DEAD SEA EARTHQUAKE OF 11 FEBRUARY 2004, ML 5.2: POST EARTHQUAKE DAMAGE ASSESSMENT IN THE WEST BANK, PALESTINE

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ABSTRACT: The 11 February 2004 earthquake (ML 5.2) with an epicenter in the northeastern part of the Dead Sea basin (at latitude 31.679 N, longitudes 35.585 E with a focal depth of 17 km) caused slight damage to several regions in the West Bank, Palestine. The earthquake was felt in the Palestinian cities: Jericho, Hebron, Nablus, Ramallah, Bethlehem and Jerusalem but no life loss was reported. Moreover, few smaller earthquakes followed the Earthquake of 11 February 2004 at different locations and times of the same year 2004: 7 July ML 4.8 (Lat 31.97 Long 35.55), 20 July ML 3.6 (32.46, 35.25), 2 December ML 2.8 (32.25, 35.37). They mainly felt in the northern part of West Bank especially in Nablus City, although they are not closed to Nablus but because of some site effects factors (geological formations, structures etc.). Based on post-earthquake investigations, many reinforced concrete buildings in Palestine suffered slight non-structural damages (damage grade 1 according to European Macro seismic scale 1998 "EMS-1998"), such as hair-line cracks in very few walls, specially over frame members or in walls at the base and fine cracks in partition walls. Three old schools suffered moderate structural damages and substantial non-structural damages (damage grade 3). The Earthquake affected also many old masonry buildings in the Palestinian old cities (Jerusalem, Nablus, Hebron, Bethlehem, ….etc), in Nablus city few historical buildings have been affected with damages between grade 2 to grade 4. The damages that had been occurred had usually been at zone of pre-existing weakness. In the light of the post-earthquake investigations the effected masonry and old masonry buildings suffered with many kinds of damages, such as: crack patterns in masonry pillars, slippage between the block, corner detachment, a flat vault's collapse, detachment between few perpendicular walls (in a corner) and crushing in masonry pillars.

INTRODUCTION

Studies of historical earthquakes for the past few hundreds years (Figure 1) demonstrate that the damaging earthquakes were located along the Dead Sea Transform fault[1-9, 26]. The largest destructive recorded earthquake (Nablus Earthquake) occurred on 11 July 1927 north Jericho at the boundary between the Arabian and the Sinai plates and had a magnitude of about 6.3 (Figure 1). The Dead Sea Transform (DST) extends from Gulf of Aqaba in the northern part of the Red Sea to the Alpine convergence zone in the Taurus Mountains, where the Arabian plate separates from the Africa plate[10, 11], a distance of some 1000 km. It forms the boundary between the Arabian plate and the Sinai Palestine sub-plate[12]. This tectonic system formed while plate convergence was continuing along the Alpine organic belt. Studies of instrumental earthquakes, on the other hand, reflects also the on going seismic activity of the Dead Sea Transform (DST)[13-15].

