Existing structures	74	20	0.74
R 6-Existing Contaminated material	65	20	0.65
R7- marshes (organic soil)	71	20	0.71
R 8- Sensitiveness of Landscape	58	20	0.58
R 9-Underground artificial debris	67	20	0.67
R10- Groundwater infiltration	74	20	0.74

It can be shown that existing structures are more likely to be impacted by the task rank presented (74 percent). R 5 which represent the impacted existing structures and R10 which represent the groundwater infiltration considered the main effective factors in region 2. To eliminate this risk effect, utilize precautionary measures to protect against deterioration and provide specific design guidelines. The information in these instructions is best practice and might be applied to other constructions in harsh situations.

AHP results

The results of the AHP analysis are reported in the sections that follow. The AHP analysis findings are shown in the tables in the following sections for each region. Based on these ranking findings, the selected 14 hazards were identified as having high importance levels in the risk assessment of infrastructure projects based on geotechnical effects. To identify risk factors in geotechnical infrastructure projects, the AHP was calculated for each factor. These criteria were ordered based on the AHP values obtained.
It poses a significant geotechnical concern. Furthermore, the parent construction waste dump is a major source of geotechnical difficulties.

Table 3: comparison between RII and AHP ranks

risk factor	AHP results	rank	RII	RANK
R1- mass of movement	0.048	9	0.67	4
R 2- Gypsum induced hazards	0.29	1	0.79	1
R 3- pollution	0.18	7	0.66	5
R4- Groundwater/water table	0.23	4	0.68	3
R 5- impacted Existing structures	0.23	3	0.73	2
R 6-Existing Contaminated material	0.08	8	0.65	6
R7- marshes (organic soil)	0.23	4	0.68	3
R 8- Sensitiveness of Landscape	0.22	5	0.66	5
R 9-Underground artificial debris	0.26	2	0.67	4
R10- Groundwater infiltration	0.20	6	0.73	2

These elements were shown to be an interesting factor in geotechnical risk factors, according to the findings. When we compare the RII and AHP findings, we can see that the top higher ranks, as indicated in table 3, are significantly higher. According to the experts, the results show that adopting the AHP approach has a higher level of reliability.

The AHP, was computed based on the second region questionnaire frequency results for each factor to identify the risk factors in geotechnical infrastructure projects. According to the computed AHP values, these factors were ranked as in table 4.

The results observed an agreement between RII and AHP results due to the similarity in R5 and R10 factors results which represent the high possibility to damage the exist building structure in this region.

It poses a significant geotechnical concern. Furthermore, the parent construction waste dump is a major source of geotechnical difficulties.

Table 4: comparison between RII and AHP ranks

risk factor	AHP results	rank	RII	RANK
R1- mass of movement	10%	6	0.67	5
R 2- Gypsum induced hazards	15%	5	0.7	3
R 3- pollution	23%	3	0.63	7
R4- Groundwater/water table	20%	4	0.68	4
R 5- impacted Existing structures	32%	1	0.74	1
R 6-Existing Contaminated material	9%	7	0.65	6
R7- marshes (organic soil)	15%	5	0.71	2
R 8- Sensitiveness of Landscape	15%	5	0.58	8
R 9-Underground artificial debris	29%	2	0.67	5
R10- Groundwater infiltration	32%	1	0.74	1

CONCLUSION

The goal of this study is to develop a novel method for predicting project risks deriving from geotechnical issues in northern Iraq by developing a model that may assist parties participating in infrastructure projects in identifying impediments and dangers early on. The following methods and processes were used to attain this goal:

1- The two surveys and the opinions of experts in infrastructure projects were used to assess effective risk aspects and the degree of their influence, as well as interviews with experts and exploratory research from prior studies. A total of 10 different categories of hazards influencing infrastructure projects were chosen.

2- There were many steps required in creating an AHP model, the first of which was selecting the program that would be used to generate the model. The Microsoft Excel tool for basic risk assessment and the Microsoft Excel software were chosen to determine the degree of effect of each category of risk because of their ease of use and ability to make conclusions.

3- The concept was put to the test by splitting Iraq's northern area into three primary sections based on soil geology, history, and degree of urbanization. Other criteria like as project size and project drilling depth were used to assess the system's adaptability.

According to specialists, the outcomes were good, and the risk prognosis was great.

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