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Site effect microzonation of Qom, Iran

Mohsen Kamalian [a,*], Mohammad Kazem Jafari [a], Mohammad Reza Ghayamghamian [a], Ali Shafiee [a], Hossein Hamzehloo [b], Ebrahim Haghshenas [a], Abdollah Sohrabi-bidar [a,b]

[a] *Geotechnical Engineering Research Center, International Institute of Earthquake Engineering and Seismology (IIEES), No. 26, Arghavan St., North Dibajee St., Farmanieh, Tehran, I.R. Iran*
[b] *Seismology Research Center, IIEES, No. 26, Arghavan St., North Dibajee St., Farmanieh, Tehran, I.R. Iran*

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Abstract

As an important step in effectively reducing seismic risk and the vulnerability of the city of Qom to earthquakes, a site effect microzonation study was conducted. Seismic hazard analysis for a return period of 475 years was carried out. Data from 160 borings was collected and analyzed, geophysical surveys were conducted and microtremor measurements taken in more than 60 stations throughout the city. The study area was divided into a grid of 1×1 km^2 elements and the sub-surface ground conditions were classified into 59 representative geotechnical profiles. Site response analyses were carried out on each representative profile using 30 different base rock input motions. Distribution maps of site periods and peak ground acceleration throughout the city were developed, providing a useful basis for land-use planning in the city.

Keywords: Qom; Microzonation; Site effect; Microtremor; Natural period; Dynamic period; Peak ground acceleration; Land-use planning; Seismic risk

1. Introduction

Ground shaking and its associated damage to engineered structures can be strongly influenced, not only by source and path effects, but also by surface and sub-surface geological and topographical conditions in the vicinity, known as "local site effects". Evidence of this can be found in the 1990 Manjil–Rudbar and the 2003 Bam earthquakes, two major seismic events in Iran in the past two decades that resulted in a large number of casualties. Although these cities had comparatively low populations, the lack of suitable development and earthquake risk management led to high human and physical costs. These tragedies prompted the government to implement earthquake risk mitigation measures, including seismic hazard zonation and microzonation of vulnerable cities, to facilitate urban planning.

The historic city of Qom, which archaeologists estimate has been inhabited since the 5th millennium BC, enjoys special status in Iran because it is the site of the shrine of Hazrat-e Masumeh, an important spiritual centre. It is home to a number of advanced theological schools and an array of rich Islamic architecture. The city is situated 120 km south of Tehran (Fig. 1) and covers an area of approximately 180 km^2. In the past two decades, it has experienced a sizeable increase in population.

In 2002, Ramazi (2002) carried out a seismic hazard zonation study of Qom Province. He estimated the horizontal peak acceleration for basement rock without considering soil types, based on the tectonics and seismicity of the Qom province using the Cornell approach. He showed that the seismicity of Qom is not only affected by well-known major faults lying between the cities of Tehran and Kashan, but also by some minor but active–or potentially active–faults under the city itself. These results prompted the local Qom government to implement immediate measures to prevent the kind of destruction seen in previous earthquakes.

As part of the program, the International Institute of Earthquake Engineering and Seismology (IIEES) carried out a seismic microzonation study of Qom in 2005. The goals of this investigation were to prepare guidelines for further land-use planning and to provide data for future studies of existing urban systems and seismic rehabilitation processes. The geotechnical

* Corresponding author. Tel.: +98 21 228 1173; fax: +98 21 280 3656.
E-mail address: kamalian@iiees.ac.ir (M. Kamalian).

