بسم الله الرحمن الرحيم

An-Najah National University
Urban Planning & Disaster
Risk Reduction Center

جامعة النجاح الوطنية
مركز التخطيط الحضري
والحد من مخاطر الكوارث

Assessment of Seismic Site Effect

(GEOPHYSICAL SEISMIC STUDY)

The Russian Business center for Sport and Art

(Plot Nr. 2, Basin Nr. 28095)

Deheisheh –Bethlehem

Final Report

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1. INTRODUCTION

1.1 Background

The site of the Russian Business center for Sport and Art is located in Bethlehem District in the southern part of West Bank (see Figure 1.1). The Urban Planning and Disaster Risk Reduction Center UPDRRC (Earth Sciences and Seismic Engineering Units ESSEU) at An Najah National University was approached by Geotechnical and Material Testing center (GMT) seeking to conduct a Geophysical Seismic Study for the Russian Business center for Sport and Art.

Figure 1.1: Geographic setting of the studied area in the West Bank

1.2 Problem Statement

Seismic information including historic and prehistoric data indicates that major destructive earthquakes have occurred along the Dead Sea Transform (DST). The DST is a left-lateral fault between the Arabia and the Sinai tectonic plates that stretches from the opening at the Red Sea to the Taurus-Zagrous collision zone. The estimated Moment Magnitude Scale (MMS) intensities of historical earthquakes in the Dead Sea region reach up to X, where the determinable magnitudes of the recorded earthquakes range between 1.0 and 7 on the local magnitude scale. These damaging earthquakes caused, in several cases, severe destruction and many hundreds and sometimes thousands of fatal casualties.

Generally, local site effects (landslides, liquefaction, amplification and faulting systems) play an important role in the intensity of earthquakes. Thus, Earthquake-resistant design of new structures and evaluating the seismic vulnerability of existing buildings take into account their response to site ground motions. Geophysical studies of seismic activity in Palestine, deep seismic sounding, paleoseismic excavation, and instrumental earthquake studies of half a century demonstrate that damaging earthquakes occurred along the Dead Sea Transform fault. The topography, geomorphology and geology of the West Bank have been the main reasons behind several sizeable landslides that occurred around ten years ago in different parts of the West Bank. Also, it has been shown that Palestine suffered from several landslides during historical earthquakes.

Based on the seismic peak ground acceleration map (PGA Map) for the region (Figure 1.2), the studied area is located in zone 2A and it is very close to zone 2B, so, it can be assumed that it is located in zone 2B. The seismic zone factor (Z) on the rock for the zone 2B is equal to 0.20. According to the Uniform Building Code (UBC97), International Building Code (IBC), Jordanian Building Code 2005 and Arab Uniform Code 2006, it can be considered as moderate seismic area.

1.3 The scope of Assessment of Seismic Site Effect (ASSE)

The UPDRR at An Najah national University was approached by the Geotechnical and Material Testing center (GMT) to conduct a geophysical seismic study at the Russian Business center for Sport and Art- Deheishe-Betlehem. This kind of studies provides engineering data and recommendation to mitigate the seismic site effect.

Based on the scope of services, field visit, data collection, data acquisition and data analysis, the geophysical seismic investigation under the contract should deliver a seismic report including the following tasks for the studied area:

1) Soil profiles.

2) Primary and shear wave velocities (V_p and V_s).

