Journal of Novel Applied Sciences
Available online at www.jnasci.org
©2015 JNAS Journal-2015-4-2/190-196
ISSN 2322-5149 ©2015 JNAS

A review of studies on seismic geotechnical Zoning and micro- zoning urban areas

Hamid AliElahi[1] and Hassan Mojtabazadeh[2*]

1.Assistant professor, ZanjanAzad Islamic university, technical and engineering faculty, civil group- a member for construction engineering organization in Zanjan
2.Masters' degree of geotechnical civil engineering - a member for construction engineering organization in Zanjan

***Corresponding author*:** Hassan Mojtabazadeh

ABSTRACT: Studies on zoning and micro- zoning have been considered as a very important stage within conclusive planning of risk management and loss reduction and potential damages from earthquake in areas which are more prone to earthquake as long as four decades. Regarding the importance of the earthquake issue in Iran and its risks, all cities are required to perform a study on zoning and micro- zoning to countermeasure about earthquake risks and damages. It allows us to identify more prone zones. Site response analysis is considered as one of basics of studies on seismic geotechnical zoning and micro-zoning which is performed using geology, geophysics, and geotechnical researches in the form of determining site properties. The site conditions vary because of thickness and property changes of soil layers, bedrock depth and water table. It also drastically affects earthquake characteristics on the earth.

***Keywords*:** zoning and micro- zoning studies, geotechnical seismic, earthquake by-law, earth ranking.

INTRODUCTION

Natural disasters have always been viewed as a barrier against a nation's development from among the earthquake is the most common and detrimental. Iran is located around earthquake belt of Alp- Himalaya and from time to time a detrimental earthquake has destroyed a part of the nation leaving high amount of loss around. The devastating earthquakes have intensified the sensitivity of administrators, engineers and even ordinary people about earthquake risks. Different behaviors expressed by a construction at the time of earthquake depend on material diversity.

In order to identify this kind of behavior and decrease future losses and increase security inside urban residential areas, the studies on seismic geotechnical and seismicity have been applied. The evaluation of abovementioned studies is of high importance due to the fact that the numbers of by-laws are low as well as the increasing development of cities within vulnerable and susceptible areas. The zoning of seismic geotechnical in more risky areas will provide organizations and professionals with valuable information in different fields. Studies on seismic geotechnical micro-zoning are known as research fundamental planning for natural disasters.

A new construction may be designed following these studies and estimating the accurate force of earthquake. Thereby, future costs of retrofitting will be saved. These results are also used for new constructions retrofitting. These studies identify more vulnerable sites within urban areas and one can decide on changing the functions and positions of buildings. Information resulted from these studies may help the crisis managers to offer suitable rescue measures. This study has tried to provide an overview about zoning and micro-zoning studies, necessity and importance of them and the map for applications resulted from them. Also the research methods regarding accuracy have been investigated and have been compared with existing by- laws.

The necessity of micro-zoning studies within urban areas

Zoning is classified into different sections including liquefaction, earth slide and site. More strong earthquakes cause the earth to slide and prone areas which are identified through the results obtained from these studies. The potential of the occurrence for this disaster is also identified when seismic zoning is performed with regard to liquefaction. Moreover, zoning and micro-zoning may be used to plan crisis management at the time of earthquake and based on this more prone zones will be identified and better assistance will be forecasted. Micro-zoning roles when designing a new town may be seen in determination of urban various spaces usage and can help engineering costs and urban management. One can decide on the type and thickness of earth layers in the range of guesses as well as chemical, physical and mechanical properties of the layers and underground waters status and regional geology using zoning and micro-zoning. The soil allowed resistance may be identified through zoning.

The position, length, mechanism and activity of faults as well as area slopes are also identifiable via zoning. The distribution rate of shear wave and soil dynamic parameters within subsurface layers are findings of maps from zoning and micro-zoning studies. Because life utilities (water piping, electricity, gas, telecommunications, land and air transportations) and keeping them in service after earthquake are of great importance, the zoning may adopt needed decisions to protect and preserve them. The map of zoning studies are mostly provided in small scales (1:50000 – 1:250000) in different levels including nation, province and region. These maps are being applied for major decisions makings for development including identifying more prone areas, positioning new cities, and selecting suitable paths for mentioned utilities. The map of micro- zoning studies are provided in big scales (1:5000-1:50000) within urban or smaller areas. The results of these studies which are in the form of maps, like determining type of land, distribution of various layers' thickness, distribution of underground waters may be applied for urban development, land use as well as refining the process of retrofitted constructions designs gains the earthquake. They also are being applied to estimate urban vulnerability as well as complying and refining conclusive, development, risk management, and crisis management designs.

