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Disaster risk assessment pattern in higher education centers

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ABSTRACT: Disasters are one of the most important challenges which must be considered by every management system. Higher education centers have high disaster risk because of their risk factors (existence of historical and scientific documents and resources and expensive laboratory equipment in these centers emphasizes the importance of disaster management). Moreover, the existence of young volunteers of human resources in universities urges the necessity of making these people familiar with disaster management rules and responses in emergency conditions. Creating appropriate tools for disaster management assessment makes it correct and precise in higher education systems using the presented conceptual model. The present model was planned so as to cover three phases which exist before, during, and after disaster. Studies were performed in one of the largest higher education centers in Tehran: Science and Research Branch of Islamic Azad University Campus. Results showed high-risk disasters in these centers which must be taken into consideration continuously. The objective of this study was to create appropriate patterns of disaster risk management in these centers.

Keywords: *Disaster risk assessment, Educational center, AHP, FMEA*

INTRODUCTION

Disasters have gloomily affected human life since our existence. In response to this issue, an individual or a society can have many approaches to decrease and reverse their harmful effects (Abdul Waheed, 2013). Disasters are often considered as unexpected events that have potentially negative consequences for organizations (Cloudman and Hallahan, 2006). In social contexts, however, disasters can be more precisely known as the state of uncertainty, resulting from a triggering event that disrupts an organization's routine activity (Ho and Hallahan, 2004). Disasters are defined by the United Nations International Strategy for Disaster Risk Reduction (UN-ISDR, 2004) as "a serious disruption of the functioning of a community or a society causing widespread human, material, economic, or environmental losses which exceed the ability of the affected community or society to cope using its own resources" (Van Westen, 2013). Disaster management consists of three parts (Jaques, 2007) activities, which must be: i) accomplished in preparation before the disaster, ii) performed during the disaster, and iii) carried out after the disaster during the rebuilding process. (Nouri *et al*., 2011; O'Connor and FSFPE, 2005). In the past, the emphasis was more on the "disaster response" phase and the disaster team only began operations after the disaster occurrence. There were two problems however: first, the disaster was supposed to occur and then the team was activated. This matter imposed more cost on the organization. Second, recognizing and mitigating disasters were not possible. Therefore, nowadays, safety system is known as a process before disaster occurrence. Governmental and non-governmental organizations, educational institutions, universities, and meteorological centers are involving for protecting the outbreak of disaster. Out of which, universities are

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one of the most important aggregation centers (Nouri *et al*., 2011; O'Connor and FSFPE, 2005). Higher education institutions are nowadays performing more than just their fundamental role of providing higher education to our society (Hirunsalee *et al*., 2013). Individuals including people of all ages and if people would have having the knowledge of disaster mitigation; then, only they can mitigate disasters by the existing background, scientific documents and resources, along with valuable equipment and urge for the necessity of creating a predefined program for all three levels of disaster management in higher education centers. One of the most significant indices which must be taken into consideration in the disaster management systems is preparation indices for foresighted disasters and relative preparation for un-foresighted disasters. Preparedness is an important element of anticipating a disaster that involves mentally rehearsing scenarios and equipping the organization with systems and procedures so that responses are appropriate, sufficient, and timely (Cloudman and Kirk, 2006 and Comfort *et al*., 1999). To reduce disaster losses, more efforts should be applied to disaster risk management with a focus on hazard assessment, mapping elements at risk, and vulnerability and risk assessment (Van Westen, 2013). Disaster risk is defined as the potential for negative impacts from disasters including loss of life, injuries and damage to assets, functions, and services (Johnson *et al*., 2014).

Although risk is inevitable, the loss of accident can be mitigated through an effective risk management program (Omidvari *et al*., 2015). Disaster risk management issues have received more and more attention in recent years and using disaster risk management pattern in universities has become an increasingly important issue. University of Florida has established a disaster management program, in which three levels of disaster management (preparations before, during, and after the disaster) have been planned (UF, 2005). The program has been started by identifying disaster and disaster-creating factor, establishing disaster teams, and analyzing situation of buildings in the university. Programming response conditions to emergency and disaster situations has been also forecasted in this program. One of the segments of this program is the role of other organizations in controlling disaster of universities (UF, 2005). Programming for the evacuation of disaster regions is one of the most significant issues which must be considered in all disaster management plans. Hirunsalee *et al*., (2013) pointed out the public attitude toward the additional roles of universities in disaster management in order to ensure the benefits that the university could have in return from the society; it was a case study of Tammasat University in the disaster of Thailand flood in 2011 (Hirunsalee *et al*., 2013). Moreover, different factors are involved in the evacuation of an environment during a disaster (such as building lay out, population density, exit doors, etc.). Detailed information of different factors was presented in an article by Liu *et al*., (2009). Factors like class position, exit doors, door numbers, and people density around the exit doors could interfere in a classroom evacuation in disaster circumstances (Liu *et al*., 2009). The same concept was also discussed by Thompson and Bank, (2010). The stochastic model for fire risk assessment using fault tree based on evacuation time was presented by Chu *et al*., (2007), who found that pre-evacuation time is the most significant and vital factor that influences fire risk assessment in a building. They also pointed out that factors like the cognizance and fire warning systems can be effective in fire reduction (Chu *et al*., 2007; Chu and Sun, 2008). At evacuation time, not only the person's identity, but also building plan is effective for both individual's identity and building plan is important (Kobes *et al*., 2010). Evacuation process is characterized by three certain basic activities (Pires, 2005; O'Connor, 2005) like awareness of danger by external stimuli (cue validation), validation of response to danger indicators (decision making), and moving to/refuge in a safe place (movement/refuge). At the time of evacuation, human behavior science is drastic in determining individuals' behaviors at disaster time. Using human behavior science, individuals' behaviors during disaster could be identified and modified (Kuligowski and Mileti, 2009). The most important reasons for implementing disaster management in a building are (Marwitz *et al*., 2007) saving lives and reducing chances of further injuries/deaths, protecting the environment, protecting assets, restoring critical business processes and systems, reducing length of the business interruption, minimizing reputation damage, and maintaining customer relations.

