Paper No. 1947. (quote when citing this article)
Eleventh World Conference on Earthquake Engineering
ISBN: 0 08 042822 3

PRELIMINARY RECONNAISSANCE REPORT ON THE 22 NOVEMBER, 1995 GULF OF AQABA EARTHQUAKE (SAUDI ARABIAN SIDE)

M.S. Al-Haddad*, M.A. Al-Dail**, A.M. Al-Amri*
* King Saud University, P.O. Box 800, Riyadh, Saudi Arabia 11421
** King Abdulaziz City for Science and Technology, Riyadh, Saudi Arabia 11442

ABSTRACT

On Nov. 22nd, 1995, a swarm of earthquakes began in the northern portion of the Gulf of Aqaba with a maximum magnitude of M_D = 5.8 and focal depth < 10 km causing damage to some buildings and houses. According to official report, the deaths are 2 and the wounded are 29 persons. During the next 40 days of activity, more than 8000 after shocks were recorded. Nearly all of events occurred north of latitude 29°, close to the eastern bank of the Gulf of Aqaba. Information compiled on effects of the earthquake is reported. Observations related to damage and secondary geological effects are exhibited by photos and preliminary assessment of the intensity distribution is made. The intensive damage and total collapse were observed in engineered buildings rather than in non-engineered ones, and that may be attributed to random problems of construction and soil. The most intensive damage occurred in government structures in Ad Durrah customhouse neighboring Jordan. Three wide space reinforced concrete sheds were totally destroyed, a precast slab of wide-span was partially collapsed, and columns of three large warehouses were severely damaged. The important lesson learned from this earthquake is that, effective measures to reduce the seismic vulnerability at the Gulf of Aqaba region must be urgently undertaken.

KEYWORDS

Reconnaissance, Gulf of Aqaba; Modified Mercalli Intensity, Satellite, Precast Concrete, Bearing Walls; Foundation, Soil; Acceleration

INTRODUCTION

The November 22, 1995, Gulf of Aqaba earthquake (M_D = 5.8) was the latest in the long historical evidences of several significant earthquakes occurred in the area in the past (i.e. 1068, 1588, 1927). This earthquake was scientifically of particular interest because it was the first known earthquake related to surface ruptures along the Southern Dead Sea transform. In addition, it followed by a long series of after shocks recorded more than 8000 events ($1.5 \leq M_D \leq 5.8$). This moderate-size earthquake was a tragic demonstration of the warning that has been revealed by several studies conducted on the seismic hazard in the region. Probabilistic seismic hazard estimates for Gulf of Aqaba region have been reported by several studies conducted in Saudi Arabia (Al-Haddad et al. 1990, 1992, 1994, Thenhaus et al. 1986). The region is classified as the most seismic active area in Saudi Arabia. Peak ground acceleration (PGA) predicted for 10% probability of being exceeded in 50 and 100 years are about 0.20 g and 0.30 g, respectively. A live demonstration of the earthquake potential in the region was also revealed by the relatively recent swarms of earthquakes in 1984 (M_L = 4.8), and 1993 (M_D = 5.5) which have been felt by the residents of the region. However, the 1995 earthquake was an unique experience for them. This earthquake is the only damaging one has ever occurred in the last few centuries in Saudi Arabia.

Field investigation conducted immediately following damaging earthquakes offers an opportunity to recommend measures that can be taken to reduce risk in future earthquakes. On the same day of the earthquake, King Abdulaziz City for Science and Technology (KACST), being the authorized agency on this matter, sent two teams to the epicentral area; one, was for reconnaissance surveying and the other for monitoring aftershocks.

This paper presents only, observations made on secondary geological and geotechnical effects of the earthquake, and observations related to damage.

INTENSITY DISTRIBUTION IN THE INVESTIGATION AREA

The reconnaissance team started the investigation in Tabuk, the main city in the northernwest region of Saudi Arabia (Tabuk province). Tabuk city is located about 240 km. from the epicenter of the earthquake and has a population of 292,000. The earthquake made people in Tabuk woke up and run from their beds, but no damage at all occurred in the city.