Stages of studies on zoning and micro- zoning

The stages of seismic zoning and micro- zoning are defined as follows. Properties of a site are determined using geology, geophysics, and geotechnical studies and integrating this data. Generally the results from these studies are provided in the form of seismic micro- zoning maps within urban areas. Each of above-mentioned studies are performed through certain stages including:

1. Existing data collection and their classification
2. Planning
3. Supplementary studies (field observations, satellite, aerial, and geomorphological images)
4. Results analysis obtained from studies, summaries and conclusions

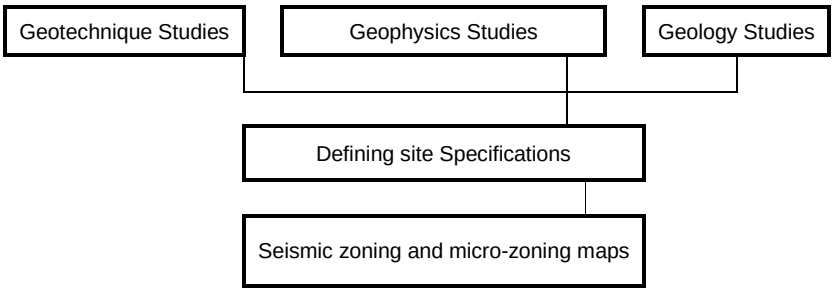

Figure 1. the stage of zoning and micro- zoning studies

The validity of finalized micro- zoning maps depends on the accuracy of available soil layers evaluation. The most economical method for data collection and site response analysis is an integrated network of different methods with an appropriate congestion. The numbers of required points on a data network are depended on geological and topographical conditions homogeneity. The denser the network, the more accurate the work is performed. But the number of operations will increase remarkably. The following specifications are recommended for a certain network:

- The points of network may be spaced 500- 1000 m regarding the geology and topography within homogeneous areas.
- A denser network than that of homogeneous conditions may be selected in heterogeneous areas considering properties and conditions modification in site.

Maps obtained from seismic zoning and micro- zoning studies
Those maps include:

1) Maps of available faults in the area
2) Maps of various layers' thickness distribution
3) Map of earth seismic ranking for construction designs and b- law usages
4) Topographical map for under study region
5) Map od distribution rate of shear waves within different layers
6) Map of zoning for potential liquefaction
7) Acceleration magnified zoning for different periods of seismic turning point like 475 years
8) Map of seismic bedrock depth
9) Map of geotechnical profiles path
10) Map of average distribution of the shear waves rate

The following figures show sample maps obtained from studies on seismic zoning and micro- zoning within different areas.

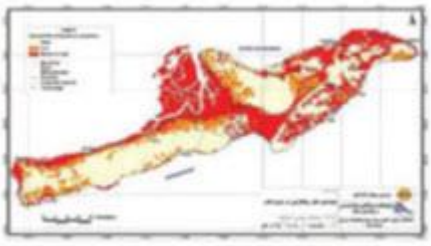

Figure 2. a zoning sample map for liquefaction risk in Qeshm

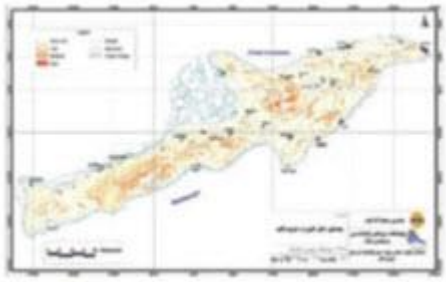

Figure 3. a zoning sample map for earth slide risk in Qeshm

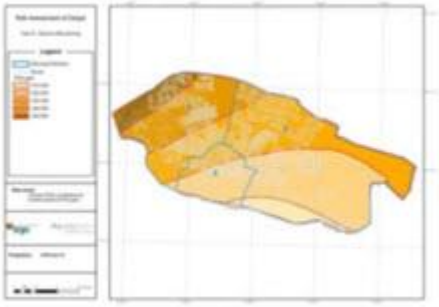

Figure 4. a zoning map sample for maxhorizontal acceleration averag in Zanjan for a turning period of 475 years