In the study written by Abdul Waheed, (2013) about fire-related disaster management in high density urban areas, the first step to making any disaster plan was to identify and mitigate the condition that might have caused the disaster. It recommended the co-ordination between various infrastructure facilities and rescue agencies as well as government institution (Abdul Waheed, 2013).

On the other hand, precise assessment can be achieved by MCDM (multi criteria decision making) methods (Rafee *et al*., 2008; Lee *et al*., 2008). Hu *et al.*, (2009) used failure mode and effects analysis (FMEA) and fuzzy analytical hierarchy process (FAHP) for the risk evaluation of green components to hazardous substance. They used three indices of FMEA in this study, which included occurrence (O), likelihood of being detected (D), and severity (S). Also, FAHP was applied to determine the relative weighting of different factors. Then, a green component risk priority number (RPN) was calculated for each of the components (Hue *et al.*, 2009). Effective factors in disaster risk assessment can be determined and ranked by AHP (analytic hierarchy process) method using the obtained factors (Nouri *et al*., 2010). AHP method of deciding on disaster risk level is used in disaster risk assessment. AHP method can also be used for determining the effective weights for risk factor (Omidvari and Mansouri, 2014).

The aim of this study was to present a disaster management model for optimum system operations against probable disasters in one of the biggest higher education centers in Tehran: Science and Research Branch of Islamic Azad University Campus. The proposed disaster management model of this study could be able to minimize the effects of personal judgment on disaster risk assessment process.

MATERIALS AND METHODS

The presented model was evaluated in one of the largest higher education centers of Tehran Islamic Azad University, Campus of Science and Research Branch. Science and Research Branch of Islamic Azad University Campus was located on the hillside of Tochal Mountains, a steep slope ground in the west of Tehran. This steepness reached thirty degrees in some parts of the university campus (steep slope can represent landslide). Regarding the campus construction on this slope, it can be concluded that landslide risk in this segment was almost increasing.

This campus had different faculties including technical engineering, management, and social sciences and consisted of nine buildings, four of which had laboratory centers and facilities.

The access of this campus to roads or highways at the time of disaster was not satisfactory, which made the availability of external relief for the campus so difficult. Furthermore, clinical and firefighting facilities have not been considered in the campus. This problem could cause the campus to face disasters at its lowest level of preparedness. The high number of students and existence of several hazardous resources revealed the importance of disaster management. Regional study of the campus location stated that it was located on Tehran’s north-western inactive fault line. Since Rey fault line in the south of Tehran city is near the north fault line and is semi-active, it is likely that the mentioned fault line also becomes active. The maps demonstrate that this campus was not located near the flood route and seasonal streams. Thus, it can be concluded that flood risk was not a threat for the campus.

The research implementation algorithm is represented in Fig. 1. As can be inferred from Fig. 1, the research was done in three steps. In the first two steps, the objective was to achieve a suitable pattern for disaster management assessment in a higher education center. In step 3, a tool for verification was defined using the previous findings. A response framework in emergency conditions in a higher education center for this study was represented based on the previous findings. Each process is described in details in Fig. 1.

Step 1: Determining safety issue of identification pattern

Risk resources in a high education center are defined by job safety analysis (JSA) method in this process. JSA can be used to educate employees on safe practices prior to utilizing the equipment. Then, using these findings, a checklist is prepared for verification. All the dangerous and existing sources in a high education center can be divided into two groups: “natural” and “human-created” sources. The main risks are earthquake, flood, and landslide as natural disasters and fire, explosion, and seepage of chemical materials as human-created crises.