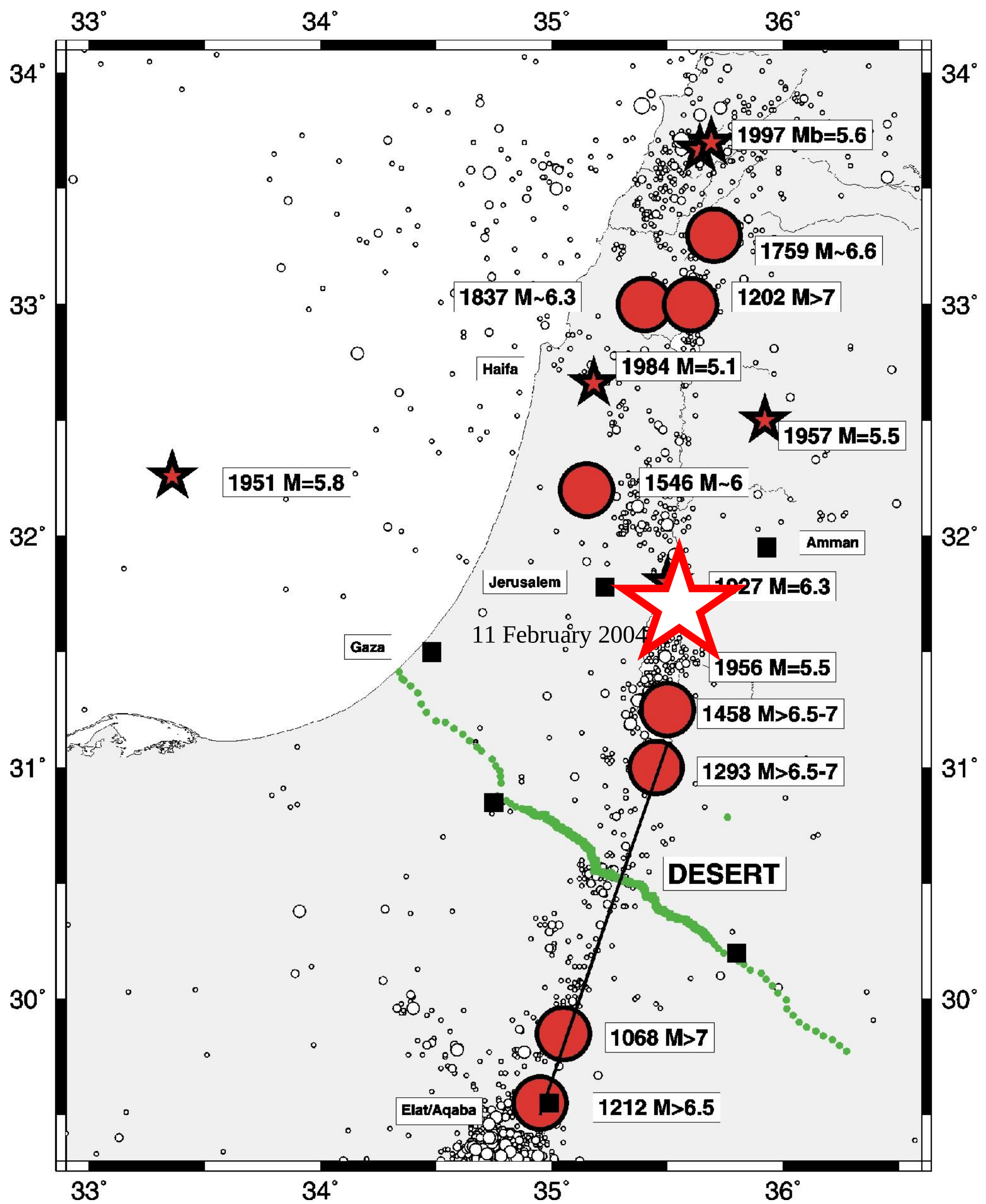

Figure 1. Seismicity map of the Dead Sea transform region[9, 15, 26] for the period 1000-2004. Also shown is the earthquake of 11 February 2004.

Despite the serious consequence that might arise from such major earthquakes, the possibility of related disasters may have disappeared from the mind of people, and anti-seismic design principles in civil engineering are not always properly considered, knowledge of the further earthquake potential of a region is essential to, e.g., planners, decision makers civil engineers and insurance industry. Based on seismic Hazard maps of various levels of excellence probabilities, measures of earthquake resistance can be taken for different kinds of structures having different risk potential. On the other hand, overall estimates are essential to assess the appropriate hazard level of certain earthquake scenarios

The level of damage is related to the building structural type, building materials and the intensity of the actions, usually the partial or total collapse of a building may be caused by substantial structural deficiencies or particularly strong actions. An examination of different types of damage is very important, since formation, crack patterns, etc, are related to structural behavior and to the actions that cause it.

