Analysis of safety parameters in the selection of optimal routes for relief and rescue (Case study: ۱۳ Aban neighborhood of Tehran)

Abstract:

Background

Occurrence of earthquake threatens strongly urban environments of Iran specially Tehran. Earthquake causes the spread destruction and lead to many casualties and injuries. The most important needs of accidentalness after happening earthquake is to Rescue and relief services for them at least time as it is possible. In order to speed up relief, the most optimal rout in term of safety should be considered. Therefore, at the phase before earthquake to survey the safety of rood network and to determine the most optimal route, it is needed to take a series of parameters together with their importance into consideration. By considering this affair at the present study, analytic multi-factor approach to determine and evaluate effective safety parameters for selecting optimal routes to relief optimal routes within the city after occurrence of earthquake has been paid attention and this study was conducted as a pilot study at ۱۳ Aban neighborhood of Tehran.

Methods

At the present study, the research aimed to determine parameters affecting on safety of road networks and analyze the relationship between them and affecting amount of every parameters on selecting the most optimal safe route for ۱۳ Aban neighborhood at the municipal district ۲۰ of Tehran. Fording this, Analytic Hierarchy process model as the main model was employed. Also, the capabilities and analytic techniques of GIS software such as layer coverage were used.

Findings

Parameters including dangerous usages, transportation buildings (such as bridge and tunnel), vulnerability and irreparable losses happened at buildings and population accumulation for determining the optimal safe route to relief as main affecting parameters, so that each of these parameters has different significance level. Also the effect of factors such as passage gradient, distance from fault and aqueducts cannot be ignored.

Conclusion

The present study that determination and optimization of relief route haven't yet paid attention. Determination and optimization of relief routes can help to provide relay services more at possible least time. Parameters affecting on determination of safe road network include population accumulation, vulnerability and irreparable losses happened at buildings, transportation constructions and dangerous usages.

Keywords: Earthquake, Rescue routes, Analytic hierarchy process (AHP), crisis management, optimization, ۱۳ Aban neighborhood of Tehran

Introduction

More than ٥٠ percent of the world population live in the great cities including less that ٪٣ of the population on the earth. High density of the population, assets, infrastructure and productive and services infrastructures are the causes for vulnerability of the metropolitans against the disasters. Natural disasters (specially earthquake) which are mostly hidden and at the same time potential for the damages threatens all the cities around the world [١]. Earthquake can leave an extensive range of damages and death. What makes a tragedy from this phenomenon is lack of prevention of its effects and lack of preparation for having the favorite responses. During the last century, more than one thousands earthquakes have occurred in seventy countries in the world and killed more than ١.٣٥ millions persons and left an huge amount of materials damages. ٨٠ percent of the damages from the earthquake are reported at ٦ countries one of them is Iran. Location of Iran on Alp – Himalaya earthquake belt has been the cause for the fact that earthquake is one of the harmful disasters in Iran. Among the ١٥٣ devastating earthquakes occurred in the world, ١٧,٦ percent have been occurred in Iran [٢]. Such events have been the causes for environmental changes and left damages. Iranian cities more or less has the problem for structure vulnerability and as the statistics show, more than ٩٠ percent of Iranian cities are vulnerable against an earthquake of ٥,٥ rectal scale [٣]. Among the Iranian cities, the city of Tehran, based on the enlarged maps is located on the earthquake belt, and is more vulnerable comparing to the other cities. Existence of ١٥ dangerous earthquake valleys in Tehran area is an evidence for proving this fact. Among these valleys, three valleys of Masha, the north valley of Tehran and the south valley at Ray have the potential for an earthquake of more than ٧ rectal scale [٤]. Tehran city has not experienced any powerful earthquake since ١٨٣٠ [٥]. As the statistical studies reveals, it takes a period of ١٥٠ years for such a powerful earthquake to re occur. Considering such a fact, the experts suggest that occurrence of such powerful earthquake is very likely [٦].

Increase of security and safety, decrease of death toll and financial damage of the citizens against the danger and events are among the very important aims and measures aims for the city crises management. Setting and optimizing and effective network with high level of tolerance for emergency discharge of the devastated area at the earliest possible time are among the very important parts before the earthquake in crises management. The metropolitan city of Tehran having more than ٧٠٠ Sq. M. and the population of more than ٨ million (more than ١١ millions at days) needs a set of plans and programs for prevention aimed at vulnerability risk management and finally an effective crises management. Cities are prone to natural disasters in different ways most of which (specially the earthquake) can not be prevented. The crises manager and administrators should prepare a favorite strategies for evacuation, relief and support at the city different areas. For this purpose, the safety exit channels should be identified for emergency evacuation for the devastated areas and the required measures should be taken for their optimization. Among the plans for evacuation at emergency in urban areas before the earthquake happens are identification of the city locations, in-the-cities paths and safety areas for emergency accommodation and the most important, identification and optimization of the emergency exit paths and registration of this information on the maps to be used by the crises management headquarter [٧ and ٨].

