



Comparison of Risk Assessment Methods within the Scope of Occupational Safety in the Construction Sector

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Abstract

Occupational health and safety (OHS) history dates back to ancient human history due to a decrease the occupational accidents and diseases. Human is obliged to do work in order to sustain life. The works in general consist of the works done with body strength. OHS is a basis to reduce occupational accidents in an acceptable level, and it covers employee health, safety, and welfare in the workplace. There are certain or uncertain risks in terms of workplace structure and location. OHS investigates the actions to be taken to minimize these risks on the basis of workplace safety. Workers exposed to occupational hazards have a higher risk of developing work-related illnesses and injuries. Risk assessment is one of the most important structures in terms of identifying and evaluating the risks to which the employee and employer are exposed. Comparisons of risk assessment methods, which are divided into two categories as quantitative and qualitative, in the scope of occupational health and safety and the detailed analysis of the study, the differences between the methodologies have been revealed and accordingly, the and the necessary applications have been put forward.

Occupational safety risk assessment is mandatory for the implementation of risk control in the workplace, professional activities and protection of worker health. The employer can carry out this work in-house or by taking external services. The aim of this study is to compare the risk assessment methods used in the analysis of hazards and risks that may arise in terms of occupational health and safety and to evaluate their effectiveness in determining the measures to be taken as a result.

Keywords: Construction, Hazard Prevention, Occupational Safety, Risk Assessment

Risk Değerlendirme Metotlarının İnşaat Sektöründe İş Güvenliği Kapsamında Karşılaştırılması

Öz

İş sağlığı ve güvenliği (İSG) iş kazalarının ve meslek hastalıklarının en düşük seviyeye indirgemeyi amaçlayan geçmişi insanlık tarihi ile paralel olan bir kavramdır. İşçinin sağlık, güvenlik ve refahı iş güvenliği kapsamındadır. İnsanoğlu geçmişten günümüze hayatını idame ettirebilmek adına iş yapmak mecburiyetinde kalmıştır. Yapılacak işler yapısı ve yerleşkesi itibariyle belirli veya belirsiz riskler barındırmaktadır. İSG temelinde bu risklerin minimum seviyede kalması için alınması gereken aksiyonları araştırmaktadır. Mesleki tehlikelere maruz kalan işçilerin işle ilgili hastalık ve yaralanma geliştirme riski daha yüksektir. Risk değerlendirmesi çalışan ve işverenin maruz kaldığı risklerin belirlenmesi ve değerlendirilmesi açısından en önemli yapılardan birisidir. Nicel ve nitel olmak üzere iki kategoriye ayrılan risk değerlendirme metotlarının iş sağlığı ve güvenliği kapsamında karşılaştırılmaları de detaylı analizlerini içeren çalışmada metodolojiler arasındaki farklılıklar ortaya konulmuş, buna bağlı olarak da uygulama aşamasında yapılması gerekenler ortaya konulmuştur.

İş güvenliği risk değerlendirmesi işyerinde risk kontrolünün uygulanması, mesleki faaliyetler ve işçi sağlığının korunması adına zorunlu niteliktedir. İşveren bu çalışmayı kendi bünyesinde yapabileceği gibi dışarıdan hizmet olarak da yaptırabilir. Bu çalışmanın amacı; iş sağlığı ve güvenliği açısından ortaya çıkabilecek tehlike ve risklerin analizinde kullanılan risk değerlendirme yöntemlerinin karşılaştırılması ve sonucunda alınması gereken önlemlerin belirlenmesinde etkinliklerini değerlendirmektir.

Anahtar Kelimeler: İnşaat, Tehlike Önleme, İş güvenliği, Risk Değerlendirmesi

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1. Introduction

Work has always been and will always be one of the main and most important aspects of human life throughout the history. Work was a matter of literal survival; with the existence of human beings came to the responsibility of having to work to get food to stay alive, to have shelter for protection, to search for water, to stay warm, all the previous are tasks that require everyone to work. People spend most of their day at their work, they make, create, interact, react, do all kinds of activities, which consequently gives the workplace a high probability as a place where accidents could happen [1]. In order to control any dangers and eliminate hazardous situations, a set of ground rules has to be made that everyone could follow to ensure everyone’s safety and health. This set of rules should be well understood by people in the workplace, and it changes from one workplace to another depending on the present factors that could cause danger or accidents in the place [2]. Occupational health and safety regulations are much needed in this particular sector because construction industry is one of the most hazardous sectors when it comes to the safety of its workers; the workers carry on very labor-intensive work while being faced with many challenges that could be a source of danger or accident-causing. Almost all sector workers carry on very labor-intensive work to bring the desired, needed output [3]. They’re faced by many challenges and dangers in their workplace as they come in contact and interact with various different factors that might be a source of danger or accident-causing; whether these factors are machines, heights, weather or tools. Construction industry has a very high rate of accidents compared to other sectors due to several factors including heights, chemicals, heavy machinery and dangerous tools and equipment [4].

