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RISK MANAGEMENT OF HIGH-RISE BUILDINGS CONSTRUCTION BASED ON MULTI-CRITERIA DECISION ANALYSIS

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Abstract- The most important part of managing a high-rise building project is to establish an appropriate safety margin to make it as safe as possible. Every factor must be taken into account before the start of construction to ensure the highest possible safety standards. In Iraq, the most difficult part of constructing a high-rise building is to identify the best way to manage the project and recognise the risks that come with it. The purpose of this thesis is to determine the risk factors associated with high-rise building projects and to develop the highest possible safety margin. To achieve this, 36 different criteria were analysed from previous studies and the risk management process was divided into four steps: using the Guttman scale, the Likert scale, a risk matrix, and multi-criteria decision-making (MCDM). The MATLAB program was utilized to explore the influence of this method, and the results were applied to a BIM model to observe significant results. Ultimately, all considerations should be taken into account before high-rise construction projects begin in order to make them as risk-free as possible.

Keywords: Risk Assessment, MCDM, BIM, High-Rise Building.

1. INTRODUCTION

Risk assessment of high-rise buildings using MCDM (Multi-Criteria Decision Making) is a powerful tool for assessing risks associated with the of high rise buildings's construction [1]. MCDM that is a combination of analytical, mathematical, and graphical techniques used to structure and prioritize risk factors associated with building design and construction [2]. MCDM can be used to identify, analyse, and prioritize risks, and provide a basis for making decisions about the design and high-rise buildings's construction [3]. The approach can be used to assess the likelihood of a range of risks, including structural failure, fire, water intrusion, and seismic activity. It can also help evaluate the potential for cost overruns, delays, and other risks related to the construction process. In addition, MCDM can be used to identify opportunities to improve the design, construction, and maintenance of high-rise buildings. By using MCDM to assess the risks associated with high rise building construction, it is possible to make more informed decisions, reduce costs, and provide greater safety and security for building occupants [4]. The building with a total height of 36 meters or more, and more than 12 stories, is considered a high-rise building, regardless of its intended use (which could be anything from an office to a hotel).

High-rise buildings are difficult to define precisely because, aside from height, almost every other characteristic is contextual. The height of a building is not an adequate descriptor on its own because of the several other criteria that go into making an assessment of a structure. From a structural perspective, however, it might be usually known as the structure whose height is so susceptible to side loads from wind and earthquake activity that it would play a decisive part in the design process. That is to say; it might be the structure whose full title reads, "building the height of which is subject to the effects of side loads" [5]. High-rises, also called multi-story structures, account for a large share of the building industry and play a pivotal role in the growth and development of countries. As the world's population rises, so too does the pressure on the construction industry to keep up with housing demand, leading to a growth in the number of skyscrapers. The risk factors in a high-rise building are, understandably, also very significant. Construction projects incorporate a lot of factors, and one of the most important is the risk connected with building tall buildings.

The goals of a construction project are always one-of-a-kind. It is important to remember that risk is always present in high rise construction projects, and that it is usually the cause of the inevitable cost and time overruns that come with them. One definition of risk management describes it as a methodical procedure [6]. Risk is inherent in the completion of every endeavor. There is an element of peril involved in any undertaking, irrespective of the scale or nature of the enterprise. Every endeavor has its share of potential risks. If risks are not accurately recognized and contingency plans are not developed to deal with them, the project is most likely going to be unsuccessful. In point of fact, these new prices are often evaluated once the project in question has been finished and its associated costs have been tallied.

Evidently, the majority of the transitional risks were shouldered by the business while utilizing this approach [7]. For the purpose of valuing variations, many recently drafted contract conditions have now incorporated a new method. This method requires the contractor to submit a quotation for the work before the instruction to proceed is given. This requirement applies to activities involving civil engineering as well as construction. By utilizing this technique, the risk is transferred to the contractor, who is compelled to include in all estimated expenses in the quotation, including those connected to delay, interruption, and risk. An unexpected risk occurrence in one project is not the same as an unexpected risk occurrence in another project. In a similar vein, the frequency of occurrence, amount of influence, and overall level of relevance change from one project to the next. This is a difficulty for management in terms of controlling risks linked with new enterprises.

If risks aren't managed effectively and no assessments are done, construction projects could be in trouble. The good opportunity to learn from mistakes made through difficult projects is a benefit that comes with those activities. On the other hand, those who have been personally touched by the scenario generally fail to remember. This is a waste of time as the lessons that we can get from the circumstance will help us enhance our competence and prevent us from repeating the same mistakes in future initiatives [8].

