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GROUND MOTION PARAMETER MAP FOR PALESTINE:

SEISMIC DESIGN BASED ON IBC 2012

اشتقاق خرائط حركة الأرض الزلزالية لفلسطين: بما يتوافق مع الكود الأمريكي (IBC 2012)

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إقــــــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

:GROUND MOTION PARAMETER MAP FOR PALESTINE

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اشتقاق خرائط حركة الأرض الزلزالية لفلسطين: بما يتوافق مع الكود الأمريكي (IBC 2012)

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بناءً على موافقة شئون البحث العلمي والدراسات العليا بالجامعة الإسلامية بغزة على تشكيل لجنة الحكم على أطروحة الباحث/ **احمد عبد العزيز محمد ابو آمنة** لنيل درجة الماجستير في **كلية *الهندسة*** / قسم <u>الهندسة المدنية – تصميم وتأهيل المنشآت</u> وموضوعها:

اشتقاق خرائط حركة الأرض الزلزالية لفلسطين: بما يتوافق مع الكود الأمريكي (IBC 2012)

GROUND MOTION PARAMETER MAP FOR PALESTINE

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وبعد المناقشة التي تمت اليوم الاثنين 02 جمادى الأولى 1438هـ، الموافق 2017/01/30م الساعة العاشرة صباحاً، اجتمعت لجنة الحكم على الأطروحة والمكونة من:

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واللجنة إذ تمنحه هذه الدرجة فإنها توصيه بتقوى الله ولزوم طاعته وأن يسخر علمه في خدمة دينه ووطنه.

والله ولي التوفيق ،،،

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ABSTRACT

This thesis includes the development of spectral response accelerations maps and risk coefficient maps for Palestine according the international building code (IBC 2012). The maps were developed for 5% damped acceleration response spectrum having a 2% probability of exceedance within a 50 year (2475 return period) in short (0.2 second) and long period (1 second). The probability seismic hazard analysis method has been used to develop the maps by using the (EZ-FRISK) software program. Thirty seismic sources have been identified and characterized using appropriate seismic parameters. The parameters of the area seismic zones determined from the historical earthquakes category. An empirical ground motion model was used due to limited ground motion data in Palestine. The developed maps were compared to Israeli and Jordanian maps for 2% probability of exceedance within a 50 year in short and long period with 5% damping. The comparison of Israeli and developed maps shows the similarity in the maps with limited difference in magnitude in the north-east of Palestine by 30% more than the developed maps. There are some differences between Jordanian and developed maps in long period which about 70% more than the developed in the eastern boundary of Palestine, while in the short period maps the magnitude are similar. A total of 16 multistory residential with five and fifteen stories in Gaza and West Bank have been used as a case study for comparison purposes. The seismic forces in the case study were calculated according to different codes (UBC97, IBC2012 with Jordan and developed maps, Israeli code SI413 2013). The calculated forces in the case study due to different codes are variable; the UBC97 result was the smallest forces in each case by decreasing from the developed forces about 10% and 30% in multistory and residential in Gaza, respectively while in Jericho 7% and 15% in multistory and residential, respectively. The Jordan maps result similar forces in Gaza cases, while in Jericho the Jordan maps result forces more than developed maps by 39% and 23% in multistory and residential, respectively. In Palestine most of designers use UBC97 in design because lake of spectral maps according IBC 2012. The final recommend in the thesis to use the developed maps and design according the IBC 2012 to be more conservative and to save the lives and building in Palestine.

ملخص الدراسة

يقدم هذا البحث خرائط حركة تسارع الارض الزلزالية وخرائط معامل تعديل الخطر الزلزالي لفلسطين بما يتوافق مع الكود الامريكي (IBC2012). الخرائط مشتقة باحتمال حدوث 2% خلال 50 سنة (2475 سنة) مع معامل تشتيت 5% لكل من الفترة القصيرة (0.2 ثانية) و الفترة الطويلة (1 ثانية). الخرائط تم اشتقاقها باستخدام طريقة تحليل احتمالات المخاطر الزلزالية (PSHA) المستخدمة لاشتقاق الخرائط في الكود الامريكي (IBC2012) و قد تم استخدام برنامج (EZ-FRISK) لحساب قيم التسارع في فلسطين. ثلاثون مصدر زلزالي تم تعريفها و تحديد خصائصها لتمثيل النشاط الزلزالي في المنطقة. خصائص هذه المصادر تم تحديدها من التاريخ الزلزالي للمنطقة. تم استخدام معادلة وضعية لتحديد قيمة حركة تسارع الارض خلال الزلزال و ذلك لمحدودية بيانات الحركة الزلزالية خلال الزلازل السابقة. تم عمل مقارنة بين الخرائط الاسرائيلية و الاردنية باحتمال حدوث 2% خلال 50 سنة (2475 سنة) مع معامل تشتيت 5% لكل من الفترة القصيرة و الفترة الطويلة و بين الخرائط المتشتقة. و قد أظهرت المقارنة تشابه كبير في الشكل و القيم بين الخرائط المشتقة و الخرائط الاخرى مع بعض الاختلافات في القيم وذلك نتيجة استخدام مصادر زلزالية مختلفة لاشتقاق الخرائط. بالنسبة للخرائط الاسرائيلية كان الاختلاف الوحيد في منطقة شمال شرق فلسطين بحيث كانت القيم الاسرائيلية اكبر من القيم للخرائط المشتقة ب 30%. كان هناك اختلاف كبير في القيم الاردنية بحيث كانت القيم الاردنية في الحدود الشرقية لفلسطين اكبر بحوالي 70% في الفترة الطويلة بينما كانت القيم متقاربة في الفترة القصيرة. 16 حالة تم افتراضها من مباني سكنية ابراج عالية كحالة دراسية لحساب القوي الزلزالية المؤثرة عليها من خلال الاكواد التالية (UBC97, IBC2012 with Jordan and developed maps, Israeli code SI413 2013). من خلال المقارنة كانت القوي الناتجة من الكود UBC97 تشكل اقل قيم في المباني المختارة للمقارنة بحيث كانت القيم اقل من القيم للخرائط المشتقة 10% و 30% للبرج و المبنى السكني على التوالي في غزة بينما في اريحا كانت اقل بنسبة 7% و 15% للبرج و المبنى السكني على التوالي. القيم الاردنية كانت متقاربة في غزة و لكن القيم في اريحا كانت اكبر بنسبة 39% للبرج و 23% للمبنى السكني. في فلسطين اغلب المصممين المدنيين يستخدموا الكود الامريكي UBC 97 للتصميم الزلزالي وذلك لعدم وجود خرائط للتصميم بناء على الكود الامريكي IBC 2012. لذلك كانت التوصية النهائية باستحدام الخرائط المشتقة للتصميم باستخدام الكود الامريكي IBC2012 لما في ذلك من حفظ االارواح و المباني في فلسطين.

DEDICATION

I would like to dedicate this work to:

My father and mother for their unlimited encouragement.

My family for their enduring support, and patience.

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LIST OF ABBREVIATIONS

BSSC	Building Seismic Safety Council
CDF	Cumulative Distribution Function
DST	Dead Sea Transform
IBC	International Building Code
MCE	Maximum Consideration Earthquake
MCE_R	Risk-Targeted Maximum Considered Earthquake
PDF	Probability Density Function
PGA	Peak Ground Acceleration
PSHA	Probabilistic Seismic Hazard Analysis
SA	Spectral Acceleration
USAID	United States Agency for International Development

LIST OF SYMBOLS

a: Logarithm of the number of earthquakes of magnitude greater than zero which are occur during the specified period of time. The a-value indicates the overall rate of earthquakes in a region

A_B: area of base of structure

A_C: combined effective area of the shear walls in the first story of the structure.

A_i: web area of shear wall i

b: the slope of the curve which considers the proportion of large earthquakes to small earthquakes with typically b ≈1

C_a: acceleration-dependent seismic coefficient given in (Table 16-Q UBC97)

C_s: the seismic response coefficient

C_V: velocity-dependent seismic coefficient given in (Table 16-R UBC97)

D: Distance in km

D_i: length of shear wall i

D_k: Possible locations in segment k for each earthquake magnitude M_j in interval j

F_a and F_v: site coefficients defined in (IBC, 2012) TABLE 1613.3.3(1) and TABLE 1613.3.3(2), respectively.

F_M (m): The cumulative distribution function for M

f_M(m): The probability density function for M

f_{Mi}(m) : Probability density functions of magnitude for source i

f_{Ri}(d) : Probability density functions of distance for source i

h_i: height of shear wall i

h_n: height of building

I: Building importance factor given in (Table 16-K UBC97)

I: the importance factor of the structure according to (Table 4 SI413, 2013)

I_e: the importance factor, determined from (ASCE7-10) Table 1.5-2

K: the force reduction factor due to seismic action structure according to (Table 5 SI413, 2013)

M: Moment magnitude

M_j: Possible range of magnitudes into small interval j in the seismic source

n(M): the annual frequency of earthquakes

P: Poisson probability of exceedance event at interval time

R: response modification factor for lateral force resisting system given in (Table 16-N UBC97)

S_1: the mapped MCE_R spectral response acceleration parameter at a period of 1s

S_a: the spectral response coefficient which compute from Equations 2.16 to 2.19

S_{D1}: the design spectral response acceleration parameter at a period of 1.0 s

S_{DS}: the design spectral response acceleration parameter in the short period range

S_s: Maximum considered earthquake ground motion for the site

S_S: the mapped MCE_R spectral response acceleration parameter at short periods

t: Interval time of the Poisson probability

T: the fundamental period of the structure

T_0: the period in the boundary between the first range to second range with value

T_a the approximate fundamental period of the structure

T_L: long-period transition period

T_R: Average return period

T_S: short period transition period with value

V: total design lateral force or shear at the base.

Vs: Shear wave velocity

W: total seismic dead load

x: number of shear walls in the building effective in resisting lateral forces in the direction under consideration

Y: Spectral acceleration of ground motion parameter

Z: Seismic Zone factor given in (Table 16-I UBC97)

Z_1: the predicted horizontal soil acceleration coefficient

γ: Annual probability of exceedance

$\lambda(Y \geq y)$: Annual frequency of Spectral acceleration exceedance y in t interval

$\nu(j,k)$: Annual earthquake occurrence of earthquakes on in segment k into the interval j

ν_i: Annual rate of occurrence of earthquakes on seismic source i

ϕ [.]: Normal Cumulative Distribution Function (CDF)

Chapter 1

Introduction

CHAPTER 1: INTRODUCTION

1.1 Background

An earthquake is a sudden and violent shaking of the earth when large elastic strain energy is released and spread out through seismic waves that travel through the body and along the surface of the earth (Levi et al., 2010). Earthquakes are one of the big challenges that face the engineers. The devastating potential of an earthquake can have major consequences on structure, infrastructures and lifelines. Earthquakes kill thousands every year. The 8.0 magnitude Sichuan Earthquake in 2008 killed over 70,000 people. The 6.8 earthquake in Algeria in 2003 killed 2,700, the 1999 Marmara earthquake in Turkey killed 17,000 (Kenny, 2009).

Up to the present, earthquakes cannot be controlled or forecasted and consequently, disasters cannot be avoided. However, the building codes improve many equations to estimate the parameters that effect at the building such as peak ground acceleration (PGA) and spectral acceleration (SA). These improvements increase the resistant of building due to earthquake. Table 1.1 shows the advantages of evolution of seismic codes (Shinozuka, 1995).

Table (1.1): Improvement of the building resistance.

	little or no damage	some damage	extensive damage
Pre-1971 Buildings	42%	22%	36%
1972-1980 Buildings	72%	17%	11%
1981-1993 Buildings	84%	10%	6%

As shown in Table 1.1 the design according to codes after 1981 improve the resistance of building to earthquake and decrease the percentage of extensive damage from 36% in building built before 1971 to 6% in building built after 1981. The 1966 Varto earthquake occurred in eastern Turkey with magnitude 6.9 on the surface wave magnitude scale. The earthquake killed 2394 and injured1489. Also 19013 buildings were demolished or heavily damaged (Wallace, 1968). On the other hand, the 2011 Van earthquake occurred in eastern Turkey, the shock had a moment magnitude of 7.1. The earthquake killed 604 and injured 4152. 11232 buildings sustained damage in the region (earthquake-report.com). This decreasing of the earthquake effect resulted from design the building according to modern codes version. The 2015 Gorkha earthquake occurred in Nepal with magnitude 7.8 killed nearly 8,700 people and injured over 16,800. The National Society for Earthquake Technology - Nepal (NSET) was reporting that over 500,000 houses were considered completely destroyed and over 269,000 houses were partially damaged. About 20% of buildings in Nepal are reinforced concrete buildings (CBS, 2012). The well-constructed reinforced concrete (RC) buildings performed in a relatively better resistance with minor damages. However, dramatic collapse of some RC structures can be attributed to open ground story, poor geometric configuration of buildings, poor reinforcement detailing in structural members, etc. (Pradhan et al., 2015). So used new version of the codes save the human life and decrease the economic losses.

Palestine is situated along the Dead Sea Transform (DST), which is a tectonically active plate boundary separating the Arabian plate and the African plate. The DST has been generating intensive earthquake activity affecting in Palestine (Levi et al., 2010). The last destructive earthquake in Palestine occurred in 1927 with magnitude of 6.2 on Richter scale and resulting in about 500 deaths (Al-Dabbeek and El-Kelani, 2004). Figure 1.1 show main earthquakes occurred in Palestine from 1900 to 2005 (Jreisat and Yazjeen, 2013). In spite of that a Palestinian code for seismic design does not exist. Seismic maps for Palestine based on IBC code also do not exist. Currently, most seismic design in Palestine still use maps based on UBC code that stopped published since 1997. Therefore, development of seismic maps for ground motion parameters for Palestine based on IBC2012 will allow the design for seismic forces based on IBC2012.

In the region there are many researches to develop the seismic maps combatable with latest versions codes, in Jordan there were many maps in research level such as (Jaradat et al., 2008) and (Al-nimry et al., 2008). Also Israeli seismic code (SI413, 2013) updates its maps and develops new approach for seismic design to be compatible with the modern approach at the world.

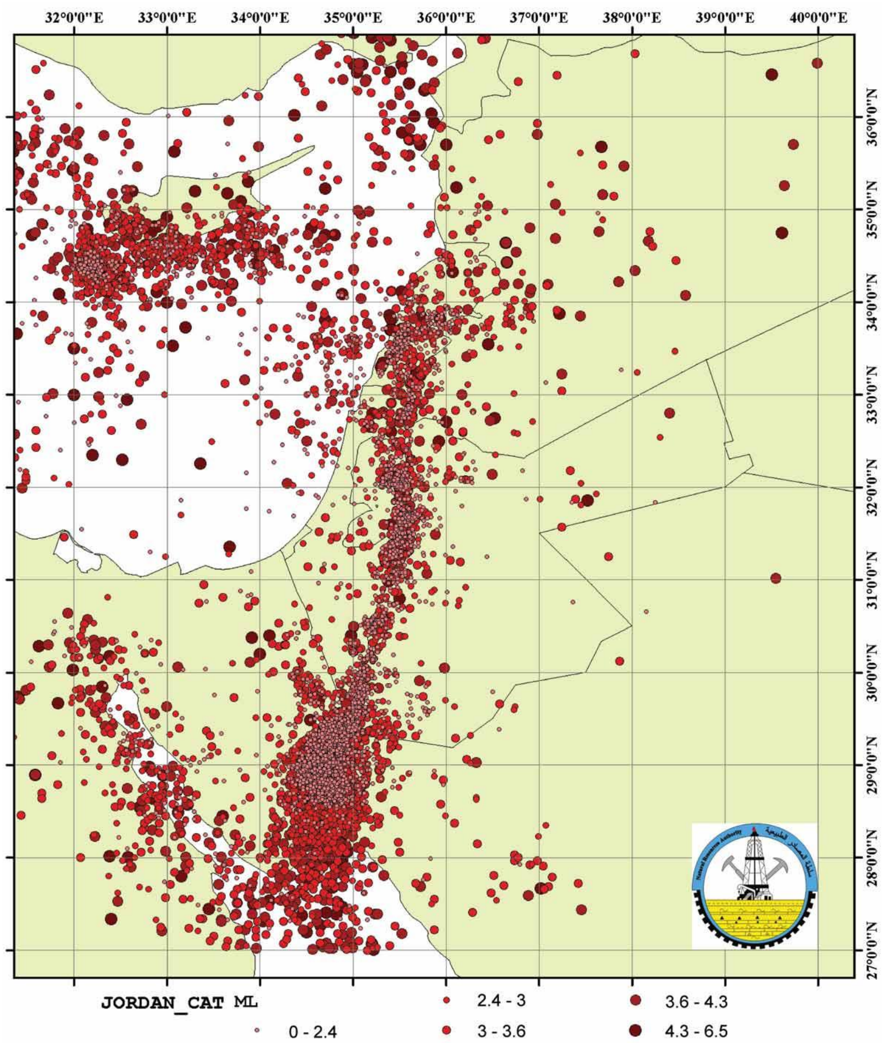


Figure (1.1): Earthquakes occurred in Palestine from 1900 to 2005, Jordan Catalogue.