There are two kinds of risk assessment approaches which are reactive and proactive. Reactive approach is a traditional approach. In this approach, it is essential to investigate accidents and system disorders. Focuses on post-event review and reorganization. Proactive approach can be accepted as a contemporary approach. It focuses on examining the safety management system, risk assessment and safety culture rather than system malfunction. It focuses on pre-incident, employee and unsafe practices. From the above examples and explanations indicates that proper, accurate risk analyses regarding construction work are needed for the protection of workers who give too much to society and provide shelter [5].

Construction leads all industries in total worker deaths. More than %20 of fatal accidents at the workplace in the European zone took place within the construction sector while closely followed by the manufacturing sector, transportation and storage. Figure.1 shows total fatal injury rates in years between 2014-2017 while Figure.2 shows total fatal injury rates in the construction sector for the same period [6-8].

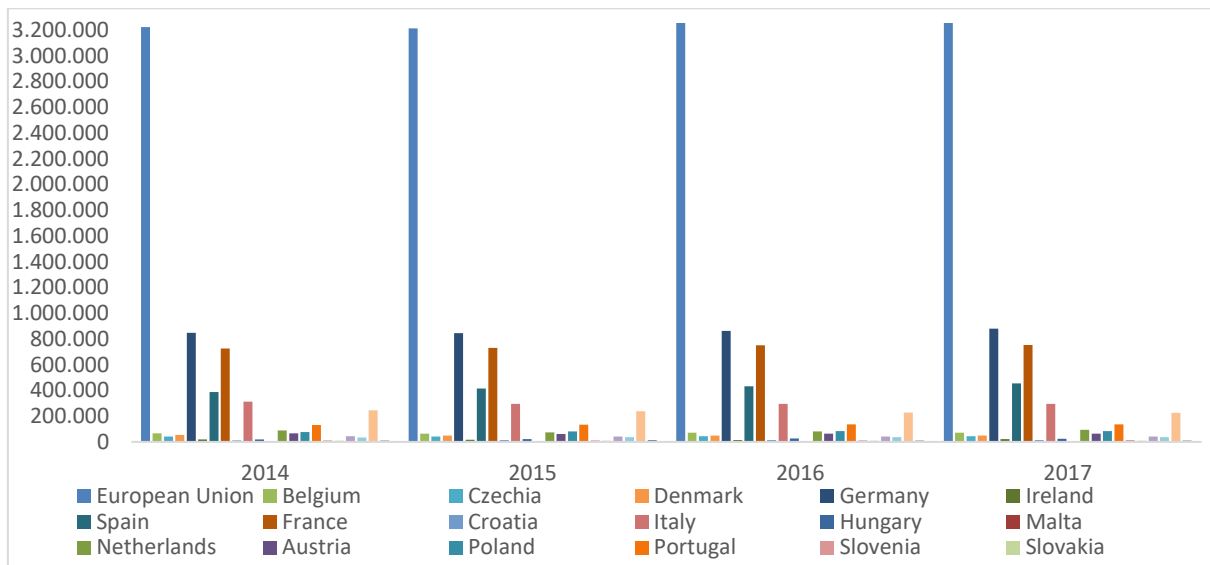


Figure 1. Fatal Injury Rates years between 2014-2015 in the EU-28 [7]