In 2016, observations and coordinate report data revealed a variety of issues in high-risk construction projects. These issues included huge accounts receivable due to owner delays in paying progress payments and profit reduction due to field error production. Other issues included a lack of quality control in the field. The above explanation makes it abundantly clear that it is necessary to both determine the risk event in general (generic) on the high-rise construction project and evaluate the risk of each risk event individually [9]. Utilizing an appropriate safety margin is required in order to make the high-rise building project as risk-free as possible. All considerations need to be taken into account before high-rise construction projects may have the highest possible prospective safety margin developed for them. The planning and carrying out of site investigations are impacted in various ways by all of the issues that go into high-rise building projects. The most challenging aspect of this research is figuring out how to investigate the most effective method for the management of high-rise construction projects and correctly identifying the risks associated with those projects.

1.1. Risk Factors

Every building project is unique and comes with its own distinct problems as well as possible benefits. When it comes to building projects, it can be tough to discover and handle possible threats. Construction risk management is vital because, in the event that a risk materializes, it has the potential to halt development on a project and even lead it to collapse totally [10]. Project management competence in accurately analyzing, managing, and monitoring recognized risks is essential for avoiding disaster. Before you can manage construction risk, you need a thorough familiarity with the many threats that could materialize during construction projects. These difficulties can come from either within the organization or from outside the company, and they can be of numerous natures, including financial, contractual, operational, or environmental concerns. The following are some of the most prevalent types of risks [9]:

a) Dangers to workers' health and safety that might result in accidents and injuries.
b) Managing change orders
c) A lack of completion in the designs and an unclear scope
d) Unknown circumstances at the location
e) Contracts with poor writing quality
f) Unanticipated rises in the pricing of materials
g) Lack of available workers
h) Loss, destruction, or theft of apparatus and instruments
i) Natural catastrophes
j) problems with both the vendors and the subcontractors
k) Accessibility of various construction supplies
l) Poor project management.

In the event that a risk materializes, it may have a significant influence on the project's costs, timelines, and performance, all of which may result in further setbacks and disagreements in the future.

1.2. Related Studies

The risk management method consists of three stages: the first step is identifying the risk, the second step is assessing the danger, and the third is formulating a plan of action. According to scholars, the RA is based on multi-factor evaluation approaches that take ambiguous data into consideration. For the purpose of applying them in construction projects, RA factors are segmented into their respective macro, mezzo, and micro levels [11].

According to researchers, in addition to lowering the likelihood that a project will be delayed or go over its allotted budget, RM helps to ensure that it will be completed on time and without incurring any additional costs. RM is a useful management tool that may be used to discover the primary reflectivity of possible issue areas in a company. This can be accomplished by using RM. RM incorporates the totality of the project, which includes the design, engineering, business, contractual, and financial aspects of the endeavor, in addition to the estimating and purchasing departments, as well as the management of the project itself [9]. According to a study, a risk was identified as the terrain in the area under review shows signs of having been affected by landslides [12].

Kishan, Bhatt et al. conducted a survey that included 47 different dangers that can arise during the building of high-rise structures. The results were reached by conducting literature research and organizing interviews with relevant construction industry professionals. Physical, legal, environmental, managerial, cultural, financial, construction and political hazards are only some of the 47 types of risk factors that can arise [13].

Verma and Verma came to the conclusion that the most significant portion of the risks associated with the construction of the technological hazards, investment risks, physical risks, and building construction risks of a high-rise building. Engineers have identified a high-risk level, and other risks include a lack of resources, an insufficient electrical supply, low-quality materials, financial loss due to fluctuations in interest rates, and accidents on the job site [14].

The researchers who inestigated a study concluded that the purpose of RA is to categorize the dangers associated with the project and manage it accordingly by taking the appropriate precautions. The method relies on data collected via a survey sent to local contractors with experience in high-rise construction. The results of a pilot research and the recommendations of industry professionals have uncovered a total of 24 dangers impacting parameters across three categories. Formal risk assessment methods are utilized in the construction sector only very infrequently [15].

According to a study that comprises 47 risk indicators that are associated with building and construction projects. the results obtained through doing literature research, conducting organized interviews with key industry experts, and analyzing the present state of the construction business. There are a total of 47 different risk factor categories, including physical, legal, environmental, managerial, cultural, financial, construction, and political risks [16].