The danger of earthquake occurrence in the city of Tehran is evaluated on the bases of its geographical position, construction, valleys around the city, past devastating earthquakes around the city and high techno-technical and geological factors. A look back to Iran earthquake history reveals that the city of Tehran, ex Ray, has been devastated many time during its history. Despite Tehran bound activity and registration of may small earthquakes around Tehran, no devastating earthquake has been occurred recently and it can be a symbol for accommodation of energy making

a devastating earthquake possible [۹]. This is the case while the city safety paths have not been examined and no safety emergency search and risqué paths network has been identified.
۱۳ Aban area at Dist. ۲۰ of the municipality, due to its social – economical and cultural formation has a considerable variety and surely is one of the city tourism and pilgrimage districts in which a huge population of the city refer for daily affairs. It has so many paths directed to the city main streets. Considering its special features, this area can be a very good sample for evaluating the city streets and safety parameters for search and risqué.

History of the Research

Among the studies conducted on our research subjects are the followings:
Sherali and Carter (۱۹۹۱), housing positioning model and preparing algorithm for planning evacuation in the status of flood and storm [۱۰]; Sattayhatewa and Ran (۱۹۹۹) presented a model for traffic dynamic management for evacuation of nuclear power stations. Pointing to the fact that all human being gear at time of emergency and loss their control and tranquility, they pointed that at this situation they compete for having a safety paths for exit. So, the roads may not be used effectively [۱۱]; Cova and Johnson (۲۰۰۶) examined emergency exit in the city locations and around the city and the possibility for firing, presented a model for dynamically assimilation based on the behavior [۱۲]; Yi and Ozdamar explained a model at their study for location distribution for emergency evacuation and support coordination for crises management and also modeling for direction and positioning, logistical coordination for resources and evacuation operation for crises stricken areas aimed at extending services provision level and quick access to stricken districts and positioning the ambulances centers temporarily in a favorite location [۱۳]. Yueming, XIAO Deyun (۲۰۰۸) presented a model and algorithm for emergency evacuation based on traffic in the city roards [۱٤]. Sargolzaee and colleagues (۲۰۰۲) examined the past earthquakes and found that the high level of death toll was due to un proper relief operation [۱٥]. Omidvar and colleagues (۲۰۱۲) regarded intercity transportation network as the main factor effecting the crises management in urban districts at time of events and stated that applying for using the available paths will be at the most possible level at emergency situation due to the crises [۸].
Nowadays, with the development of different methods of creating transport routes, the routing problem is more complex than the past. Accordingly, the researchers are always looking to find the best solution to this problem which can, due to the characteristics and parameters of the problem, find a proper answer for it. But in the meantime, the city issue of emergency evacuation has been less dealt with. On the other hand, the standard indexs and parameters assessed have not been defined in determining the need for any responsible for the proper evacuation at emergency and relief. Due to the nature of accident-prone of Iran on one hand, and existence of the metropolitans in Iran having vulnerable structures against the earthquake, the need of addressing this issue is more and more required.

Methods

Generally this study is conducted on indexing, modeling and analysis of information between the parameters of safety with determining the paths for search and risqué at ۱۳ Aban district for District ۲۰. for reaching the purposes of this analysis, the process model hierarchy has been used as the basic model. Therefore, after the library study and analyzing the data and the results of the studies from the previous research, a questionnaire based on this method has been prepared and submitted to the experts to be used for effective assessments of the parameters in network extracted. For evaluation and assessment of the judgment, the software of Expert Choice was used, and the techniques and capabilities for analysis by the software GIS, such as overlapping of the plies has been used as a supportive technique. The total flowchart of the operation for determining the path for emergency exit has been shown in the Figure ۱.