1.2 Problem Statement

Palestine is situated along tectonically active plate boundary separating the Arabian plate and the African plate (Levi et al., 2010). But seismically information including historic and prehistoric data indicate that major destructive earthquake have occurred in the Jordan- Dead Sea Rift region, caused in several cases severe. At the same time, the engineering studies showed that local site effect played an important role on the intensity of historical earthquakes. Although that there is no seismic code for Palestine, so the most designers engineers in Palestine applied UBC code. The UBC code publishes the last version in 1997 then stopped to be issued. IBC replace the UBC with 2000, 2003, 2006, 2009 and 2012 version. But to use IBC code it is necessary to develop maps for Palestine based on the IBC code.

1.3 Research Aim and Objectives

The aim of this research is to develop maps of earthquake response spectral acceleration for Palestine at two specific periods short (T = 0.2 sec) and long (T = 1 sec) that have a probability of 2% of being exceeded in an exposure time of 50 years (2500 years return period) and damping ratio of 5% to be used in reference with IBC 2012 and ASCE/SEI 7-10. The design based on these maps will decrease the risk for life and economic loss during earthquake in Palestine.

<u>Objectives of this research will be:</u>

1) Determine the approach to develop maps for Palestine compatible with IBC 2012 and ASCE/SEI 7-10.
2) Determine and collect all missing data.
3) Develop ground motion parameter seismic maps for Palestine.
4) Case study building design based on UBC, Israeli and IBC codes for comparison.
5) Make comparative with available maps developed in Israel and Jordan.

1.4 Methodology

The methodology shown in Figure 1.2 has been followed in this research to achieve the research objectives.

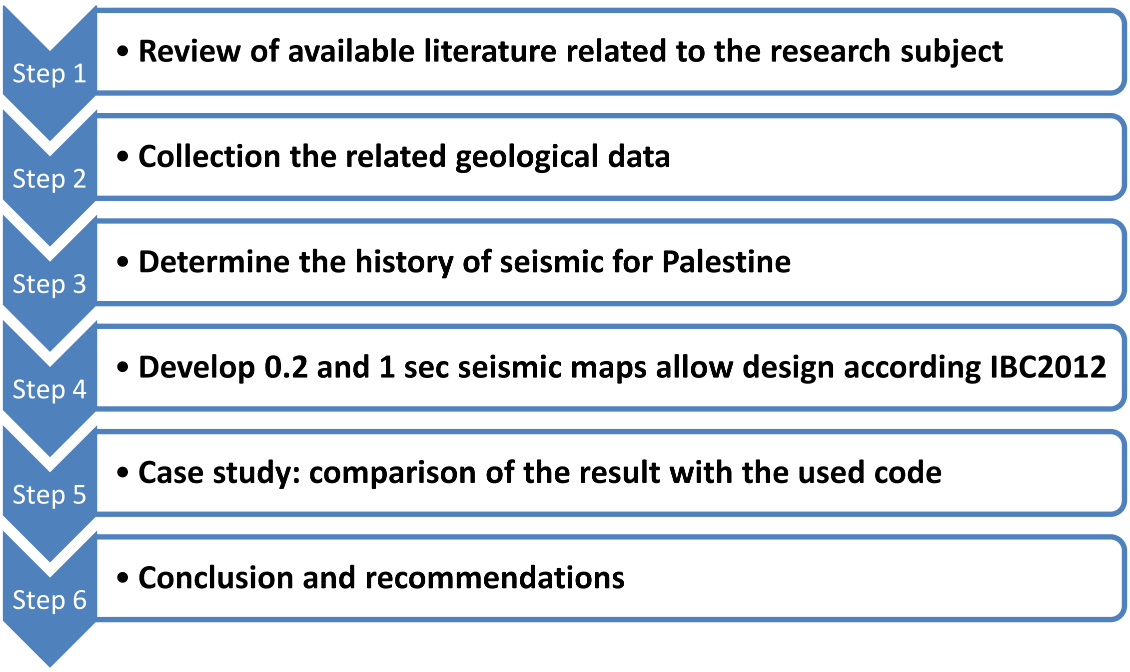


Figure (1.2): Methodology has been followed in the research

Step 1: Review of available literature related to the research subject

Review available literature for the seismic hazard map, the approach of probabilistic seismic hazard analysis and the codes that used to seismic design at Palestine, such as:

IBC 2012: equations of seismic design, maximum considered earthquake (MCE), ground motion response acceleration, seismic design category, seismic force- resisting system, site class and site coefficients.

ASCE/SEI 7-10: seismic ground motion values, mapped acceleration parameters, site class, site coefficients and adjusted (MCE), design spectral acceleration parameters, MCE response spectrum and site-specific ground motion procedures.

Israel code: concept of the seismic design, the parameter use in seismic design, the maps in code and the equations in the Israeli code.

Proposed seismic maps in Jordan: the bases of the proposed maps, equation and methodology used to develop the maps.

Review available geological studies for the Palestine, seismic studies and historical seismic study.

Step 2: Collection the related geological data

The earthquake sources have been selected from the geological studies.

The geological characteristics and the seismically active for each source have been determined from the geological data collected for Palestine.

Step 3: Determine the history of earthquakes for Palestine

Analysis of historic seismicity indicates usually the future moderate and large earthquake will occur near areas that have had smaller earthquake in the historic past. The one component of ground motion hazard calculation is the spatially history of earthquakes. History of earthquakes has been determined for the select return period for Palestine from the centers work on seismic.

Step 4: Develop ground motion seismic maps

Maps of earthquake response spectral acceleration that have a probability of 2% of being exceeded in an exposure time of 50 years (2500 years return period) for short and long period with damping ratio of 5% have been developed to be used in reference with IBC 2012 and ASCE/SEI 7-10.

Step 5: Case study: comparison the result with the used code

A case study of 2 building have been used to compare result with the hazard maps develop in Jordan and Israel and the code used in the region as UBC 97, IBC 2012, and Israel code.

Step 6: Conclusion and recommendations

Results of develop maps for Palestine and comparison have been analyzed and conclusion have been presented.

1.5 Structure of Thesis

The thesis contains seven chapters as following:

Chapter 1 (Introduction): This chapter gives some background information regarding earthquakes in Palestine, research problem and scope, objectives and methodology used to achieve the research objectives. Also it describes the structure of the thesis.

Chapter 2 (Literature Review): A review of relative seismic researches for the region, the common seismic design codes and the methods used in the world to calculate the seismic hazard have been discuss in this chapter.

Chapter 3 (Parameters for Developing the Seismic Maps): This chapter includes the concept of seismic maps, the software used in the study, the parameter used to develop the seismic maps for Palestine and the equation used in hazard calculation.

Chapter 4 (Development Bases of Seismic Hazard Maps for Palestine): This chapter discussed the methodology has been used to develop the Palestinian seismic maps, the geological study for Palestine, the probabilistic seismic hazard analysis (PSHA) method used to analysis the hazard for Palestine and the method has been used to calculate the risk coefficient.

Chapter 5 (Maps Development): The maximum considered earthquake ground motion for Palestine of 1 and 0.2 sec spectral response acceleration with 5% damping and site class B present in this chapter also the comparison between the Israeli Jordan seismic maps and the develop maps included in this chapter.

Chapter 6 (Case Study): The calculations of seismic base shear force for tower and Residential building according the UBC97, IBC2012with Jordan maps, Israeli codes and the develop maps have been presented in this chapter. Also comparison between the shear forces result from the difference codes include in this chapter.

Chapter 7 (Conclusion and Recommendations): The general conclusions from this research work are presented and recommendations for future research are also provided.

Chapter 2

LITERATURE REVIEW

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter presents an overview of previous work on related topics that provide the necessary background for the purpose of this research. The literature review concentrates on a range of seismic hazard maps topics and seismic in Palestine. For the understanding of seismic in Palestine, a review of seismic history is required in develop new seismic hazard maps for Palestine. The literature review begins with coverage of general earthquake topics, the seismic researches for the region and the codes that used around the world which serves to set the context of the research.

2.2 Earthquake

An earthquake is the sudden movement of the ground that releases elastic energy that has accumulated over a long time in rocks and generates seismic waves. These elastic waves radiate outward from the source and vibrate the ground. In an earthquake, the initial movement that causes seismic vibrations occurs when two sides of a fault suddenly slide past each other. A fault is a large fracture in rocks, across which the rocks have moved. Faults can be microscopic or hundreds-to-thousands of kilometers long and tens of kilometers deep. The width of the fault is usually much smaller, on the order of a few millimeters to meters (Tripathi and Pandey, 2016).

The point within the Earth where the earthquake rupture begins is termed the focus or hypocenter and may be many kilometers deep within the earth. The point on the Earth's surface directly above the hypocenter is called the earthquake epicenter. The basic concept is that the Earth's outermost part (called the lithosphere) consists of several large and fairly stable rock slabs called tectonic plates. The ten largest plates are mapped in Figure 2.1. Each plate extends to a depth of about 80 km and includes the Earth's outermost rigid rocky layer, called the crust. The elastic energy that causes an earthquake is created by a movement of almost rigid tectonic plates (Bozorgnia and Bertero, 2006).

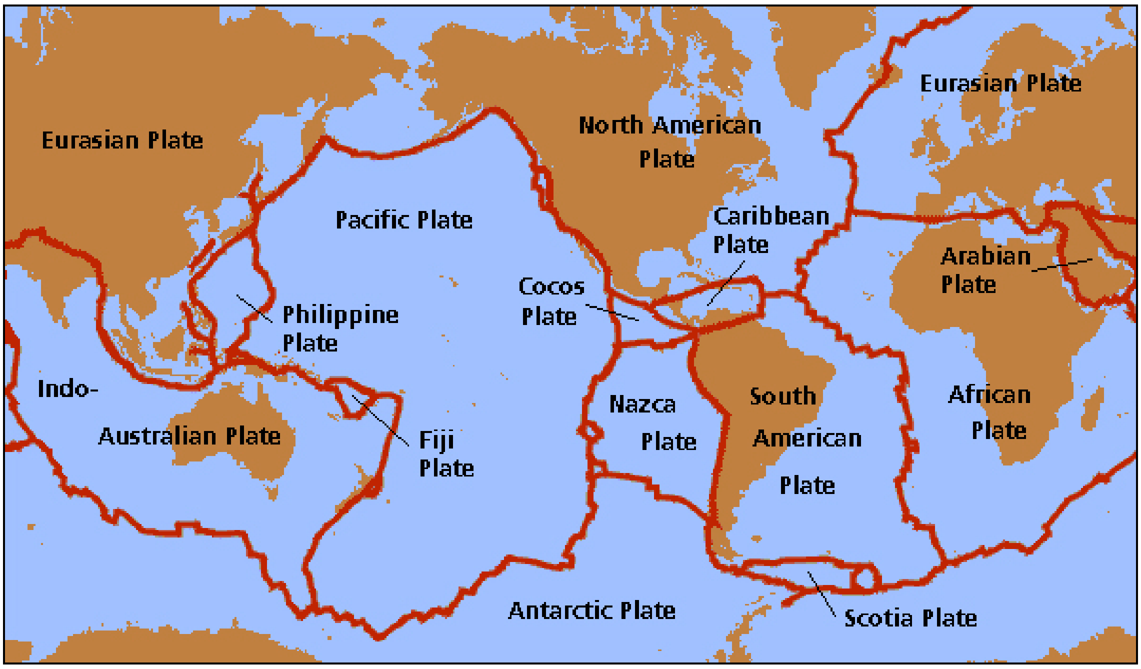


Figure (2.1): Tectonic plates in the world (Bozorgnia and Bertero, 2006)

Earthquake hazard is anything associated with an earthquake that may affect the normal activities of people. This includes surface faulting, ground shaking, landslide, liquefaction, tectonic deformation and tsunamis (Bachmann, 2003).

Earthquakes pose the most dangerous natural threat to the built environment and rival all other natural disasters in the threat to human life (Thomas, 2003). Earthquakes account for the majority of deaths from a range of natural disasters which amounts to about 60,000 people a year worldwide around 90 percent of which occur in developing countries. Most earthquake deaths are related to building collapse or damage. In the 2008 Sichuan earthquake, for example, hundreds of thousands of buildings collapsed. Beyond the human toll, the cost of this physical destruction can be considerable. The Marmara earthquake was estimated to have had a direct economic impact of over $5 billion (Kenny, 2009).

2.3 Earthquake in Palestine

The tectonic of our region is closely related to the tectonic of the Middle East and the Eastern Mediterranean region, which is considered one of the main belts and active zone of the earth. Three tectonic plates can be identified for the Middle East region; they are the African, the Eurasian and the Arabian. There is movement between the African and Arabian plates occur mainly along the Dead Sea Fault. There are 9 major faults in the region of Palestine, which are responsible for the seismic activity in Palestine. Figure 2.2 show the main faults affect in

Palestine as following: 1-Dead Sea Fault 2-Wadi Araba Fault 3-The Wadi Sirhan Basalt Area 4-The Paran Fault 5-The Fault of the Northern Zone 6-Northern Red Sea Faults 7-Al-Galiel Fault 8-The southeast Mediterranean Fault 9-The Cyprus Fault (Husein et al., 1995).

Some of these faults are more active than others. The Dead Sea fault is responsible for most seismic activity in our region. This fault extends from the Red Sea in the south to the Taurus Mountain (Turkey) in the north. The largest earthquake had been occurred along this fault had a magnitude of 7.8±0.5 at 748 A.C. The largest recorded earthquake had a magnitude of about 6.2 and occurred in 1927 and was named as Nablus Earthquake (Jardaneh, 2004). Table 2.1 list the strong earthquakes occurred in Palestine.

The historic seismic for Palestine indicate that the region is seismically active and there was many destroyed earthquake act in Palestine.

