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Paper No. 1723. (quote when citing this article)
Eleventh World Conference on Earthquake Engineering
ISBN: 0 08 042822 3

MICROZONATION OF A SOUTHERN PART OF TEHRAN TO LIQUEFACTION

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ABSTRACT

Liquefaction of sand layers is one of the main causes of heavy damages to cities during earthquakes.It depends on different geoligical and geotechnical factors of the ground . In this study an extensive geological and geotechnical data of Tehran (capital of Iran) is collected .Based on the data , the potential of liquefaction of different areas of the city is investigaed. Then according to different analyses methods , by using a computer program the most susceptible zones of the city to liquefaction are determined . Finally a microzonation map based on different liquefaction potential indices for the most heavy probable earthquake is presented

KEYWORDS

liquefaction ; microzonation ; cyclic strength; potential index ; SPT.

INTRODUCTION

Liquefaction is a general term which denotes the unstable behavior of saturated sand layers due to a sudden increase in pore pressure. The consequence of this behavior would be large deformation of the sand layer or even complete loss of strength.

Many researchers have concentrated on laboratory studies using cyclic simple shear or cyclic triaxial apparatus and in a limited range , shaking table . Besides the serious problem in preparing undisturbed sand samples , the difficulties and relatively high expenses of the laboratory studies, caused new analytical methods to be developed.Liquefaction potential of saturated sand layers can be evaluated by these methods which are based on results of the most popular in - situe tests mainly SPT and CPT. Among these methods , the most common ones are those based on SPT numbers , developed by Seed, Iwasaki , Tatsuoka , Ishihara and others.Due to many field and laboratory data in recent years, the above mentioned methods have been gradually corrected and modified .More over, new approach has offered by Ishihara and Iwasaki to evaluate the influence of liquefaction of a sand layer in the ground surface . One of the most effective way to decrease liquefaction damages during earthquakes is to zoning areas based on the liquefaction potential of the sand layers. In 1993 the technical committee for earthquake geotechnical engineering,TC4, of the ISSMFE prepared a manual for zonation on seismic geotechninal hazards .The microzonation against liquefaction is suggested to be carried out on three different grades depends on the type and accuracy of the avialable geotechnical data . The principles of such recommendations have been used in this study, which is explained in next section .

EVALUATION OF LIQUEFACTION ON THE GROUND SURFACE

In many cases liquefaction is not important by itself since it has not caused any effect in the ground surface . There are two methods for investigating this subject . In the first one which is suggested by Ishihara the effect is determined by comparing the thickness of the surface layer with the liquefied layer .

the second method , offered by Iwasaki et.all (1982) , is based on liquefation potential index (P_L) which is calculated for each site as follows:

$$P_L=\int_0^{20} F(z)\, W(z)\, dz \qquad (1)$$

in which z is the depth of the liquefied layer from surface (in meter), F(z)is a function of liquefaction safety factor (F_L) defined as below :

for: $F_L \leqslant 1$ $F(z)=1-F_L$ (3)

for: $F_L \geqslant 1$ $F(z)=0$ (4)

and: $W(z)=10-0.5z$ (5)

the above index (P_L) is obtained in the ranges of 0 to 100 . According to the field observation and based on the calculated P_L there are three risk levels for damages in the ground surface :

low risk	$0<P_L\leqslant 5$	(6)
high risk	$5<P_L\leqslant 15$	(7)
very high risk	$P_L>15$	(8)

THE GENERAL CHARACTERISTICS OF TEHRAN

The city of Tehran has located in northern part of Iran. It has an average height of 1300 meters from the sea level , with some variations from 1000 meters in the south to about 2000 meters in the north. The city is located in the southern skirt of the Alborz mountain chains in a big flat of about 1200 square Kilometers, which is mainly consisted of alluvium soils. From geological point of view , the flat of Tehran with a remarkable slope from north to the south can be divided into four zones: the Alborz high area , the Alborz side folds , the Tehran mountain - sides , and the central Iran northern subsidence.