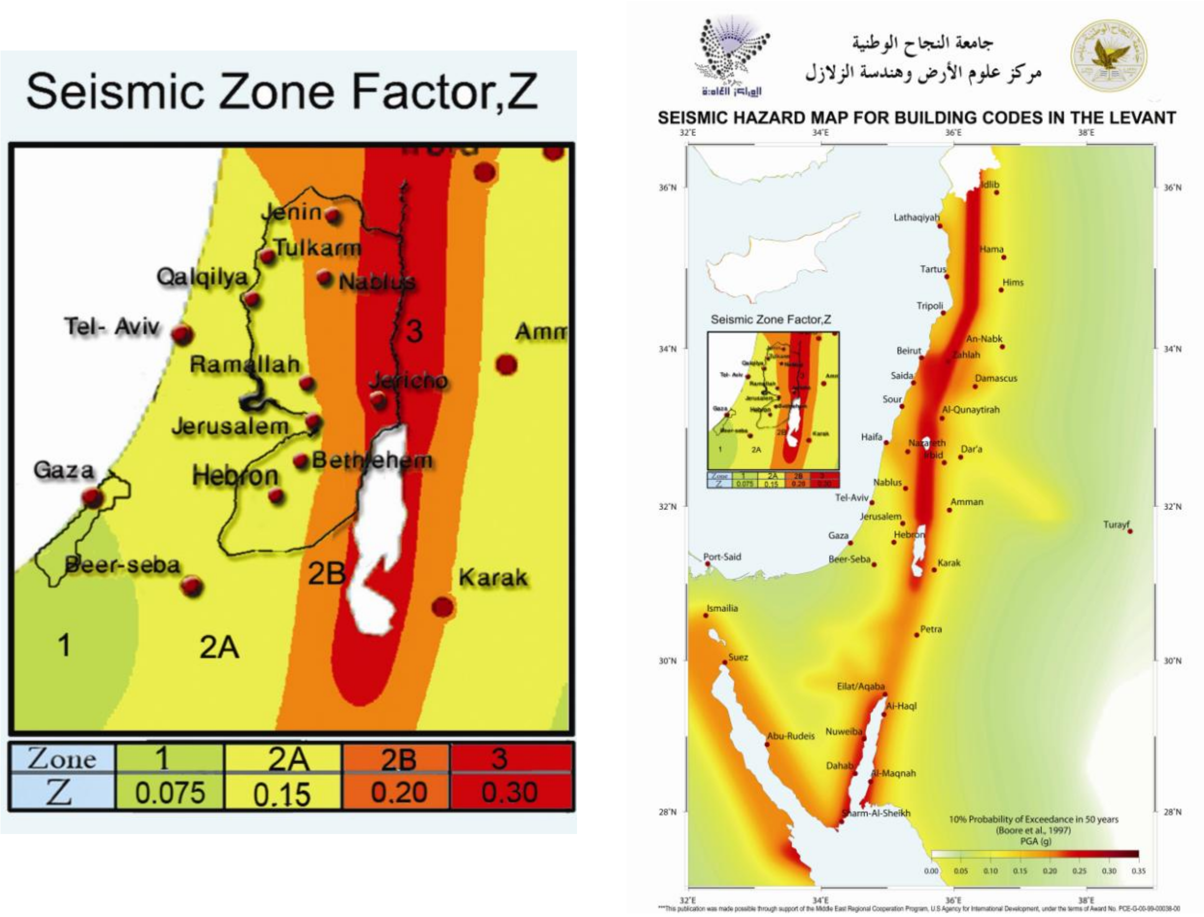

Figure 1.2: Seismic Hazard Map and Seismic Zone Factor (Source UPDRR)

2. GEOPHYSICAL SEISMIC STUDY: Site Investigations

2.1 Local Geology

Investigating the subsurface geology of a site is critical in order to select the kind of structure foundation design to use in a given area since sedimentary deposits are often the prime locations for the development of urban areas.

The exposed sequence of rocks in the studied area (Southern part of West Bank) mainly consists of chalky limestone and chalk, and it includes other sediments such as marl. The age of this formation is upper Cenomanian from the upper Cretaceous.

2.2 Cavities in Rock

A topic of concern in many projects involving rock excavation is whether or not there are undetected cavities below an apparently solid bedrock surface or whether cavities could develop after construction. These cavities may occur naturally in karst or pseudokarst terrains, may be induced by human interference in natural processes, or they may be totally due to man's activities. The term "cavities" is used since it covers all sizes and origins of underground openings of interest in rock excavations.

Geophysics may be of some use in initial site investigations in locating larger cavities but may also miss smaller ones. Remote sensing using air photos, infrared imagery, and side-looking radar are useful in determining trends of cavities and jointing in an area, as well as determining the structural geology features associated with rock salt exposures.

Since cavity occurrence is difficult to determine on a local scale, the only practical solution, after initial site studies, is to place a test boring at the location of each significant load-bearing member. Such an undertaking is costly, but represents the only reasonable approach in areas of high concern.