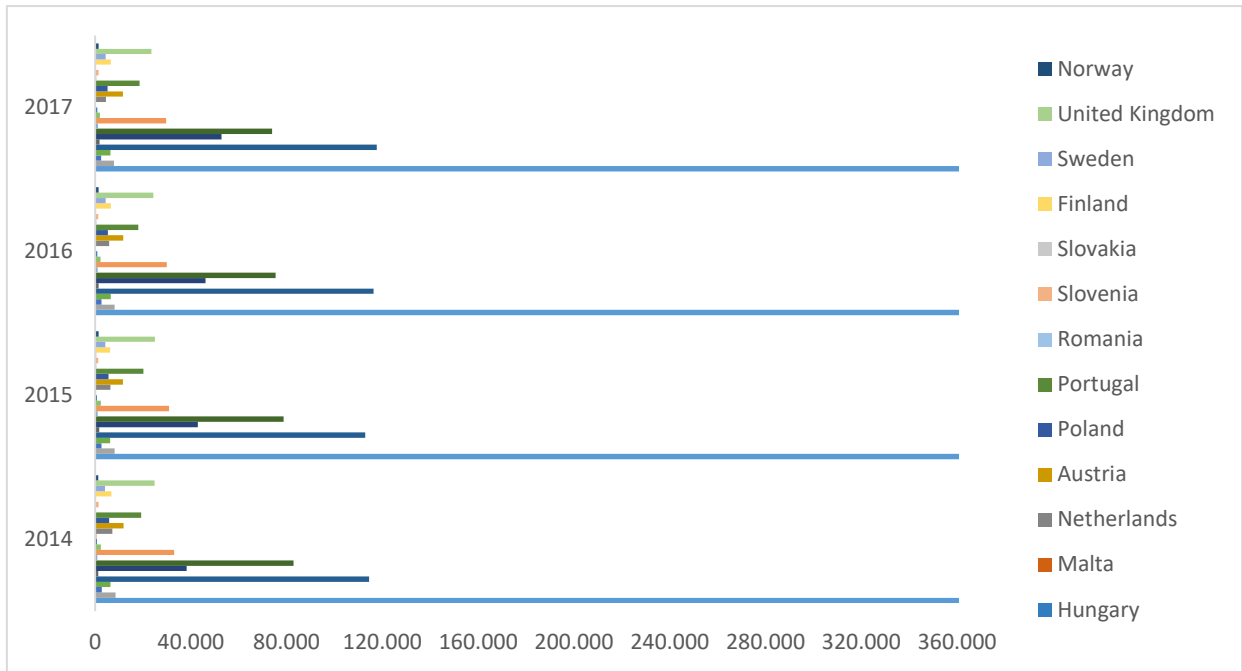


Figure 2. Construction Worker Fatalities and Injury Rates years between 2014-2015 [7]

The chart compares the fatal injury rates of different sectors in years between 2014-2017. It can be seen that all sectors witnessed inclination in the injury rates in the year 2015 except for construction sector, whose fatal injuries rates increased. Throughout the world it can be observed that construction industry has been accepted as very hazardous industry. Figure.2 shows the rates of accidents from 2014 to 2017 in the construction sector. We can see that the total fatal injuries as well as the fatal injury rate increased from 2014 to 2017. Falls, slips and trips have the highest rate of fatal injuries, which explain why in the previous chart roofers had the highest rate of injuries. The construction sector in Turkey ranks first in fatal accidents. Construction sector is classified as 'very hazardous' class where fatal occupational injuries occur more frequently. Figures 3 and 4 show the total number of accidents for Turkey in the construction sector by year.

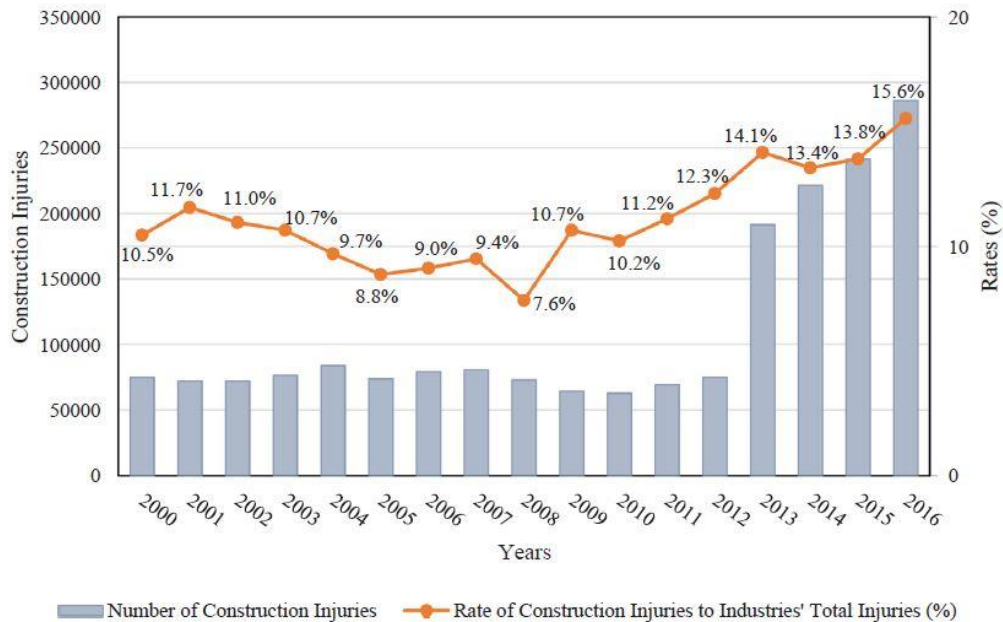


Figure 3. The number of occupational accidents occurred and the total number of occupational accident rate in the construction sector [8].