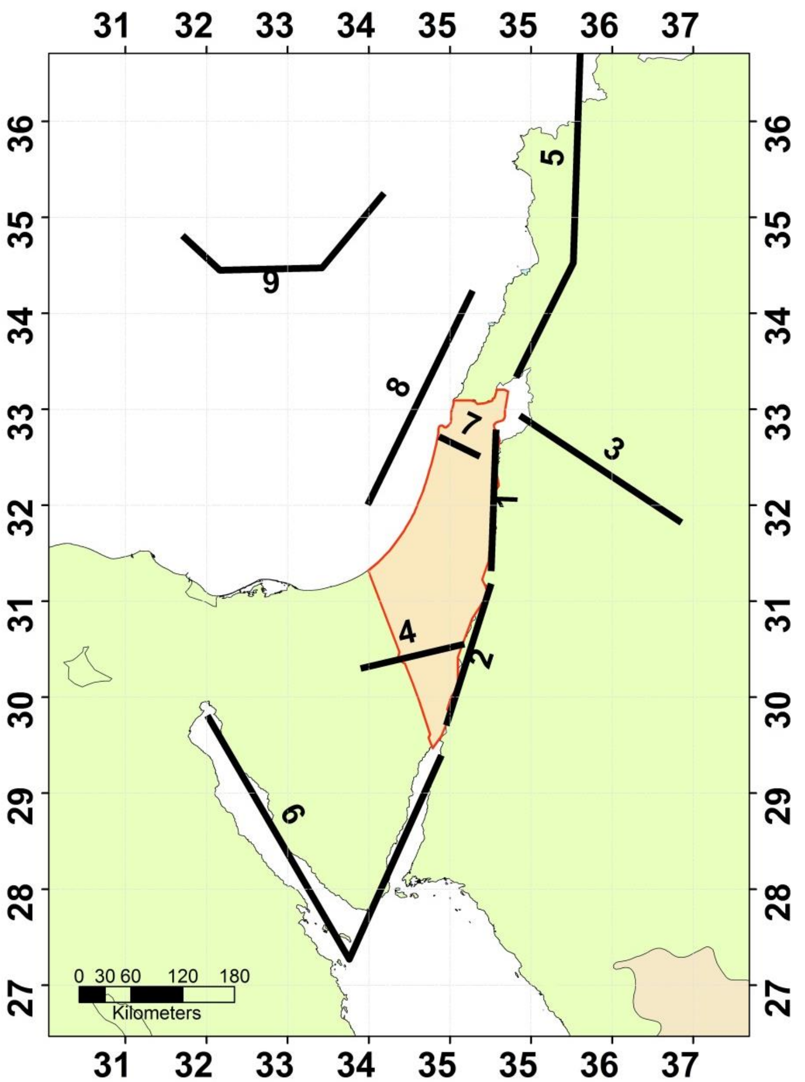


Figure (2.2): Main faults affect in Palestine

Table (2.1): Strong earthquakes occurring in Palestine (Sbeinat et al., 2005)

Year	Magnitude of earthquake
747	7.2
1170	7.7
1202	7.6
1546	7
1568	6
1759	6.6
1837	6.7
1927	6.2

2.4 Design Concepts and Codes

2.4.1 Concepts

The concept of seismic design started in early 20th century by discussions on deficiencies of structural systems and the resulting damage due to the 1906 San Francisco earthquake. Since those days, people in seismically active countries like USA, New Zealand, and Japan have been working towards forming a robust earthquake resistant design. The first active step in mitigating seismic risk was taken by the Seismological Society of America in 1910, when it identified three earthquake-related issues requiring further investigation: phenomenon of earthquakes (when, where and how they occur), the resulting ground motions, and their effect on structures. The seismic performance of then-existing structural forms had been perceived to be weak. Records show that structural engineering communities throughout the world had understood that earthquakes expose structures to lateral forces that are different from the vertical gravity loads and structures need to be specially designed to withstand earthquake induced ground shaking (Dhaka, 2011).

The work done after the 1908 Reggio-Messina Earthquake in Sicily by a committee of nine practicing engineers and five engineering professors appointed by the Italian government may be the origin of the equivalent static lateral force method, in which a seismic coefficient is applied to the mass of the structure, or various coefficients at different levels, to produce the lateral force that is approximately equivalent in effect to the dynamic loading of the expected earthquake. The

Japanese engineer Toshikata Sano independently developed in 1915 the idea of a lateral design force V proportional to the building's weight W. This relationship can be written as F = W C′ where C is a lateral force coefficient, expressed as some percentage of gravity. The first official implementation of Sano's criterion was the specification C′ = 10 percent of gravity, issued as a part of the 1924 Japanese Urban Building Law Enforcement Regulations in response to the destruction caused by the great 1923 Kanto earthquake. In California, the Santa Barbara earthquake of 1925 motivated several communities to adopt codes with C′ as high as 20 percent of gravity (Committee on the Science of Earthquakes, 2003).

2.4.2 Historic of seismic design codes

The interest in gaining better understanding of the seismic behavior of reinforced concrete building structures has grown in the past two decades. Seismic provisions typically specify criteria for the design and construction of new structures subjected to earthquake ground motions with three goals: (1) minimize the hazard to life from all structures, (2) increase the expected performance of structures having a substantial public hazard due to occupancy or use, and (3) improve the capability of essential facilities to function after an earthquake. (Taranath, 2010)

The building code is a document containing standardized building requirements applicable throughout the States. The most common codes are the United States codes.

The earliest model code in the United States (US) was the National Building Code recommended by the National Board of Fire Underwriters, published in 1905 in response to fire insurance losses in the Great Baltimore Fire of 1904 (ASEP, 2010).

Then three legal building codes used within the United States

• The Uniform Building Code (UBC), published in 1927 by the International Conference of Building Officials, Whittier, California.

• The Standard Building Code (SBC), published in 1945 by the Southern Building Code Congress International, Birmingham, Alabama.

• The Building Officials Code Administrators International BOCA National Building Code (BOCA/NBC), published in 1950 by the Building Officials and Code Administrators International, Country Club Hills, Illinois.

In the mid-1990s, there was a concerted attempt at developing a single unifying model building code for the entire country, to replace the three regional model building codes mentioned above.

This resulted in the International Building Code (IBC), developed by the three model code groups under the auspices of the International Code Council which they had together formed. Unfortunately, before the first edition of the IBC could even come out in April 2000, the unification process came unraveled. (Ghosh, 2002)

2.4.3 Uniform Building Code (UBC)

In 1927 the Pacific Coast Building Officials Conference adopted the Uniform Building Code (UBC). The provisions required that the building should be designed for a lateral force applied at each floor and roof level as a constant percentage (7.5 to 10%) of the total dead plus live loads of the building above the plane. Although the 1927 UBC provisions were not adopted by some of the larger California cities, the concept of using a constant coefficient to estimate the lateral force for seismic design continued to appear in the next editions of UBC (Bozorgnia and Bertero, 2006).

The first seismic probability map for the United States, distributed in 1948 by the U.S. Coast and Geodetic Survey (USCGS), simply used the locations of historic earthquakes and divided the country into four zones ranging from no expected damage to major damage. This map was adopted in 1949 by UBC, as well as subsequent editions until 1970. In 1969, S.T. Algermission of the USCGS produced a national map with maximum MMI values from historic earthquakes contoured as zones, along with a table and map of earthquake recurrence rates. The maximum-intensity map was the basis for the UBC national zoning map published in 1970(Committee on the Science of Earthquakes, 2003).

The 1961 UBC Code introduced the use of four factors to categorize building system types. The 1970 UBC used a zoning map which divided the United States into four zones numbered 0 through 3. The concept of soil factor was first acknowledged by recognizing the importance of local site effects in the 1976 edition of UBC. In addition to this, UBC 1976 Added zone 4 to California, and included new seismic provisions especially those related to the importance of local site effects.

The seismic input used in seismic design has changed in a number of significant ways in recent years. Through its 1985 edition, the Uniform Building Code (UBC) used a Z factor that was roughly indicative of the peak acceleration on rock corresponding to a 475-year return period earthquake. Until 1997 edition of UBC, seismic provisions have been based on allowable stress design. In UBC 1997 revised base shear and based it on ultimate strength design. The 1997 UBC used soil-modified spectral quantities as the ground motion input. The soil profile categories S_A through S_F, has been adopted and replaced the four site coefficients S1 to S4 of the previous edition. The new soil profile types were based on soil characteristics for the top 30 m of the soil (Ghosh, 2002).

The total design base shear V (UBC, 1997) in a given direction is to be determined from the Equation 2.1:

$$V = \frac{C_V W I}{R T} \qquad \text{Eq. 2.1}$$

The total design base shear should not exceed the V_{max} and shall not be less than V_{min} which determine from Equations 2.2 and 2.3 respectively.

$$V_{max} = \frac{2.5 C_a W I}{R} \qquad \text{Eq. 2.2}$$

$$V_{min} = 0.11 C_a W I \qquad \text{Eq. 2.3}$$

Where;

C_a: acceleration-dependent seismic coefficient given in (Table 16-Q UBC97)

V: total design lateral force or shear at the base.

W: total seismic dead load

I: Building importance factor given in (Table 16-K UBC97)

Z: Seismic Zone factor given in (Table 16-I UBC97)

R: response modification factor for lateral force resisting system given in (Table 16-N UBC97)

C_V: velocity-dependent seismic coefficient given in (Table 16-R UBC97)

T: elastic fundamental period of vibration, in seconds, of the structure in the direction under consideration evaluated for shear walls from Equations 2.3

$$T = 0.0743 \frac{(h_n)^{3/4}}{\sqrt{A_C}} \qquad \text{Eq. 2.4}$$

Where;

h_n: total height of building in meters

A_C: combined effective area of the shear walls in the first story of the structure.

2.4.4 International Building Code (IBC)

For much of the 20th century there were three predominant models building code organizations in the US.

From a purely a structural engineering perspective, each of these organizations tended to focus upon the predominant natural hazards in their geographic areas. By mid-1999, a complete final first draft of the IBC was assembled and ready to be processed through the new procedures of the ICC. In response to an appeal for more unified design procedures across regional boundaries, the International Building Code was developed and the first edition introduced in 2000. Subsequent IBC code editions were introduced in 2003, 2006, 2009 and 2012.

The IBC upgraded its design parameters by requiring the design to about 2,475-year return period earthquake versus a 475-year return period of an earthquake in the previous edition of the UBC codes. This change incorporated a substantial shift in earthquake regulations and how the seismic base shear was determined. The new formulation took into account very specific site characteristics insofar that the specific latitude and longitude in conjunction with the United States Geological Survey (USGS) ground response information could be utilized. This technology allowed the use of spectral response acceleration. In IBC, the UBC 1997 seismic zones were replaced by contour maps giving MCE spectral response accelerations at short period and 1-second for class B soil. The probabilistic MCE spectral response accelerations shall be taken as the spectral response accelerations represented by a 5% damped acceleration response spectrum having a 2% probability of exceedance within a 50 year period. In addition, the Seismic Use Group was established that was a modification of the previous Seismic Importance Factor. The types of structural systems were expanded considerably and, when used with the revised base-shear formulation, gave very site-specific seismic loading. The IBC 2006, IBC 2009 and IBC 2012 reference ASCE/SEI 7-10 for virtually all of its seismic design requirements (Commercial Structures Code Specialist, 2012).

The seismic base shear V (IBC, 2012) in a given direction is determined from Equation 2.5.

$$V = C_s W \qquad \text{Eq. 2.5}$$

Where;

C_s: the seismic response coefficient determined in accordance with Equations 2.6

$$C_S = \frac{S_{SD}}{R/I_e} \qquad \text{Eq. 2.6}$$

S_{DS}: the design spectral response acceleration parameter in the short period range as determined from Equation 2.9

R: the response modification factor, given in (ASCE 7-10) Table 12.2-1

I_e: the importance factor, determined from (ASCE7-10) Table 1.5-2

The value of C_s shall not exceed $C_{s\,max}$ which computes from Equation 2.7 or Equation 2.8

$$C_{S\max} = \frac{S_{S1}}{T(R/I_e)} \qquad for T \le T_L \qquad \text{Eq. 2.7}$$

$$C_{S\max} = \frac{S_{S1}T_L}{T^2(R/I_e)} \qquad for T > T_L \qquad \text{Eq. 2.8}$$

Where;

T: the fundamental period of the structure, the approximate T_a determined from Equation 2.11

T_L: long-period transition period, in this research the Israeli T_L code map used to determine T_L

S_{D1}: the design spectral response acceleration parameter at a period of 1.0 s, as determined from Equation 2.10

$$S_{DS} = \frac{2}{3}F_a S_S \qquad \text{Eq. 2.9}$$

$$S_{D1} = \frac{2}{3}F_v S_1 \qquad \text{Eq. 2.10}$$

Where;

S_S: the mapped MCE_R spectral response acceleration parameter at short periods

S_1: the mapped MCE_R spectral response acceleration parameter at a period of 1s

F_a and F_v: site coefficients defined in (IBC, 2012) Table 1613.3.3(1) and Table 1613.3.3(2), respectively.

$$T_a = \frac{0.0019}{\sqrt{C_w}} h_n \qquad \text{Eq. 2.11}$$

$$C_w = \frac{100}{A_B} \sum_{i=1}^{x} \left(\frac{h_n}{h_i} \right)^2 \frac{A_i}{\left[1 + 0.83 \left(\frac{h_i}{D_i} \right)^2 \right]} \qquad \text{Eq. 2.12}$$

Where,

h_n= height of building in ft

A_B = area of base of structure, ft^2

A_i = web area of shear wall i in ft^2

D_i = length of shear wall i in ft

h_i = height of shear wall i in ft

x = number of shear walls in the building effective in resisting lateral forces in the direction under consideration

2.4.5 ASCE 7-05 seismic maps

The MCE ground motion with uniform-hazard (2% in 50-year) maps in ASCE 7-05 can be described as applications of its site-specific ground motion hazard analysis procedure in Chapter 21 (Section 21.2), using ground motion values computed by the USGS National Seismic Hazard Mapping Project for a grid of locations and polygons that covers the US. The USGS computation of the probabilistic ground motions that are part of the basis of the MCE ground motion maps in ASCE 7-05 is explained in detail in (Frankel et al., 2002). In short, the USGS combines research on potential sources of earthquakes (e.g., faults and locations of past earthquakes), the potential magnitudes of earthquakes from these sources and their frequencies of occurrence, and the potential ground motions generated by these earthquakes. Uncertainty and randomness in each of these components is accounted for in the computation via contemporary Probabilistic Seismic

Hazard Analysis (PSHA), which was originally conceived by (Benjamin and Cornell, 1968). The primary output of PSHA computations are called hazard curves, for locations on a grid covering the US in the case of the USGS computation (NEHRP, 2012).

2.4.6 ASCE 7-10 seismic maps

Like the MCE ground motion maps in ASCE 7-05 reviewed in the preceding section, the new Risk-Targeted Maximum Considered Earthquake (MCE_R) ground motions in the 2009 Provisions and ASCE 7-10 can be described as applications of the site-specific ground motion hazard analysis procedure in Chapter 21 (Section 21.2) of both documents. For the MCE_R ground motions, however, the USGS values (for a grid of site and/or polygons covering the US) that are used in the procedure are from its 2008 update. Still, the site-specific procedure of the Provisions and ASCE 7-10 calculates the MCE_R ground motion as the lesser of a probabilistic and a deterministic ground motion. The definitions of the probabilistic and deterministic ground motions in ASCE 7-10, however, are different than in ASCE 7-05. The definitions were revised for the 2009 Provisions and ASCE 7-10 by the BSSC Seismic Design Procedures Reassessment Group (SDPRG), also referred to as Project '07. Three revisions were made:

1) The probabilistic ground motions are redefined as called risk-targeted ground motions, in lieu of the uniform-hazard (2% in 50-year) ground motions that underlie the ASCE 7-05 MCE ground motion maps.

2) The deterministic ground motions are redefined as 84th-percentile ground motions, in lieu of median ground motions multiplied by 1.5.

3) The probabilistic and deterministic ground motions are redefined as maximum-direction ground motions, in lieu of geometric mean ground motions.

In addition to these three BSSC redefinitions of probabilistic and deterministic ground motions, there is a fourth difference in the ground motion values computed by the USGS for the 2009 Provisions and ASCE 7-10 versus ASCE 7-05:

4) The probabilistic and deterministic ground motions were recomputed using updated earthquake source and ground motion propagation models.

For the MCE ground motion maps in ASCE 7-05, probabilistic ground motions are specified to be uniform-hazard ground motions that have a 2% probability of being exceeded in 50 years. But the ground motion with 2% probability of being exceeded in 50 years does not represent the probability of structural failure due to ground motion, and the geographical distribution of that probability is not necessarily the same as the distribution of the probability of exceeding some ground motion. The primary reason that the distributions of the two probabilities are not the same is that there are geographic differences in the shape of the hazard curves for the specific location from which uniform-hazard ground motions are read.