The damage caused by the earthquake is localized in the sparsely and lightly populated coastal part of Tabuk province. Specifically, the affected areas (within 90 km from the epicenter) have population of 30,000 to 35,000. According to official report, the deaths are 2 and the wounded are 29 persons.

Figure 1 is a preliminary map of the Modified Mercalli Intensity (MMI) distribution of the earthquake. Areas of inspection are along the eastern coast of the Gulf of Aqaba as far south as Saudi-Jordanian borders, east, along Tabuk-Haql road, as far as Tabuk. The smoothed contours of the isoseismal map represent the highest predominant levels of (MMI) based on building damage and the secondary geological affects.

MMI (VII) effects were widespread in the coastal area of Tabuk province to approximately 90 km from the epicenter. The principal bases of this estimate were the widespread of rockfalls in the area fall of unbraced brick parapets, and severely cracking in infill walls of few reinforced concrete in newer three- and two-story reinforced concrete buildings. The considerable damage in columns of a main bridge, approximately 60 km east of the epicenter, also qualify for a site-specific MMI assessment of VII. Complete collapse of three reinforced concrete-framed sheds in Ad Durrah-customhouse, about 87 km from the epicenter, would qualify for a site-specific MMI of IX. This case was not considered in assessment of the intensity because it was considered an isolated case of collapse of a structure with engineering deficiencies.

Maximum MMI VIII effects were observed at the epicentral area (30 km from the epicenter). The bases of this assessment were, the widespread structural cracks in reinforced concrete-bearing walls of two-story dwellings, heavy rockfalls, and ground fractures, with up to 40 centimeter of opening.

