PROPOSAL ON DISASTER MANAGEMENT PLAN OF SAUDI ARABIA BASED ON EARTHQUAKE DAMAGE ESTIMATION OF TABUK CITY

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Abstract

In this study, the earthquake damage in Tabuk city in Saudi Arabia, which is prone to earthquake disaster, has been estimated by using the RADIUS (Risk Assessment tool for Diagnosis of Urban Areas against Seismic Disaster) program regarding two proposed scenario earthquake, with magnitude 7.3 and magnitude 7.8 and the epicenter distance of about 190 km as same as Al-Aqaba Earthquake (magnitude 7.3) in 1995, which caused severe damage to the area. The result shows that the number of causalities will be approx. 1,460, injured 14,700, and that 49,800 buildings, 33 % of the total buildings, will be damaged because many old buildings lack seismic design. Based on the damage estimation, the earthquake damage scenario of Tabuk city has been also developed. Then, this study reviewed the government disaster management plans in Saudi Arabia, taking into consideration the result of damage estimation and damage scenario of the Tabuk city. In addition, the author made recommendations for the government. Saudi Arabia government needs to review the disaster management plans, and all the government authorities should be prepared for a potential earthquake in the near future.

Introduction

Saudi Arabia is an earthquake prone country, which has been hit by strong earthquakes in the past. As it will be also stricken by some major earthquakes in near future, Saudi Arabia should be prepared for such disasters and make every effort to reduce the probable damage. Hence, this study aims to review the government disaster management plans of Saudi Arabia, taking into consideration the damage estimation and the earthquake damage scenario of Tabuk city and make recommendations for the government to prepare for future probable disasters. The RADIUS program is used for damage estimation of Tabuk city.

Methodology

The RADIUS Tool is a computer program running on the widely available Excel. The user needs to input some basic information such as area and population by district, the number of buildings, building types and their distribution, ground conditions (soil type), lifeline facilities (optional). After the choice of a scenario earthquake and its parameters, the program then validates the input data and performs analysis. Figure 1 shows the general flow of earthquake damage estimation.

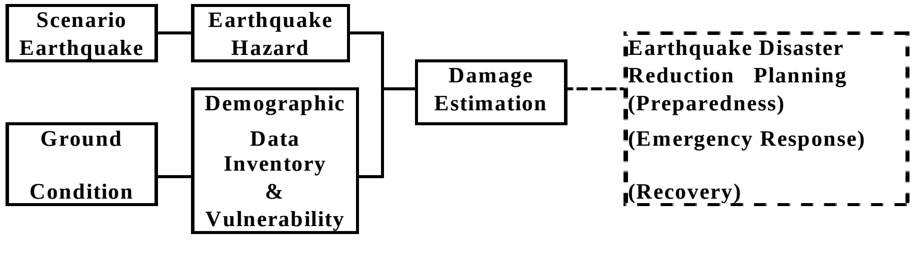

Figure 1. General flow of earthquake damage estimation (RADIUS program)

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RADIUS Application for TABUK City

Tabuk city is located in north west of Saudi Arabia. It was hit by Al- Aqaba Earthquake with magnitude 7.3 in 1995. The epicenter was about 190 km away from the city. Fortunately, damage was small as the city was a small city at that time. In the future, however, Tabuk city which is now a big city with population of approx. 280,000, will be seriously damaged by a big earthquake. The indication for future tells that the next one could be a devastating earthquake with magnitude of more than 7.5 and would hit Tabuk area.

However, among the decision makers and the government officers in Tabuk city, there is a pre-conceived idea that Tabuk is relatively safe with respect to earthquakes, which leads to flexible application of the rules. There is no focus on earthquake-related disasters in disaster management planning, since the earthquake-related disaster is considered in a limited way.

Copyright problem

Figure 2. Location of Tabuk city

City	Tabuk city
Location	Western North of KSA
Population	279,700
Longitude	26° 35′ 0″ E40
Latitude	28° 32′ 0″ N24.29.5°
Elevation	900 m
City Area	35,000 km^2
Annual temperature	0–15 C° in winter 27– 43 C° in summer

Table 2. Basic data of Tabuk city

Step 1: Basic Data Inventor
The total area of Tabuk city is (35,000 km^2) is divided into 283 meshes as the built-up area of the city is 283 km^2. Most of the remaining areas are farms and desert. Each mesh represents 1km x1km (1 km^2).

Step 2: Soil Amplification Setting
Soil condition of Tabuk city van be classified into 2 kinds of soil types. According to the available data, North and City Center are classified as "Medium soil" while the other areas are classified as "Unknown".