Step 2: Determining risk assessment framework

Analytic hierarchy process (AHP)

AHP method introduced by Saaty, (1980) shows the process of determining the priority of a set of

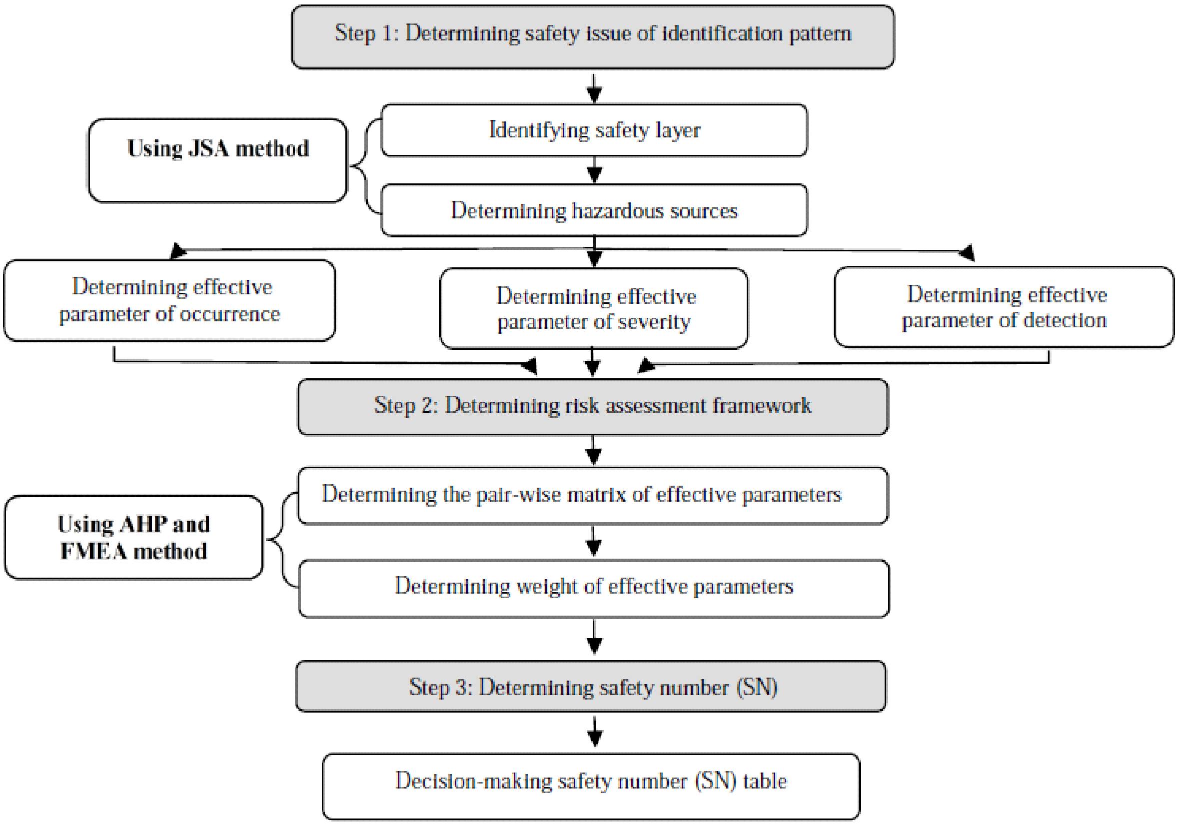

Fig. 1: Research implementation algorithm

alternatives and the relative importance of attributes in a multi-criteria decision-making (MCDM) problem (Saaty, 1980). AHP is a mathematical theory that systematically deals with all kinds of dependence and has been successfully applied in many fields (such as decision-making management, priority, etc.) (Saaty, 1996). AHP has a systematic approach to set priorities and trade-offs among goals and criteria and also can measure all tangible and intangible criteria in a model. The primary advantage of this approach is to perform qualitative and quantitative data (HU *et al*., 2009). Many decision problems cannot be structured hierarchically, because they involve the interaction and dependence of higher-level elements in a hierarchy of lower-level elements. The importance of the criteria is determined by the importance of not only the criteria which determine the importance of the alternatives as in a hierarchy, but also the alternatives themselves.

In this process step, using the views of sophisticated experienced experts, influencing factors for risks are specified and then the weight of each factor is determined by AHP (Saaty, 1980). For this purpose, the factors are compared in pairs with the help of a judgment matrix to determine how important one element is as compared to the other element. This comparison is made on a 9 point scale where 1= equally important, and 9= extremely important. As the comparison are done subjectively, the consistence ratio is arrived at and the same being less than 0.1 will be more consistent with human judgment decisions. Cumulative judgment weights are computed and the final weight represents the weight of each factor (Mani *et al*., 2014). For better understanding the conditions of indices and their grouping method, a schematic plan of the hierarchical structure is shown in Fig. 2.