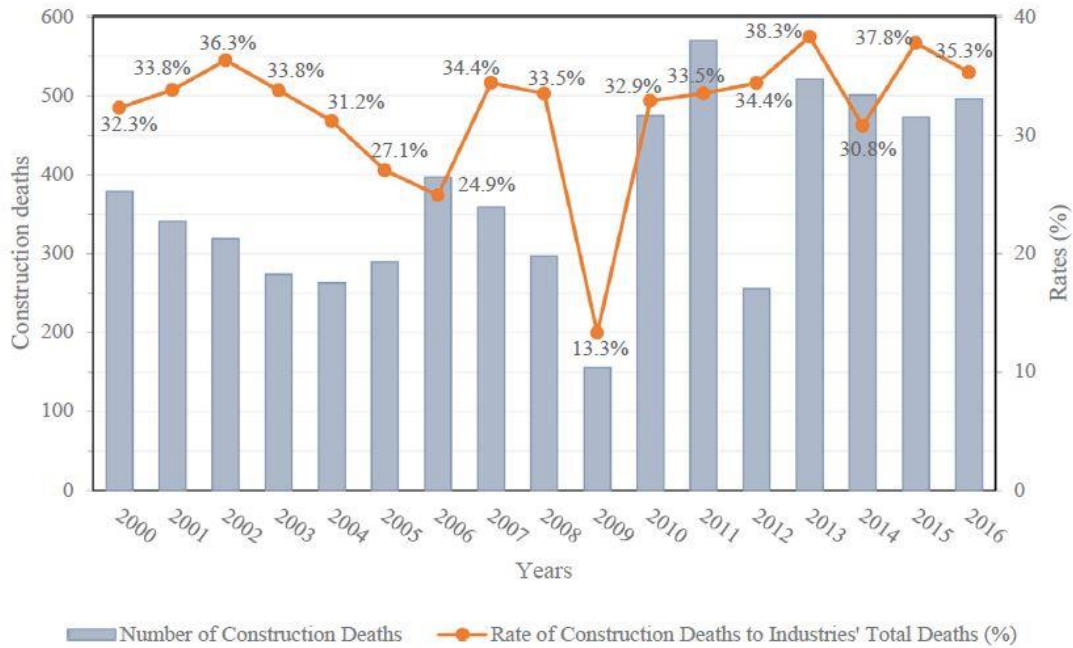


Figure 4. The number of deaths and the total number of deaths rate occurred in the construction sector [8].

In this study, risk assessment methods are compared with the occupational health and safety perspective. The risk is the inability to achieve a targeted result, loss or damage over a period of time. Risk assessments indicate the most important risk groups to take control measures. Risk management is the process of identifying, controlling, eliminating or minimizing uncertain events for proper risk assessment. Risk assessment process requires and contains necessary actions are taken without delay for undesired trends or results. The importance of the issue in the risk management of the occupational health and safety will be examined with content that provides practical solutions and explains how it can identify and meditate their risks. Risk assessment studies give an opportunity to identify potential hazards for the general system and indicate the significant and base problems of it. It also indicates the factors that affect the risk management system and gives proactive measures in order to deal with problems.

2. Literature Review

In the light of reviewing and observing studies that have been carried out regarding the occupational risk analysis in the construction sector. A number of specific studies were considered for comparison explained. Samantra et al. (2017) suggest an integrated risk assessment way for metropolitan construction projects. Fuzzy sets used to weigh the parameters (occurrence and impact). Nieto-Morote and Ruz-Vila (2010) present a fuzzy set theory integrated risk assessment methodology in the construction sector with using Analytical Hierarchy Process (AHP). AHP is used to build and weigh risks and fuzzy sets approach is used to deal with subjective perceptions. Zavadskas, E. K et.(2010) proposes a risk assessment model for risk identification in the construction industry. TOPSIS method was used to classify objects and seek the most optimum solution. Taylan et al. (2014) aim to assess construction projects and their risks under specific uncertain situations, to locate the risk under a suitable category and expect its severity in advance. In this study, Fuzzy AHP (FAHP) and Fuzzy TOPSIS were used to create favorable weights for a fuzzy linguistic variable of construction projects overall risk. A. Ahmed et al. (2014) made analysis tool for construction projects with using classical Failure Mode and Effects Analysis (FMEA) Method. The main aim was to create an improved FMEA approach. Aminbakhsh et al. (2013) present a robust method for prioritization of occupational risks in the construction projects to create more adequate targets without compromising safety. They used used AHP method to make a decision help system in order to classify risk factors. Shin et al. (2016) suggest the appropriate choice between two decision-making methods. AHP and FAHP methods used to analyze criteria, make pairwise comparisons and rank alternatives in nuclear power plant construction project. Amiri, M. P. (2010) proposes risk assessment model selection. TOPSIS method used to produce a standard rational procedure for developing the ideal model according to the selection criteria. Zavadskas et al. (2010) present the applicability of grey theory techniques for defining the utility of an alternative. Gul et al. (2018) create a new approach to a Fine Kinney-based risk assessment in comparison to other methods. FAHP- FVIKOR is used to rank hazards [9-20]. According to the previous studies, it can be observed that: FMEA, Fine Kinney, L Matrix, AHP are the most commonly used methodologies when it comes to risk assessments. Table.1 indicates literature review studies for construction risk assessment.

Table 1. Occupational safety risk assessment studies in the literature.

	Study	Applied Method	Application Area
1	S.Aminbakhsh et al.(2012)	AHP	Construction
2	A.Pinto (2013)	QRAM	Construction
3	A.Karasan et al.(2018)	FMEA,Fine-Kinney	Medical
4	A.Azimifard et al. (2018)	AHP-TOPSIS	Mining
5	W.Wang et al. (2018)	Fine-Kinney	Construction, Manufacturing
6	A. Kokangül et al. (2015)	AHP-Fine-Kinney	Manufacturing Company
7	G. Raviv et al. (2016)	AHP	Construction
8	R. Fattahi et al. (2017)	FMEA	Steel Industry
9	E.Ilbahar et al. (2017)	Fine-Kinney	Construction
10	M.Gul and M.F.Ak (2018)	Fuzzy Risk Assessment: L-Matrix	Mining
11	M.Yazdi (2017)	AHP-TOPSIS	Manufacturing
12	C.Dagsuyu et al. (2016)	FMEA-L Matrix	Medical
13	M. Mangeli et al. (2018)	FMEA	Copper Leaching Factory

3. Risk Assessment in the construction

In order to choose a comprehensive and consistent risk assessment study, there are several conditions exist. Objectives of the study, requirements of decision-makers, type and scope of risk under analysis, the possible significance of results, required expertise, person and other resource levels, availability of information and data, need to change or update risk assessment, other regulatory and contractual requirements are conditions to apply proper risk assessment.