Code	Description
0	Unknown
1	Hard Rock
2	Soft Rock
3	Medium Soil
4	Soft Soil

Table 2. Soil type description

Step 3: Structure inventory setting
The buildings types of Tabuk city are classified as shown in Table 3. There are a number of houses very old and weak, made from mud and stone, but nobody lives there any longer. According to the RADIUS program, the buildings of Tabuk city are classified into 7 types of building, namely, RES2, RES3, RES4, EDU1, EDU2, MED1, and MED2 as shown in Table 4. "Buildings with steel frame and bricks" and "Brick buildings" are usually sub-standard construction with low quality building materials up to three stories. Therefore, they are categorized as RES2 in this study. "RC buildings" are usually 4-6 stories, not complying with the

local codes. Thus, they are categorized as RES 3. As "RC with steel buildings" are engineered buildings with high quality of materials, they are categorized as RES 4.

Buld. Loc.	Buld. Tape count	Steel Frame With brick concrete	RC	RC with Steel	Brick	EDU1	EDU2	MED1	MED2	Area Sq Km	Pop
(5) W	16360	4,348	3,804	2,536	5,481	120	11	13	11	55	100,000
(1)N	196,15	40,36	1,742	7,805	5,582	300	120	17	13	72	41,000
(3)C	52195	15,514	2,996	29,959	3,073	450	160	19	14	85	85,000
(2)E	38219	7,889	15,144	4,567	10,380	170	45	13	11	32	32,700
(4)S	25316	5,902	6,581	2,529	10,109	125	37	12	11	39	21,000
Total	151705	37689	30,267	47396	34,625	1165	373	74	60	283	279,700

Table 3. Building types of Tabuk city

Area ID	Area Name	RES1 (%)	RES2 (%)	RES3 (%)	RES4 (%)	EDU1 (%)	EDU2 (%)	MED1 (%)	MED2 (%)	COM (%)	IND (%)	Sum (%)
1	west	0.00	59.00	26.00	10.00	1.70	0.12	0.10	0.08	3.00	0.00	100.00
2	north	0.00	49.00	38.00	10.00	1.60	0.60	0.20	0.40	0.20	0.00	100.00
3	ty cent	0.00	36.00	54.00	6.00	0.80	0.13	0.04	0.03	3.00	0.00	100.00
4	east	0.00	45.00	12.00	40.00	0.50	0.20	0.20	0.10	2.00	0.00	100.00
5	south	0.00	62.00	10.00	26.00	0.10	0.07	0.09	0.04	1.70	0.00	100.00

Table4. Building inventory by area

Step 4: Arranging population distribution

Out of the total of population of 279,700, 36% live in West district, 30% in City Center, 15% in North district, 12 % in East district, and 7% in South district. Mesh weight is given to each district according to the population density.

Step 5: Defining Scenario Earthquake

Al-Aqaba Earthquake with magnitude 7.3 in 1995 is taken as the scenario earthquake. The other scenario earthquake is the same one but with magnitude 7.8. The time of occurrence is AM 12:00 noon.

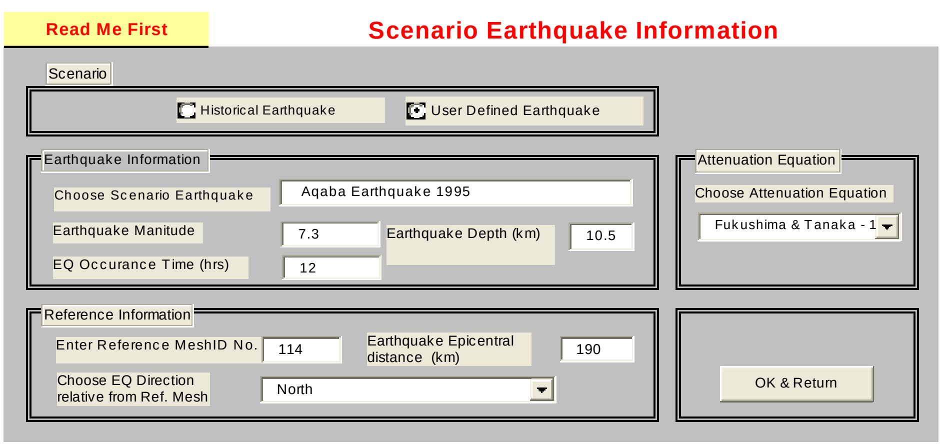

Figure 3. Setting of a scenario earthquake

Step 6: Calculation of base rock motion and surface motion and converted into PGA, and converted into MMI.

MMI distribution in the case of magnitude 7.3 is shown in Table 5. .

Average MMI is 8.58

Sr.No	AreaID	Area Name	Average Distance	Average PGA (g)	Average MMI
1	1	west	13.3	0.4	8.7
2	2	north	11.7	0.4	8.7
3	3	city center	13.2	0.4	8.7
4	4	east	14.7	0.4	8.6
5	5	south	17.9	0.4	8.6
Average Information			13.6	0.4	8.6

Table 4. Average MMI

Step 7: Calculate damage to building and infrastructure/ lifeline facilities

In the case of magnitude 7.3, approximately 34% percent of total buildings will be damaged as shown in Table 5. The total buildings count is 151,705 and the number of building damaged is 52,200. In Figure 5, the large damage is seen in West of the city with red color and the next large damage with yellow color, and the lowest damage with green color.