El-Azzazy discovered that researching risk analysis approaches were being utilized in order to examine hazards in construction projects in the Gaza strip. It suggests that during the pricing phase of construction projects, construction companies select and use any of the aforementioned risk analysis methods is the most effective and appropriate technique, in order to accurately estimate risks and figure out the most comfortable precautionary technique to react to risk effects [17]. The researchers of a study performed a survey as well as creating a questionnaire based on a review of the relevant literature. In order to gather the required information, a comprehensive questionnaire survey was carried out. The questionnaire was developed as a direct consequence of doing research based on previously published material and consulting with experts in relevant fields to ascertain the key risk factors. We distributed questionnaires to the on-site project manager, project engineer, and any additional site engineers who happened to be around at the time. These are the most pressing difficulties in high-rise construction, as cited by them: Risks related to building, physical environments, finances, and other technologies [18, 19].

The scholars of a study concluded that fundamental variables of risk had a significant bearing on total output. Most people are worried about technical risk (44.2%), which regularly influences high-rise development. This is accompanied by environmental risk (48.2%), physical danger (48.8%), financial risk (49.2%), socio-political risk (51.2%), and constructional risk (51.2%) (52.8 percent) [15].

Saeed Talebi carried out a poll with the individuals who work on building sites for a variety of businesses. It has been decided that risk management is necessary for building operations in order to lessen the amount of money lost and to raise the amount of productivity achieved. In Saudi Arabia, high-rise building projects might utilize RM plan summaries with strategies for identifying risks, evaluation, qualitative and quantitative approaches, mitigating and contingency plans, control and monitoring communication, and reporting [20].

According to Verma, Concerns regarding the building's construction, as well as its technical and financial aspects, as well as its physical environment, account for the vast majority of the dangers associated with high-rise buildings [14]. Engineers identify the following as the most severe risk factors: lack of raw materials, lack of electricity, poor quality of materials, lost opportunity due to interest rate variability, accidents on the job site, issues with subcontractors, inaccurate drawings, confirmation of incorrect tender documentation, and competition from other firms.

Design risks in design-build projects were highlighted by scholars, who conducted an analysis of the influence they had on the performance of the project [21]. They came up with a total of 23 design risk indicators, 17 of which came from an examination of the relevant literature and six of which came from in-depth discussions with five seasoned construction professionals. According to the results of the route modeling, the lack of accountability and responsibility on the part of the designer, as well as the lack of expertise on the part of the designer, and the delay in receiving information from third parties are all to blame for the risk implications.

A study discovered alternate methods for risk event, consequence, and effect predictions that could be used to reduce uncertainty in high-rise construction projects [22]. Qualitative methods were used for statistical data analysis. Contractors, especially those working on high-rise projects, can benefit from risk estimation since it allows them to assess the probability, severity, and impact of potential problems.

The scholars of a study noted that the objective of risk assessment is to analyze the dangers that a project poses and devise strategies for effectively mitigating those dangers [15]. The methodology was developed by the administration of a questionnaire to local contractors working on high-rise building projects. A preliminary analysis and the input of industry professionals have led to the identification of a total of 24 risk-influencing factors organized into three categories. In the construction industry that Ernakulum is a part of, formal risk assessment approaches are only sometimes used. Combining qualitative and quantitative research approaches is one way to develop the RM and RA, which can then be used to analyze the risks [23].

2. MATERIALS AND METHODS

2.1. Risk Analysis

The rating approach is usually applied for the aim of undertaking qualitative analysis of the dangers. The relevance of risk is readily apparent, and the level of practical convenience it gives is unprecedented in situations involving a sudden shift in circumstance and little information. Since the rating method is governed by the subjectivity of the evaluator's view, which is based on their prior experience, a quantitative risk analysis methodology is utilized in addition to the rating method. Statistical approaches that employ statistical data, impact methods that foretell the mutual impacts of risks using probability models, and sensitivity analysis that probes the causal link between risk variables are all examples of quantitative risk analysis techniques.

2.1.1. MCDM Method

An application of the MCDM theory uses computational methods that consider many criteria and preference orders in evaluating and choosing the best choice among numerous options depending on the desired outcome. This is done following the multi-criteria decision-making (MCDM) theory. It is used in various sectors to get an optimal solution to a problem in which there are a great deal of parameters to take into consideration, none of which can be selected by the users' experiences. The program generates a ranking result by using the specified criteria, the values that correspond to those criteria, and the weights that have been assigned.