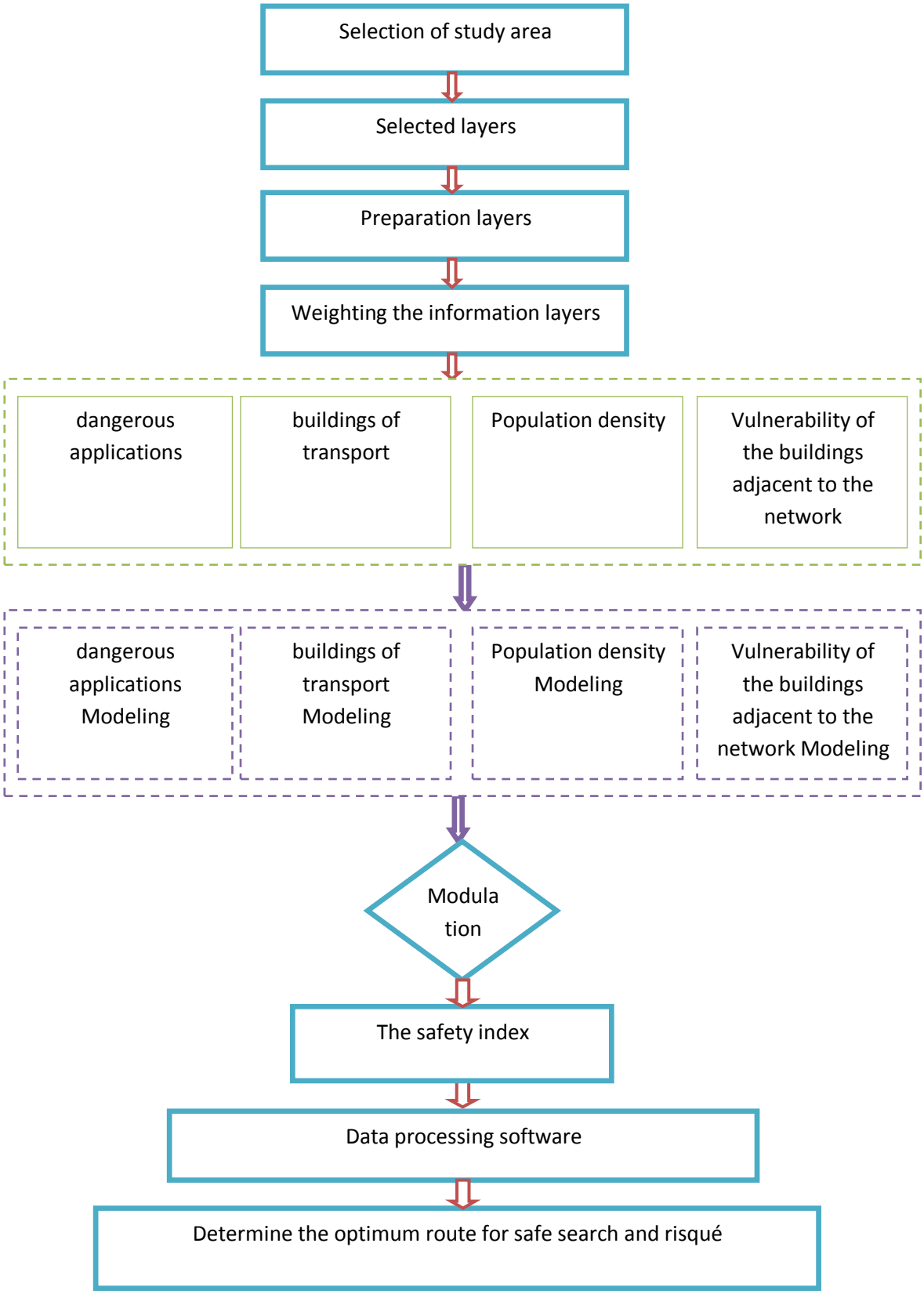

Figure ١. Total flowchart of the operation for determining the search and risqué optimized safety path