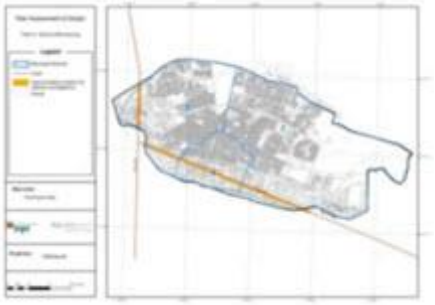

Figure 5. a sample map of fault rupture in Zanjan

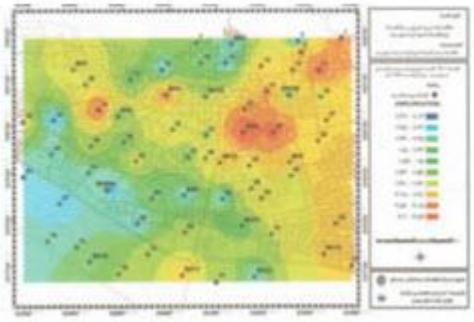

Figure 6. a zoning map sample for distribution of Magnification Coefficient in Zanjan (turning period of 475 years)

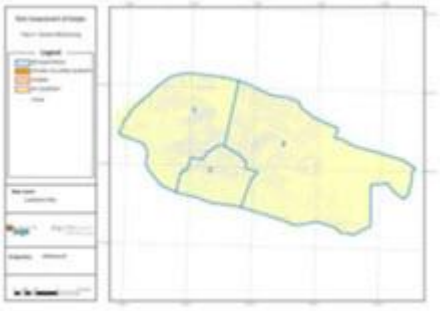

Figure 7. a sample map of liquefaction potential in Zanjan

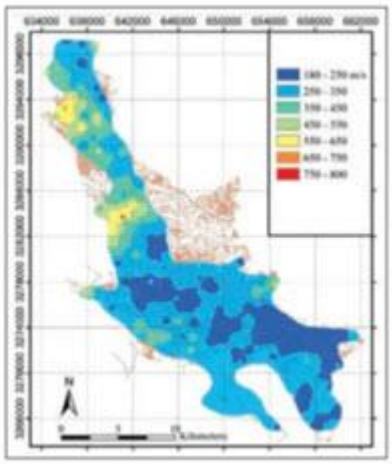

Figure 8. a sample of rate of shear wave the in first layer within Shiraz range

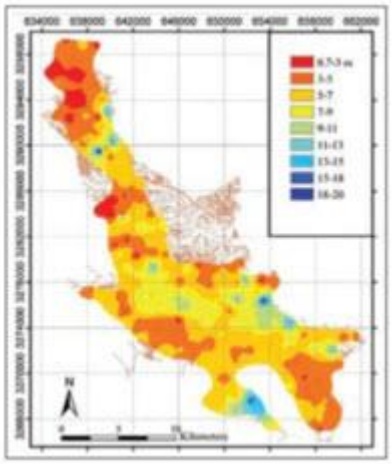

Figure 9. a sample of the depth of the first layer within Shiraz range

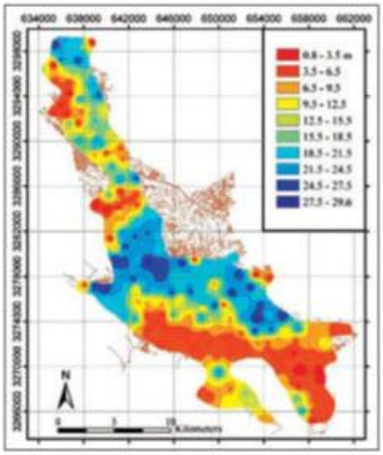

Figure 10. a sample of depth of bedrock within Shiraz rangeWith 30 m depth

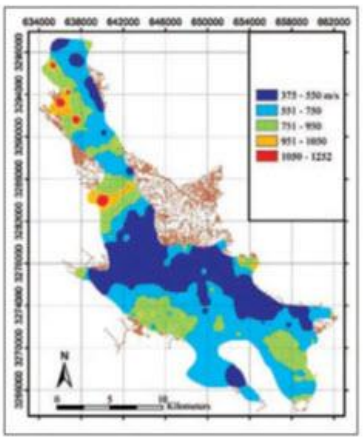

Figure 11. a sample of the average rate of shear wave within Shiraz range

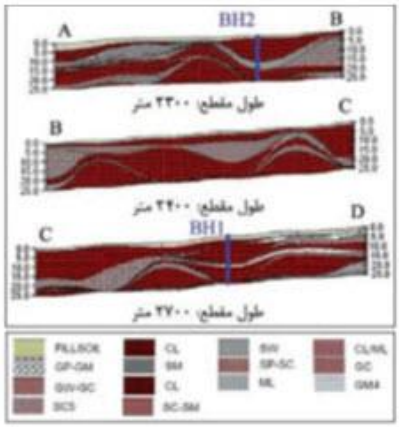

Figure 12. a sample of type and sequence of layers resultedfrom available geotechnical guesses within southern Shiraz

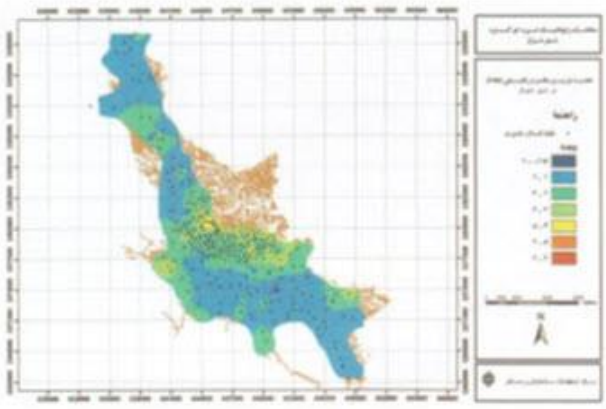

Figure 13. a sample of micro –zoning map of magnification coefficient distribution

Methods of seismic micro zoning studies regarding the accuracy

The entry data accuracy here is considered as one of the most important and principal factors of studies and computations. The method division and accuracy based on instructions of the technical committee of the international association for soil mechanics and foundation engineering (TC4) are including as follows:

1) Low accurate methods (rate I)
2) Moderate accurate methods (rate II)
3) High accurate methods (rate III)

Low accurate methods(rate I)

A vast area like the whole country or a province is covered in this accuracy rate. The maps obtained from such studies are of the scale of 1:50000- 1:1000000. These methods have certain advantages including low cost and in case of disadvantages very low accuracy. The required studies and resources are as follows:

a. Data collected from old documents including investigation of past earthquake intensity and resulted damages and losses (determining zones with same intensity during past earthquakes) and statistics of past earthquakes
b. Published reports and other available resources including surface geological maps (estimating effects coming from changes in different geological formation on earthquake intensity using surface geology)
c. Relying on by- law classifications

Moderate accurate methods(rate II)

Those maps applied in these studies are of 1:10000 – 1:100000 scale. The required resources and studies here include:

a. Collecting more accurate data like geological maps and aerial photos
b. Limited geotechnical studies
c. Standard penetration (SPT) an/ or cone penetration (CP)tests for determining soil layers properties
d. Determining soil layers depth up to bed rock

High accuracy methods(rate III)

The areas prone to high rate of earthquake are covered within this range of accuracy. The maps obtained through these methods are of 1:5000 – 1:250000 scale. One of the advantages here is the high accuracy and a drawback has high cost. The resources and studies required in this rank include:

a. Geophysical investigations like geo-electrical studies and etc.
b. Boreholes and geotechnical studies and performing laboratory and field tests
c. The ground response analysis

Local conditions of the site vary because of changes in soil layers thickness and properties, bedrock depth, and water table and have effects on earthquake characteristics on earth surface. The ground response analysis is provided using the model of waves' distribution and production of transition function among entering waves in the rock and movement on earth surface. The obtained results must be provided in the form of applied and appropriate maps including max acceleration distribution map on the earth, distribution map for magnification coefficient, and period distribution map corresponding to the highest intensity.

A comparison between earthquake by- law (Iranian 2800 standard) and seismic micro- zoning studies

The computation of earthquake force on ordinary buildings based on Iranian 2800 standard (third edition) is one of the common issues while designing. It has alternatively been observed that the designer and structural assessor have conservatively assumed the type of the ground but in case of seismic geotechnical micro- zoning studies one can compute the force applied on the building interacted with the soil accurately for each zone and avoid conservative one. Moreover, the need for retrofitting the buildings will be less required providing local design spectrum. On the other hand, the 2800 standard provides no suggestions regarding the force on the building at the time of earthquake near faulted zones. Regarding the fact that most cities are in these areas it is highly recommended that designers should consider seismic geotechnical micro-zoning identifying faults for future constructions as well as retrofitting existing buildings located near zones with fault.