Failure mode and effects analysis (FMEA)

FMEA is one of the first systematic techniques for failure analysis which has been developed by reliability engineers in 1950s to study problems that might arise from the malfunctions of military systems. An FMEA is often the first step of a system reliability study and involves reviewing as many components, assemblies, and subsystems as possible to identify failure modes and their causes and effects. The first step in FMEA is to identify all the possible potential failure modes of products or systems by the sessions of systematic brainstorming. Afterward, critical analysis is performed on these failure modes while taking into account risk priority number (RPN) using three risk factors of occurrence, severity, and detection (Liu *et al.*, 2013). This conceptual model is shown in Fig. 2. As stated, disaster risk with severity (S), probability (P), and detection (D) parameters is assessed based on FMEA by Eq. (1).

$$\text{RPN} = S \times O \times D \qquad (1)$$

In this study, a conceptual fire risk assessment model is determined by FMEA method (ISO, 2009). This conceptual model is shown in Figs. 3, 4, and 5. Five experts with enough knowledge in AHP, FMEA, and safety science along with educational training abilities are assigned to determine the weight of each parameter between 1 to 9 (Saaty, 1980). A standard form of a pair-wise matrix is shown in Eq. (2) and the inconsistency index is defined as in Eq. (3), (Saaty, 1980).

$$E1 = \begin{bmatrix} 1 & a_{ij} & . & . & . & a_n \\ \frac{1}{a_{ij}} & 1 & . & . & . & . \\ . & . & 1 & . & . & . \\ . & . & . & 1 & . & . \\ . & . & . & . & 1 & . \\ \frac{1}{a_n} & . & . & . & . & 1 \end{bmatrix} \rightarrow w_s = \begin{matrix} w_1 \\ . \\ . \\ . \\ w_n \end{matrix} \qquad (2)$$

$$I.I. = \frac{\lambda_{\max} - n}{n-1} \rightarrow I.IR = \frac{II}{IR} \prec 0.1 \qquad (3)$$

Determining effective parameter of severity

Effective parameters of severity of an unsafe situation in a higher education center are shown in Fig. 3. Weights of effective parameters are determined by AHP method. Severity of consequences is calculated based on the conceptual model by Eq. (4). Severity number (S) is calculated by Eq. (5).

$$w_{i(s)} = \begin{bmatrix} 0.131 \\ 0.040 \\ 0.289 \\ 0.102 \\ 0.200 \\ 0.238 \end{bmatrix} \rightarrow \begin{matrix} w_{1(s)} = 0.131 \\ w_{2(s)} = 0.040 \\ w_{3(s)} = 0.289 \\ w_{4(s)} = 0.102 \\ w_{5(s)} = 0.200 \\ w_{6(s)} = 0.238 \end{matrix} \qquad (4)$$

$$I.I.R = 0.0167 \langle 0.1$$

$$S = 10 \sum_{i=1}^{n} W_{i(s)} \qquad (5)$$

$W_{i(s)}$: Weight of severity factor (see Fig. 3)

Determining effective parameter of occurrence

Effective parameter of the occurrence of disaster risk in a higher education center is shown in Fig. 4. Weights of effective parameters are determined by AHP method.

The occurrence is calculated based on the conceptual model by Eq. (6). Occurrence number (O) is calculated by Eq. (7).

$$w_{i(O)} = \begin{bmatrix} 0.061 \\ 0.216 \\ 0.115 \\ 0.147 \\ 0.210 \\ 0.122 \\ 0.066 \\ 0.063 \end{bmatrix} \rightarrow \begin{matrix} w_{1(O)} = 0.061 \\ w_{2(O)} = 0.216 \\ w_{3(O)} = 0.115 \\ w_{4(O)} = 0.147 \\ w_{5(O)} = 0.210 \\ w_{6(O)} = 0.122 \\ w_{7(O)} = 0.066 \\ w_{8(O)} = 0.063 \end{matrix} \qquad (6)$$

$$I.I.R = 0.0028 \langle 0.1$$

$$O = 10 \sum_{i=1}^{n} W_{i(O)} \qquad (7)$$

$W_{i(O)}$: Weight of occurrence factor (see Fig. 4)

Determining effective parameter of detection

Effective parameters of detecting disaster risk in a higher education center are shown in Fig. 5. Weights of effective parameters are determined by AHP method. Detection parameters are calculated based on the conceptual model by Eq. (8). Detection number (D) is calculated by Eq. (9).

$$w_{i(D)} = \begin{bmatrix} 0.284 \\ 0.220 \\ 0.165 \\ 0.087 \\ 0.091 \\ 0.153 \end{bmatrix} \rightarrow \begin{matrix} w_{1(D)} = 0.284 \\ w_{2(D)} = 0.220 \\ w_{3(D)} = 0.165 \\ w_{4(D)} = 0.087 \\ w_{5(D)} = 0.091 \\ w_{6(D)} = 0.153 \end{matrix} \tag{8}$$

$$I.I.R = 0.0028 \langle 0.1$$

$$D = 10\sum_{i=1}^{n} W_{i(D)} \tag{9}$$

$W_{i(D)}$: Weight of detection factor (Fig. 5)

Step 3: Determining safety number (SN)

Safety number (SN) is determined using incident severity (S), incident probability (P), and Detection (D) parameters. Further, by involving the weights obtained from step 2, SN is assessed based on FMEA (Eq. (10)).

$$SN = S^{Ws} \times O^{Wo} \times D^{WD} \tag{10}$$

The weight of each parameter is calculated by AHP method and each parameter is assessed based on conceptual model by Eq. (5).