In the following part of the paper, the methods mentioned before are defined and explained in order to provide a clear understanding of each one.

3.1 L-Matrix Method

Risk matrices are a method of combining qualitative or semi-quantitative outcome / probability ratings for determining risk level or risk rating. The format of the matrix and the definitions used are based on the context in which the matrix is used, and it is important to use a design that suits the conditions. The matrix method (L-type Matrix) is especially used to evaluate cause and effect relationships. It is used for determining the risks that require urgent and needs to be taken as soon as possible. Risk assessment matrices have more traditionally been used by Military Standard, System Safety Program Requirements. The risk score is calculated on the basis of probability and severity parameters. The work should not be started until the identified risk is reduced to an acceptable level and should be stopped immediately if there is an ongoing activity. In the L matrix method, the probability and severity parameters are evaluated on a scale of 1 to 5 and the risk score is calculated by multiplying them. The risk assessment format is shown in Table.2 [21-24].

Table 2. Risk Evaluation of L Matrix

RISK LEVEL	DESCRIPTION
TRIVIAL	No action and document records are required to be kept.
TOLERABLE	No control is required except routine and periodic control. Long-term research can be done for better alternatives. Monitoring is required to ensure that controls are maintained.
MODERATE	Efforts should be made to reduce risk. Risk mitigation measures should be assessed and implemented in the medium term.In assessments, control steps should be tightened to identify the need for measures for improvement.
SUBSTANTIAL	The work should not be started until the risk is reduced. Important resources and necessary individual, collective protection methods and equipment are needed to reduce risk.
INTOLERABLE	Work must not be started or stopped until the risk is reduced. The study should be continued when the risk is reduced to an acceptable level. Time to take action is instant, not to be expected.

Cause and effect relations are considered in evaluation step of the L-matrix. Furthermore, it is used for the risks that are urgent and that should be taken immediately. Simplicity of application and limited requirements are two main reasons to prefer L-matrix method. The success rate precautions could be subjective since the method allows to application of risks with limited experts. Using this method, the likelihood of an event occurring, and its consequence is graded and measured. The multiplication of likelihood, P and severity, S gives an estimated value of risk. In the L matrix method, 5x5 matrix is used [25,26].

3.2 FMEA

FMEA method is used in identifying and reducing existing failures or failures that could happen in the future, with the input of the three factors: severity (S), probability (P) and detectability (D) which are multiplied to calculate a risk priority. Since the classical risk assessment method consists of two parameters, FMEA gives the advantage to make a detailed analysis of risk with its three parameters. Risk priority number can be found with the multiplication of three parameters. The purpose of the FMEA method is to determine the system faults in the company and the effect of these faults. Furthermore, easiness of use and limited requirements are two main reasons to choose to apply FMEA method. Design FMEA, Process FMEA, System FMEA, Service FMEA are 4 different types of FMEA that are mostly used. FMEA method consider reliability, quality, maintainability at the same time for whole organization and whole system. The following relation is used in the calculation of the Risk Priority Number [27-28].

$$RPN = \text{Probability (P)} * \text{Severity (S)} * \text{Detectability(D)} \quad (1)$$

The numbering scale is 1 to 10 and 10 is the worst case of the risk. The risk priority number (RPN) is calculated regarding the multiplication of the three factors to clarify the decision. The problems of the FMEA are: each factor has the same value during the multiplication, however, it is not a realistic approach on the operational leg. On the other hand, the result of the RPN may have many possible combinations thereby it establishes an ignorance of each factor's importance. Moreover, personal viewpoints also decline the reliability of the FMEA method. In terms of preference, FMEA method is mostly coming from the health sector. Figure 5. Shows the flowchart of FMEA method [29-30].

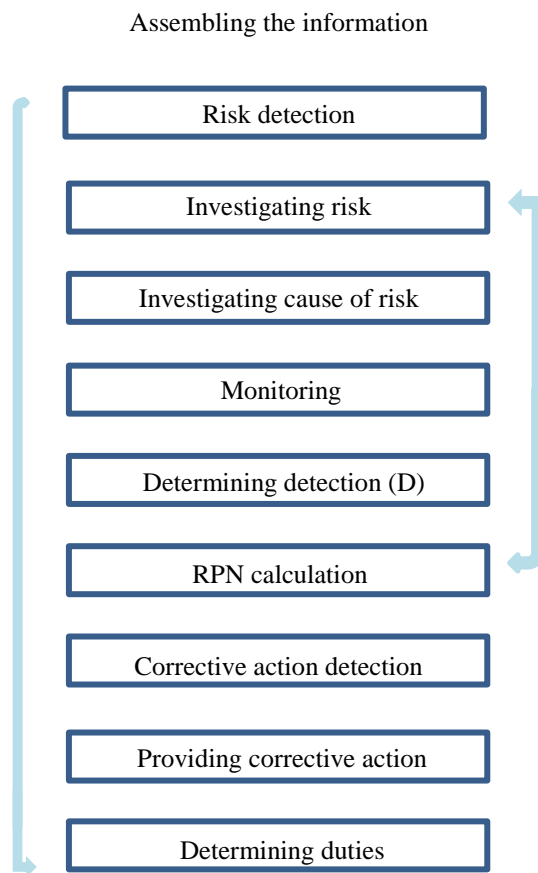


Figure 5. FMEA Method Flowchart [30]

