Seismotectonic characteristics of dam construction in Makran subduction zone; case study of Taradan dam

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Abstract

Investigation of seismotectonic aspects of Taradan dam site in Makran subduction zone shows that regional tectonics has a key role in the stability of dam site in the region. Makran is an accretionary wedge with unique structural properties important in dam site selection. Tradan dam site is located in Sistan and Baluchestan Province and north of Chabahar city. Here, a brief presentation of the studies is given to show the key role of Makran tectonics in evaluating seismic parameters. The tectonic zone embracing the site is an E-W fold belt extending from Oman Line (Minab fault) in the west to Oman Sea to the east. Particular structural features of the zone made it necessary to study seismotectonic aspects of the area in detail. The E-W trend of the folds indicates a northward direction of shortening so that most of the lithostratigraphic units show thrust contacts. The most frequent faults in the study area are genetically of the types say, longitudinal faults with north to northeast dip direction and conjugate faults with NW-SE or NE-SW trends with right-lateral or left lateral displacement, respectively. The study includes identification of most important seismic sources, review of seismological history, analysis fault hazard and finally determination of maximum strong motion values for different levels in dam construction procedure. Accordingly, Ghasr-e Ghand fault is the most hazardous fault in the vicinity which can produce a 7.4 magnitude event in a 475y return period. Historical and instrumental data show that the nearest earthquake event to the dam site had a 4.7 magnitude at a distance of 40km and the largest one had a magnitude of 6.5 at 167km distance. Based on the calculations, the maximum acceleration of strong motion for MCL design level is 0.71g. Finally, an earthquake with a magnitude of 6.1 to 6.7 can at least occur one time during life time of the dam that is 50 to 100y in 200 km radius from the site.

Key words: *Makran zone, Seismicity, Taradan dam, Geologic structure*

1.Introduction

Makran subduction zone is an accretionary prism which is known as an important division of the Iranian Playeau based on its tectono-sedimentary characteristics [1]. The zone is composed of E-W trending mountains which extend from the Oman Sea margins to Jazmurian Depression and its western boundary is separated from Zagros Collision zone by Oman Line (Minab Fault). Its complicated structural features resulted in dam construction projects to be much more sensitive in view point of engineering geology and seismotectonics. Here, a brief presentation of seismotectonic studies of Tradan dam site in Sistan and Baluchestan Province and north of Chabahar city, as part of the Makran zone is given to recognize its seismotectonic features and their subsequent effects on the engineering

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properties of the dam [2]. The attitude of the study area is 60º 26′ 27.6″ and 25º 47′ 9.4″ (Figs.1,2) In this regard, seismic parameters of the dam site have been estimated through seismotectonic investigation and risk analysis in an area of 200 km around the dam site.

2. Geology and regional tectonics

The Makran continental margin of Iran in the Gulf of Oman forms the seaward margin of a folded and faulted accretionary sediment and colored mélange wedge which extends several hundred kilometers inland. There are three important geologic features in southeastern Iran: (i) the Makran accretionary prism; (ii) the Jaz Murian depression, which is located at the southern end of the Lut Block north the Makran accretionary prism; and (iii) a zone of Cenozoic volcanic and plutonic rocks of andesitic to rhyolitic composition [3]. To the west of the Jaz Murian depression is the Oman Line which is a zone of north–south trending faults which separates the deep ocean sediments of the Makran from the platform deposits of the Zagros. The geology of the Iranian Makran region was divided into eight geotectonic provinces, including a zone of colored melange and the inner Makran spreading zone, which is a zone of rifting occupied by largely deformed ophiolites. Makran mountains manifest as an accretionary prism due to an old geosuture and lie on the hanging wall of a shallow dip and low depth subdction zone [4]. Its geomorphology is closely related to the existing structural pattern, folding intensity and lithofacies. Three physiographic units can bee recognized as: sea terraces parallel to the shore, northern sediments, and Makran highs. Genetic mechanism of faults in this zone is significant and two types of them can be found: a- conjugate convergent strike – slip faults, and b- reverse faults and syn-folding thrusts (Fig. 3). These structural features are very important in determining seismicity parameters and risk analysis of the dam site area [2].

3. Makran and dam site Seismotectonics

Seismic activity of Makran zone as a subduction zone is very weak due to its low dip of and placement of accretionary deposits within the sea water. Presence of water within the rock pores highly changes their behavior from brittle to ductile. However, occurrence of sea terraces and 9 geysers are indications of seismic activity in the region of which. Epicenters of Makran earthquakes are low in a distance of 70 km from the shoreline [5] but will be deeper with increasing distance so that it will reach an 80 km depth in the south of magmatic arc. The most important faults of the region are: Ghasre Ghand, Bam Posht, Beshagard, Pip, Lashar, Kahourak and Makran marginal fault. The trend of regional shortening is N-S as part of the Eurasia-Indian Ocean Collision [4]. According to previous studies, the direction of stress vector around the dam site is NE-SW to N-S [2].

4. Seismic Risk analysis of the dam site

Generally, two approaches are considered to analyse seismic potential around a dam site: deterministic and probabilistic approaches. To determine Maximum Credible Acceleration (MCA) of a region, the selected model should be as much as possible coincident with the geologic properties of the seismic sources. In the studied region, maximum values of magnitude have been estimated using different attenuation models [6]. To determine maximum horizontal and vertical accelerations as the most important seismic parameters,

three models were applied and their weighed average was selected to calculate the mentioned parameters.