Introduction area studied

There is a plane on the southern corners of Tochal mountains, which has been residential in common from so long ago. The Zone is the Ancient Ray limit which is now one of the areas at District ۲۰ of Tehran Municipality and is one of the old areas in Tehran. The Area is ۲۳ square kilometers within the urban limits and ۱۵۳ km. Area. The district ۲۰ of Tehran Municipality is located at South of the city of Tehran. It is limited to the Districts ۱۵, ۱۶ and ۱۹, on the north, to Qom city on the South, on the East to Pakdasht and Varamin cities and to Islamshahr and Zarandiyeh and Robatkarim on the west. From Major most Physical properties of the District ۲۰ are its placement at South of the city of Tehran as one party and establishment the main users of Administrative Services of Functional districtal at the urban area at the National level. The special attractions to this area are valuable places of historical and religious types including the holy shrine of Imam Abdolazim (P. B. U. H.) as the examples of the case adding attraction to this district. This area has the special apposition die to the landscapes in as the main sources for main element of the attraction. This area has more than ۹۱،۵۰۰ families in the district, including the district ۵ in the district, district ۲ out of the district, and ۲۱. These are the factors for the huge day trips to the district and the presence of many Tehran citizens in this area. The one area of the ۱۳ Aban has the area of ۲۷۵۰ square kilometers and a total population of ۳۱،۹۴۵ people as one of the areas within the scope of district ۲۰ of Tehran municipality, which nearly is ۲۴ percent of area ۲۰. ۱۳ Aban district is limited from the of North to Azadegan Highway, from the south to VTir hospital, end of the street Sahraee, Amani, Molaii, Arabi, Enayati and Rajaie, from the east to Metro station walls to the length of ۳۲۰ meters and to Behesht-e Zahra Highway from west to the length of ۵۰۰ meters to Sahraee Street. Other particulars of ۱۳ Aban district are given in Table ۱.

Table ۱. Description of the ۱۳ Aban District Tehran [۱۶]

Index	Unit	Amount
Population	Person	۳۱۹۴۵
Spread	Square kilometers	۲۷۵۰
Household	Households	۱۹۷۰۰
Green Space	Square meter	۶۴۵۸۴۸
Waste (monthly)	Thousand kilograms	۱۰۹۸

۱۳ Aban District vulnerability against earthquake

According to Iran earthquake map, Tehran is are located in areas of high risk. However, according to studies by consultants of Iran and the Agency for International Cooperation of Japan (JICA) and the Center for Earthquake and Environmental Studies of Tehran, approximately ۴۸۰،۰۰۰ buildings in Tehran will be severely damaged and about ۲۲۰ Billion will be at in direct damage when an high earthquake is occurred. Damage in the district ۱۱, ۱۲, ۱۶ to ۲۰ will be very high, at about ۸۰ percent. The area of ۱۳ Aban at the district ۲۰ of Tehran municipality, has approximately ۰,۰۱ percent of worn construction which is about ۰,۰۴ percent of the district and ۰,۰۲ percent of Tehran old structure. Some parts of the ۱۳ Aban District in the event of earthquake are vulnerable. The extent of the damage likely to be inflicted on the population of the Area in comparison with the district and city of Tehran, based on the plan for operational scenario is presented in Table ۲ while image view of the streets to be studied in the network is shown in the Figure ۲ as a representation.

Table ۲. The extent of the devastation and damage inflicted on the population of ۱۳ Aban district compared with Tehran city. [۱٦]

Status	In the neighborhood (to the people)	The area (in percent)	City of Tehran (in percent)
Number of deaths	۲۱۷	۱۰	۰,۶
The number of injuries requiring hospitalization	۳۰۳	۶	۰,۴
The number of injured outpatient	۲۱۳۰	۱۰	۰,۶
Number of IDPs	۲۲۲۳۹	۹	۰,۴