Patients, doctors, hospital managers, engineers, and anybody else with a stake in healthcare or biomedical engineering could stand to benefit much from exploring the application of MCDM theory. Whether it is to improve the delivery of healthcare or to make a choice that is both sensible and safe for the patient's benefit, decision-makers, including those in the healthcare industry, are constantly entangled in difficult situations. When dealing with difficulties that occur in the real world, the results of the choices we have to make can be affected by a wide variety of important factors. When there is a risk to human life, the stakes are always extremely high, and as a result, it is critical to constantly make the appropriate choices. Not only are the challenges involving many factors exceedingly complicated when determining whether or not to employ a specific drug, therapy, or piece of medical equipment, but several parties are also profoundly affected by the implications of the decision [24-26].

- Step 1: putting together a standard matrix. The process of producing a standard matrix for each comparison matrix involves adding up the column values and then dividing those column values by the summation of the column values [27].

$$f(\lambda)=|A-\lambda|=\begin{vmatrix} a_{11}-\lambda & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22}-\lambda & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n1} & a_{n1} & a_{nn}-\lambda \end{vmatrix} \quad (1)$$

- Step 2: After that, we determined the priority vector by computing the mean value of each row, also known as the priority vector. According to Equation (2), the eigenvectors of matrix A are each column and any non-zero vectors that are X_i. The following equality holds true for thes

$$(A-1_t)X_l=0 \quad (2)$$

$$Aw=\lambda_{\max}w \quad (3)$$

- Step 3: First, multiply the priority vector by the standard matrix, then add the values of each column together, and finally, take the average of those values [27].

The maximal eigenvector, denoted by max, can be found by using the Equation (4). In this context, n refers to the total number of components, while w denotes the weight matrix.

$$\lambda_{\max}=\frac{1}{n}\sum_{i=1}^{n}\frac{(Aw)_i}{W_i} \quad (4)$$

2.1.2. HIRA Ranking the Risk Factors

Managers can find some answers to these issues with the use of a Hazard Identification and Risk Assessment (HIRA). It's a systematic way to evaluate danger, and it may be used to examine the risks posed by various dangers. There are three ways in which the use of an HIRA.

It helps those who work in emergency management get ready for the worst risks and/or the dangers that are the most likely to happen by accident. (Allows for the creation of plans, activities, and training programs that are based on the circumstances that are most likely to arise.) By isolating threats that cannot materialize inside the permitted area, we are able to save both time and resources. A risk is an uncertain and potentially negative outcome that might be brought about by an occurrence or sequence of events.

The existence of risk occurs from the simultaneous occurrence of a number of factors that have the potential to result in danger, which then leads to an accident that may take the shape of anything, including a fire or an explosion. Risk assessment, which is sometimes referred to as RA, is a method that has proven its value as a multi-purpose tool for improving the safety criteria that are usual in every hazardous line of work.

3. RESULTS AND DISCUSSION

Construction of a High-Rise Building (HRB) increases the project's complexity, adds new challenges, and poses new risks. Anxiety about the successful conclusion of construction projects in Iraq has increased in part due to the potential for project hazards to hamper project operations and accomplishments. In order to establish stricter regulations for the design, construction, and occupation of "higher-risk buildings," the current study provides further clarity on the definition of "higher-risk buildings." The efforts put in thus far allow for this to be possible. Constructions that are either taller than 18 meters or have more than seven stories are considered to be higher risk. In any event, these structures are more vulnerable. For this reason, it's more crucial than ever to identify the causes of the risks related to the construction of tall structures. The success of a project is crucial to realizing its goals. The Iraqi construction industry has a poor track record of delivering HRB projects on time and within budget.

3.1. Guttman Scale Results

The "strength" of a respondent's view may be measured with the use of the Guttman scale, which is also known as the cumulative scale or scalogram analysis. In other words, it indicates the degree to which people have a good or negative attitude about a specific subject matter. Louis Guttman, a social scientist and mathematician who worked in the 20th century, was the one who established the scale and utilized it to make predictions about which exam questions his pupils answered correctly based only on their overall score. The outcome of this strategy was to determine which risk variables in the environment of Iraq are the most significant for HRB. Table 1 represents the Guttman scale results of group 1 where significant amount of factors were identified according to theirs impact such as construction management risk, scarcity of coordination among the team member, lack of planning, managing resources etc. are prominent.