It is possible to optimize construction costs with regard to earthquake forces induced on the buildings and considering the response spectrum and subsurface layers. Thus, providing micro- zoning maps is considered as an advanced stage of seismic zoning maps provision. Computing an appropriate seismic coefficient of a certain site leads in optimized design of passages based on designing requirements thereby optimized materials usage. Soil ranking based on the third edition of earthquake by-law compared to the case performed based on European by-law is of shortages. Later type of ranking consists of seven groups and four groups in case of the first one.

The group A in European standard stands for group I based on the 2008 standard while group B which is based on seismic bedrock depth stands for groups I and II. There is a group, labeled E in European standard and such a

ground contains a weal alluvium settled on a hard layer. Although it's here possible that the average for the rate of shear wave to indicate ground types of A and B, considering depth and rate of the layers the ground is classified in the E category. The importance of such a ground results from the significant promotion of spectral acceleration against the fixed time of frequency range of fixed acceleration for design spectrum proportionate to spectra from grounds labeled A and B. grounds labeled E are prone to waves range intensification at the time of earthquake and leads to spectral acceleration to increase. Thus, the buildings undergo higher forces. This type is not included in 2008 standard. Therefore, proper decisions must be made in this regard.

Table 1. ground type ranking based on 2008 standard (permanent revision committee of buildings design by- law against earthquake, 2005)

Ground type	Compositions of the site	Approximate limits $\overline{V_s}$ (m/s)
I	Igneous rock (containing coarse and fine- grained texture) hard and resistant sedimentary rocks and metaphoric mass rocks (ganeiss and silica crystalized rocks) kanglou layers of rock	Higher than 750
II	Weak igneous rocks (like tuff), sedimentary weak rocks, layered metaphoric rocks and generally those rocks weakened by weathering. Hard soils (compressed sand and ruble, very hard clay) with thicknesses higher than 30 m	$375 \leq \overline{V_s} \leq 750$
III	Collapsed rocks via weathering Moderate dense soils, sand and rubble layers with moderate link intra-grain and moderate hard clay	$175 \leq \overline{V_s} \leq 375$
IV	Soft deposits with high humidity because of high level of underground water Any kind of soil profile containing at least 6 m clay with a paste index more than 20 and humidity rate higher than 40%	Lower than 175

Table 2. ranking ground type based on European by- law (CEN, 2004)

Site rank	Soil layers description	parameters Shear wave rate $\overline{V_s}\, m/s$	Standard penetration figure $\overline{N}$ $(blows/30cm)$	Undrainedshear resistance $C_u(kPa)$
A	Rock or other rock like geological structures and containing utmost 5 m of weaker materials on the surface	> 800	-	-
B	Highly dense sand deposits and rubble or very hard clay with at least some ten m of thickness whose mechanical properties increase as depth does.	$360 - 800$	> 50	> 250
C	Deep dense sand deposits, or half dense, very hard rubble or clay with some tens or hundreds thickness	$360 - 180$	$15 - 50$	$70 - 250$
D	Non viscous soils' weak to moderate deposits (with or without certain viscous layers) or soft to hard soils with dominant viscosity	< 800	< 15	< 70
E	Soil profile or surface layer with shear wave rate ranking C or D and with a thickness of 5- 20 m which is located on a harder layer or $\overline{V_s} > 800\, m/s$.	---	---	---
S_1	Deposits containing or composed of a layer of soil or at least 10 m thickness clay/ soft silt or $\mathrm{PI} > 40$and high rate humidity	< 800	---	$10 - 20$
S_2	Deposits with liquefaction ability, sensitive clays and/ or any kind of soil haven't ranked previously as $A - E$ and S_1	---	---	---

Therefore, shortages of Iranian 2008 by- law compared to micro- zoning studies are including:

- Lack of considering site effects on the acceleration rate of design base
- Low values for acceleration rate of design base
- Low values for max proposed spectral accelerations
- Lack of considering special effects of spring and basin within fault proximity
- Over-conservativeness of building reflection coefficients within high periods range
- Lack of considering the topographical effects on surface seismic response

Certain micro- zoning studies performed in Iran

Regarding the fact that Iran is a seismic area and it has high earthquake risks, micro- zoning studies are of higher importance. Hence, during recent decades, certain actions have been taken in this field including the followings:

- ❖ Japanese international cooperation agency, official representative and responsible for fulfilment of technical cooperation projects of Japanese government sent its expedition group to Tehran on 24th of Farvardin 1999. It was to initiate seismic micro- zoning studies in Tehran according to Japanese regulations and by- laws.