3.3 Fine Kinney

The Fine Kinney method is one of the most commonly used methods in risk assessment. Probability (P), severity (S), and frequency (F) that would occur at the end of the event. Risk assessment depends on P, S and F. Combination of historical data and forecasts values can be obtained with the Fine Kinney risk analysis method. Moreover, the Kinney method also contains the risk exposure of people at risk. Since it contains frequency and past data, it is more reliable than the classical risk assessment methods, which are easy and common to use. Due to the reasons mentioned, the Fine Kinney method is preferred by many businesses. Table 3. indicates Fine Kinney risk assessment scale for Fine Kinney method [30-31]. The severity scale ranges from 0.1 to 10 while the probability and frequency scale ranges from 1 to 10. Risk priority number can be calculated as follows:

$$RPN = \text{Probability} * \text{Severity} * \text{Frequency}$$

Table 3. Description of risk classification

TOTAL RATING	RISK LEVEL	DESCRIPTION
0.1-20	NEGLIGIBLE	No action and document record are required to be kept.
21-70	LOW	No control is required except for routine and periodic control. Long-term research can be done for better alternatives. Monitoring is required to ensure that controls are maintained.
71-200	MEDIUM	Efforts should be made to reduce risk. Risk mitigation measures should be assessed and implemented in the medium term. In assessments, control steps should be tightened to identify the need for measures for improvement.
201-400	HIGH	The work should not be started until the risk is reduced. Important resources and necessary individual, collective protection methods and equipment are needed to reduce risk.
Over 400	EXTREME	Work must not be started or stopped until the risk is reduced. The study should be continued when the risk is reduced to an acceptable level. Time to take action is instant, not to be expected.

3.4 Analytic Hierarchy Process

Analytic Hierarchy Process was proposed by professor Thomas Saaty in 1980. It is used in the area of decision making for complicated cases by setting priorities and pairwise comparisons. AHP produces weights for the evaluations. The weights are higher for the more important evaluations. An application consists of ; i) evaluating criteria weights ii) calculating the matrix of scores, iii) rate the options.

The subjective views of the experts are not an obstacle for Analytic hierarchy process (AHP) due to the geometric mean of each individual judgment. Therefore, the inconsistency is declined by the monitoring method of AHP. Moreover, this method is also open to multi-variables via group decisions and pairwise comparisons. The lack of measurements for the risk analysis is not a problem for AHP since it values the facts with the scaling tool. Atomization of the structure, expert comparison and hierarchical order are the three fundamentals of AHP. After the determination of the main problem, the subproblems are determined and compared in pairwise to place in a hierarchy form with the given scale values. The diverse risk variables adapt to AHP method easily due to its subproblem features, however, not many risk assessments are preferred the AHP method due to its lack of financial perspective. In other words, this method forms a framework, which sets realistic and objective decisions on investments to occupational safety from experts. AHP model can be used in risk analysis with considering main objectives of occupational safety and health AHP exposes relevant priority vector when interpreting information preferred by decision makers based on a set of pairwise comparison values of objects. The AHP is based on the hierarchical structure and it is a kind of MCDM method. Goal, criteria and alternatives are 3 important elements of AHP. Goal shows the aim of the problem. Criteria is problem related elements that can be used for decision process. Saaty’s scale of 1–9 has been used for each hierarchical level and pairwise comparisons are made with judgments using numerical values. AHP has the ability to evaluate hierarchical structure as a whole of both quantitative and qualitative criteria. The pairwise comparisons are organized in a matrix and priorities are derived from the matrix as its principal eigenvector. Sample AHP structure can be seen in Figure 6. The consistency of decision makers can be checked in AHP with the help of consistency ratio (CR). 0.1 value is the maximum limit to ensure that judgment is adequately done. Steps of AHP are shown below: [33-35].