Every community must choose whether to invest in risk reduction actions before the disaster strikes or to wait and pay the consequences, which could include high costs of recovery and reconstruction after the disaster strikes. Therefore, the implementation strategies of risk reduction program should have three basic objectives[16, 18]stop increasing the risk for new construction; start decreasing the unacceptable risk for existing structures; and continue preparing for the consequences of inevitable earthquake.

PROBLEM STATEMENT

The problems relating to earthquakes in the Palestinian Territories can be summarized, but not limited, to the following:

(1) High vulnerability to earthquake damages and losses, as a direct result of high percentage of weak buildings that do not comply with seismic resistance requirements. This situation was created by the following major factors:

(a) Bad construction practices and common fatal design mistakes of the buildings (soft story, short column, etc…).
(b) Lack of a national code for seismic design and construction;
(c) Absence of national legislative laws and regulations for protection against earthquakes; and
(d) Absence of effective mechanisms for control of application (design and construction) and enforcement of regulations.

(2) Lack of national programs and public policies on preparedness, mitigation, and emergency response.
(3) Weak institutional capacity in disaster management and rescue operations.
(4) Lack of awareness by citizens, and weak capacity of professionals, engineers, and decision makers.

POST DISASTER DAMAGE ASSESSMENT

Damage resulting from several actions has generally been highly variable. Moreover, building performance depends on many factors. In addition to variations in the action intensities, the individual characteristics of structures, even of the same age and designed will have a primary effect on damage levels. Combination of structural materials, structural systems, and architectural design create variety of building; as well as variety of damage observed[19-23].

Classification of Damage

In order to assess the field investigation of damages it is necessary to define several standardized damage grades. The classification of damage grades for reinforced concrete, masonry and old masonry buildings according to European Macro seismic scale (EMS-98)[17] are shown in the appendix.

Field Investigation

To investigate the earthquake intensity, a special questionnaire was distributed. Hundreds of people filled the questionnaire among them people who were indoor and people who were outdoor when the earthquake occurred (at 08:15:03 GMT). People have been asked many questions such as: what did you feel? 94% felt some sorts of vibration, 23% described it as strong, 11% described it as weak, 6% felt no shaking; were you frightened or alarmed? 82% said they were, 12% said they were not. Many people said they ran outdoors- commentary: the intensity looks to be in the range 5-7.

In addition to the above mentioned questions, the questionnaire also included more questions:
How many floor in the building? Did doors or windows rattle? Did any hanging objectives swing? Did any thing fall over or upset? Was there any damage? What is (if known) the type of soil and building structural systems?

Taking into consideration the variety of answers to questionnaire, the earthquake intensities felt at the Palestinian cities were as follows: Hebron city (v-vi); Jenin and Tulkarem (v); Gaza strip (iv-v); Nablus (vi-vii); Jericho, Jerusalem, Ramallah and Bethlehem cities (vi)

Based on post-earthquake investigations, the occurred damages can be classified according to the building types to the following:

Many reinforced concrete buildings in Palestine suffered slight non-structural damages (damage grade 1) according to European seismic scale 1998 (EMS-1998), such as: hair-line cracks in very few walls, especially over frame members or in walls, at the base; fine cracks in partitions and in fills.

Figure 2. Reinforced Concrete Buildings (Aqraba School).

Three old schools suffered moderate to substantial damage: slight to moderate structural damage and moderate non-structural damage (damage grade 3), see figure 2.

Also the Earthquake affected many old masonry buildings in the Palestinian old cities (Jerusalem, Nablus, Hebron, Bethlehem,….. etc), these buildings include hospitals schools and other public buildings (see figures 2 and 3) in Nablus city only few historical buildings have been affected with damages between grade 2 to grade 4: nine old masonry buildings suffered damages grade 2; four old masonry buildings suffered damages grade 3; two buildings (masonry and old masonry buildings) suffered very heavy damage (grade 4).

Figure 3. Masonry Building (5 floors), crack patterns in masonry pillars and expulsion of blocks.