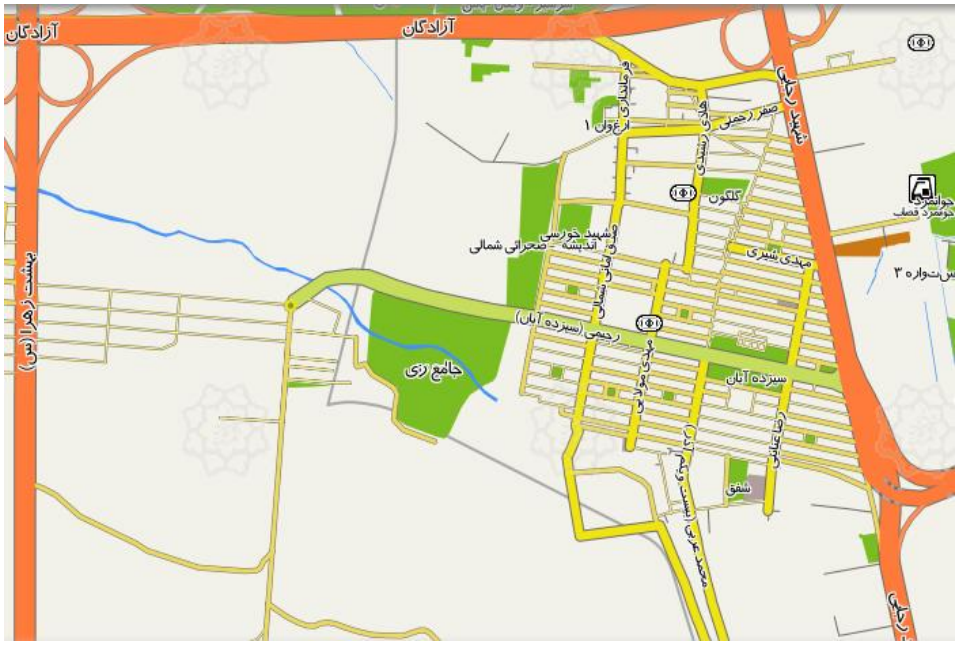

Figure No. ۲. ۱۳ Aban Street Network [۱۷]

Based on the studies, if in North East of ۱۳ Aban district an earthquake is occurred, the buildings will be faced with high damages. The level of structural damage, based on the scenario, comparing the district and the city of Tehran, at ۱۳ Aban is shown in Table ۳.

Table ۳. Structural damage in the area comparing to the city of Tehran. [۱٦]

TThe situation	In the neighborhood (to the people)	The area (in percent)	City of Tehran (in percent)
Heavy structural damage to the area	۹۹۰	٥,۸	۰,٤
Moderate structural damage to the area	٥٦٥	٦,۱	۰,۳
Partial Structural damage to the area	٦۰۸	٥,۸	۰,۳

In the northern area about ۲۹۰ underground rivers (ghanat) and ۱۰۲ ones are scattered in the southern area of the area. In total there are ۳۹۲ ghanats in the area. In this case, the level of vulnerability to the earthquakes is increased. All these affairs are the symbol for preparing an

comprehensive plans for indentifying the paths and ways at the state of emergency of earthquake for search and risqué. since the earthquake occurs, along with increasing demand for use of the road network and the efficiency of network from the drop down given will be increased as well. Therefore, in the absence of free paths in the identification of the emergency phase of the earthquake lie in the heart of the operation and the release of the damages from blocked areas increases. At time of the accident, the ten areas, holding one of these stones, ineffective assistance for collecting the deaths and damage will be increased. But for identifying and determining the paths for safety escape and determining the optimized paths based on the indexs and parameters are of importance of each of the parameters obtained.

Using hierarchical analysis in assessment and determining the parameters affecting the relief operation

The method for evaluation is assessments hierarchy of the methods of assessments of the indexs have been used in this study. Using this method, considering the simplicity, flexibility, using both qualitative and quantitative criteria and the ability to simultaneously surveyed, the frequency and optimum consistency in judgments favorable results have been come to bring. [١٨].

Hierarchy analysis process is started by identification and priorities of decision maine elements. These four elements include a four-level of objectives, indexs, parameters, and possible reports applied for the priorities of the work. The identification process of the elements and the relation between them results in a structure called the hierarchical structure. Conversion of the study subject to a hierarchical structure is the most important part of study [١٩].

In this study, by determining the parameters of the effective safety parameters in determination of safety optimized path for search and risqué, the questionnaire, based on a hierarchical analysis method is prepared and delivered to the relief staff, crises manager, urban planners, civil engineers, earthquake and other related topics cited by the experts. The experts have been asked to specify the parameters affecting the search and risqué and finally the importance of each parameter are visible. Based on the results obtained from the experts, the parameters responsible for the release are divided into four groups whose final results are shown in the table ٤.

Table No. ٤. The process of hierarchy analysis from the experts comments in determining the effective parameters for the characterization of diagrams effective in search and risqué of safety paths.

Target (level one)	Parameters to determine the optimal route for safe search and risqué
Indicators (level II)	Safety
Parameters (level III)	Vulnerability of the buildings adjacent to the network
	Population density
	buildings of transport
	dangerous applications
Options (Level IV)	١.Very dangerous ٢.dangerous ٣.Middle ٤. Low Risk

The findings

Calculating the as weight (coefficient of importance) parameters:

For determining the coefficient of importance for the parameters, they should be compared by two by two. In this judgment, the basis of the comparison, is a table for ٩ quantities as per the table ٥. Based on this table and according to the survey aims, the ration of the parameter i against the parameter j is determined. So, for n the index of ^{n}n Will be compared. Two by two comparison in a matrix is called "parameters two by two matrix" are registered. These matrix elements are positive

and considering the principle of "adverse condition" in the hierarchy based analysis have been prepared.
In this study for determining the parameters of the best type, the experts and specialists opinions of ٥٨٨٨ were used and the results in Table ٦ and Figure ١ is a representation for this.