- Step 1: Definition of problem and identifying target of problem
- Step 2: Criteria, sub-criteria and alternatives are determined by creating hierarchical structure.
- Step 3: Pairwise comparison matrix is created with respect to experts
- Step 4: Computation of λ_{max} (average) of values from previous step.
- Step 5: Computation of consistency index, $CI = (\lambda_{max} - n)/(n - 1)$.
n : total number of items being compared.
- Step 6: Estimation of CR and CI and obtaining random index (RI)

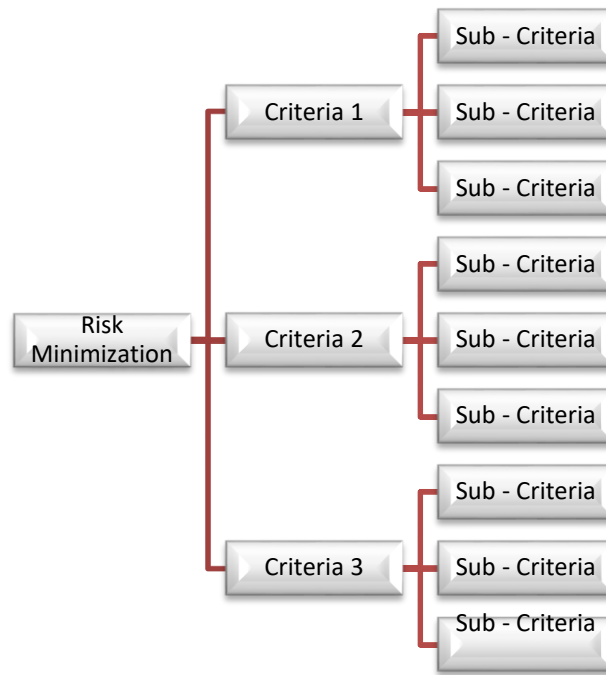


Figure 6. AHP Structure

3.5 Preliminary Hazard Analysis

Preliminary hazard analysis (PHA) is used as initial stage of risk assessment. It is used for identification of existing hazards, possible consequences of hazards and determination of control measures to be taken to eliminate or reduce corresponding risks. Precautionary measures for existing risks prevent major risks that may arise later. Expert opinion is crucial for hazard analyses and evaluation of them. Prioritization process helps to deal with with occupational safety and health issues. In order to be able to carry out preliminary hazard analysis, one or two experts who are confident in their knowledge will suffice [36-37]. There are 5 basic steps of preliminary hazard analysis. Firstly, all relevant documents, data, diagrams should be examined to define hazards. Evaluation of hazards includes errors and safety issues. Then the consequences of the identified hazard are determined. Exposure and effect correlations are used to measure the effects. For specific events which have critical effects, the event frequency is considered and estimated. Frequency and consequence parameters are used to propose control measures to decrease critical risk level into acceptable level.

4. Research Findings and Discussions

After risk assessment methods application has been determined to deal with and avoid occupational risks, it can be easily set up control measure planning according to obtained results. Occupational risk analysis comes up with the benefits of decreasing accidents and diseases. All risk assessment methods are separated from each other under certain criteria.

L and X matrix methods are applicable for almost every sector but when it comes to the construction sector they may not be preferable. It's easy to apply this technique because of the low level of document requirements and relatively small sets of risk parameters. It could be a useful guide for pre risk assessment process. It is not possible to carry out a risk assessment with fewer parameters and narrow scale in a for construction sector with the high possibility of occupational hazards and related risks. It is very difficult to avoid, understand and take control measures with these methods.

Comparisons of risk assessment methods under certain criteria are shown in Table 4. Comparisons of risk assessment methods have been compared in terms of low (+), medium (++) and high (+++) according to 5 basic criteria which are teamwork, required documents, required time, scope and required expertise.

Table 4. Comparison of Risk Assessment Methods for Construction

Criteria List	AHP	Fine Kinney	FMEA	PHA	L Matrix
Teamwork	+++	+++	+++	+++	+
Required Documents	++	+++	+++	+	+
Required Time	+++	+++	+++	++	+
Scope	++	+++	+++	++	++
Required Expertise	+++	++	++	++	+

+++ : High ++: Medium +:Low

Fine Kinney method consists of commonly used mathematical technique and easy to apply. The probability, frequency and severity parameters give more quantitative results. However, Fine Kinney technique is not recommended for cumulative risk groups. Risk cannot be identified if the factors are not identified correctly. In case of being exposed to the same risk by multiple employees, a mistake can occur in scoring. The Fine Kinney method has not been proposed as a unique methodology for risk assessment in the construction that's why fuzzy logic and multi criteria decision making methods integration can be done for more comprehensive studies. Fine Kinney method can be referred to a complementary method.

Consideration of detectability as one more parameter of risk assessment process makes FMEA different from classical risk analysis methods, in addition to the probability and severity factors. It is used as a reliable evaluation technique for determining the effects of system and equipment faults. FMEA is so common risk assessment method in the space industry, chemical industry, and the automotive industry. It can easily have implemented by a risk assessment team with moderate experience. It is an easy technique to use. FMEA can applied for different systems, processes, design, and services in different ways. FMEA can be a proper risk assessment method for construction but a long time is required to apply this technique, so it is a time-consuming technique. Today, construction structures are large-scale. This includes physical, chemical and ergonomic risks together. In such a structure, the FMEA method alone is not sufficient. If a team does not focus on details properly, some occupational hazards would be lost.