The changeover to risk-targeted probabilistic ground motions for the 2009 Provisions and ASCE 7-10 takes into account the differences in the shape of hazard curves. Where used in design the risk-targeted ground motions are expected to result in buildings with a geographically uniform mean annual frequency of collapse, or uniform risk. The BSSC, via Project '07, decided on a target risk level corresponding to 1% probability of collapse in 50 years. This target is based on the average of the mean annual frequencies of collapse across the Western US (WUS). The values of MCE_R in the ASCE7-10 maps are including the risk coefficient (NEHRP, 2012).

2.5 Related Research

2.5.1 Probabilistic seismic hazard analysis method (PSHA)

The goal of many seismic hazard analyses is to ensure that a structure can withstand a given level of ground shaking while maintaining a desired level of performance. But what level of ground shaking should be used to perform this analysis? Considering the randomness in the occurrence of earthquakes with respect to time, location and magnitude as well as the various other sources of uncertainties, probabilistic concepts and statistical methods are the appropriate tools for the assessment of seismic hazard maps. PSHA methodology was first proposed by (Benjamin and Cornell, 1968) to quantify the seismic hazard at a site of interest in terms of a probability distribution.

The goal of many earthquake engineering analyses is to ensure that a structure can withstand a given level of ground shaking while maintaining a desired level of performance. But there is a great deal of uncertainty about the location, size, and resulting shaking intensity of future earthquakes. Probabilistic Seismic Hazard Analysis (PSHA) aims to quantify these uncertainties, and combine them to produce an explicit description of the distribution of future shaking that may occur at a site (Baker, 2008).

Advances in PSHA have resulted in refined methods that address a breadth of the variables that affect earthquake occurrence and subsequent ground motion (Hobbs, 2013). At its most basic level, PSHA is composed of five steps.

1. Identify all earthquake sources capable of producing damaging ground motions.

The first step in PSHA analysis is to determine the spatial distribution of potential seismic sources of future earthquakes in the interesting area. In PSHA, a seismic source can be as a point, line or area in which seismicity characteristics such as annual earthquake occurrence rate, attenuation characteristics and maximum earthquake magnitude value, are considered to be the same. In other words, in each seismic source, earthquakes are assumed to occur at the same rate with same magnitude at any location in source (Reiter, 1990). The geological and seismological data as well as present earthquake catalogs are the useful tools for the delineation of seismic sources (Budnitz et al., 1997).

There are three general types of seismic source models; point, line (fault model) and area (source zone model). Among them, the point source model is the simplest case. When epicenters of past earthquakes are occur in a relatively small area and they are far away from the site, they can be assumed to occur from a point in space (Ozturk, 2008).

Line sources are used to model well defined faults. This model can be present as map view representation of three dimensional fault planes. It is assumed that the earthquakes occur with equal probability at anywhere along the length of a line source. Therefore, line sources are divided into small segments and each segment is treated as a point source in PSHA calculations (WGCEP, 1999).

Area source model is generally applied in the regions where past seismic activity may not correlate with any one of the active geologic structure or the available data are not adequate to recognize a particular fault system. Area sources have uniform seismicity characteristics that are different from neighboring zones and exclusive of active faults that are defined as line sources. In other words, area sources are assumed to have distributions of seismicity characteristics that do not vary in time and space. In the simplest way, the geometry of these sources is described by using past seismic activity (McGuire, 2004). Similar to line sources, an area source can be divided into small elements and each element can be treated as a point source in PSHA calculations (Ozturk, 2008).

2. Characterize the distribution of earthquake magnitudes

The sources are capable of producing earthquakes of various magnitudes. The constants for each source should estimate using statistical analysis of historical observations, with additional constraining data provided by other types of geological evidence. Randomness in the number of large, moderate and small magnitude earthquakes that will occur on a given source can be defined through a probability density function (Godinho, 2007).

3. Characterize the distribution of source-to-site distances associated

To predict ground shaking at a site, it is also necessary to model the distribution of distances from earthquakes to the site of interest. For a given earthquake source, it is generally assumed that earthquakes will occur with equal probability at any location on the source. Given that locations are uniformly distributed, it is generally simple to identify the distribution of source-to-site distances using only the geometry of the source. There are several definitions commonly used in PSHA. One can use distance to the epicenter or hypocenter, distance to the closest point on the rupture surface, or distance to the closest point on the surface projection of the rupture. Some distance definitions account for the depth of the rupture, while others consider only distance from the surface projection of the rupture (Baker, 2008).

4. Predict the resulting distribution of ground motion intensity as a function of earthquake magnitude and distance

The next step is therefore a ground motion prediction model. These models predict the probability distribution of ground motion intensity, as a function of many predictor variables such as the earthquake's magnitude, distance, faulting mechanism, the near-surface site conditions, the potential presence of directivity effects, etc. Ground motion prediction models are generally developed using statistical regression on observations from large libraries of observed ground motion intensities.

5. Combine uncertainties in earthquake size, location and ground motion intensity, using a calculation known as the total probability theorem. With the above information in place, the next step is combining it using the PSHA equations (Baker, 2008).

2.5.2 Proposed ground motions maps for Jordan

Probabilistic Seismic Hazard Analysis (PSHA) approach was adopted to investigate seismic hazard distribution across Jordan. Their earthquake recurrence relationships were developed from instrumental and historical data. Maps of peak ground acceleration and spectral accelerations (T=0.2 and T=1.0 sec.) of 2% and 10% probability of exceedance in 50 years were developed. Results indicated that seismic hazard across these cities is mainly controlled by area sources located along the Dead Sea Transform (DST) fault system. Cities located at short distances from the DST tend to show higher spectral acceleration than other cities. Some discrepancies may exist due to the proximity or remoteness of these cities relative to the DST seismic sources and local seismicity. The influence of adjacent seismic sources to the seismic hazard of each city is more evident for the long period spectral acceleration. Distant sources, such as the eastern Mediterranean, Cyprus, Suez and the southern region of the Gulf of Aqaba are relatively low, but cannot be neglected due to the intrinsic uncertainties and incomplete seismic data (Jaradat et al., 2008).

2.5.3 Ground motions maps for Israel code

In 2001, the Israel Geological Survey defined the regional seismic zones and these where approved in 2007 in Israeli standard with minor changes by experts from all neighboring countries. 27 seismic zones were defined as area seismic source in the region (Shapira et al., 2007). The seismic parameters associated with each of the seismic zones were defined by the Geophysical Institute of Israel. Those efforts have led to updating of the requirements in the Israeli Code 413 in terms of Peak Ground Acceleration (PGA) and Spectral Acceleration (SA). The seismic requirements in the Israeli Code 413 are based on map of earthquake response peak ground acceleration and spectral acceleration at two specific periods short (T = 0.2 sec) and long (T = 1 sec) that have a probability of 10%, 5% and 2% of being exceeded in an exposure time of 50 years (475, 975 and 2475 years return period) and damping ratio of 5% (SI413, 2013).

In general the equations used to calculate the seismic base shear V according SI413 2013 are similar to IBC 2013 equations. According to Israeli code (SI413, 2013) the probability of being exceeded should determine as the following:

Structures that belong to the importance group A shall be analyzed in accordance with the most severe of the two cases:

1. Based on probability of 10% in 50 years;
2. Based on probability of 2% in 50 years, divided by factor of 1.4

Structures that belong to the importance group B shall be analyzed in accordance with the most severe of the two cases:

1. Based on probability of 10% in 50 years;
2. Based on probability of 5% in 50 years, divided by factor of 1.2.

Structures that belong to the importance group C shall be analyzed in accordance the probability of 10% in 50 years only.

The seismic base shear V (SI, 2013) is similar to IBC 2012 equation which determined from Equation 2.5

The C_s determined according to Equation 2.13, while C_{smin} determine from the maximum of Equation 2.14 and 2.15

$$C_S = \frac{S_a I}{K} \qquad \text{Eq. 2.13}$$

$$C_{Smin} = 0.2 Z_1 I \qquad \text{Eq. 2.14}$$

$$C_{Smin} = 0.015 I \qquad \text{Eq. 2.15}$$

Where;

S_a: the spectral response coefficient which compute from Equations 2.16 to 2.19

I: the importance factor of the structure according to (Table 4 SI413, 2013)

K: the force reduction factor due to seismic action structure according to (Table 5 SI413, 2013)

Z_1: the predicted horizontal soil acceleration coefficient

The spectral response coefficien is determine according to four ranges of periods as given in Equations 2.16 to 2.19

$$S_a = S_{DS}(0.4 + 0.6T / T_0) \qquad for T \le T_0 \qquad \text{Eq. 2.16}$$

$$S_a = S_{DS} \qquad for T_0 < T \le T_S \qquad \text{Eq. 2.17}$$

$$S_a = \frac{S_{D1}}{T} \qquad for T_S < T \le T_L \qquad \text{Eq. 2.18}$$

$$S_a = \frac{S_{D1} T_L}{T^2} \qquad for T > T_L \qquad \text{Eq. 2.19}$$

Where;

T: the fundamental period of the structure

T_0: the period in the boundary between the first range to second range with value

$$T_0 = 0.16(S_{D1}/S_{DS})$$

T_S: short period transition period with value

$$T_S = S_{D1}/S_{DS}$$

T_L: long-period transition period

S_{DS}: the design spectral response acceleration parameter at a period of short 0.2 s, as determined from Equation 2.20

S_{D1}: the design spectral response acceleration parameter at a period of 1.0 s, as determined from Equation 2.21

$$S_{DS} = F_a S_S \qquad \text{Eq. 2.20}$$

$$S_{D1} = F_V S_1 \qquad \text{Eq. 2.21}$$

F_a and F_v: site coefficients defined in (SI413, 2013) Table 2 and Table 3, respectively.

2.5.4 Seismic study for region

The “earthquake hazard assessments for building codes” research project produced maps and charts that provide up 2004 and basic seismological data for use in the development and implementation of modern building codes and regulations in Jordan, Israel and the Palestinian National Authority. The most important product, for immediate application is the newly developed regional seismic hazard map, which displays peak ground acceleration (PGA) levels that have a probability of 10% of being exceeded at least once within a period of 50 years. This map provides the basic seismic input parameter that is considered in all modern building codes containing a seismic design provisions.

During the course of developing the new probabilistic ground shaking hazard map, the multinational project participants: (1) created a unified earthquake catalogue for the period 0-2004 (2) developed an epicenter map, (3) developed a seismic zone scheme for the region, (4) compiled and integrated all relevant, existing geological and geophysical information for the region and (5) enhanced the monitoring capabilities in both Jordan and the territories of the Palestinian Authority.

The project increased understanding of the response of buildings typical in the region to earthquake ground shaking and facilitated empirical determinations of the dynamic characteristics of existing buildings (Shapira et al., 2007).

2.6 Conclusion

The purpose of this review was to view the way that use by the countries to avoid seismic hazard and see how they reduced the loss due to earthquakes. As explain in this review Palestine located in active seismic zone, and it's clear from seismic history of Palestine that there possibility of strong earthquakes. The international codes update their version from time to time to improve the seismic resistant of building. The update results due to more understanding of the earthquakes hazard. The countries around Palestine developed new seismic maps for their countries such as Jordan and Israel to improve the seismic building resistance and decrease the earthquakes loss. Also according to some donors in Palestine (e.g. USAID) they required in their projects to be designed based on IBC2012 to save lives and money.

In Palestine the absence of Palestinian seismic code, using different codes in seismic design and absence of seismic maps based on IBC2012 led the designers to assume approximate value for S_s and S_1. Thus, this research may offer the based for a Palestinian code for seismic design and overcome the existing shortages.

Chapter 3

PARAMETERS FOR DEVELOPING THE SEISMIC MAPS

CHAPTER 3: PARAMETERS FOR DEVELOPING THE SEISMIC MAPS

3.1 Introduction

The future earthquake threat at a site is generally quantified by carrying out a seismic hazard analysis. Probabilistic seismic hazard is method for seismic hazard assessment. In the probabilistic seismic hazard analysis (PSHA) method, randomness in earthquake magnitude, location and time is taken into account by considering all probable earthquake scenarios that are capable of affecting the site of interest and frequency of their occurrences. There are also uncertainties in the attenuation of ground motion of an earthquake by distance as well as in the spatial locations of faults or boundaries of area sources. In PSHA, the uncertainties in these parameters are described by probability distributions and systematically integrated into the results via probability theory (Godinho, 2007)

In this chapter, the basic concepts, software, required data and models used in seismic hazard analysis for Palestine are explained.

3.2 The Concept of Seismic Design and Maps

The Seismological Society of America identified three parts of the earthquake problem that merit study: the event itself (when, where, and how earthquakes occur), the associated ground motions, and the effect on structures. These are still the fundamental elements in evaluating earthquake risk. Reducing this risk requires a consistent approach to evaluating the effects of future earthquakes on structures. To achieve this consistency the seismic engineer use the PSHA approach, this gives a probabilistic description of earthquake characteristics such as ground motion acceleration and fault displacement. Buildings suffer damage during an earthquake; the Damage of structures can be expressed in these categories:

• No damage.

• Slight: damage to architectural features.

• Minor: damage to structural features that can be repaired easily.

• Moderate: damage to structural features that can be repaired with significant effort.

• Major: damage that is not worth repairing.

• Total collapse.

Structural engineers allow some damage of structures due to strong earthquake, this damage dissipation a part of earthquake energy and reduce the force that effect on the structure this dissipation increase the damping for structure (McGuire, 2004).

If a structure is made to vibrate, the amplitude of the vibration will decay over time. Damping is a measure of this decay in amplitude, and it is due to internal friction and absorbed energy. The nature of the structure and its connections affects the damping; a heavy concrete structure will provide more damping than a light steel frame. Architectural features such as partitions and exterior facade construction contribute to the damping.

Damping is measured by reference to a theoretical damping level termed critical damping. This is the least amount of damping that will allow the structure to return to its original position without any continued vibration. For most structures, the amount of damping in the system will vary from between 3 percent and 10 percent of critical. The main significance of damping is that accelerations created by ground motion increase rapidly as the damping value decreases. The response spectra in Figure 3.1 shows that the peak spectral acceleration is about 14 m/sec^2 for a damping value of 2 %, 9 m/sec^2 for a damping value of 5 % and a value of about 7m/sec^2 for a value of 10 %. Response spectra generally show acceleration values for 0, 2, 5, and 10 % damping. A damping value of zero might be used in the design of a simple vibrator, such as a flag pole or a water tank supported on a single cantilever column. Most of the building without damping system have a damping value about 5% due earthquakes, so for typical structures engineers generally use a value of 5 % critical. The damping systems can be used to increase the damping in the structures to be 10 to 20% (EERI, 2006).