Table 1. Guttman Scale Results Group 1

No.	symbol	Hazer description	Guttman scale results
1	A	Risk of Construction Management	1
2	A1	Lack of leadership and teamwork	1
3	A2	Incapable team in planning	1
4	A3	Submission of construction claim	0
5	A4	Improper planning; inadequate resources; missed deadlines; poor quality	1
6	A5	Accuracy in mapping out the structure of the organization	1
7	A6	Weak work-place discipline	1
8	A7	Challenges in obtaining necessary authorizations to carry out project tasks	0
9	A8	Unaccepted work by Owner	1
10	A9	Level of overheads	0
11	A10	The administration of a project's assets (material, employee, equipment, financial method)	1
12	A11	Insufficient procedures for tracking progress on projects	1
13	A12	Lack of detail in the daily report and sloppy record keeping	1
14	B1.	Difficulties with material supply due to preexisting damage	0
15	B2.	Accuracy in acquiring materials and machinery	0
16	B3.	Site-related material losses	0
17	B4.	Material expense	1
18	B5.	Subpar output as a result of subpar materials and machinery	1

Table 2 represents the Guttman scale results of group 2, where most of the factors were identified as impactful except for some factors like bad weathering conditions, delayed project and difficulties in reaching the site.

The Guttman scale is composed of interconnected questions that get progressively more precise over time. It is made up of a sequence of dichotomous questions, which are more often known as 'yes/no' questions, and it is designed to establish the degree to which an individual agrees with or disagrees with a certain viewpoint by having the respondent answer the questions "yes" or "no." The replies are taken into account in accordance with the most recent statement that was agreed upon for the scale, and the responses are cumulative. Because of the deterministic structure of this scale, it is possible to evaluate the responses to all of the questions by just looking at the cumulative score. The list of assertions is organized in an ordinal fashion, as seen above.

Table 2. Guttman Scale Results Group 2

No.	Symbol	Hazer description	Guttman scale results
19	B6.	Material is a low specification	1
20	B7.	Equipment is broken	1
21	B8.	Material lack of storage	1
22	B9.	Productivity reduction due to ineffective materials and machinery	1
23	B10.	Severe shortage of workers at the site	1
24	B11.	Lack of a proper site safety plan	1
25	B12.	The work being produced is of poor quality	1
26	B13.	Faulty implementation of the building procedure	1
27	B14.	Challenges posed by the introduction of novel techniques (equipment, procedures) in building and manufacturing	1
28	B15.	Design error	1
29	B16.	Change design	1
30	B.17	Delay project	0
31	B.18	Bad weather	0
32	B.19	Constraints in getting to the place	0
33	B.20	Due to the drawbacks in execution and job requirements, wrong reading	1
34	B.21	Price increase	1
35	B.22	Shortage of Funding	1
36	B.23	Due to nonpayment in the contract	1

3.2. Risk Matrix Ranking Results

A risk assessment matrix, also known as a Probability and Severity risk matrix, is a graphical tool that illustrates the potential dangers. Another name for a risk assessment matrix is a probability and severity risk matrix. The risk matrix is constructed on the basis of two overlapping factors: The probability that the risk event will take place and the possible impact that the risk event might have on the company.

Table 3. Risk Matrix Ranking Group 1

Symbol	Hazard	Severity	Probability	Risk rank
R1	Risk of Construction Management	4	5	20
R2	Less control and coordination in team	4	4	16
R3	Incapable team in planning	3	4	12
R4	Improper planning; inadequate resources; missed deadlines; poor quality	5	4	20
R5	Accuracy in mapping out the structure of the organization	2	5	10

Risks can be ranked as high, moderate, or low depending on how often they are to occur and how severe their consequences are. In the course of this research, the researcher constructs the risk matrix in order to recognize the relevant risk variables, which are presented in the tables. Table 3 shows the risk matrix ranking of group 1, where accuracy in the determination of the organization structure is determined as the top rank factor in this group. Group 2 is ranked highest in the risk matrix in terms of a lack of process in monitoring project parties' actions, as seen in Table 4.

Table 4. Risk Matrix Ranking group 2

Symbol	Hazard	Severity	Probability	Risk rank
R6	Low level of employee discipline	5	5	25
R7	Unaccepted work by Owner	4	5	20
R8	Management of project resources (material, equipment, employee, financial, and method)	3	4	12
R9	Low level of process in observing activity by project parties	1	2	2
R10	Incomplete daily report and low level of project document management	2	2	4

Table 5 shows the risk matrix ranking of group 3, where Poor safety plan on the site and material lack of storage are identified as top rank (1) factors in this group.

Table 5. Risk Matrix Ranking Group 3

Symbol	Hazard	Severity	Probability	Risk rank
R11	Material price	3	4	12
R12	Material and equipment low productivity	3	3	9
R13	Material is a low specification	4	3	12
R14	Equipment is broken	2	2	4
R15	Material lack of storage	1	1	1

Table 6 shows the risk matrix ranking of group 4, where Poor safety plan on the site is identified as the top rank factor in this group.