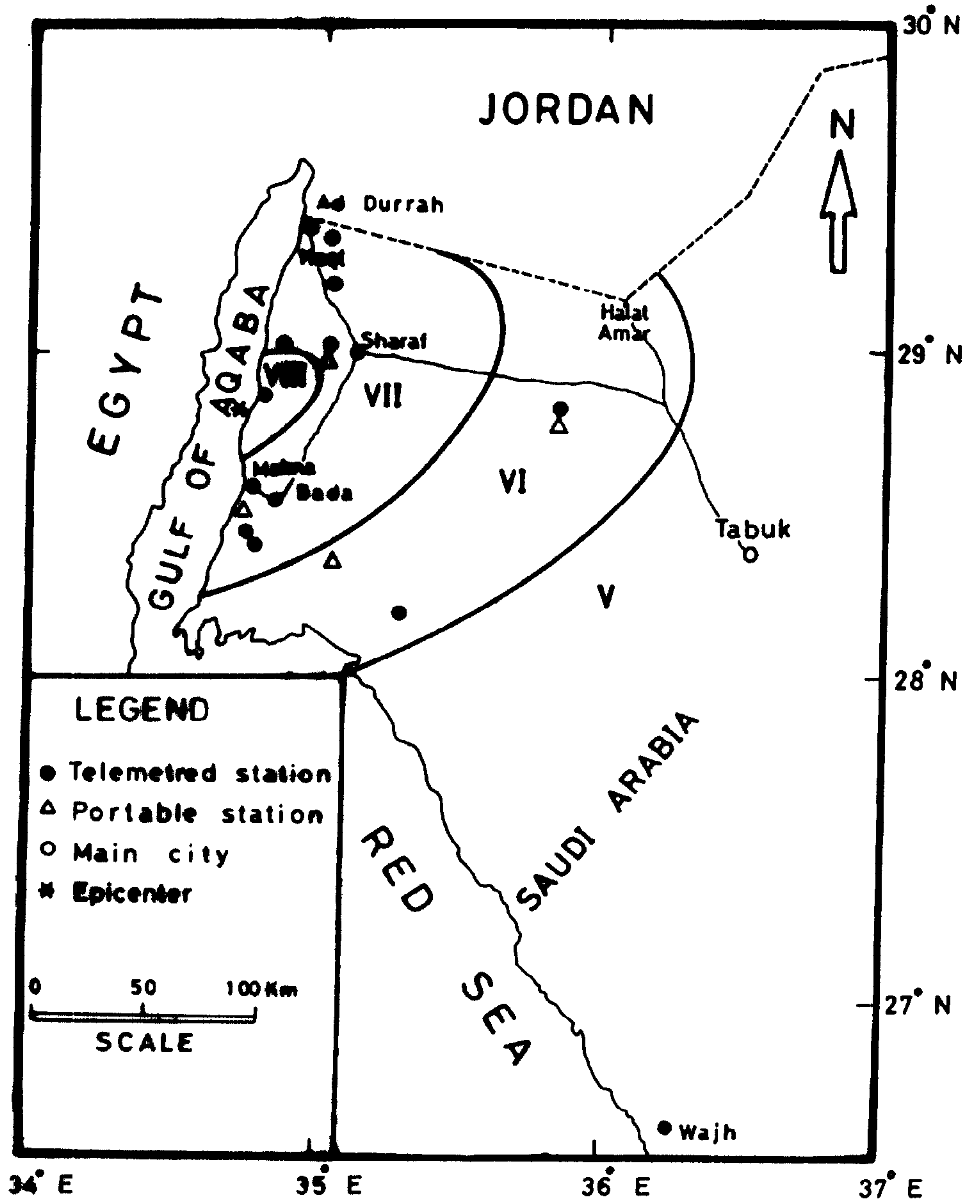

Fig. 1. Preliminary intensity distribution of the Nov. 22, 1995 Gulf of Aqaba Earthquake

GEOLOGICAL EFFECTS OF THE EARTHQUAKE

Geologic effects of the earthquake included widespread of rockfalls and ground fractures. This could be a source of great danger to the traffic on the local roads. Actually, one of the local main roads was blocked for a while by the fallen rocks. Also the concrete fence of a coast guard center was damaged by a big fallen rock in its way into the yard of the center. Fractures in wet ground surface were observed in different sparsely places in areas of inspection. The predominant fractures showed at most only few centimeters of opening. Few wider fractures of up to 40 cm opening were observed 30 km, east and NE from the epicenter. Figures 2 and 3 show examples of observations on geological effects.

Fig. 2. Typical ground fracture observed in the epicentral area

Fig. 3. Fence wall of a coast guard center damaged by fallen rocks

OBSERVATIONS RELATED TO DAMAGE

As mentioned earlier the affected area is lightly populated. As shown on map of Fig. 1, within 90 km from the epicenter, there are only sparsely few towns and villages, namely, Haql and Bada towns and Makna and Sharaf villages. The relatively biggest town in the area is Haql which has a population of about 18,000. Figure 4 is a French satellite (SPOT-2) panchromatic data showing Haql town. The image processing was made using the Meridian software at the Saudi Center for Remote Sensing at KACST. The majority type of buildings (more than 90%) are of typical two-story reinforced concrete-framed buildings, with unreinforced masonry infill walls. Except governmental ones, these buildings are with at most, if any, little engineering input. The other existing buildings are single-story masonry dwellings with either concrete or wood roofs, which were mainly constructed without legal permission.

Fig. 4. High pass filtered SPOT-2 Satellite data of Haql town
at a scale 1 : 112000

In addition, there are several two-story dwellings built of precast-bearing walls in governmental residential complexes in Haql and Makna. The only industrial facilities existing in the area are desalination plants and electricity power stations in Haql and Makna towns.

Damage can be best described by classifying them into two categories: typical damage and isolated damage of substantial structures with engineering deficiencies. Typical damage included widespread of slight to severe cracking in infill masonry walls of reinforced concrete-framed buildings and in bearing walls of masonry and precast buildings, and minor flexure and shear cracking in reinforced concrete beams and columns.