Table No. ٥. Table ٩ A comparison of the two by two low efficiency indexs

Score (level of priority)	Definition	Description
١	Equal importance	Two criteria are of equal importance in achieving the goal
٣	Slightly more important	Experience shows that to achieve the objective of i is More than j
٥	More important	Experience shows that the importance of i is more than j
٧	Much more important	Experience shows that the importance of i is much more than j Is
٩	The absolute	Much more importance of i rather that j has been proved.
٢, ٤, ٦, ٨	Preferences interstitial	

Table ٦. two by tow comparison matrix of safety parameters indexs

indexs	Vulnerability of the buildings adjacent to the network	Population density	buildings of transport	dangerous applications	Normalized	Factor of importance (weight)
Vulnerability of the buildings adjacent to the network	١	٢,٥٠	١,٨٤	١,٣٩	١,٥٩	٠,٣٨
Population density		١	٠,٧٤	٠,٥٧	٠,٦٤	٠,١٥
buildings of transport			١	٠,٧٦	٠,٨٦	٠,٢٠
dangerous applications				١	١,١١	٠,٢٧

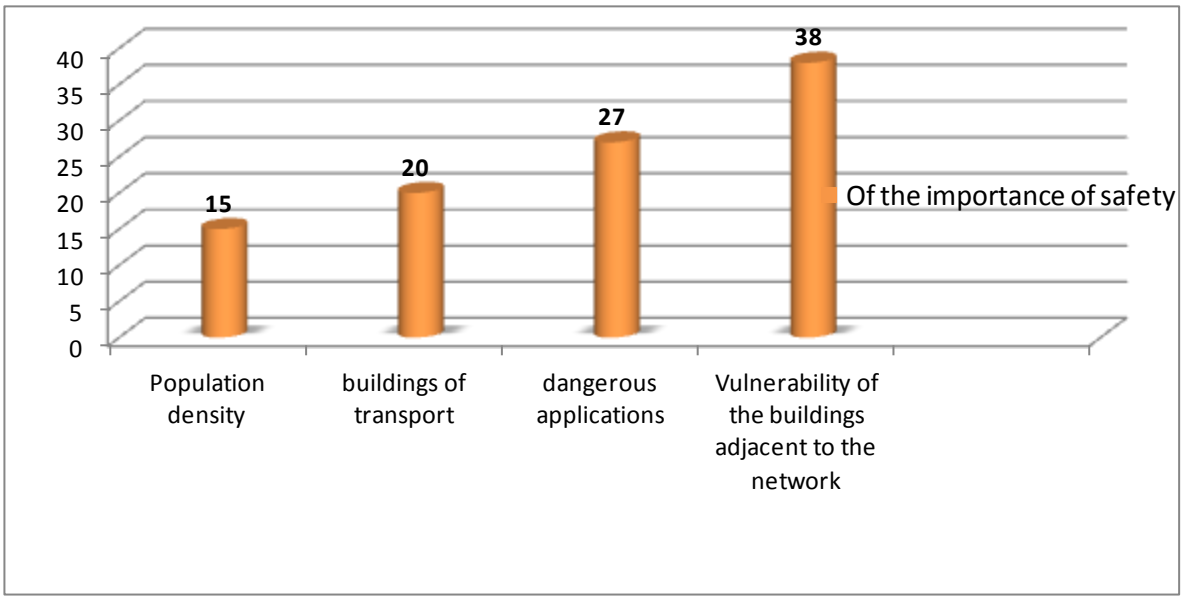

Figure ١. Comparing the importance of the safety indexs parameters from the perspective of the experts

Adoptive examination of judgments

The benefits of a hierarchy system analysis is adoptive examination of judgments made in determining coefficient for the importance of the criteria and sub criteria. When the importance of the criteria are estimated comparing each other, a kind of inconsistency in the judgments may be observed. The mechanism for checking the inconsistent areas in which judgment is intended to be done is calculation of an coefficient called Inconsistency Ratio which is th result of inconsistency index divided to random index. If the result is smaller or equal to ٠,١, the consistency is accepted and otherwise the judgments should be reconsidered. In other words, the matrix of two by two compare will be again made.

Index of incompatible $$I.I. = \frac{(\lambda max - n)}{(n-1)}$$

Certain number of random index of the SRs (n) can be extracted from Table V.