Table 6. Risk Matrix Ranking group 4

Symbol	Hazard	Severity	Probability	Risk rank
R16	Low level of employer productivity	2	2	4
R17	Lack of manpower on the site	4	5	20
R18	Poor safety plan on the site	1	1	1
R19	Quality of work is low	1	4	4
R20	Error execution of construction method	2	1	2

Table 7 presents the risk matrix ranking of group 5, where differences in implementation and job specifications due to draw read error are identified as the top rank factor in this group.

Table 8 presents the risk matrix ranking of group 6, where lack of payment in time according to the contract is identified as the top rank factor in this group.

In the current investigation, there are four primary goals that need to be accomplished in order to construct the risk assessment matrix. The first reason is that because the scale and complexity of HRB risks are only expected to increase, it is very necessary for you to compile an exhaustive picture of the whole risk environment. The second step is to define the criteria that will be used to assess these dangers.

Table 7. Risk Matrix Ranking Group 5

Symbol	Hazard	Severity	Probability	Risk rank
R21	Challenges posed by the introduction of novel techniques (equipment, procedures) in building and manufacturing	2	2	4
R22	Design error	2	2	4
R23	Change design	3	2	6
R24	Due to the drawbacks in execution and job requirements, wrong reading	2	1	2
R25	Inflation	5	4	20

Table 8. Risk Matrix Ranking group 6

Symbol	Hazard	Severity	Probability	Risk rank
R26	Lack of capital availability	3	4	12
R27	Lack of payment in time according to the contract	3	2	6
R28	Effective training to the employers	4	2	8
R29	Country policy changes	3	3	9
R30	Cultural differences of employers	5	4	20

3.3. MCDM Results

The MCDM analysis not only makes it possible to determine the majority of the pertinent criteria based on the replies of the participants, but it is also a helpful method for ranking the indicators in descending order of importance. The findings of the MCDM analysis are shown in the tables that may be found in the subsequent sections. These tables are broken down into their respective groups of variables. As a consequence of the outcomes of these rankings, the dangers were recognized as posing high degrees of significance in the evaluation of the cost overruns associated with the construction projects. According to the findings of the building construction study, the 36 HRB risk variables that were chosen to be emphasized as having high important levels in the cost overrun of projects are as follows:

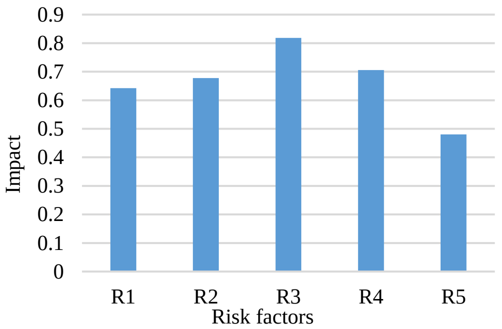

Figure 1. MCDM Results Group 1

Figure 1 represents the MCDM results of group 1, where different risk factors were demonstrated based on their impact. On many different construction projects, one or more teams have been unsuccessful. In HRB initiatives, the repercussions for a failing team are significant. Both productivity and efficiency take a significant nosedive, and it becomes nearly difficult to collaborate or innovate in any way. The primary indicator of the breakdown of cohesiveness within a team is the transition from an inwardly-focused, group-oriented attitude to an outwardly-focused, self-centred one. The focus shifts to one of individual survival rather than the success and accomplishment of the group. The unfavorable work contact has a substantial influence on creativity, and the combination of the two has a devastating effect on the successful completion of the project. It is essential to have a solid understanding of the importance of teams and to maintain a team operating effectively.

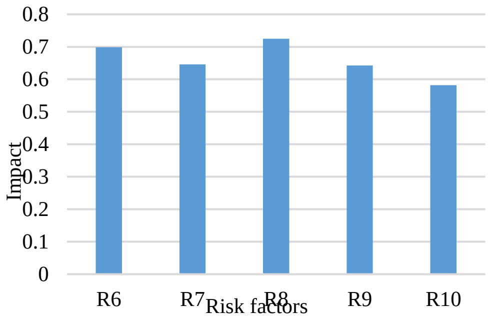

Figure 2. MCDM Results Group 2

Figure 2 represented the MCDM results of group 2, where different risk factors were demonstrated based on their impact. Management of project resources is referred to as the R8 factor (material, equipment, employee, financial, and method). A project is said to be at risk of resource risk if there is a possibility that it will be unable to acquire all of the essential resources that are necessary to finish a piece of work. There is a wide variety of things that might have an effect on this risk, and the project manager may not have any influence over the majority of these things. In order to carry out all of the tasks that have been planned, you are going to need resources such as people, equipment, space, money, or anything else that may be required. It is necessary to give resources to each and every action that is included in the activity list. Information on the availability of resources, such as which resources may be utilized in the project and the conditions under which they are available, are included in this category.