The total building count are 151705 and 34% damaged

No	Area ID	Area Name	Bldg Counts	Damaged Counts	MDR (%)
1	1	west	47332	16037	33.9
2	2	north	21542	7919	36.8
3	3	center	51580	20069	38.9
4	4	east	18811	4848	25.8
5	5	south	12440	3309	26.6
Summary Information			151705	52182	34.4

Table 5. Summary information of building damage

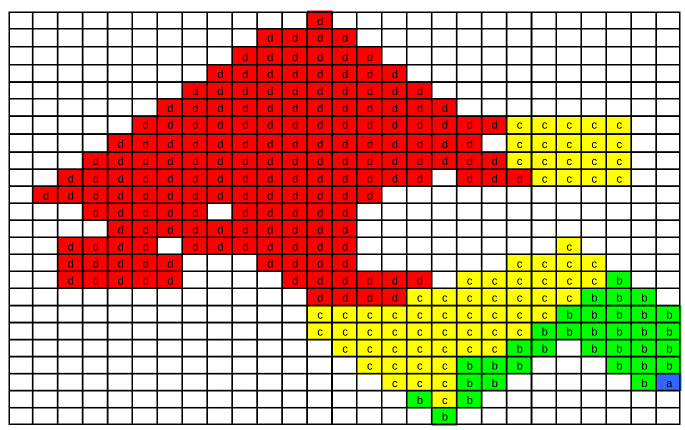

Figure 5. Building damage distributions map

Step 8: Casualties

About 14,700 people, 6% of the total population will be injured and about 1,460 people will be killed as shown in Table 6. Most of injuries and death concentrated in the west and city center of Tabuk city.

279700 and 5.2% will be injured 5.2%injuried

Area ID	Area Name	Day Pop Counts	Night Pop Counts	Death	Injury
1	west	44585	71442	426	4023
2	north	23149	37309	240	2369
3	city center	52940	92130	588	6079
4	east	28653	53069	138	1509
5	south	13600	25750	68	720
Summary Information		162928	279700	1460	14700

Table6. Summary of number of casualties

Step 9: Summarize Results
Two scenarios were chosen, the first is 7.3 and the second is 7.8. The summary of the damage in the two cases are shown in Table 7.

Scenario	Total buildings	Total population	Buildings damage	Death	Injuries
Scenario (1) Magnitude 7.3	151,705	279,700	52,182 34 %	1,460 0.52 %	14,700 5.2%
Scenario (2) Magnitude 7.8	151,705	279,700	57,625 38 %	1,847 0.66 %	17,165 6.1 %

Table 9 Summary results of two earthquake scenarios

Earthquake Scenario

The Earthquake Event Scenario outlines the direct effects that would occur if the Al-Aqaba Earthquake would hit Tabuk city. The scenario intends to identify the weak points of disaster management of Tabuk city. The scenario was developed based on the results of the RADIUS application, my own experiences as the responsible person for disaster management in Saudi Arabia, and my own imagination. Needless to say different earthquakes will provide a different pattern of damage and influences.

Problems in Disaster Management in Tabuk City

Building Damages: Around 34% of the total buildings will be heavily damaged..
Casualties: Most of the death toll (1,460) will result from the collapse of houses..
Fire, Blockage and Debris: Most of fires will not spread due to the primarily inflammable materials in side buildings.
Medical Care and Hospitals: Serious injuries will require hospital care, and the other injuries will be treated on site. There will be limited resources of doctors, nurses, medicines.
Homeless, Refugees, Shelters: Most of affected people will be left homeless and they will gather in shelters or open spaces, searching for their families and relatives.
Education and schools: Many public schools will be damaged, because their buildings are poorly constructed and vulnerable. Most of children will be affected. Many remaining schools will be used as shelters for a long time.
Infrastructure (Roads, Bridges and Airport): There will not be too many incidents of damage or cracks in highways and roads, except blockage by collapsed buildings in dense areas.
Water Supply and Sewage: Damages to water pipelines will affect most of the users in the city areas. All available water supply trucks will try to move among the dwellings to compensate for the loss of supplies from broken pipelines. In order to mitigate the damages from an earthquake and prepare for disaster management and emergency response, increasing the knowledge and disseminating information are important such as training and education for government staff, school students, and community. Also, social education by NGOs could be effective as knowledge of earthquake disaster would be disseminated through various seminars and trainings.

Recommendations

- No single ministry can handle effectively all aspects of managing earthquake risk or managing an earthquake disaster. All ministries, local governments, and other sectors of society must participate individually and collectively.
- Update of institutional system for disaster management in Saudi Arabia comprises major elements.
- Clear assignment of responsibilities to ministries, local governments, and other institutions.
- Creation and strengthening of sustainable mechanisms for cooperation
- Development and implementation of policies

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