Table V. Table of random parameters computation

n	٢	٣	٤	٥	٦	٧	٨	٩	١٠	١١	١٢	١٣	١٤	١٥
R.I.	٠	٠,٥٨	٠,٩	١,١٢	١,٢٤	١,٣٢	١,٤١	١,٤٥	١,٤٩	١,٥١	١,٤٨	١,٥٦	١,٥٧	١,٥٩

In the average geometric method which is an approximate method, instead of calculating the maximum possible value (λmax), L is used as following:

$$L = \left(\frac{1}{n}\right) \sum_{n=1}^{\infty} \left[\frac{AWi}{Wi}\right]$$

Where AWi is a vector of multiplication of the criteria two by two comparing in the vector Wi (Weight vectors or coefficient of criteria). As mentioned earlier in this study the software Expert Choice is used for adoptive Judgments determination. Examining the judgments consistency in matrixes of two by two parameters is the index for judgment consistency; as CR = ٠,٠٠٣٠٧ <٠,١ Be given.

Modeling the parameters for safety index

The proposed model for implementation and assessments of safety indexs in the city in this research includes examining the status of the adjacent buildings, roads and assessment of vulnerability, the

effect of its hazardous application in the area, checking the status buildings for Transport and Population density. Modeling each of these parameters are shown in the figures ٣, ٤, ٥ and ٦.