Figure 3 represented the MCDM results of group 3, where different risk factors were demonstrated based on their impact. The material shortage in terms of storage is represented by the number R15 in this group. It is of the utmost importance to store supplies in the proper manner in order to reduce the possibility of incurring losses as a result of theft, damage, or a reduction in the resources' overall quality.

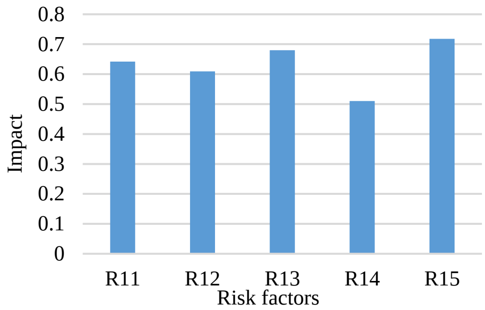

Figure 3. MCDM Results Group 3

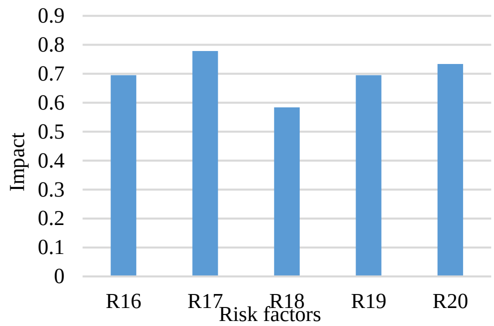

Figure 4. MCDM Results Group 4

Figure 4 shows the MCDM results of group 4, where different risk factors were demonstrated based on their impact. Employees who have received inadequate training are more likely to have poor job performance as well as heightened levels of the stress connected to their place of employment. If your workers have the impression that they are not being appreciated or treated fairly, there is a greater likelihood that they may go elsewhere for opportunities to further their careers. It is a common assumption in the business world that employees who are more content with the physical environment at their place of employment are more likely to deliver better results in their work. Conditions in the office, such as temperature, air quality, lighting, and noise, all have an impact on workers' ability to concentrate and their overall output. There are six variables that greatly contribute to a lack of skilled labor, and they include investment, obstacles in the labor wage market, talent management, the state of the working environment, training and experience, and policy decisions made by the government.

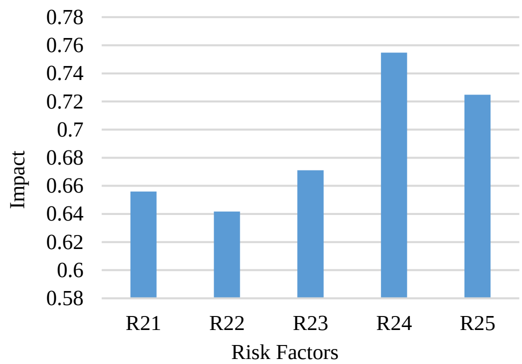

Figure 5. MCDM Results Group 5

Figure 5 represents the MCDM results of group 5, where different risk factors were demonstrated based on their impact. It is common practice for a complete set of construction drawings to include floor plans, elevations, sections, and detail drawings. These individual components, when combined, offer a comprehensive illustration of the structure. Drawings are essential to any undertaking since contractors must base their work on them throughout the entirety of the project, including the phases of planning and obtaining the necessary supplies and carrying out the work.

To reduce the likelihood of this happening, it is essential to ensure that all drawing designers have consistent access to all of the drawings throughout the duration of the design process. Furthermore, these individuals must have adequate practical knowledge of the logistics involved in the installation of multiple services in a single location. This will make it possible for them to discover any problems of this nature and guarantee that they are fixed in a timely manner.

Figure 6 represented the MCDM results of group 6, where different risk factors were demonstrated based on their impact. Lack of capital availability (R26) was the top most impactful factor, with a value of about 0.9. The building company will be unable to buy the assets and resources necessary for expansion if they are unable to obtain finance.