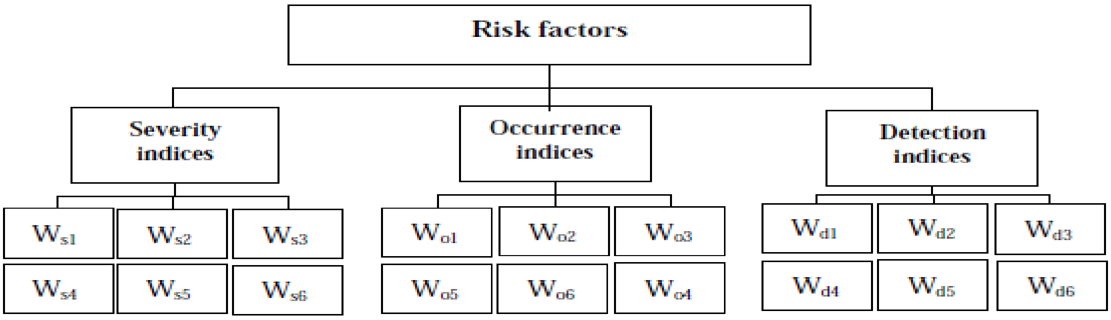

Fig. 2: Hierarchical structure for disaster risk assessment

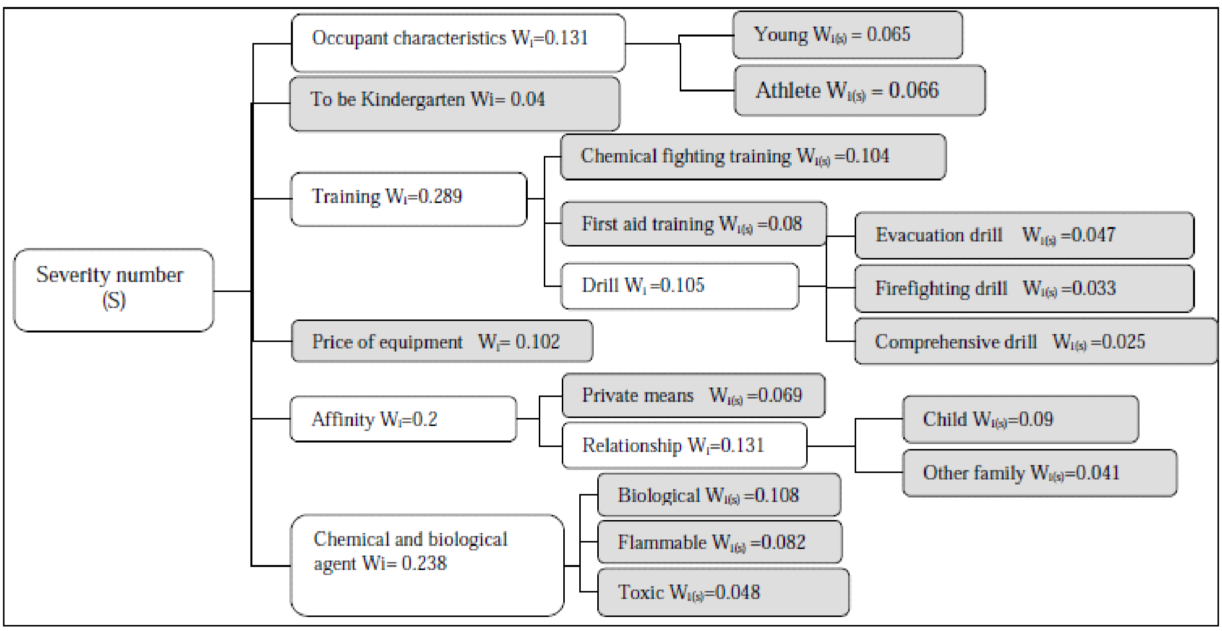

Fig. 3: Conceptual model of disaster risk severity assessment

$$SN = \begin{bmatrix} 0.56 \\ 0.15 \\ 0.29 \end{bmatrix} \rightarrow \begin{matrix} W_S = 0.56 \\ W_O = 0.15 \\ W_D = 0.29 \end{matrix} \qquad (11)$$

$$I.I.R = 0.0167 \langle 0.1$$

The final pattern of safety number is calculated by Eq. (12).

$$SN = S^{0.56} \times O^{0.15} \times D^{0.29} \qquad (12)$$

The basis of the first part of disaster management is preparedness and control of the disaster creation factors. So, decision making model for disasters and developing a sustainable risk scale are included in this part. Decisions for disaster risk are made on the basis of Table 1.