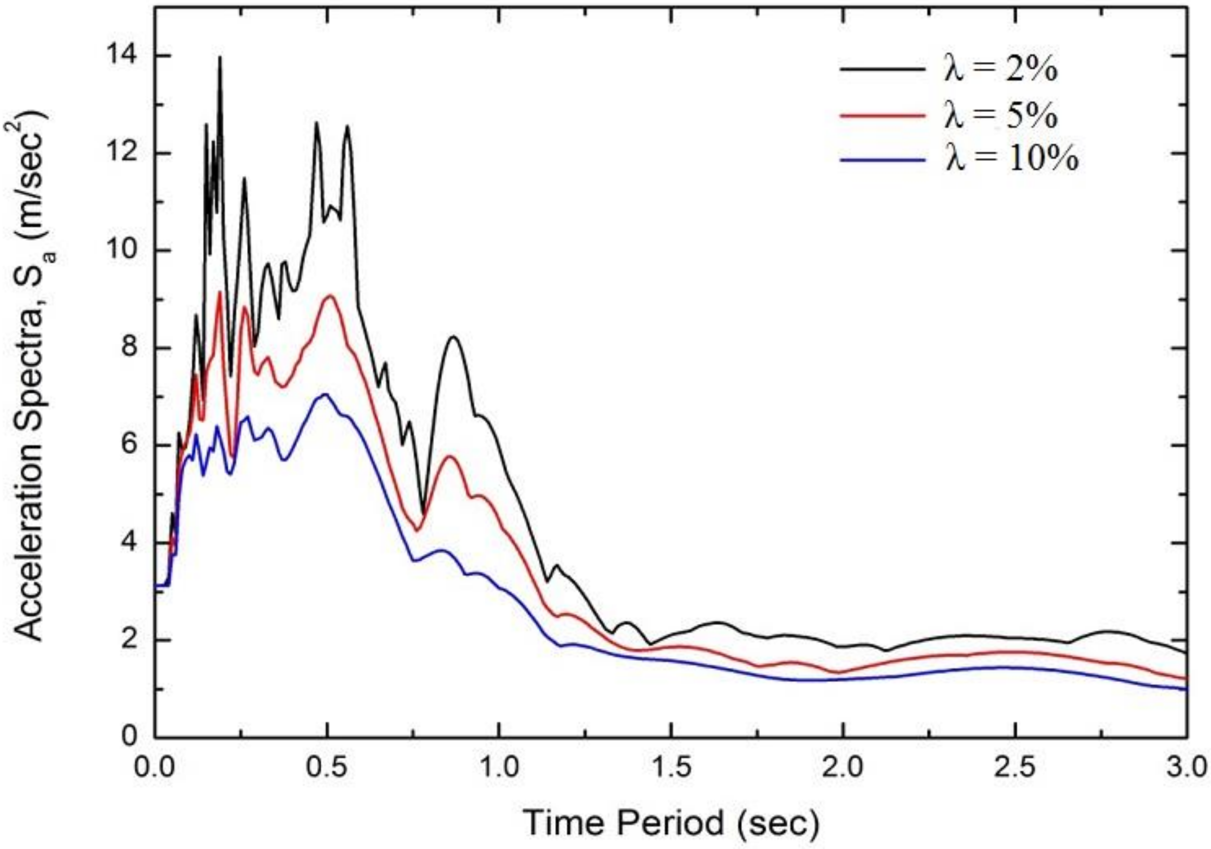


Figure (3.1): Acceleration response spectra of El-Centro, 1940 earthquake ground motion (Chopra, 2001)

The maps used for design in IBC 2012 code shows levels of earthquake shaking that have a 2% chance of being exceeded in a 50-year period. The time period of 50 years is commonly used because it represents a typical building lifetime, while the 2-percent probability level is usually considered an acceptable hazard level for the building codes (U.S. Geological Survey, 2008).

The random nature of the seismic events and the many uncertainties entering in the determination of the seismic hazard at a site, render a probabilistic approach to the subject very appropriate. In the ensuing analysis the underlying fundamental probabilistic model is that of a stationary Poisson process. That is the occurrence of a ground motion parameter at a site in excess of a specified level is a Poisson process. Clearly this implies that any seismic event is independent of the occurrence of all others, and this could be approximately true for major earthquakes, excluding associated foreshocks, aftershocks etc. (Solomos et al., 2008).

The annual rate of exceedance γ is first defined as the number of exceedances per year of the ground motion at the site under consideration. The average return period, T_R, of the ground motion at the specific site is defined as simply the inverse of the annual probability of exceedance as Equation 3.1,

$T_R = 1/\gamma$ Eq. 3.1

Where;

T_R: Average return period

γ : Annual probability of exceedance

A 2% probability of exceedance in 50 years corresponds to a 2475-year return period; this period is derived by assuming a Poisson process for ground motion occurrences, wherein the probability of an event, P, is related to the annual frequency of exceedance of the ground motion γ and the exposure time t through the relation in Equation 3.2,

$P = 1 - \exp(-\gamma\, t)$ Eq. 3.2

Where;

P: Poisson probability of exceedance event at interval time

t: Interval time of the Poisson probability

Rearranging the Equation 3.2 to be as Equation 3.3,

$\gamma = -[\ln(1 - P)]\,/t$ Eq.3.3

Substituting a probability P = 0.02 and an exposure time t = 50 years gives γ = 0.000404054 per year, which is 1/2475 years (Solomos et al., 2008).

The 2% probability of exceedance in 50 years of the spectral acceleration of ground motion due to earthquakes have been used to develop the maximum consideration earthquake for Palestine to be complemented with IBC 2012 code.

3.3 Software

3.3.1 Introduction to software (EZ-FRISK)

The EZ-FRISK program contains three main capabilities:

1) Seismic Hazard Analysis

2) Spectral Matching

3) Site Response Analysis

These capabilities allow a wide range of seismic hazard problems to be solved with straightforward specification of input using a graphical user interface. EZ-FRISK is designed to be easy-to-use for beginners and occasional users, yet to be powerful and productive for frequent users. It allows the hazard analyst's effort to be directed toward identifying the critical inputs and decisions affecting seismic hazard evaluations, rather than the tedium of preparing input files, running command line programs, and generating plots from calculated results. EZ-FRISK helps the analyst make better design- and risk-mitigation decisions in the face of an earthquake threat.

3.3.2 Overview of capabilities

1) Seismic Hazard Analysis

Seismic hazard analysis calculates the earthquake hazard at a site under certain assumptions specified by the user. These assumptions involve identifying where earthquakes will occur, what their characteristics will be, and what the associated ground motions will be. EZ-FRISK performs both probabilistic and deterministic seismic hazard calculations:

Probabilistic Calculations: The results of the program's probabilistic calculations are annual frequencies of exceedence of various ground motion levels at the site of interest. EZ-FRISK also calculates the mean and distributions of magnitude, distance, and epsilon causing exceedence of a specified ground motion level.

Deterministic Calculations: The program's deterministic calculations estimate ground motions (for the mean and specified fractiles of the ground motion dispersion) corresponding to the largest magnitude occurring on each seismic source at its closest approach to the site of interest. These results can be applied to various types of structural analyses. Seismic hazard analysis with EZ-FRISK is driven by databases of ground motion equations and seismic sources. EZ-FRISK provides users with tools to create and maintain their own databases, and to download extensive and up-to-date databases from Risk Engineering's web server for the user's licensed regions.

2) Spectral Matching

Spectral matching makes adjustments to an input accelerogram so that its response spectrum matches a target response spectrum. You can perform spectral matching as a stand-alone task by directly providing the target spectrum, or in conjunction with a probabilistic seismic hazard analysis. When using spectral matching with probabilistic seismic hazard analysis, the target response spectrum is the uniform hazard spectrum for a specified return period. EZ-FRISK uses the well know RspMatch2009 spectral matching algorithm under license from Norm Abrahamson This code is based on the time domain method of Tseng and Lilanand (1988), with modifications to preserve non-stationarity at long periods by using different functional forms for the adjustment time history. The matched accelerogram can then be used as input into a site response program such as Shake91 to obtain an accelerogram that is suitable for structural analysis and design. A key benefit of using EZ-FRISK for spectral matching is that it has a powerful search feature which quickly provides key information in choosing an appropriate initial accelerogram. It contains a scoring feature to select the best accelerograms based on the initial response spectrum's match to the target spectrum, the degree of scaling required for the accelerogram, and the duration of the event. The search gives immediate feedback in the form of thumbnails of the unscaled and scaled accelerograms, as well as the response spectrum.

3) Site Response

Analysis Site response analysis determines a design ground motion at the surface given an input motion at bedrock. It adapts a design earthquake for rock conditions to use as a design earthquake for a particular building site. Design earthquakes are used in structurally engineering buildings or structures and analyzing the dynamic response of these buildings and structures. EZ-FRISK provides an easy-to-learn, yet powerful user interface to create your soil profile. You can analyze your simpler profiles using the industry-standard site response code, Shake91, or by using our enhanced version, Shake91+. This enhanced version analyzes more complex profiles, and accelerograms with longer durations, without compromising precision in high frequency content of the motion. A key benefit of using EZ-FRISK for site response analysis is its capability to use explicitly confining-pressure dependent dynamic soil properties (Risk Engineering, INC., 2011).

3.3.3 Advantages of software

1) There is no quicker way to create earthquake design ground motions that accurately reflect a desired degree of risk, that have realistic time-dependent features of actual ground motions, and that incorporate site specific amplification effects.

2) EZ-FRISK has a sophisticated user interface that allows user to quickly define and execute his analyses, and review the results in graphical and tabular form.

3) The possible of license up-to-date world-wide seismic data for almost all populated areas. The users will not have to compile own data for these locations with widely-accepted government sponsored or Risk Engineering proprietary data sets.

4) All of EZ-FRISK's non-proprietary data can be customized and extended by the end-user.

5) EZ-FRISK is under active development, so it works well with modern operating systems and computers.

Thus, the EZ-FRISK software has been used to compute the spectral acceleration maps for Palestine in this research.

3.4 Statistical Data

Probabilistic seismic hazard analysis begins with identifying source zones from the historical record. The second step is to quantify the recurrence rates for events of different sizes, using a catalogue of historically or geologically-determined events (Main et al., 2011).

3.4.1 Definition of the seismic zones

The characterization of seismic zones is a key element in the process of earthquake hazard assessment and depends on the surface and sub-surface geometric, mechanic properties of active faults (e.g. slip rate, typical faulting mechanism, return time, etc.) and the geology survey for the faults zones, as well as on the seismicity distribution. To determine the characteristics of the seismicity and deformation field for each seismic zone a revised and updated catalogue was used. The earthquake catalogue compiled by (Shapira et al., 2007) was used in the assessment of earthquake hazards in the Palestine. The unified catalogue covers the period 0-2004 AD. Different magnitude scales usually considered were converted into a single scale (moment magnitude Mw) in order to homogenize the magnitudes of large and small, crustal and intermediate-depth earthquakes as shown in Figure 3.2.

Figure 3.2 shows the main active faults in Palestine and Earthquakes occurred in Palestine from 1900 to 2004, based on these active faults and the historical seismic of Palestine 30 seismic source zones have been defined as area sources. The main classification of seismic zones was defined as the following:

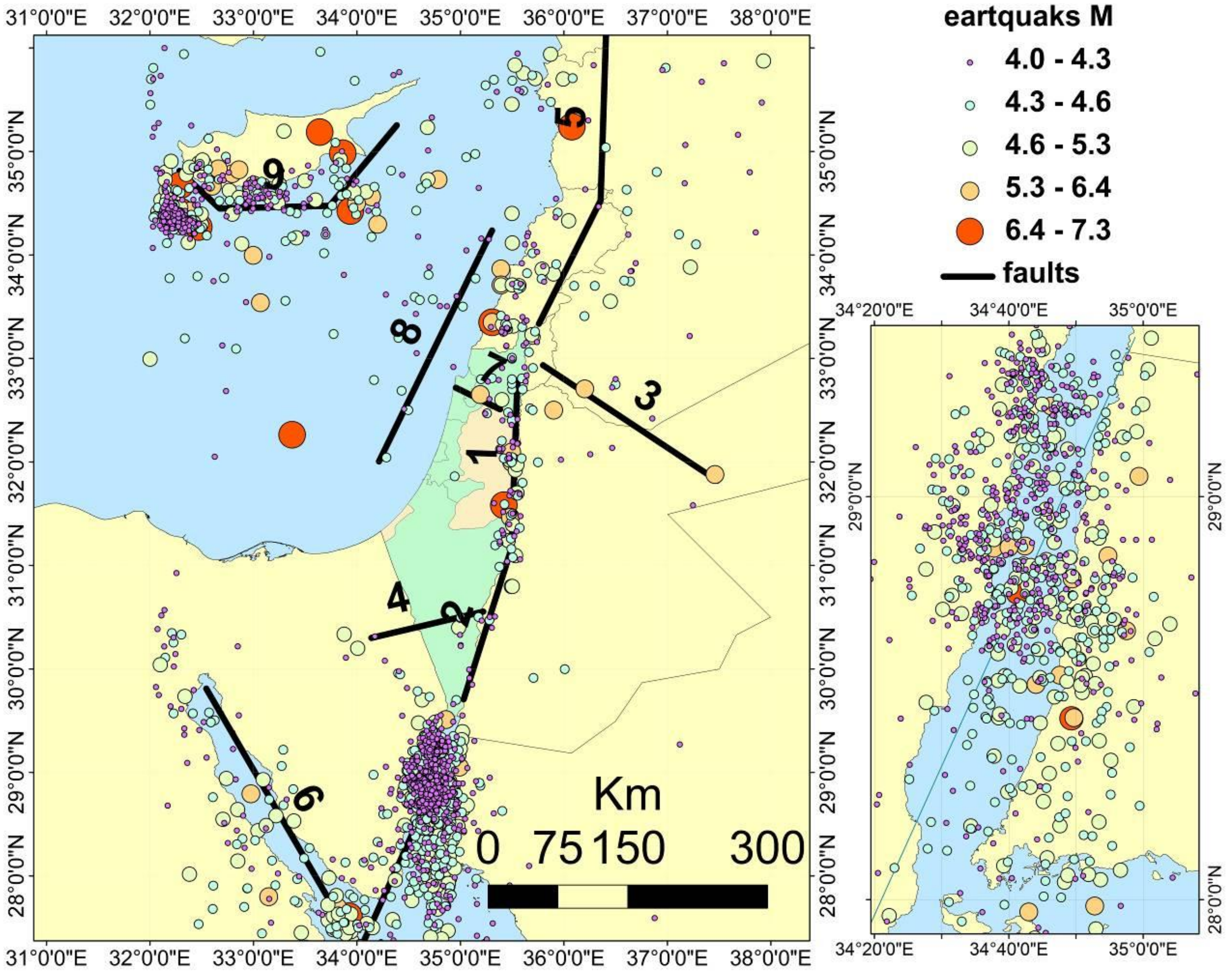


Figure (3.2): Main faults effect on Palestine and Earthquakes occurred in Palestine from 1900 to 2004

1. Wadi-Araba, Dead Sea, Jordan valley, and Hula represent the main segments of the Dead Sea Fault (faults number 1 and 2 shown in Figure 3.2) with the segment fault number 2 being less active than the segment fault number 1, and it have seismic historic with around 70 earthquakes with magnitude more than 4 at period 1900- 2015 as shown in Figures 3.2. Suez, Aqaba, Amona-Dakar and Aragonese represent the fault number 6 and the record more than 300 earthquakes with magnitude more than 4 in this region at the same period. Cyprus represents fault number 9 with more than 300 earthquakes. These seismic zones consider the historic seismicity clearly associated with geological active faults.

2. Seismic zones Sirhan, Galilee and Carmel are located to the northeast and northwest of Jordan valley represent the moderate seismic active faults number 3 and 7. In the historical

data there was within Sirhan seismic zone three destructive earthquakes are reported to have occurred in 1924, 1930 and 1989 with magnitude 5.7, 4.2 and 5.4 respectively. Also within Carmel seismic zone the 1984 earthquake with magnitude 5.3 was reported. But there is limited number of historical earthquakes in Carmel and Sirhan regions, so these seismic sources selected due to the geological activity without consider to the historical data.

3. Yammouneh seismic source represent the fault number 5, this fault have high active geological but there is about 20 earthquakes with magnitude more than 4 recorded in this region at period 1900 to 2015, only one earthquake considered as destructive earthquake with magnitude 7.3 in 1918 occurred at the north of Lebanon. The fault number 8 is active and there about 140 records of earthquake earthquakes with magnitude more than 4 recorded at period 1900-2015 in wide area around the fault, so its divide to three seismic source (Mediterranean 1, 2 and 3). The fault number 4 is active faults and the historical earthquakes category show random earthquakes occurred in large area around the faults, so the Paran represents this fault. These seismic sources selected due to the activity of theses faults and sporadic seismicity with no coherent relation between them.

4. The other sources have been identifying by historical seismic active without geological activity appear in this seismic zones.

Some additional considerations in defining seismic zones are as follows:

1. The Dead Sea Fault was subdivided in such a way that basins (Hula, Dead Sea, Gulf of Eilat basins) and inter-basin segments (Arava, Jordan Valley) form distinct zones. The rationale is that basinal sections are characterized by continual, low to medium magnitude or group-type activity, while inter-basin sections have either been relatively quiescent over the instrumental period (e.g. the Arava) or ruptured in large earthquakes as the 1995 Gulf of Aqaba earthquake. An alternative approach could be placing zone boundaries halfway in basins, which are the expression of fault step-over zones. This is based on the observation that the Gulf of Aqaba earthquake nucleated and was arrested within the Aragonese and Eilat basins, respectively. Seismic zones are defined as area sources, rather than line sources, even where the fault zone is well defined, both geologically and seismologically.