2.3 Methodology and Data Analysis

2.3.1 Geophysical experiment

The subsurface geology determined by seismic studies is extremely important for the development of highly populated, tectonically arid regions such as the Middle East. The shallow upper part (ten to hundred meters) of the rock formation section is the most significant part for civil infrastructures. The seismic refraction technique is considered an accurate geophysical method to investigate the shallow geological structures of an area. During the past decades, the seismic parameters obtained by a refraction survey have been widely used in cases of site investigation as indicators of rock mass quality. The main objective of the seismic refraction method is to estimate the first arrival velocities of P-waves, which are used to determine the depths of different layers and obtain the dynamic characteristics of rocks. These parameters are of great importance in land use management of various civil engineering purposes.

2.3.2 Detection of Seismic Waves

Seismic waves are generated usually by weight dropping, i.e. a sledge hammer. The seismic signals generated from the shot propagate in different direction; it is reflected, refracted, or diffracted. The different seismic signals can be recorded using a system of receivers (geophones) distributed in a profile in the direction of the shot point. In detecting direct and refracted waves a number of detectors are placed on the ground along a straight line passing through the shot point, this system is known as (In-line spread) and is widely used in most seismic refraction techniques.

For this study the system used was the Smart Seis Exploration seismograph model S/N 70253, manufactured by Geometric Europe (U.K). The detectors used in the present study have a natural frequency of 28 Hz each, the signal is amplified and the undesirable frequencies can be filtered out. These signals, after suitable amplification and filtering, are fed into a recording unit. The recording system contains 24 channels.

2.3.3 Data Acquisition and Analysis

The seismic refraction survey was conducted on 6 seismic profiles (see Figure. 2.1 for the location of the profiles and the photos in Appendix no.1). The distance between the two receivers (geophone interval) were 5 meters for the Line 1-1, 3 meters for the Lines 2-2, 5-5 and 6-6, and 2 meters for the lines 3-3 and 4-4. Many interpretation techniques are published in seismic refraction data analysis and each of them depends on the character of the refractor. In the present study, the seismic refraction data was interpreted using the modeling and interactive ray tracing techniques.

The travel time-distance curves and the corresponding ground models for P-waves were obtained. Depths of the interfaces were obtained from the travel time-distance curves for the P-waves. Table 2.1 summarizes the results obtained from the seismic profiles for this study.