The lower the risk scale, the higher its preparedness would be. Controlling the factors and determining the effects on risk have great importance in “before the disaster phase”. The basis of “during the disaster phase” is time and speed. Arrival of relief forces at the disaster location, its control, and preventing the disaster from extension are the main factors in this phase. In the third phase, attempts are made to return the system activity to its preliminary situation by identifying the internal and external resources of organizations. In future studies, based on the results of this research, an executive program can be defined to increase the rate of preparedness, decrease disaster effects, and identify resources by applying the results of the previous phase.

All of the marked parts in Figs. 3, 4, and 5 and their models can be represented as disaster verification indices in the higher education centers. For example, modified exit doors and corridors reduce the amount of stored material, defined master points in campus, control of ignition source, supply and installation of firefighting equipment, installation of detection and alarming system, and so on.

RESULTS AND DISCUSSION

All mentioned parameters in the conceptual models of figure 3, 4 and 5 were assessed and inserted in the check list resulted of these models. According to the whether the considered parameter was adjustable or not, a proper weight was assigned to it and the risk parameters weight was calculated. Results of the campus buildings verification are represented in Table 2.

The data resulted from nine mentioned buildings was demonstrated in Table 3. As the tables represent data of each particular building, the highest severity and probability is related to the laboratory complex due to the presence of the hazardous materials, store

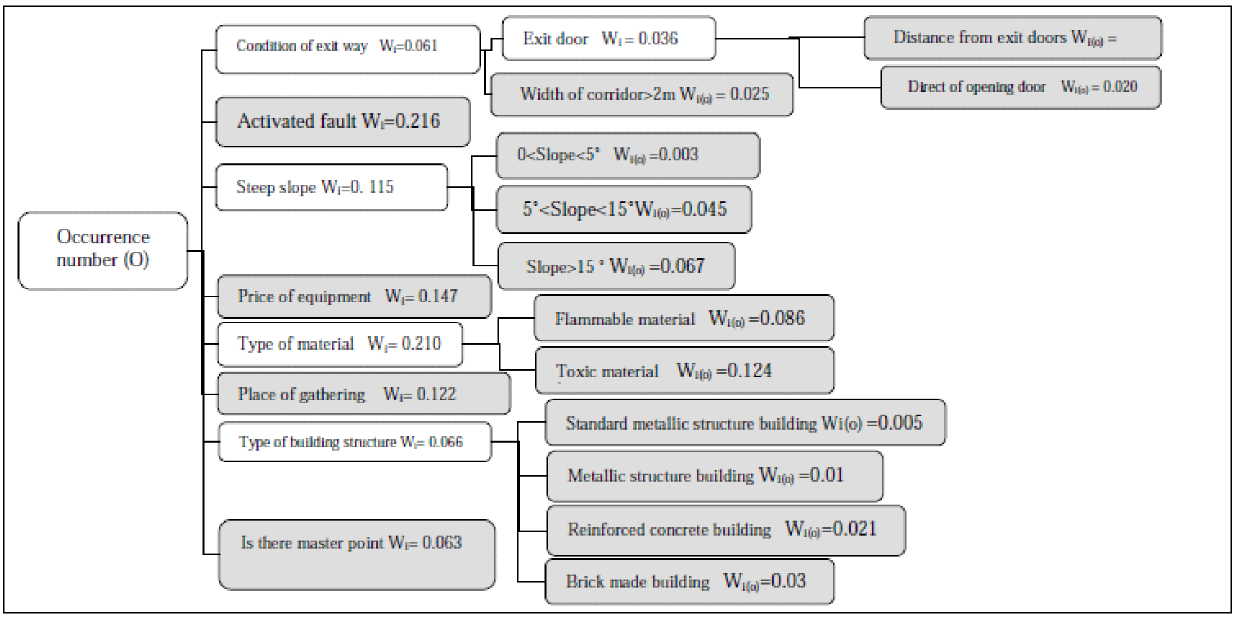

Fig. 4: Conceptual model of disaster risk occurrence assessment

Table 1: Decision-making table of safety number (SN)

Rank	Description of the probability of danger accordance	Degree
<2	Urgent measures are required and corrective measures should be taken quickly.	High
2-1	Corrections should be carried out (un-acceptable risk or tolerable risk).	Moderate
>1	Monitoring and controlling are required (acceptable risk).	Low