The alluvium sediments of Tehran, which extends from Alborz mountain side to Tehran southern desert , is the results of activities of rivers and seasonal floods , flowed from Alborz mountain chanis. These sediments are categorized to different sections such as Hezardarreh alluvium formation (Aluvium class A), Tehran north alluvium formation (Alluvium class B), Tehran Alluvium formation. (Alluvium class C), Khoram abad alluvium formation (Alluvium Class D) choronologically.

From seismological point of view , there are many faults in Tehran. Among These faults , 12 main and large , 8 medium with length between 2.to 10 kilometers and more than 40 small faults with less than 2 kilometers length can be mentioned. There have been heavy earthquakes in the city during few past centuries. There have been about 60 earthquakes with magnitudes more than 4 Richters recorded during a period of 83 years (1900 to 1983) happened in a radius of 150 Km. from centre of Tehran, from which 12 earthquakes had more than 5 Richters magnitude.

Based on the geological organization studies of the country (report No.56) for a return period of 100 years and probability of 64 percent, an earthquake with acceleration of o.27 g and magnitude of 7.2 Richters is anticipated. In a current study which is being done by IIES of Iran to provide a microzonation of Tehran for seismic waves amplification, the accelerograms of Manjil, Ab- bar , Tabas and El- Centro earthquakes are normalized for acceleration of O.27 g and the accelerations in the ground surface are determined. These results have been used to analyse data and assess liquefaction potential of the city in this study.

The city of Tehran still does not have an overall sweage system to collect waste waters.They are somehow collected by local wells.The surface waters are collected by open channels which join together in the southern part of the city.All underground and surface waters are flowing towards the southern areas, leading to relatively high water table in this part of the city. As a major factor this increases the risk of liquefaction on this area. The countours of the underground waters surface in this area are shown in fig.2.

GEOTECHNICAL DATA AND ANALYSIS RESULTS

The geotechnical data from more than 500 bore holes provided by differert governmental and non-governmental organizations all over the city were collected. According to an initial evaluation based on geotechnical information and underground waters,the north part of the city was recognized as the most improbable zone to liquefaction. The water table in this zone is very deep(more than 50m.) and the soil layers comprise mostly from medium to dense sandy gravles materials.In the south-western of the city the soil texture is mainly cohesive and there are thick layers of normally consolidated clays. The south-eastern of the city with medium to low dense sand and silty sand layers with high water table is the most propable zone to liquefaction. For this reason this zone of the city as shown in fig.1 was chosen for more accurate analyses and microzonation studies.

Among collected 500 bore holes,more than 100 belong to the selected zone . A grid of 1×1 km.dimensions was plotted on a map of 1:50000 scale of the city in this zone and all data were distributed and allocated to the relevant blocks.A special computer program was written by which liquefaction potential index (P_L) based on different analytical methods was calculated for each block.Seed; Ishihara; Iwasaki and chinese methods are those were tried to calculate the liquefaction index for different points.The Robertson method which is based on the shear waves velocity was also used. The results of analyses which are plotted in the selected zone are presented as the microzonation against liquefaction in fig.3.The microzonation map is provided based on the most conservative results obtained from different analyses methods used in this study.

SUMMARY AND CONCLUSIONS

The liquefaction potential of Tehran, capital of Iran ,was investigated. Geotechnical and

Geological data from more than 500 bore holes were collected and used in this study.The south-eastern part of the city was recognized as the most susceptible zone to liquefaction.According to different analyses methods the microzonation map for this zone is provided .Among different methods used in this study, the shear waves velocity is the least and Ishihara method is the most conservative ones.Seed et.all method is very sensitive to SPT(N) numbers,while Iwasaki method shows the same sensitivity to the particles mean size (D_{50})as far as using them for data collected in this study.