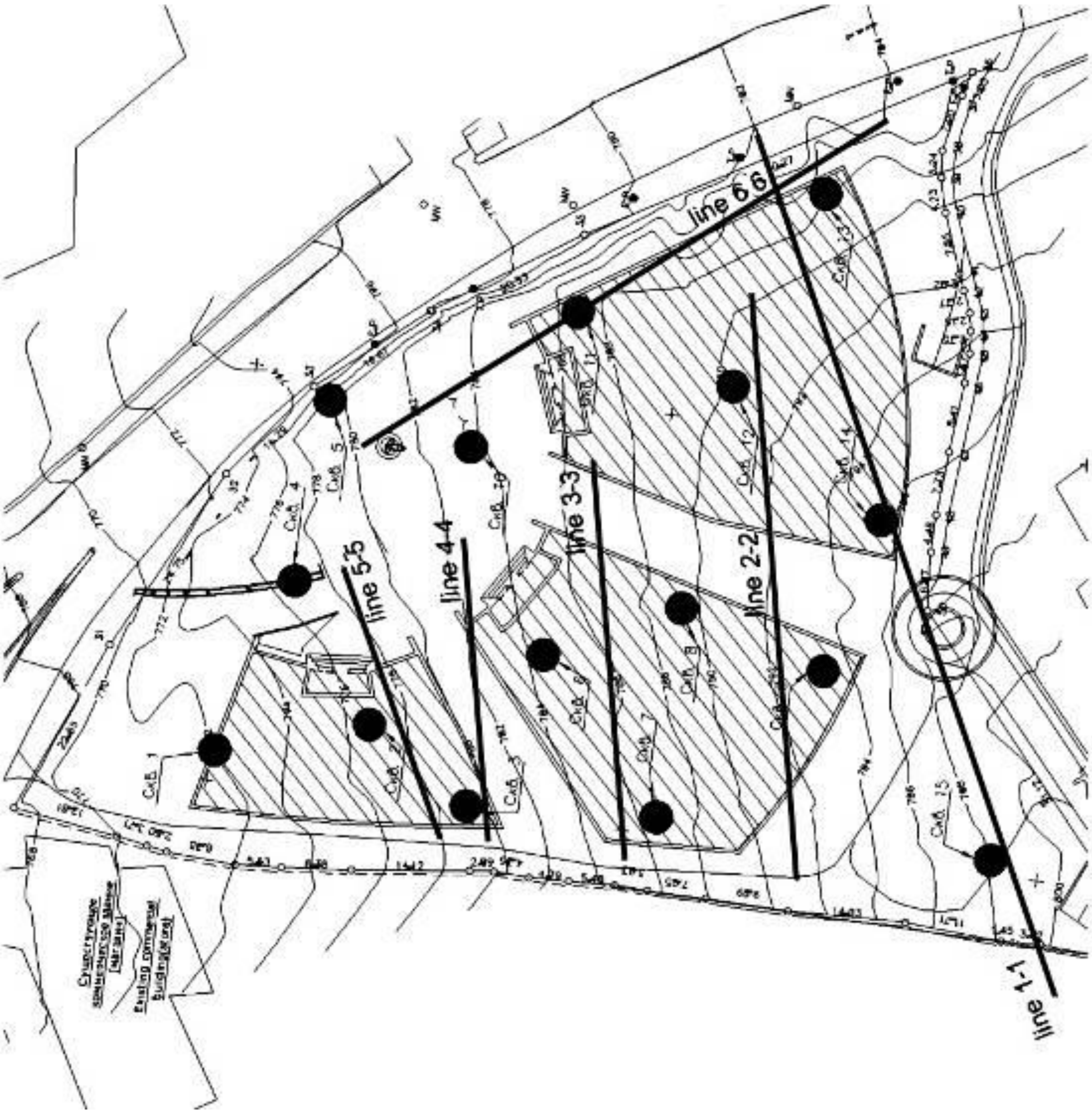

Figure (2-1): location of the seismic lines.

The P-waves were picked up as first arrivals. The underground model beneath the profiles indicates two different layers beneath the seismic lines. The bed rocks beneath these profiles from the two main layers, the first layer with thickness ranges between 1 to about 2 meters (see appendix no. 2). The travel time curves analysis showed longitudinal wave velocities (P waves) ranging from about 300 to about 1100 m/s for the first layer and about 2800 to about 3250 m/s for the second layer beneath all seismic lines. The first layer is interpreted as weathered materials, where the second layer is interpreted as consolidated carbonate materials of chalky limestone and chalk, the typical lithology of layer two for all seismic profiles (lines).

Table 2.1: Summary of results obtained from the seismic profiles

Line Nr.	Layer 1		Layer 2	
	Vp m/sec	**Thickness (m)**	**Vp m/s**	**Thickness (m)**
Line 1-1	952	1-2	2885	∞
Line 2-2	255	1-2	3244	∞
Line 3-3	1181	1-2	2813	∞
Line 4-4	930	1-2	3180	∞
Line 5-5	500	1-2	3250	∞
Line 6-6	600	1-2	3200	∞

Appendix no. 2: shows the travel time curves and the corresponding velocity ground models (geological cross sections for the two layers) beneath the seismic lines.

4 Conclusions and Recommendations

Based on the outcropping geological cross-section in the study area and the ground velocity models deduced from the P-wave velocities of this study, the subsurface geological formations beneath the seismic profiles are interpreted as soil cover of soft weathered material which forms the first layer beneath all seismic lines. The range of the thickness of the first layer is about 1 to 2 meters. The second layer is explained as consolidated carbonate materials of chalk and chalky limestone for all seismic lines. The outcrops can be easily seen in some places on the surface.

The corresponding velocity ground models (geological cross sections for the two layers) beneath all the seismic lines show clearly an overlapping between layer one and layer two at different locations of the study area which means that there are lateral and vertical variations in the mineralogy and the geomorphology of the layer boundaries.

The investigated subsurface geology beneath the profiles does not show clear cavities at shallow depths.

Based on the values of P-wave velocities and using the approximate values of the Poisson's Ratio (ν) for each layer (ν = 0.40 – 0.45 for clay and weathered materials and Around of 0.30 for chalk and chalky limestone), the value of shear wave velocity (V_s) for the second layer will be around 1400 – 1500 m/sec

Based on international and regional seismic design codes, (such as: Uniform Building Code 97, International Building Code IBC, Jordanian Building Code 2005 (or 2008) and Arab Uniform Building Code 2006) the type of soil profile for the shear wave velocities mentioned above will be S_B for the second layer.

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