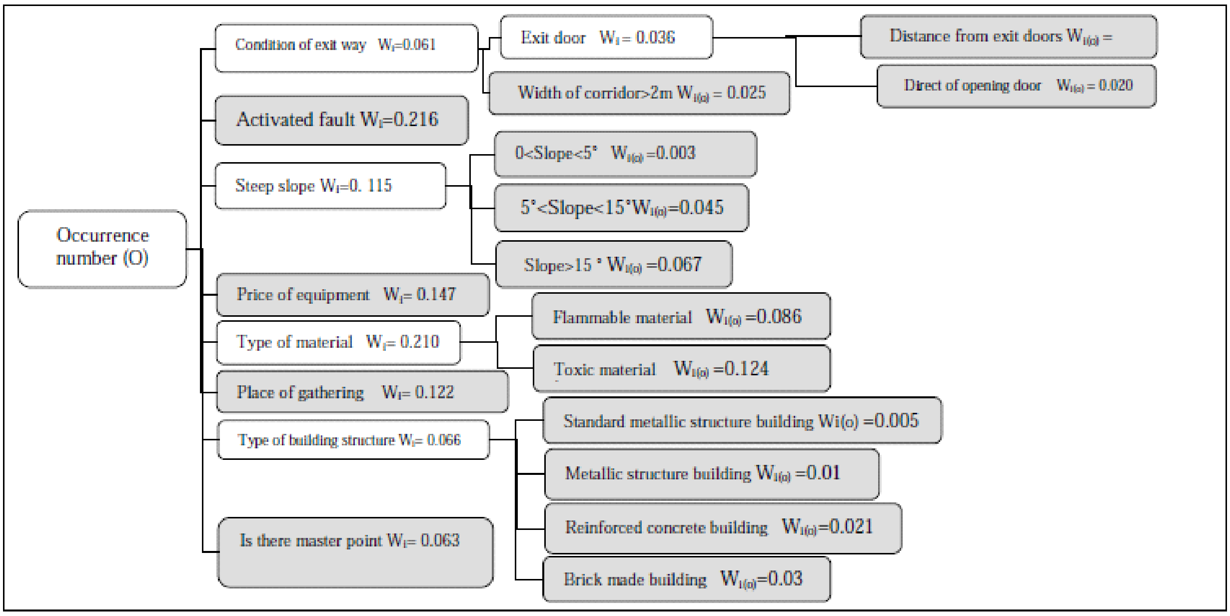

Fig. 5: Conceptual model of disaster risk detection assessment

beans and expensive equipment. The highest detection is related to the laboratory 1 building due to the lowest presence of hazard control systems.

Regarding the verification that was separately done in each building of this campus, risk scale is shown in Fig. 6.

As obvious in Fig. 5, the laboratory had maximum disaster risk, the main reasons of which could be different disaster-causing resources such as fire, keeping toxic chemical materials in vast scales, and inappropriate maintenance of dangerous chemical materials that increase disaster risk of the building. Totally, no building had a low degree of disaster risk and the main reasons could be steep slope, the campus location on the fault line, lack of disaster management facilities in the campus, and lack of nearby relief sources.

The results showed that disaster management in the universities is an important issue which must be precisely considered. The existence of risky resources and their incorrect control along with also the existence of valuable equipment and scientific and social human resources urges us to have an adequate preparedness rate. The methodology in the present study was the same as Nouri *et al.*'s (2011) study which was about the conceptual model using AHP and FMEA for vulnerability assessment. According to Nouri's study (2011), the weight of vulnerability parameters (S, P, and C) were constant (S=building layout and structure, P= characteristic and knowledge of occupants, and C=disaster detection and controlling equipment); but, in this study, weights of FMEA parameters (S, O, and D) are considered as the variables and calculated by AHP (Nouri *et al.*, 2011). In a program about disaster management by Florida University, three levels of disaster management (before, during, and after disaster actions) were considered. One parts of this program

Table 2: Investigating characteristics of the educational center for safety assessment

Questions \ Building name	Laboratory 1	Laboratory complex	Physics plasma	Old Physics building	Metal logical laboratory	Faculty of Management	Faculty of Engineering	Faculty of Humanity	Faculty of Basic Sciences
Type of application	Laboratory	Laboratory	Laboratory and training	Laboratory and training	Laboratory	Training	Training	Training	Training
Are 50% of occupants older than 30?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Are 50% of the occupants athletes?	N	N	N	N	N	N	N	N	N
Is there any training program?	N	N	N	N	N	N	N	N	N
Are there any drill programs?	N	N	N	N	N	N	N	N	N
Do occupants have relationship and private means in the campus?	N	N	N	N	N	N	N	N	N
Are there any materials in the building (F.M./E.M./ T.M.)?	F.M	F.M./E.M./ T.M.	T M	T.M.	F.M.	N	N	N	F.M.
Are exit ways suitable?	N	Y	N	N	N	N	Y	Y	N
Are there any activated faults?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Is the educational center in a steep slope?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Are the equipment expensive?	N	Y	N	Y	N	N	N	N	N
Is the building structure standard?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Is any master point marked in the site?	N	N	N	N	N	N	N	N	N
Is there any firefighting equipment?	M.E.	F.B./M.E	M.E.	M.E.	M.E.	M.E.	M.E.	M.E.	M.E.
Are there any detection devices?	N	N	N	N	N	N	N	N	N
Are there any alarming systems?	N	N	N	N	N	N	N	N	N
Is there any connection equipment?	N	N	N	N	N	N	N	N	N
Are there any exit signs?	N	N	N	N	N	N	N	N	N
Electrical safety	Y	N	Y	N	Y	Y	Y	Y	Y
Is the exterior facility suitable?	N	N	N	N	N	N	N	N	N