2. Where the exact structural association between earthquake epicenters and specific fault systems is unclear, overlapping zones were introduced (e.g. Bet She'an-Jordan Valley-Carmel, Baraq-Paran).

3. In the original model the Yarnmouneh source has been extended to the North to reach latitude 37o N and narrowed in the Southern part to avoid overlapping with the Sergayha source.

4. Sources N-Lebanon and S-Lebanon correspond to the Northern and Southern regions in Lebanon with assumed activity rates similar to neighboring regions and consistent with the assumptions in the hazard assessment in Lebanon (Shapira, et al. 2007).

3.4.2 Recurrence rates and b value

The recurrence relationship curve is usually, simply presented by a straight line whose ordinate shows the logarithm of the number of earthquakes of a given size or larger and whose abscissa shows the size of the earthquakes. The frequency magnitude distribution for a given source zone at low magnitudes M has the Gutenberg-Richter Equation 3.4:

$$\text{Log } n(M) = a - bM \qquad \text{Eq.3.4}$$

Where;

a: Logarithm of the number of earthquakes of magnitude greater than zero which are occur during the specified period of time. The a-value indicates the overall rate of earthquakes in a region

b: slope of the curve which considers the proportion of large earthquakes to small earthquakes with typically b ≈1

M: Moment magnitude

n(M): annual frequency of earthquakes (Genc, 2004).

The Gutenberg-Richter equation (Equation 3.4) can be written with maximum and minimum magnitude of earthquake as shown in Equation 3.5:

$$N(\geq M) = \alpha \frac{\exp[-\beta(M - M_{\min})] - \exp[-\beta(M_{\max} - M_{\min})]}{1 - \exp[-\beta(M_{\max} - M_{\min})]} \qquad \text{Eq.3.5}$$

$$\beta = b \ln(10) \qquad \text{Eq.3.6}$$

$$\alpha = a \ln(10) \qquad \text{Eq.3.7}$$

Where;

N(M) is the annual number of events with magnitude between M_{min} and M_{max}

Figure 3.2 shows the earthquake catalogue applies to the Palestine. Hence, assuming that M_{min}=2.0 and M_{max}=7.5. The amount of information available for each seismic zone may be found insufficient for accurate statistical assessments of the seismicity parameters. However, the b-value is indicative of the tectonic characteristics of a region and so the b-value for the seismic zones that constitute the Dead Sea Rift and the zones which branching off the Dead Sea Rift have been assumed to be the same value of b=0.96. This assumption is considered to better represent the tectonic characteristics of the seismic zones in the region.

The seismo-tectonics of the Cyprus zone and possibly also in the Gulf of Suez have different character. For both zones there are sufficient data to perform a separate analysis, and that yield b=1.07 and b=0.98 for the Suez and Cyprus, respectively. The summary of the statistical data that used to product the seismic map for Palestine are shown in Table 3.1(Shapira, et al. 2007).

3.4.3 Controlling earthquake

The controlling earthquake has been selected from the geological activity and the historical earthquakes category for each seismic source. Based on historical studies the maximum magnitude along the Dead Sea fault has been assumed to be 7.5 with the exception for the Yamouneh fault it's assumed higher magnitudes (M_{max}=7.75), because this area is more active than the Dead Sea zone. The faults that are branches of the Dead Sea fault 5.5 and 6.0 assigned as maximum magnitudes. These estimations are based mainly on the limited seismic history and partially on the length of the mapped fault. These faults, with the exception of the Carmel fault, are currently away from populated areas, so the maximum magnitude for the Carmel fault assumed M_{max}=6.5 mainly due to the accumulated length of that fault system and due to its proximity to the population centers. Maximum magnitudes associated with the zones that are characterized as zones of background seismicity follow the seismicity record (Shapira, et al. 2007). The estimated maximum magnitudes for the different seismic zones are shown in Table 3.1.

Table (3.1): Sources and seismic parameters, Mmin: Minimum magnitude, Mmax: Maximum magnitude.

No	Source	Mmin	Mmax	β	α
1	Amona-Dakar	4	7.5	2.21	0.5654
2	Aqaba	4	7.5	2.21	0.1925
3	Aragonese	4	7.5	2.21	0.1925
4	Arif	4	5.5	2.21	0.0302
5	Barak	4	5.5	2.21	0.0371
6	Beitshean-Gilboa	4	6.5	2.21	0.0599
7	Carmel	4	6.5	2.21	0.1199
8	Central	4	5.5	2.21	0.0232
9	Cyprus	4	8	2.25	2.7769
10	Damascus	4	5	2.21	0.0641
11	Dead sea	4	7.5	2.21	0.2887
12	East-Sinai	4	6	2.21	0.0333
13	Galilee	4	5.5	2.21	0.0348
14	Hula	4	7.5	2.21	0.2526
15	Jordan valley	4	7.5	2.21	0.3729
16	Malhan	4	5.5	2.21	0.0162
17	Mediterranean 1	4	6.5	2.21	0.3956
18	Mediterranean 2	4	6.5	2.21	0.2277
19	Mediterranean 3	4	6.5	2.21	0.2158
20	N-Lebanon	4	5.5	2.21	0.0903
21	Paran	4	6	2.21	0.0238
22	Roum	4	7.5	2.21	0.2887
23	Sergayha	4	7.5	2.21	0.0820
24	Sinai-T.J	4	7.5	2.21	2.2726
25	Sirhan	4	7	1.63	0.0500
26	S-Lebanon	4	6.5	2.21	0.0364
27	Suez	4	7	2.46	2.0425
28	Thamad	4	6	2.21	0.0642
29	Wadi-Araba/Arava	4	7.5	2.21	0.3007
30	Yammouneh	4	8	2.21	0.9144

3.5 The Attenuation Relationship

The attenuation relationship is essential for performing the probabilistic seismic hazard analysis. The seismic activity along the Dead Sea Fault system is moderate. There are insufficient acceleration data to enable developing a regional attenuation function so to determine the empirical equations that were developed elsewhere can be used. One of the most used attenuation function, for rock site conditions was that of Joyner and Boore (1981) equation. This relationship was widely used in the Middle East to prepare seismic hazard maps (Shapira, et al. 2007).

The necessity to reconsider the applicability of the Joyner and Boore (1981) attenuation equation and reanalyze the seismic hazard in the region by use the ground motion data collection from strong motion recordings of the 22-th November 1995 Gulf of Aqaba earthquake (Mw=7.2). This event is the strongest ever recorded in the region and it triggered strong motion accelerometers installed at distance of more than 400 km. Ten stations of strong motion installed in Israel, Jordan and in Saudi Arabia, recorded this event. Other smaller earthquakes were also recorder (Shapira, et al. 2007). Also Joyner and Boore 1994 equation (Boore et al., 1994), the equation of (Ambraseys et al. 1996) , Boore-Joyner-Fumal 1997 equation (Boore et al., 1997) and other equatines were used in different countries in Middle East (Jaradat, et al, 2008).

The Boore-Joyner-Fumal 1997 equation (Boore et al., 1997) have been used to calculate the ground motion parameter for Palestine in this research.

Chapter 4

DEVELOPMENT BASES OF SEISMIC HAZARD MAPS FOR PALESTINE

CHAPTER 4: DEVELOPMENT BASES OF SEISMIC HAZARD MAPS FOR PALESTINE

4.1 Introduction

In this chapter, the bases of the seismic hazard maps and the needed data for Palestine are presented. The PSHA method and the parameters which have been used to develop the Palestine seismic maps are explained in this chapter. The effects of all future possible earthquakes in Palestine with all possible magnitudes and at all significant distances from the site have been integrated in the PSHA method. Also random nature of earthquake occurrences and uncertainty in attenuation of ground motion have been taken into consider. It's should be note that the PSHA method has been used to develop the seismic maps in the International Building Code (IBC2012), Israeli Code (SI413 2013), (Eurocode 8, 2004) and in many proposed research (Jaradat, et al, 2008).

4.2 Methodology

The development of the seismic hazard maps has been subdivided into two main stages. The first stage was the collection of seismic sources data from the geological and historical studies. This stage was discussed in Chapter 3, the final seismic sources used in this study shown in Table3.1 and Figure 4.1. The second stage comprises the collection of the data associated with PSHA methodology. In order to calculate the level of seismic hazard at the selected sites in Palestine boundary, a PSHA methodology has been applied by using the EZ-FRISK program which has been developed for seismic hazard estimation. The EZ-FRISK program calculates the hazard for the selected site and shows the result in table form. The tables then converted to maps by using Arcmap program.

The risk coefficients for main cites in Palestine have been calculated from the seismic hazard curve. The hazard curve was compute by using EZ-FRISK program. Online software (Risk Targeted Ground Motion Calculator) has been used to calculate the risk coefficient for each city, after that counter maps for short and long period have been developed by Arcmap program.

- **Probabilistic seismic hazard analysis (PSHA) method**

The basic steps for second stage involved in the process of PSHA as follow:

1. Identify all earthquake sources

Thirty seismic zones have been used within Palestine region to define the seismic sources in the PSHA method as shown in Figure 4.1. These seismic zones represented the seismic activity in Palestine.

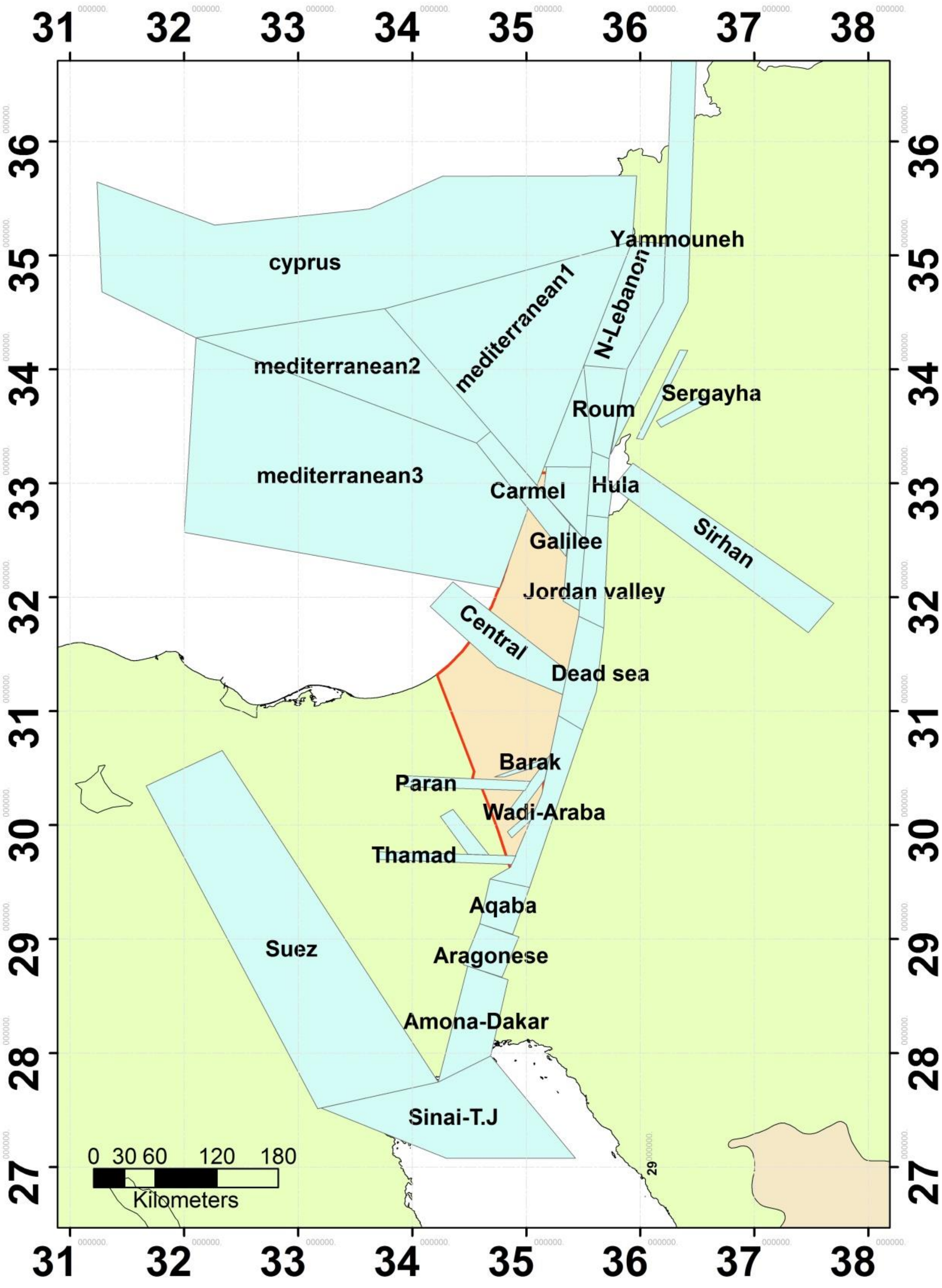


Figure (4.1): Seismic area source for Palestine (Shapira, et al. 2007)

2. Characterize the distribution of earthquake magnitudes

Equation 4.3 can be used to compute a cumulative distribution function (CDF) for the magnitudes of earthquakes that are larger than some minimum magnitude M_{min} as shown in Equation 4.1 to Equation 4.3 (Baker, 2008).

$$\mathrm{F_M(m)} = P(M < m | M > m_{\min}) \qquad \text{Eq.4.1}$$

$$\mathrm{F_M(m)} = \frac{\text{Rate of earthquakes with } \mathrm{m_{min}} < \mathrm{M} \leq \mathrm{m}}{\text{Rate of earthquakes with } \mathrm{m_{min}} < \mathrm{M}} = \frac{n(m_{\min}) - n(m)}{n(m_{\min})} \qquad \text{Eq.4.2}$$

$$\mathrm{F_M}(m) = \frac{10^{a-bm_{\min}} - 10^{a-bm}}{10^{a-bm_{\min}}} = 1 - 10^{-b(m-m_{\min})} \qquad \text{Eq.4.3}$$

Where,

F_M (m): The cumulative distribution function for M

One can compute the probability density function (PDF) for M by taking the derivative of the Equation 4.3 (CDF)

$$\mathrm{f_M}(m) = \frac{d}{dm} F_M(m) = \frac{d}{dm}[1 - 10^{-b(m-m_{\min})}] \qquad \text{Eq.4.4}$$

$$\mathrm{f_M}(m) = b\ln(10) * 10^{-b(m-m_{\min})} \qquad \text{Eq.4.5}$$

Where,

f_M(m): The probability density function for M

The PDF equation given in Equation 4.5 relies on the Gutenberg-Richter law of Equation 3.4, which theoretically predicts magnitudes with no upper limit, although physical constraints make this unrealistic. There is generally some limit on the upper bound of earthquake magnitudes in the region, due to the size and other characteristics of the source faults. When the maximum magnitude compute in the Gutenberg-Richter Equation 3.4 the Equation 4.3 becomes to Equation 4.6 (Baker, 2008):

$$F_M(m) = \frac{1-10^{-b(m-m_{min})}}{1-10^{-b(m_{max}-m_{min})}} \qquad \text{Eq.4.6}$$

And Equation 4.5 becomes to Equation 4.7:

$$f_M(m) = \frac{b\ln(10)*10^{-b(m-m_{min})}}{1-10^{-b(m_{max}-m_{min})}} \qquad \text{Eq.4.7}$$

Table 4.1 and Figure 4.2 show the probability of earthquakes magnitude occurring due to the Dead Sea source by using Equation 4.7 with b=0.96 and m_{min} =2 and m_{max}=7.5

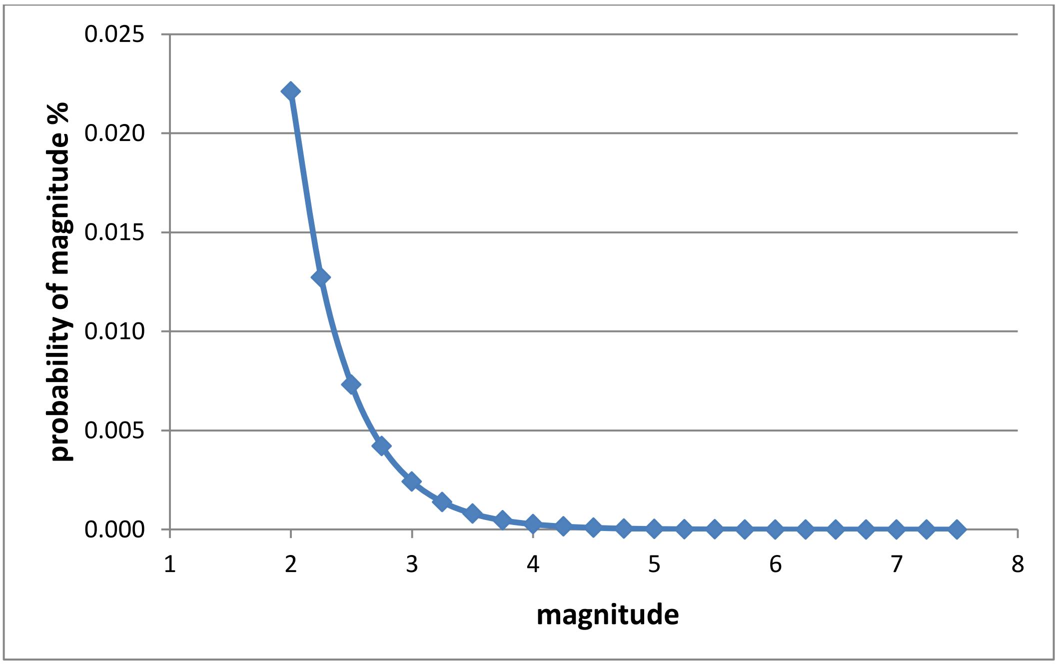


Figure (4.2): Probability of earthquakes magnitude occurring due to the Dead Sea source

Table (4.1): Value of probability of earthquakes magnitude occurring due to the Dead Sea source.