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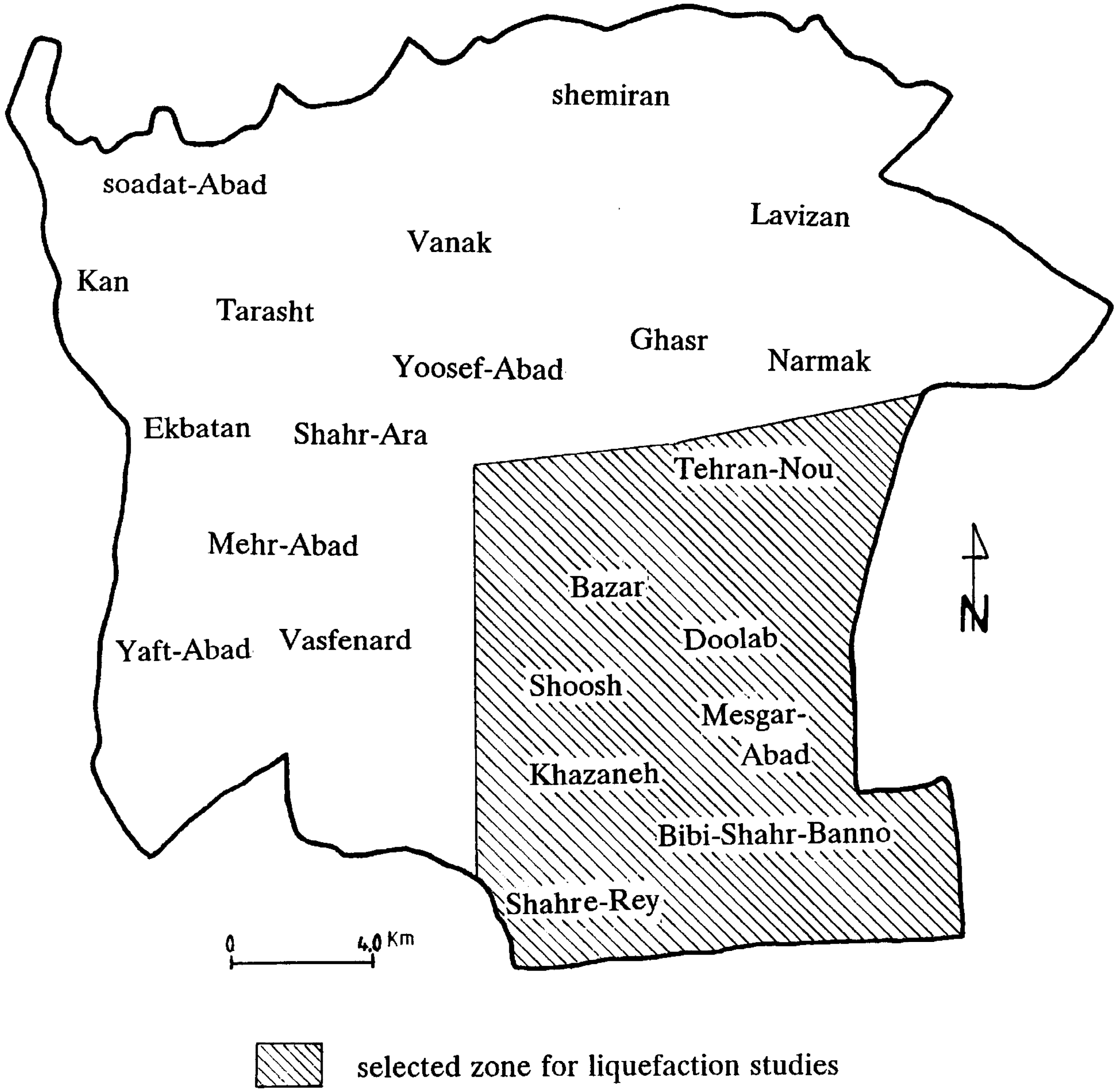

Fig.1- The city of Tehran and selected zone for liquefaction studies.