The damages that had been occurred had usually been at zone of pre-existing weakness, in the light of the post-earthquake investigations the effected masonry and old masonry buildings suffered with the following damages: crack patterns in masonry pillars; slippage between the blocks; expulsion of blocks in poor mortar stone masonry; large permanent deformation (due to the seismic action); corner detachment; a flat vault's collapse; detachment between few perpendicular walls (in a corner); and crushing in masonry pillars.

CONCLUSIONS

In conclusion we may say that the different intensities of the earthquake, felt in the Palestinian regions, and the various level of damaging at the urban areas reveal a few aspects about the structural design of the buildings and the geological features:

(1) The effect of the local geological conditions on seismic signals was observed from the site response at different locations in Nablus city. Where in the southern and northern mountains, consist of consolidated carbonates bedrock, slight damage grade was reported in comparison with quite larger damage grade were observed at the eastern and western rims of the city and the downtown built on soft clay, marl and wadi deposits where the thickness of fluvial deposits and soft formations is more than 10 m[23, 24].

(2) The obvious difference of intensity grades felt in the Palestinian regions and the differences in damaging levels at the urban areas could be attributed to variations in

the thickness and physical properties of Tertiary-Cretaceous sediments, which appear to be rather hetero- geneous in the lithology[23].

(3) The observations and analysis of questionnaire indicates that, geographically, in Nablus City the people felt the earthquake stronger than the other Palestinian regions, where one puts a (?): which are the related seismic active fault segments (branching faults of the Carmel-Wadi Al Far'a fault system(?)) and what is the corresponding stress pattern(?)[15] plays a role in Nablus region.

(4) The field investigations showed that the damages have been at zone of pre-existing weakness, and many existing buildings, among the new and old ones, have high vulnerability to earthquake damages and losses.

(5) Taking into consideration the seismic vulnerability of the common buildings (reinforced concrete, masonry and old masonry), very heavy structural and non structural damages are expected under the influence of moderate-strong (M 6-7) earthquakes in the future.

As the above mentioned conclusions and observations, a national strategic program should be adopted in seismic risk mitigation. The main strategy in this regard should concentrate on public awareness through local media, workshops, training courses and conferences. Based on this fact, and through the Earth Sciences and Seismic Engineering Center at An-Najah National University, the authors managed to aware and talk with different members and groups of the Palestinian society including citizens, professionals and decision makers, and they also conducted several research projects for reducing the earthquake losses in the Palestinian territories.

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APPENDICES:

Classification of damage

The classification of damage grades for both reinforced concrete, masonry and old masonry buildings according to European Macro seismic scale (EMS-98) [17] are:

Grade 1: Negligible to slight damage (no structural damage, slight non-structural damage): Hair-line cracks in very few walls; fall of small pieces of plaster only, fall of loose stones from upper part of buildings in very few cases. In reinforced concrete buildings: Fine cracks in plaster over frame members or in walls the base; Fine cracks in partitions and infill.

Grade 2: Moderate damage (slight structural damage, moderate non-structural damage): Fall of fairly large pieces of plaster; cracks in many walls; partial collapse of chimneys. In reinforced concrete buildings: cracks in columns and beams of frames and structural walls; cracks in partion and infill walls, fall of brittle cladding and plaster.

Grade 3: Substantial to heavy damage (moderate structural damage, heavy non-structural damage): Cracks in columns and beam column joints of frames at the base and at joints of coupled walls; spalling of concrete cover buckling of reinforced rods; large cracks in partition and infill walls, failure of individual infill panels. In the case of masonry and old masonry buildings: large and extensive cracks in most walls; roof tiles detach; chimneys fracture at the roof line; failure of individual non-structural elements (partitions, gable wall).

Grade 4 : Very heavy damage (heavy structural damage, very heavy non-structural damage): large cracks in structural elements with compression failure of concrete and fracture of reburies; bond failure of beam reinforced bars: tilting of columns; collapse of a few columns or a single upper floor. In the case of masonry and old masonry building: serious failure of walls; partial structural failure of roofs and floors.

Grade 5 : Destruction (very heavy structural damage): Total or near total collapse.