AHP implementation includes a hierarchical process by its structure. It is so straightforward and favorable, simple to apply by pairwise comparisons, all-purpose usage, it is beneficial to see relationship between sub-processes, Since it decomposes a problem into parts and builds a hierarchy, it helps to determine importance of each element, moreover, AHP is very convenient to changes and additions to the hierarchy due to its flexibility and stability, one of the main advantages of AHP is that decision-maker can evaluate each risk and source of hazard separately. It provides not only subjective but also objective information, it gives the opportunity to consider consistency in evaluation, it is applicable for any system or company. AHP method requires a high level of expertise and long-time for construction sector because a total number of pairwise comparisons can be too much and the capacity of decision makers can be limited to solve problems.

PHA is one of the simplest approaches applied in risk assessment methods. It can be used with other techniques such as; checklists and decision matrix. It can be used to determine the best options for equipment or installation. In this method, all-hazards cannot be considered and evaluated. Generally, it is not enough alone for risk analysis. It requires additional techniques. Quality of team knowledge affects the result and this may subjectivize the risk assessment study. The PHA method is one of the qualitative methods but not enough for comprehensive risk assessment. Since construction sector requires detailed and comprehensive risk assessment studies. The application of PHA is difficult and inefficient to apply to complex systems. It has not been proposed as a common risk analysis methodology to be applied to indirect and directly related parts of a construction organization. It can be used as a complementary technique.

It is very difficult to find a study that specifically integrates classical methods, fuzzy sets and multi criteria decision making methods when considering occupational safety risk assessment. In the literature there is a specific study which combined the Fine-Kinney method, and fuzzy inference systems in occupational safety and health risk assessment is that of Ilbahar et al. (2018) [26]. The current study is different from previous studies on several points: (1) Where this study deals with the comparison of the risk assessment methods in the construction sector in accordance with the specified criteria. (2) It is shown that the integration of multi criteria decision making methods into classical methods will increase consistency and scope, although it requires expertise. (3) While this study presents comparison of risk assessment methods and depends on a real case of construction sector, previous studies had focused only application of occupational safety and health risk assessment. The uncertainty level can be reduced to the lowest level by adding multi criteria decision making methods to the comparison methods, prioritizing and weighting risks.

5. Results

Occupational health and safety is the whole of studies and analyzes aimed at minimizing the problems that may occur in all processes related to work and workers. In terms of occupational health and safety, the construction sector requires detailed examination and research in terms of structural difficulties, sensitivity, and rapidly changing equipment and technologies. Workers are one of the most important and constant parts of construction works. Employees' working in an unsafe and dangerous environment and the inadequacy of the precautions required different risk assessments. The fact that construction works are included in the most dangerous group in terms of occupational accidents and occupational diseases in the OHS hazard classification list necessitates a comprehensive and effective risk assessment in the construction sector. Statistical data also show that fatal occupational accidents occur in this sector and are among the most important sectors. Risk assessment is one of the most important elements in this system. It is an essential part of a proactive system. This study aims to make a comparison of occupational safety risk assessment methods for construction sector. The methods that consider occupational safety impact from other viewpoints such as because of the major accidents or applicability, expertise requirement, teamwork, duration, scope, documentation requirement were also discussed. It is the first study that particularly reviewed and compared common occupational safety risk assessment methods for construction sector in detail. Observations and findings show that research in inherent occupational safety assessment is still very much lacking of occupational safety and health concepts and future works should at least adhere to these concepts. Especially nowadays, it has been observed that risk assessment studies are carried out with simple methodologies on paper and the scope is quite limited. The point to be expressed in this study is the integration of these methods, which can be dealt with as a basis, and their integration with more comprehensive and specialized structures. Construction sector is one of the most hazardous sectors. Considering these reasons, risk assessment studies should be established in a more comprehensive, feasible, objective structure that requires teamwork. This study is done in order to increase awareness to set an example of possible occupational accidents and diseases in the construction sector. This study also compared the advantages and disadvantages of the methods that can be used with the studies in the literature and indicated the necessity to update and elaborate the risk assessments with the results obtained.

As conclusion, the study reveals that each method has its unique characteristics. However, it can be so clear some reviewed methods such as L matrix and PHA can not be enough for comprehensive risk assessment in the construction sector. It is not the purpose of the paper to criticize any of the existing and traditional methods. Rather the main goal is to provide a comprehensive comparison of methods with their specifications and applicability for occupational safety risk assessment of construction sector and design to select the appropriate method that is convenient for their needs. The study also indicates the significance of integrated methods dedicated to different construction stages to increase reliability, flexibility and accuracy of the occupational safety risk assessment process. Occupational safety risk assessment is mandatory for the implementation of risk control in the workplace, professional activities and protection of worker health. The employer can carry out this work in-house or by taking external services. The aim of this study is to compare the risk assessment methods used in the analysis of hazards and risks that may arise in terms of occupational health and safety and to evaluate their effectiveness in determining the measures to be taken as a result. In the study, it has been emphasized that the construction sector risk assessment studies should be carried out more comprehensively and consistently because they are in a very dangerous group. For this reason, the necessity of integrating multi criteria decision making methods into classical risk assessment methods has been demonstrated. Objective and comprehensive risk assessment studies based on expert opinions will contribute to the proactive approach to prevent accidents in the construction industry.

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