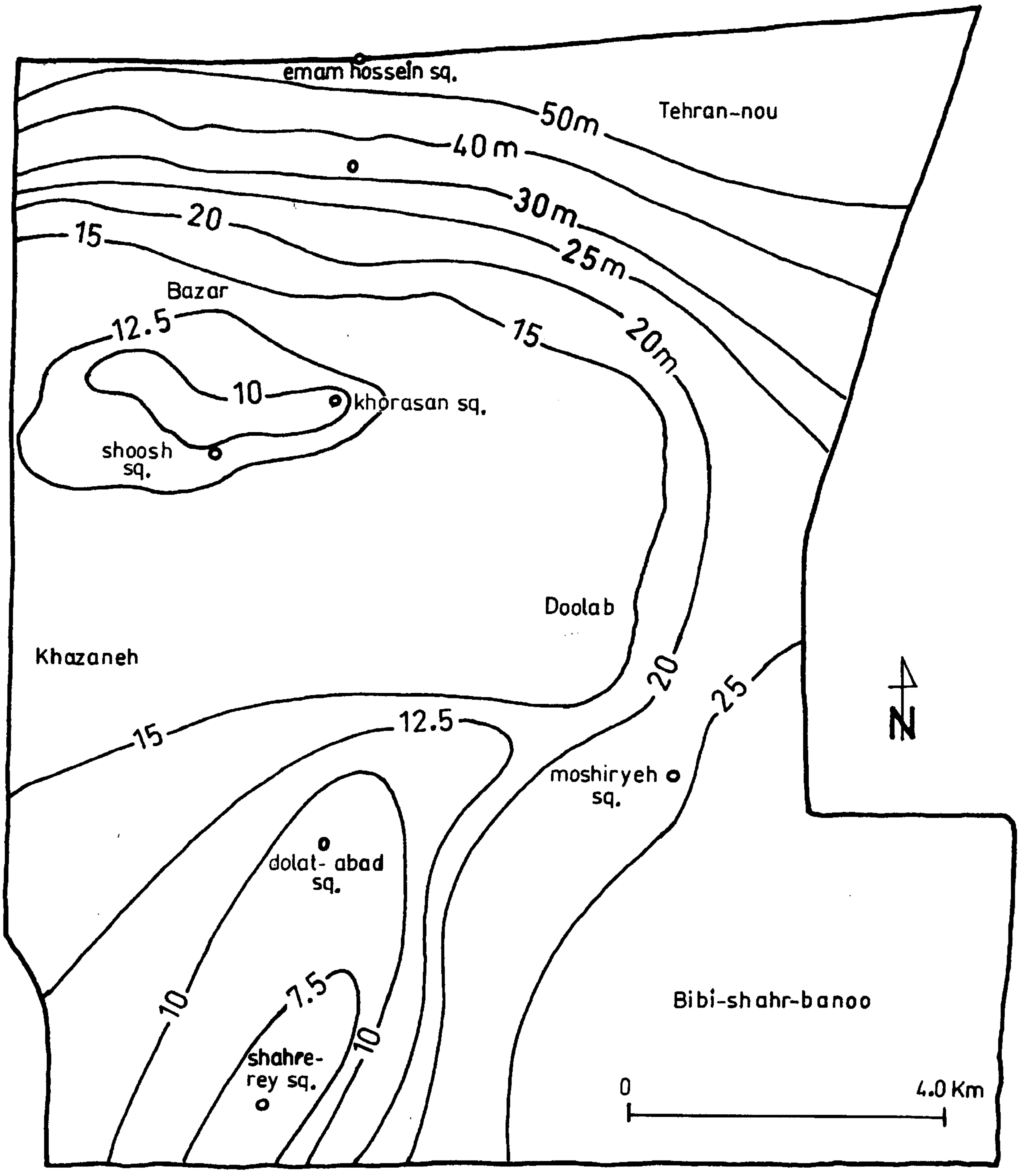

Fig.2- Contours of the underground waters.