M	f(m)
2	2.21049
2.25	1.27201
2.5	0.73196
2.75	0.42120
3	0.24238
3.25	0.13947
3.5	0.08026
3.75	0.04618
4	0.02658
4.25	0.01529
4.5	0.00880
4.75	0.00506
5	0.00291
5.25	0.00168
5.5	0.00096
5.75	0.00056
6	0.00032
6.25	0.00018
6.5	0.00011
6.75	0.00006
7	0.00004
7.25	0.00002
7.5	0.00001

3. Characterize the site to source distance

To increase the accuracy of the PSHA calculation each seismic source has been divided to small segments with same characteristic of the seismic source. The used site to source distance was from the central of the segment of the area source on the surface projection to the site.

4. Modeling of ground motion

Due to the limited strong motion data in Palestine, published empirical ground motion relationships specifically developed for the DSF region are not available. However, Boore-Joyner-Fumal (Boore et al., 1994) relationships for both Peak Ground Acceleration (PGA) and Spectral Acceleration (SA) in terms of surface magnitude (M) were found to be appropriate to be used for the DST region. (Leonov, 2000) investigated a number of attenuation relations against strong motion data of the 22nd November 1995 Gulf of Aqaba earthquake of magnitude

(Mw=7.2) that occurred on the Aragonese fault, 70 km south of the towns of Eilat and Aqaba. (Leonov, 2000) stated that the equations of (Ambraseys et al. 1996) and Boore-Joyner-Fumal (Boore et al., 1997) are very representative for the Dead Sea region as shown in Figure 4.3.

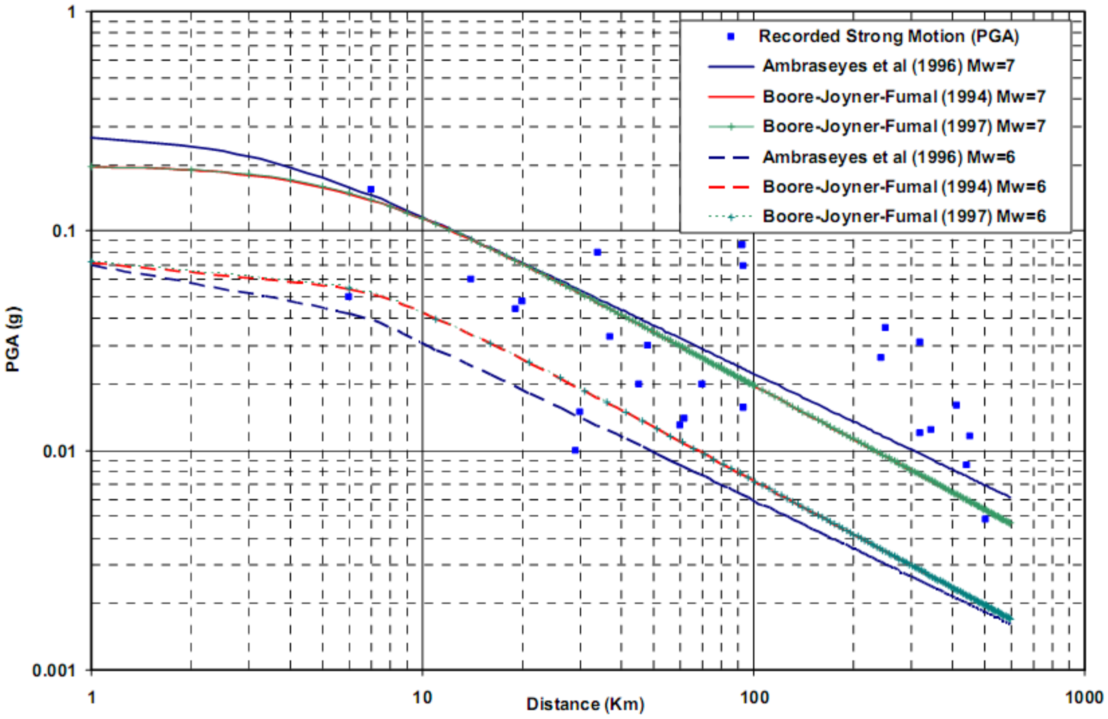


Figure (4.3): Comparison between the attenuation equations of (Ambraseyes et al. 1996), Boore-Joyner-Fumal (1994 and 1997) against PGA values of strong motion stations from Jordan and Israel, using Mw=6 and 7

Eqution 4.8 is the Boore-Joyner-Fumal (1997) have been used to compute the spectral accalaration for short period (0.2 second):

$$\ln Y = 1.089 + 0.711(M-6) - 0.207(M-6)^2 - 0.924 \ln D - 0.292 \ln \frac{Vs}{2118} \quad \text{Eq.4.8}$$

And Equation 4.9 is the Boore-Joyner-Fumal (1997) have been used to compute the spectral accalaration for long period (1 second) (Boore et al., 1997):

$$\ln Y = -1.08 + 1.036(M-6) - 0.032(M-6)^2 - 0.798 \ln D - 0.698 \ln \frac{Vs}{1406} \quad \text{Eq.4.9}$$

Where;

Y: Spectral acceleration of ground motion parameter

M: Moment magnitude

D: Distance in km

Vs: Shear wave velocity

5. Combine all steps

The spectral acceleration for long and short period for Palestine have been developed by combining all previous steps using the PSHA equation. In order to construct a spectral acceleration maps for Palestine, a set of spectral ground motion values for each site are selected and the annual frequency of the ground motion parameter, Y, exceeding each ground motion value, y, is calculated from Equation 4.10.

$$\lambda(Y \geq y) = \sum_{sources\,i} v_i \iint \Pr[Y \geq y / M, D] f_{Mi}(m) f_{Di}(d) dmdd \qquad \text{Eq.4.10}$$

Where,

$\lambda(Y \geq y)$: Annual frequency of Spectral acceleration exceedance y in t interval

$f_{Mi}(m)$: Probability density functions of magnitude for source i from Equation 4.7

$f_{Di}(d)$: Probability density functions of distance for source i

ν_i: Annual rate of occurrence of earthquakes on seismic source i

It is too difficult to evaluate the integrals in Equation 4.10 analytically. Therefore, in practice, earthquake magnitude distribution is discretized by dividing the possible range of magnitudes into small intervals. Then, center of each interval, denoted as M_j, is used in calculations. The possible locations of each earthquake magnitude, M_j, are also discretized by distance D_k. Therefore, a set of earthquake scenarios with magnitude, M_j, occurring at a distance of D_k from the site of interest are defined.

For each scenario, the annual earthquake occurrence rate, $\nu(j,k)$, is calculated based on probability distributions of earthquake magnitude and ruptures. Then the annual frequency of exceedance, $\lambda(Y \geq y)$, is calculated from Equation 4.11.

$$\lambda(Y \geq y) = \sum_{sources\, i} \sum_{magnitudes\, j} \sum_{distances\, k} v(j,k) \Pr[Y \geq y / M_j, D_k] \qquad \text{Eq.4.11}$$

M_j: Possible range of magnitudes into small interval j in the seismic source

D_k: Possible locations in segment k for each earthquake magnitude M_j in interval j

ν(j,k) : Annual earthquake occurrence of earthquakes on in segment k into the interval j

4.3 Risk Coefficient

The steps to calculate the risk coefficient

1. The hazard curves have been computed using the EZ-Frisk program for the main cities in Palestine. Figure 4.4 shows the hazard curves for Gaza and Jericho for long and short period.

2. The cumulative distribution function (CDF), denoted $P[\text{Collapse}|\text{Y} = \text{s}_\text{s}]$ for the hazard curve have been calculated from Equation 4.12 and plotted as shown in Figure 4.5 (the Figures 4.5 ,4.6, 4.7 and 4.8 plotted by online web site to calculate the risk coefficient for the hazard curve 0.2 sec for Gaza) (Risk Targeted Ground Motion Calculator).

3. Online website application (Risk Targeted Ground Motion Calculator) has been used to plot Figure 4.6 which shows the derivative cumulative distribution function curve.

4. The probability density function (PDF) for the hazard curves, denoted P [Collapse] is given in Equation 4.13. Figure 4.7 shows the derivative cumulative distribution function curve multiplicand by the hazard curve for short period in Gaza and Figure 4.8 shows the Cumulative integral of hazard curve multiplicand derivative cumulative distribution function curve.

$$P[\text{Collapse}|Y = s_s] = \phi\left[\frac{\ln Y - \ln(s_s) + 1.28 * 0.8}{0.8}\right] \qquad \text{Eq. 4.12}$$

$$P[\text{Collapse}] = \int_0^\infty \frac{dP[\text{Collapse}|\text{Y} = \text{s}_\text{s}]}{da} P[Y > s_s]da \qquad \text{Eq. 4.13}$$

Where,

ϕ [.]: Normal Cumulative Distribution Function (CDF)

S_s: Maximum considered earthquake ground motion for the site (Luco, et al., 2007).

5. If the Conditional Probability of Collapse calculated during first Iteration exceeds 1%, the initial ground motion value is increased for Iteration 2. If on the other hand the probability of collapse calculated during Iteration 1 is less than 1%, the initial ground motion value is decreased for Iteration 2.
6. With the First and Second Iterations bracketing the target probability of collapse (1%), the ground motion for the Final Iteration can be precisely selected during Step 1 to result in Steps 2 through 5 to correspond to a 1% probability of structural collapse. This ground motion value is referred to as the risk-targeted ground motion (for Gaza from Figure 4.6 is 0.214).
7. The Risk Coefficient (RC) is simply the ratio of the risk-targeted ground motion divided by the uniform hazard ground motion.

$$RC = \frac{0.214}{0.210} = 1.02$$

8. Convert the points Risk Coefficient for each city to make contour maps for long and short period by using Arcmap program.

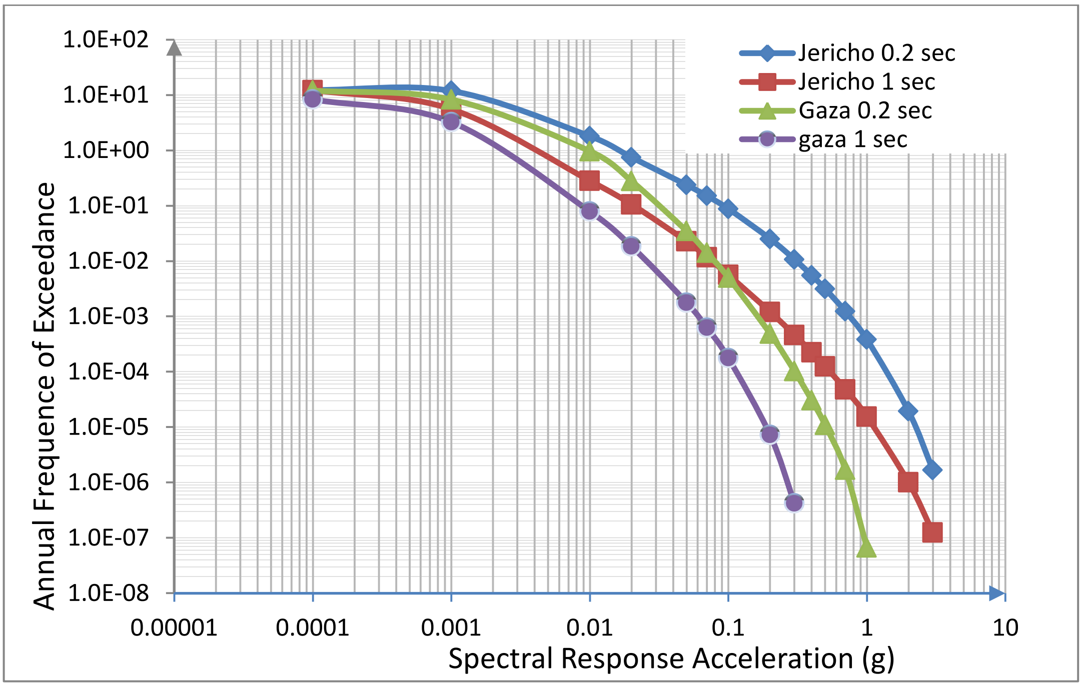


Figure (4.4): Hazard curves for Gaza and Jericho for long and short period

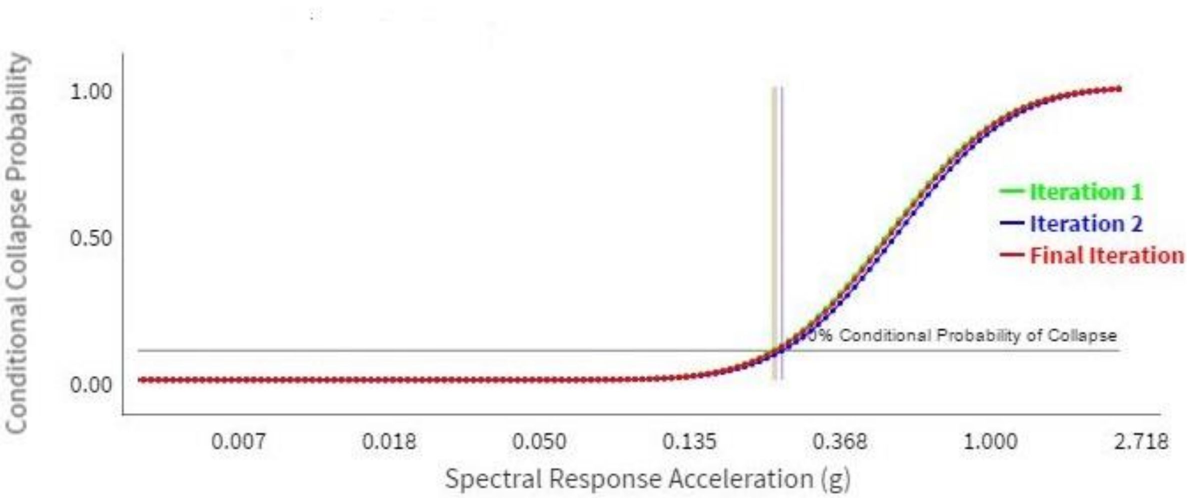


Figure (4.5): Cumulative Distribution Function (CDF) curve for short period hazard curve in Gaza