- Seismic geotechnical micro- zoning within south-east Tehran from viewpoint of effects of site which has been initiated in 1994 and completed in 1998 cooperating seismology international research institute and earthquake engineering.
- Liquefaction micro- zoning studies of south-east Tehran which has been initiated in 1998 and completed in 2001 cooperating the international research institute of seismology and earthquake engineering.
- Supplementary studies of seismic micro- zoning in south Tehran which has been finalized in 2002 cooperating the international research institute of seismology and earthquake engineering.
- Studies estimating risks and geotechnical micro- zoning of Boushehr in 2005 cooperating the international research institute of seismology and earthquake engineering.
- Studies on seismic risk zooning and seismic geotechnical telecommunications in Qeshm and micro-zoning studies of seismic geotechnics in Qeshm and Dargahanwhich completed in 2008 cooperating international research institute of seismology and earthquake engineering.
- Zoning map of liquefaction potential in southern coasts which was completed in 2009 cooperating international research institute of seismology and earthquake engineering

and the research institute of transportations.

- Ground type ranking using the rate of shear wave within Shiraz range based on buildings by- law which has been performed by Saeid Hashemi Tabatabaei et.al in 2011.
- Seismic micro-zoning of Gorgan (consequences and requirements) which has been performed by AlirezaTabarsi et.al in 2014.
- Liquefaction risk zoning in Lorestan province which has been performed by FrajollahAsgari&AmirGhasmi in 2009.
- Seismic geotechnical micro- zoning of Arak from view point of intensification phenomenon which has been performed by MortezaJiriayi et.al.

Summary and conclusion

In this research, it has been tried to indicate the importance and necessity of seismic geotechnical zoning and micro- zoning studies and its roles decreasing losses resulting from earthquake and increasing studies accuracy when seismic designing. It also is required to perform these studies nationwide for the purpose of development and preparations against earthquake. Thereby, a deep change will be cast on construction system and security of buildings. Those studies need cooperation of all officials and professionals as well as government supports and national determination.

REFERENCES

Consortium of BRGM and Darya KhakPey firms. 2010. risk evaluation and seismic risk province wide (Hamedan, Qazvin, Kermanshah, and Zanjan cities), ministry of interior affairs.

Haeri SM and Getmiry B. 1997. seismic micro- zoning in urban areas, Islamic Revolution Housing Foundation, the Center forstudies against natural DisastersIran.

Hashemi Tabatabaei S, FatemiAghda M, Beytollahi A, Nariman S, Mohammadi A and Salamat S. 2014. "guidelines of engineering geological map preparing for seismic geotechnical micro- zoning in urban areas, building and housing research center.

Hashemi Tabatabaei S, Fatemi Aghda M, Ghalandar zade A, Shahnazari H, Araei A, mohammadi A and Salamt S. 2014. guidelines for site response analysis for seismic geotechnical micro- zoning in urban areas, building and housing research center.

Hashemi Tabatabaei S. 2012. risks of seismic geotechnical phenomena and selecting secure site for buildings, building and housing research center.

Hashemi Tabatabaei S. 2012. ground type ranking using the rate of shear wave within Shraz range based on buildings by- law, building and housing research center.

Jafari MK and Kamalian M. 2009. general criteria of urban construction planning based on seimic geotechnical considerations, Iranian international seismology research center.

Kamalian M. 2008. considerations on certain specifications of seismic geotechnical standard 2008 Iran, geotechnical engineering research center.

MirmohammadiHosseini M, Arefpoor B and Ghasemi A. 1999. guidelines for zoning of risks from seismic geotechnic, Iranian international seismology research center.

Permanent revision committee of buildings design by- law against earthquake, 2005- the by- law of building design agains earthquake, third edition, building and housing research center.

Tabarsi A. 2014. Gorgan seismic micro- zoning: consequences and requirements, Golestan symbol.