The extensive damage and total collapse observed in the area appear mainly from engineering deficiencies. Most of deficiencies that contributed in the extensive damage observed in isolated locations are exhibited in Figs. 5 to 8. Figure 5 shows serious typical fall of 8 cm thick heavy sand brick parapet in downtown of Haql which caused death of one person. Although several of this type of parapets had fallen, unbraced masonry parapets which are predominantly existing in the area remained intact. In addition to the obvious lack of lateral supporting, the damage in sand brick parapets appear mainly from their heavy weights.

Fig. 5. Sand brick parapets fallen in downtown of Haql

The most intensive damaged occurred in government structures in Ad Durrah customhouse neighboring Jordan. More specifically, three single story (45m long x 20m wide) reinforced concrete-framed sheds were totally destroyed, a precast shed of wide-span was partially collapsed, and columns of three large warehouses were severely damaged (Unrepairable). Damage in the precast shed shown in Fig. 6 can be obviously attributed to engineering deficiencies in the beam-column joints. The total collapse of the reinforced concrete sheds shown in Fig. 7 appear mainly from random problem encompassing one or more of the following:

(1) Poor concrete and detailing
(2) Heavy load of the shed which was built of 50 cm thick joist construction with permanent filler of concrete bricks.
(3) The foundation soil is loss fill. Great amplification of ground motion is expected at the area. Actually, the preliminary data obtained from the Jordanian strong motion network indicates that the level of the horizontal component of the PGA of the main shock (on rock) was about .05 g in city of Al-Aqaba which is located only 17 km from the site of the collapsed buildings.

In general, damage in bridges, roads, and life line system was minimal. Figure 8 show, the only case of damage observed in bridges. The bridge experienced severe cracking in the columns which can be attributed to poor concrete.

Fig. 6. Precast concrete shed partial collapsed in Ad Durrah customhouse

Fig. 7. Reinforced-concrete sheds completely collapsed in Ad Durrah customhouse

Fig. 8. Severe damage in columns of a main bridge

CONCLUSION

It was obviously observed that the intensive damage and total collapse were in engineered buildings rather than in non-engineered ones, and that can be attributable to random problems of construction and soil. The important lesson learned from this earthquake was not of scientific nature. Rather, it was the live demonstration of the potential for catastrophe in the Gulf of Aqaba region if the warning of this moderate-size earthquake is not heeded in the future development, planning, and earthquake preparedness. More important is that, the existing structures must survive more severe motions than those inflicted by this earthquake. Therefore, effective measures to reduce the seismic vulnerability at the Gulf of Aqaba region must be urgently undertaken.

REFERENCES

Al-Haddad, M.S., Al-Zaid, R.Z., Wazera, K., and Arafah, A., (1991), "Seismic Design Criteria for Buildings in Haql Region", Proceedings of the Third Saudi Engineering Conference, Nov. 24-27, 1991, Riyadh.

Al-Haddad, M.S., Siddiqi, G.H., Al-Zaid, R.Z., Arafah, A., Necioglu, A., and Turkelli, N., (1992), "Seismic Hazard and Design Criteria for Saudi Arabia", proceedings of the Tenth World Conference on Earthquake Engineering, July, 1992, Madrid, Spain.

Al-Haddad, M., Siddiqi, G.S., Al-Zaid, R., Arafah, A., Necioglu, A. and Turkelli, N., (1994), "A Basis for Evaluation of Seismic Hazard and Design Criteria for Saudi Arabia", Journal of Earthquake Engineering Research Institute, EERI, Spectra, Vol. 10, No. 2, May 1994, Oakland, California.

Thenhaus, P., Algermissen, S., Perkins, D., Hanson, S., and Diment, W., (1986), "Probabilistic Estimates of the Seismic Ground-Motion Hazards in Western Saudi Arabia", Deputy Ministry for Mineral Resources, Saudi Arabia, Open-File Report, USGS-OF-06-8.