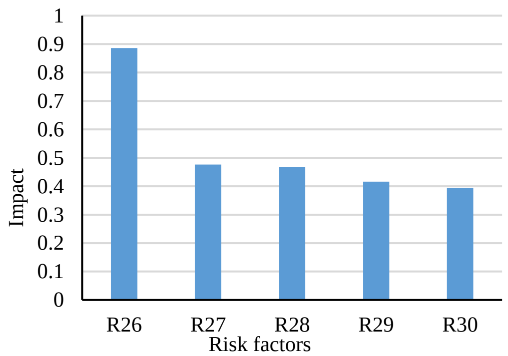

Figure 6. MCDM Results Group 6

The capacity of the project managers to handle day-to-day operations may be put in jeopardy if they do not have sufficient money. Rent, salary, and insurance are all examples of recurrent expenses that need financial outlay. The problem of insufficient capital in small businesses can be remedied by the use of compensation solutions that are efficient in terms of cost.

3.4. Total Risk Results

The method of risk appraisal provides assistance with decision-making on the ordering of hazards of concern. Estimating risk scores are an extremely important part of the risk prioritization decision-making process in practice. The analysis of hazards may be done in a semi-quantitative manner by using risk scoring. A number ranging from one to five is frequently awarded for the likelihood of the risk as well as the consequence of the risk. As a consequence of this, a risk score on a scale from 1 to 25 is derived by multiplying the two scores together. On the other hand, the use of risk scores alone could not be helpful when trying to prioritize risks. When deciding what should be prioritized, there are several aspects that should be addressed.

At this same moment, academics have been making extensive use of Multi-Criteria Decision-making (MCDM) approaches in order to prioritize various choices based on a variety of competing criteria. For the purpose of prioritizing the risk activities, this study made use of expert judgment, MCDM methodologies, and the Risk Priority Number (RPN). The final findings on the HSB risk effects may be seen in the matrix. Table 9 and figure 7 demonstrate the total risk factors results. Lack of storage for materials was identified as the low impactful risk with a lower effect of about 15.33%.

Table 9. Total Risk Factor Results

Symbol		MCDM RANK	RISK EFFECT
R3	Incapable team in planning	0.81849	17.49%
R8	Controlling the means at hand in a project (equipment, material, financial employee, and method)	0.72478	15.49%
R15	Material lack of storage	0.71774	15.33%
R17	Lack of manpower on the site	0.77837	16.63%
R24	Due to the drawbacks in execution and job requirements, wrong reading	0.75474	16.13%
R26	Lack of capital availability	0.88629	18.94%

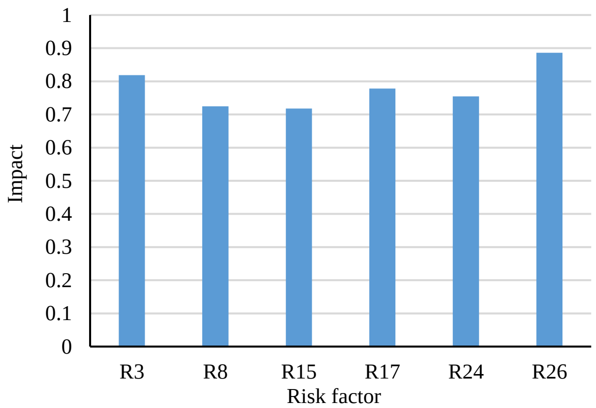

Figure 7. Plot of Total Risk Factor Results

The R26 has a higher rank; therefore, it was signalling that the lack of capital availability is the most important risk factor.

4. CONCLUSIONS

Risk, danger, and uncertainty are inherent throughout the many phases of a construction project's development. Health, the environment, property, and people's safety are only some of the things that might be jeopardized by the situation. Construction projects involving investments are significantly difficult to carry out, particularly in Iraq. The aim of this research is to provide a new approach to risk identification in high-rise Iraqi building projects by creating a model that may help the parties involved in building projects in obtaining the obstacles and delays during the beginning of a project's development. To achieve this, 36 different criteria were analysed from previous studies and the risk management process was divided into four steps: using the Guttman scale, the Likert scale, a risk matrix, and multi-criteria decision-making (MCDM). The MATLAB program was utilized to explore the influence of this method, and the results were applied to a BIM model to observe significant results. According to the findings of the study, the following observation can be concluded:

a) An effective risk factor from MCDM results is lack of capital availability which can affect on near about 19% of the project processes.

b) The Incapable team in planning factor can affect 18% of the project process.

c) About 16% of project processes can be impacted by issues such as management of the project's resources (material, equipment, personnel, financial, and method), lack of storage for materials, shortage of workforce on-site, and variations in execution and job specifications owing to draw read error.

d) The system was tested, and the results were excellent results according to the the expert's opinions which can be useful for future policy maker and the relevant stakeholders.

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