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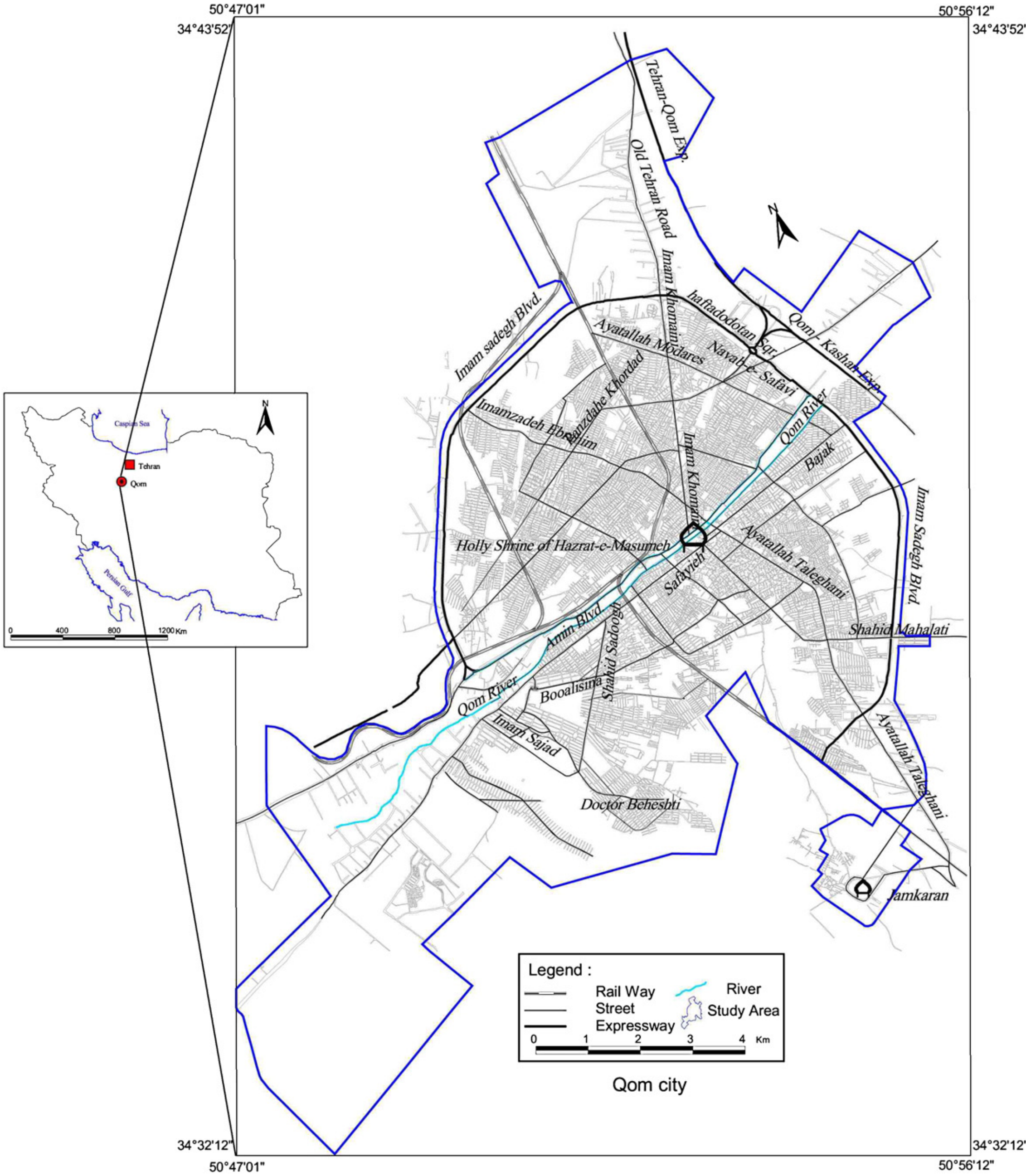

Fig. 1. Location of Qom and study area limits.

aspects of the program were divided into two parts: site effects estimation and geotechnical hazards evaluation. This paper presents the major results obtained during the site effect microzonation study.

2. Methodology

The methodology of site effect microzonation adopted in this study falls into the category of Grade-3 zoning methods of the Japanese TC4 Zoning Manual (1999). After dividing the city into a grid of 1×1 km^2, the following steps were taken:

- Preparation of a seismic hazard map of the study area for a return period of 475 years;
- Gathering and investigation of the existent geological, geotechnical and geophysical data of the study area, including field observations and aerial photo studies;
- Conducting complementary geophysical investigation, as well as microtremor measurements, throughout the study area;
- Preparation of representative geotechnical profiles of the city based on the geological, geotechnical, geophysical and microtremor data;
- Estimation of strong ground motion characteristics using one-dimensional site response analysis of the representative geotechnical profiles;
- Preparation of the final site periods and peak ground acceleration (PGA) maps of the study area in the Geography Information System (GIS) media.