5. Conclusion

1- According to the geological maps of the area, Ghasre Ghand fault is the nearest fault to the dam site which is capable to trigger a 7.4 earthquake in Richter scale.

2- Review of historical and instrumental events in the region, indicated that 1991 event with a distance of 40 km was the nearest event to the site with a magnitude of 4.8 in Richter scale. The largest instrumental event in the area was 1929 earthquake of 6.5 magnitude in Richter at 167 km distance.

3- It is expected that during life time of the dam structure that is between 50 to 100 years, an earthquake of 6.1 to 6.5 Richter magnitude could happen in an area with 200 km radius around the site.

6-References

1-Falcon, N. L. Southern Iran – Zagros Mountains, in Spencer, A. M., editor, Mesozoic Cenozoic orogenic belts: London, Geological Society Special Publication 4, p.199– 211, 1974.

2-Dez Ab Conslting Eng. Co. Seismicity Seismotectonics report, Phase 1 studies of Taradan Dam, 2009.

3-Farhoudi, G., Karig, D. Makran of Iran and Pakistan as an active arc system. Geology 5, pp. 664– 668, 1977.

4-Berberian ,M. and Killg, G..C..P., Toward a paleogeography and tectonic evolution of Iran. Can. J. Earth. Sci., 18, 210 – 265, .(1981).

5-Jackson, J. A. and D. P. Mckenzie Active tectonics of the Alpian-Himalayan belt between Western Turkey and Pakistan. Geophys. R. Astr. Soc. London, 77, 185-264, (1984).

6-Campbell,K.W. and Bozorgnia, Y, Update Ground Motion (Attenuation) Relations for the Horizontal and Vertical components of peak Ground Acceleration and Acceleration Response Spectra, (2003).

7-Zare, M., and Bard, P. Y., Genie parasismique et response dimming des our rage: Attenution des movement, forts en Iran, (1999).

Figure1. Location of the study area (blue circle) in the south of Iran

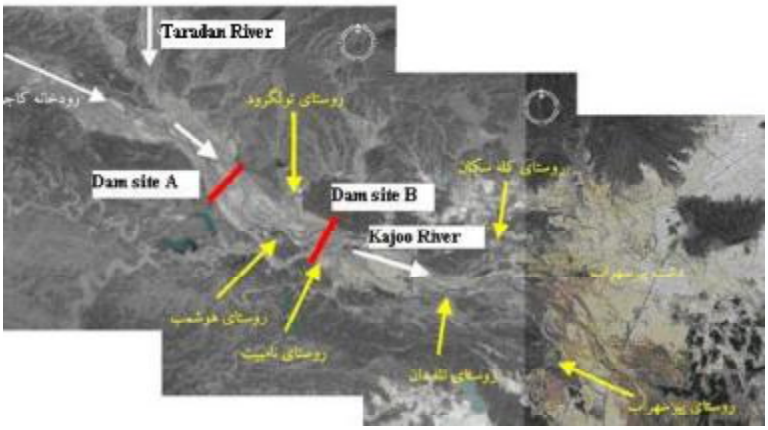

Figure2. Satellite image of the proposed dam sites.

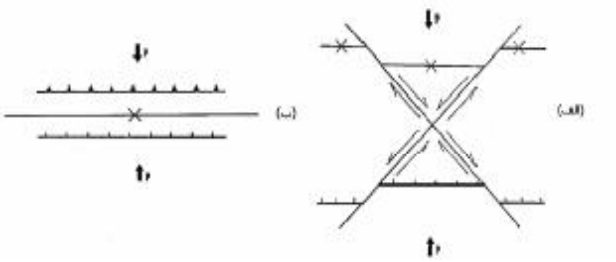

Figure3. Main fault systems of the study area.

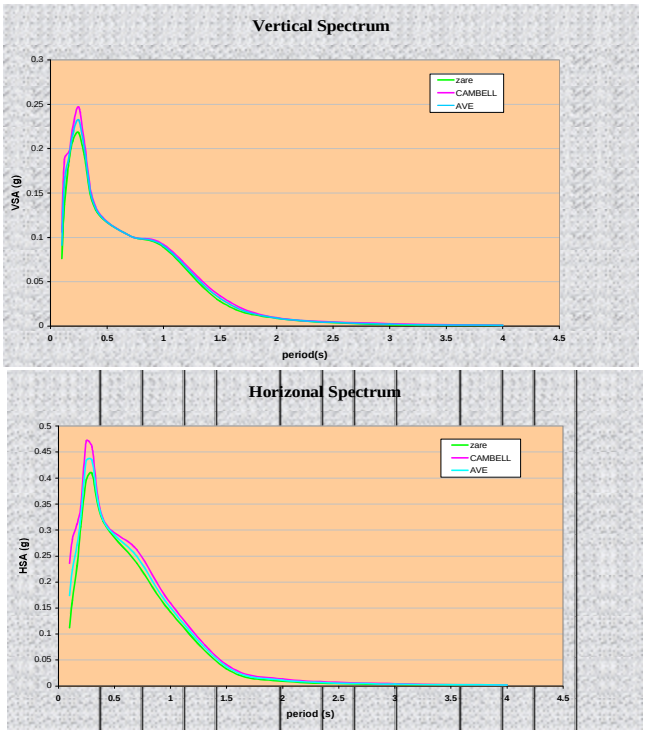

Figure4. Spectral response graph for vertical (upper) and horizontal (lower) components of acceleration using Campbell [6] and Zare [7] relations.