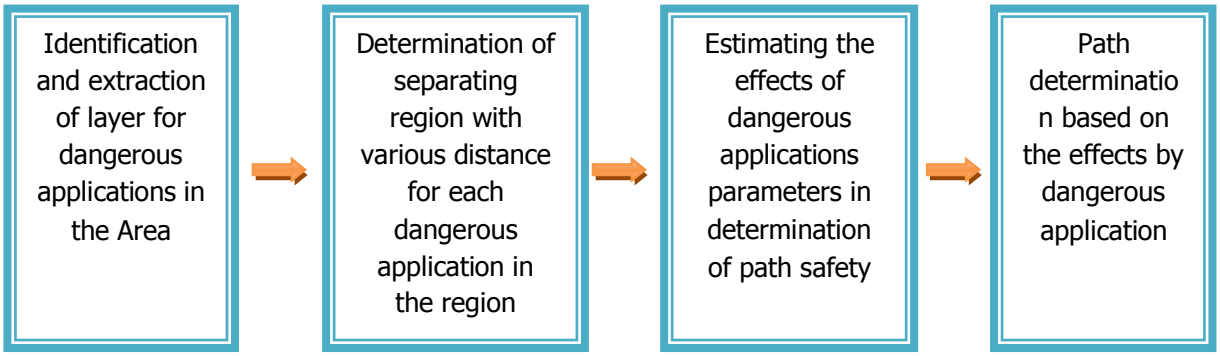

Fig ٣. Method for estimation of the hazardous application and its modeling

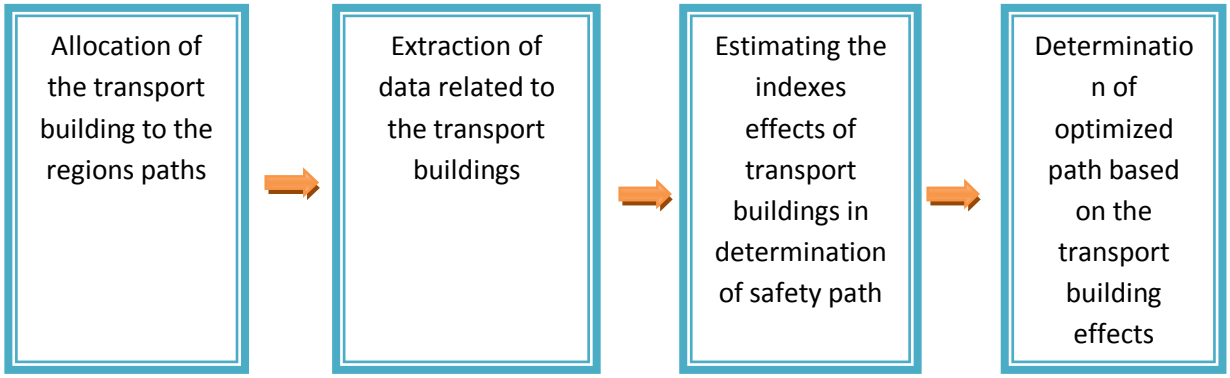

Figure ٤. Method for estimation of transport building indexes and its modeling

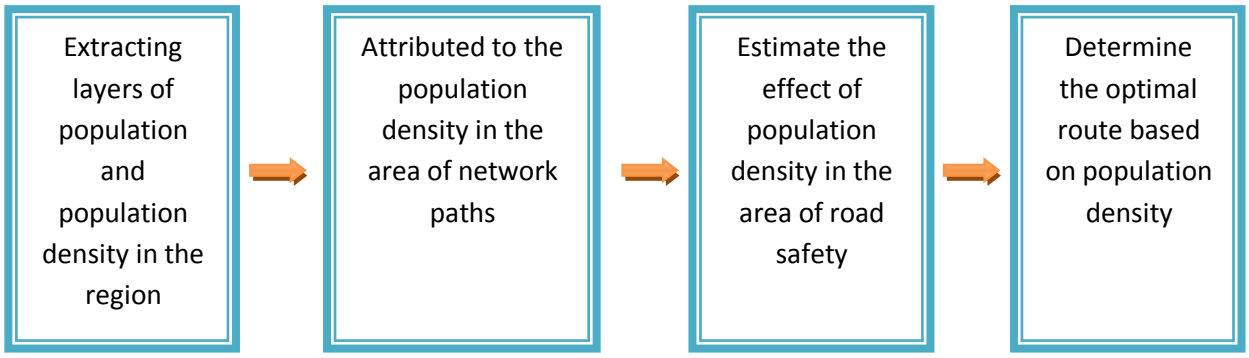

Figure ٥. Method for estimation of population density and its modeling

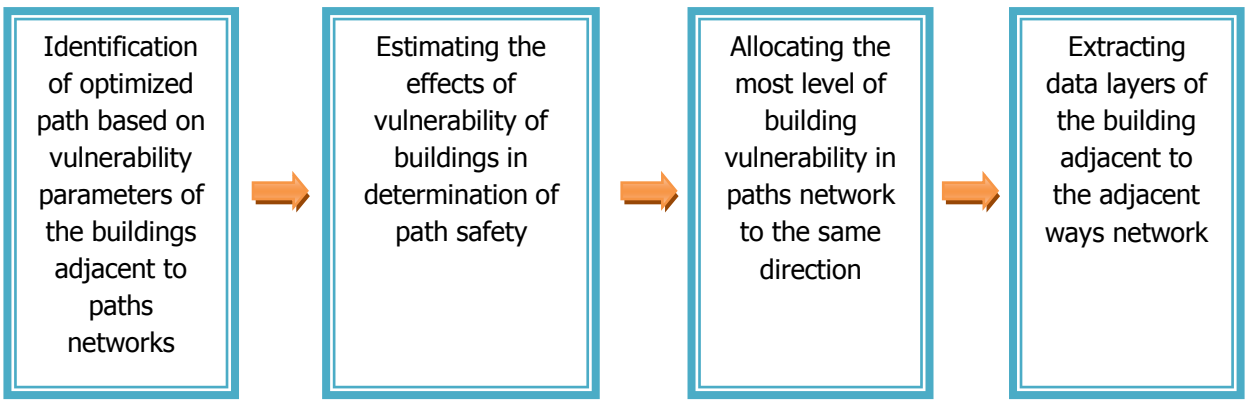

Figure ٦. Methods for estimation of the vulnerability of buildings adjacent to the street network and its modeling

Discussion and Conclusions of the larger

By analyzing and assessing the effective parameters in safety of the paths for search and risqué in ۱۳ Aban district by hierarchy analysis model and considering the indexes of this study, the following points are the most important of them:

۱ - The optimized path for search and risqué for district ۱۳ Aban at Rigion ۲۰ of Tehran is in form of the figure V. Emergency accommodation places have been selected based on the open spaces in the adjacent areas and safe paths are identified for emergency accommodation in the district.

Figure V. Conclusions on the implementation of the data model of indexes in the ۱۳ Aban district

۲ - Many of the indexs are bases for choice of path. but the most important index in selecting the paths for search and risqué, is safety. Safety include in priority for the importance: ۱. Vulnerability of the buildings adjacent to the road network and the losses occurred to the buildings ۲. Dangerous application, ۳. transfer buildings, ٤. Population density in the residential complex blocks adjacent road network.

۳ - With increase of the population domiciled at the residential blocks adjacent to the road network, the optimum amount of path used for the purposes are reduced. In other words, the administrative paths have more population that the other areas and are higher dangerous for optimization of the paths.

٤ – existence of bridges and tunnels on the search and risqué paths can be dangerous or even very dangerous. Therefore, no bridge should be made on the paths as possible as or at least the minimum requirements of the building safety and strengthening should be applied as the case may be to the best quality.

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