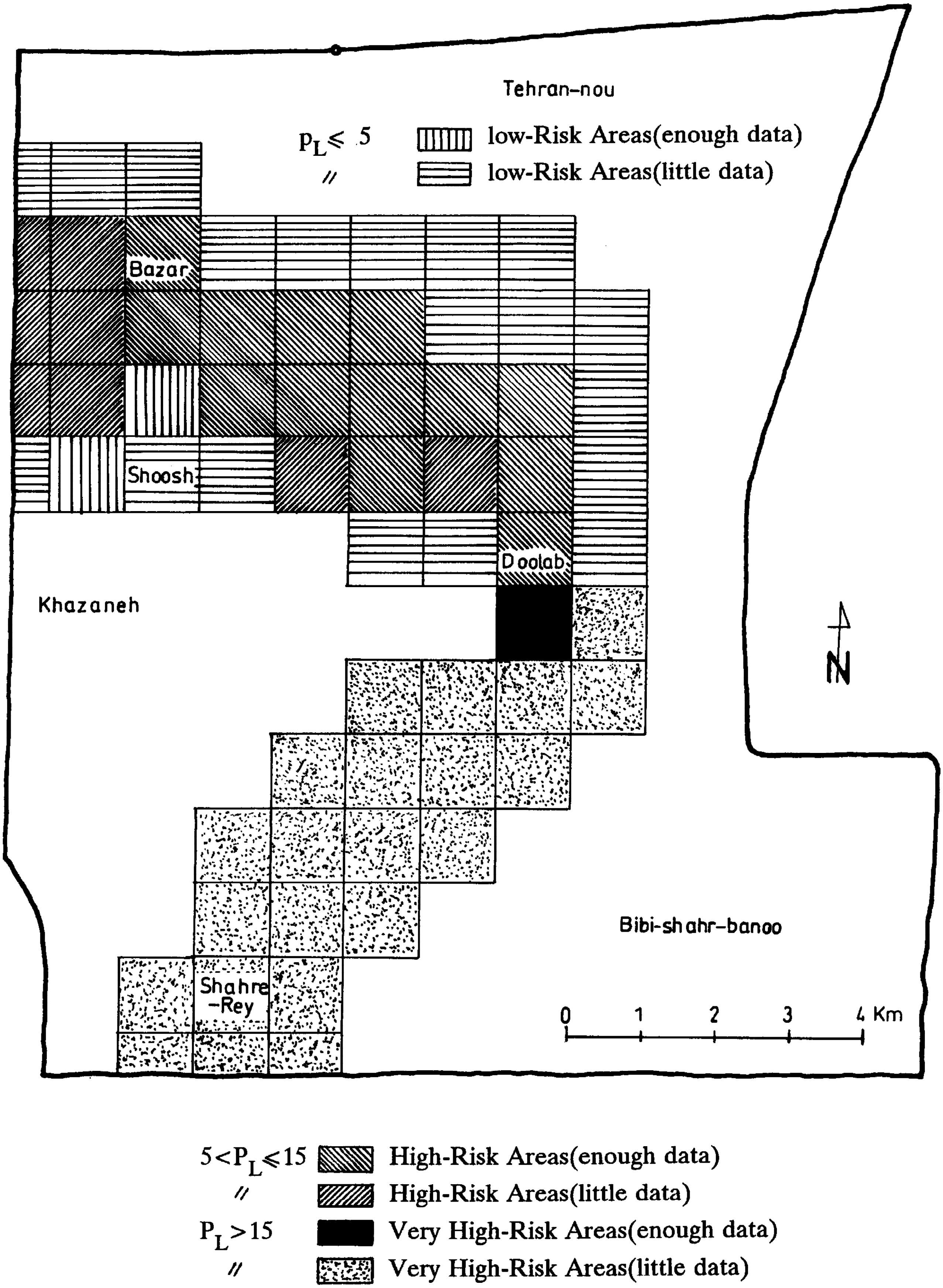

Fig.3- Microzonation map of south-eastern part of Tehran to liquefaction.