F.M.: Flammable material/ E.M.: Explosive material/ T.M.: Toxic material
F.B.: Fire box; M.E.: Manual extinguisher; A.E.: Automatic extinguisher

Table 3: The rate of severity, probability and detection in the studied buildings

No.	Building name	S	O	D
1	Laboratory 1	1.3	1.8	2.8
2	Laboratory complex	2.5	1.9	2.2
3	Physics plasma	1.9	0.8	1.4
4	Old Physics building	0.9	0.9	2.5
5	Metal logical laboratory	0.8	0.9	2.3
6	Faculty of Management	0.7	1.3	2.5
7	Faculty of Engineering	0.7	1.7	2.5
8	Faculty of Humanities	0.7	1.2	2.5
9	Faculty of Basic Sciences	0.9	2	2.8

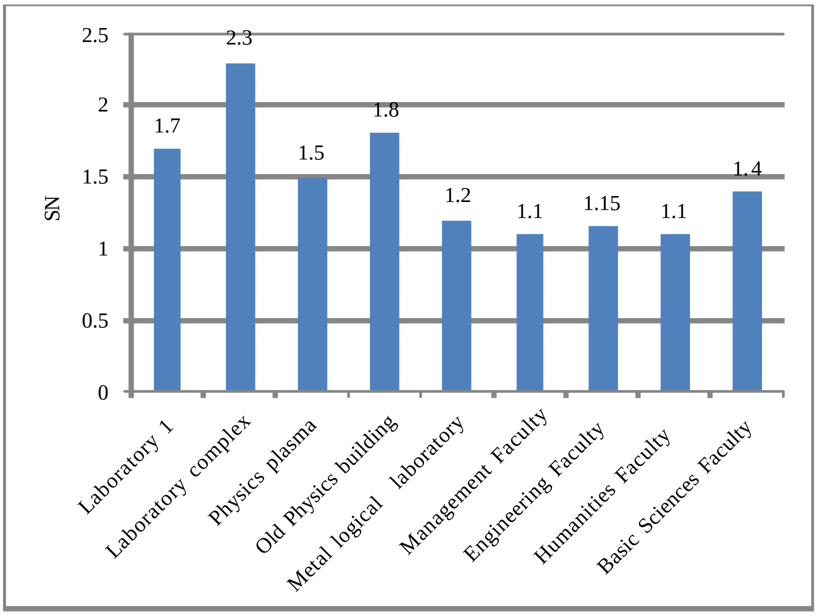

Fig. 6: Disaster risk scale in each building of the university campus

was the role of other organizations in controlling the campus disaster considered in this study (UF, 2005). In a research by Stenson (2006), it was stated that the presented program for preventing disasters was not a comprehensive one and could not be impressive. The impact of government's regulations on disaster management systems and emergency conditions was also emphasized by Porfiriv's (Porfiriv, 2001) study.

CONCLUSION

One of the problems in FMEA method is the combination of three parameters (S, O, and D; significance weights of S, O, and D are not equal [for example: a pattern with S=3, O=4, and D=10 (3×4×10=120) is equal to another with S=10, O=2, and D=6 (10×2×6=120)]). This problem can be solved by the pattern provided in this study. In this pattern, the power of each parameter was not equal; so, when the weights of S, O, and D were equal, SN was not equal. The methodology was based on AHP theories offering great potential in the assessment of such a problem. Using this method, just the worse indices and suggestions were provided for definitely improving the emergency planning. The originality of the method was, among other things, in its capability to gear the control activities to the three mentioned levels and hence to help agents and managers take the right measures in order to minimize the impact of the factor underlying the corresponding risk. The findings indicated that many parameters, including building structure, people, and detection and control devices, could influence the vulnerability of buildings. The buildings in which expensive hazardous materials and equipment are kept can have a higher safety value. The buildings used for learning objectives, with no hazardous materials, are subject to less safety. Thus, disaster-related rules should be studied in order to eliminate deficiencies and increase efficiency of disaster systems. This research showed that universities have hazardous resources with disaster capacity which is essential to be controlled. Moreover, regarding the potential forces of universities, if we are ready to encounter disaster conditions, these forces can be used as a volunteer resource with a high level of productivity.

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