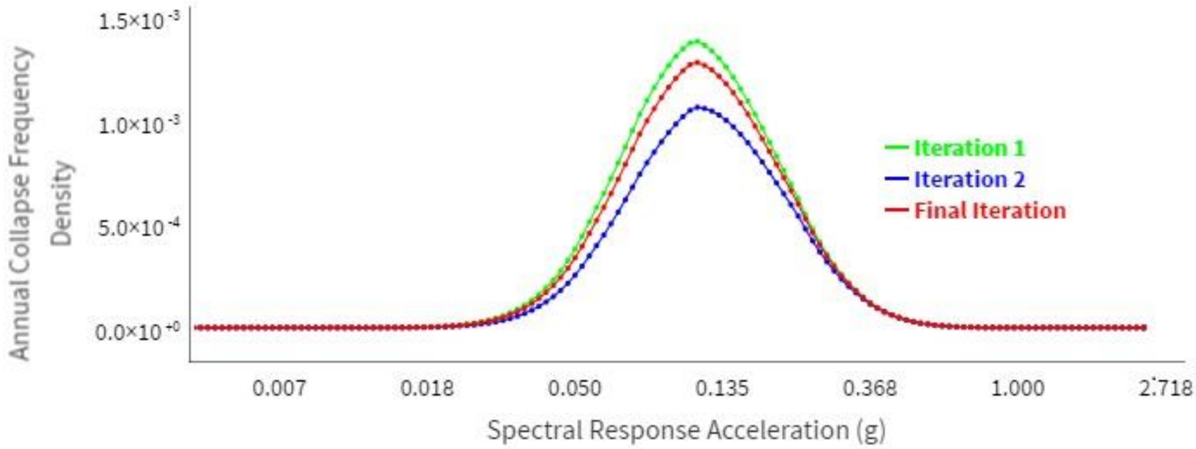


Figure (4.6): Derivative Cumulative Distribution Function (CDF) curve for short period hazard curve in Gaza

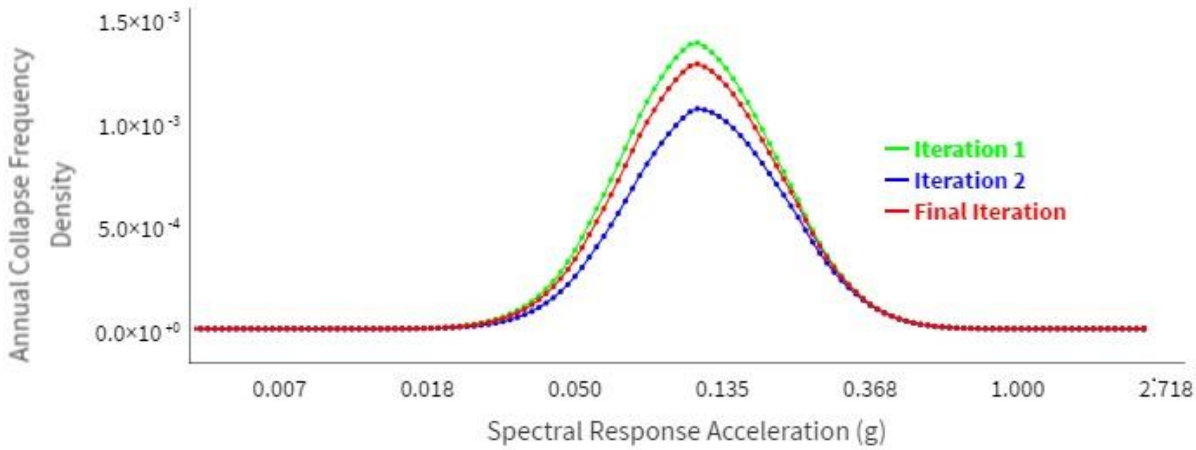


Figure (4.7): Derivative cumulative distribution function curve multiplicand by the hazard curve for short period in Gaza

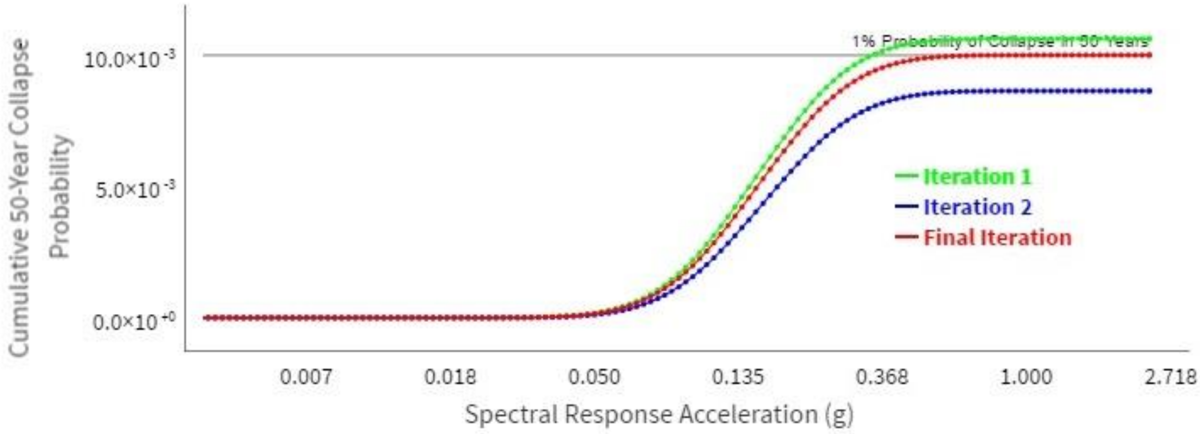


Figure (4.8): Cumulative integral of hazard curve multiplicand derivative cumulative distribution function curve

4.4 Concluded Remarks

Probabilistic seismic hazard analyses (PSHA) method has been used to develop the basic of seismic maps for Palestine. Thirty seismic zones have been used within Palestine and the around region to represent the faults system and seismic activity in Palestine according to historical and geological data. The probability density function used to determine the probability of occurring earthquake with magnitude between m_{min} and m_{max} inside each seismic source. Due to the limited of ground motion records during the earthquakes the empirical Boore-Joyner-Fumal (1997) equation has been used for modeling the ground motion results from the earthquakes. The probability of the occurring ground motion due to earthquake with magnitude between m_{min} and m_{max} inside seismic source with probability of distance D from the interesting site computed by the PSHA equation.

Chapter 5

MAPS DEVELOPMENT

CHAPTER 5: MAPS DEVELOPMENT

5.1 Introduction

In the previous chapter, the basic of the probabilistic seismic hazard analysis were explained in detail. Input parameters for Palestine and the calculation for develop seismic maps for Palestine were discussed. A comprehensive probabilistic seismic hazard analysis has been performed for Palestine using modified source model and attenuation equations.

In this chapter, the software used in the study and the results are discussed. All results correspond to 2 % probability of excedence in 50 years on rock sites. This level of probability corresponds to the ground motion at the site. The results include contour maps of risk coefficient for short and long period spectral accelerations. Also a comparison between the study result maps and the proposed Jordan (Jaradat, et al, 2008) and Israeli maps (SI413 2013) are including in this chapter.

5.2 Software

The steps that have been followed to calculate the seismic hazard analysis for Palestine using EZ-FRISK were as follows:

1) The boundary of Palestine has been selected by identifying the multisite analysis from site location box as shown in Figure 5.1. Then the program sketch tool has been used to drawing the boundary of Palestine in map view. The buffer of Palestine boundary was 5km to 40km to increase the accuracy of the boundary value as shown in Figure 5.2. Then the resulting distance between the grid points was 0.2 degree in longitude and latitude on the World Geodetic System 1984 coordinate system (WGS84). (0.2 degree equal 22.3 km)

2) Spectral response with 5% damping has been chosen for the intensity type to be conform to IBC2012 code from the analysis option box as show in Figure 5.1. Also the soil type B has been chosen form analysis option box by identifying V_{S30} =720m/s. The period 0.2 second and 1second selected for spectral value to analysis from spectral value to analysis box and the analysis amplitude unite and interval have been selected from amplitudes to analysis box as shown in Figure 5.1.

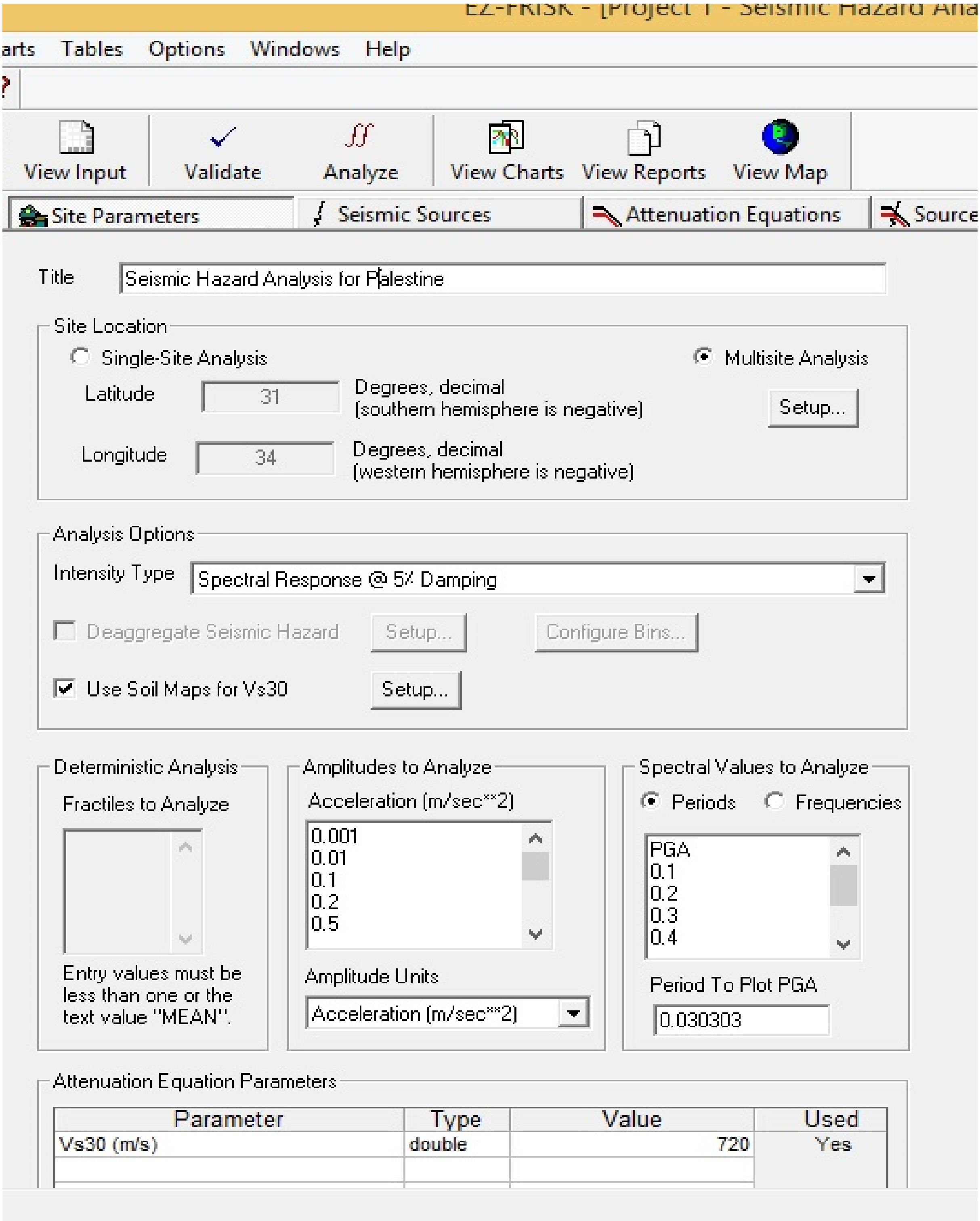


Figure (5.1): Site parameter window

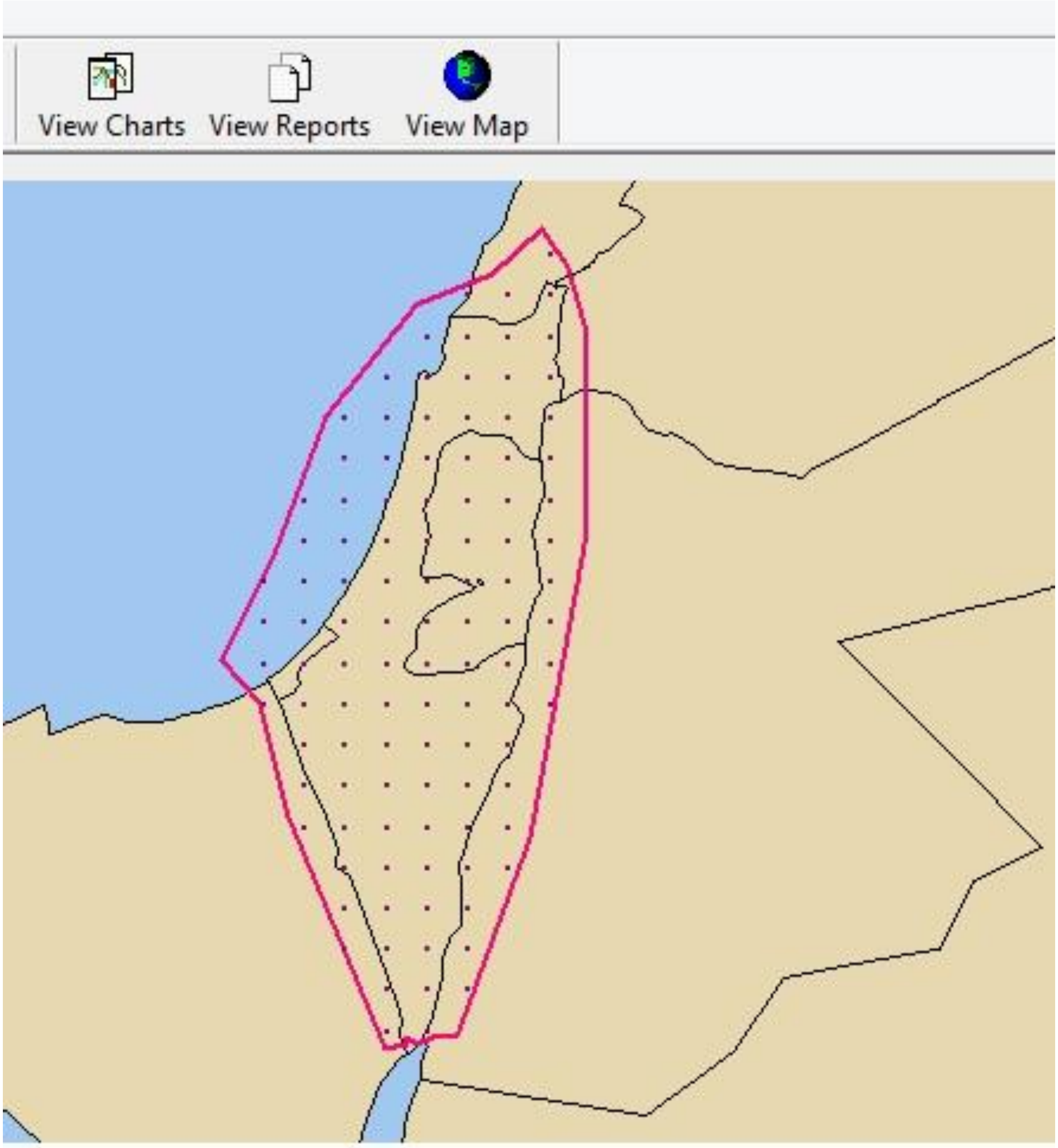


Figure (5.2): Boundary of the study region

3) 30 seismic sources have been identified as area source in the study region from user seismic source window as shown in Figure 5.3. The corner coordinate for each source was used to identify the boundary of each seismic area source at the program. Then identify the characteristic of each source as list in Table 3.1.

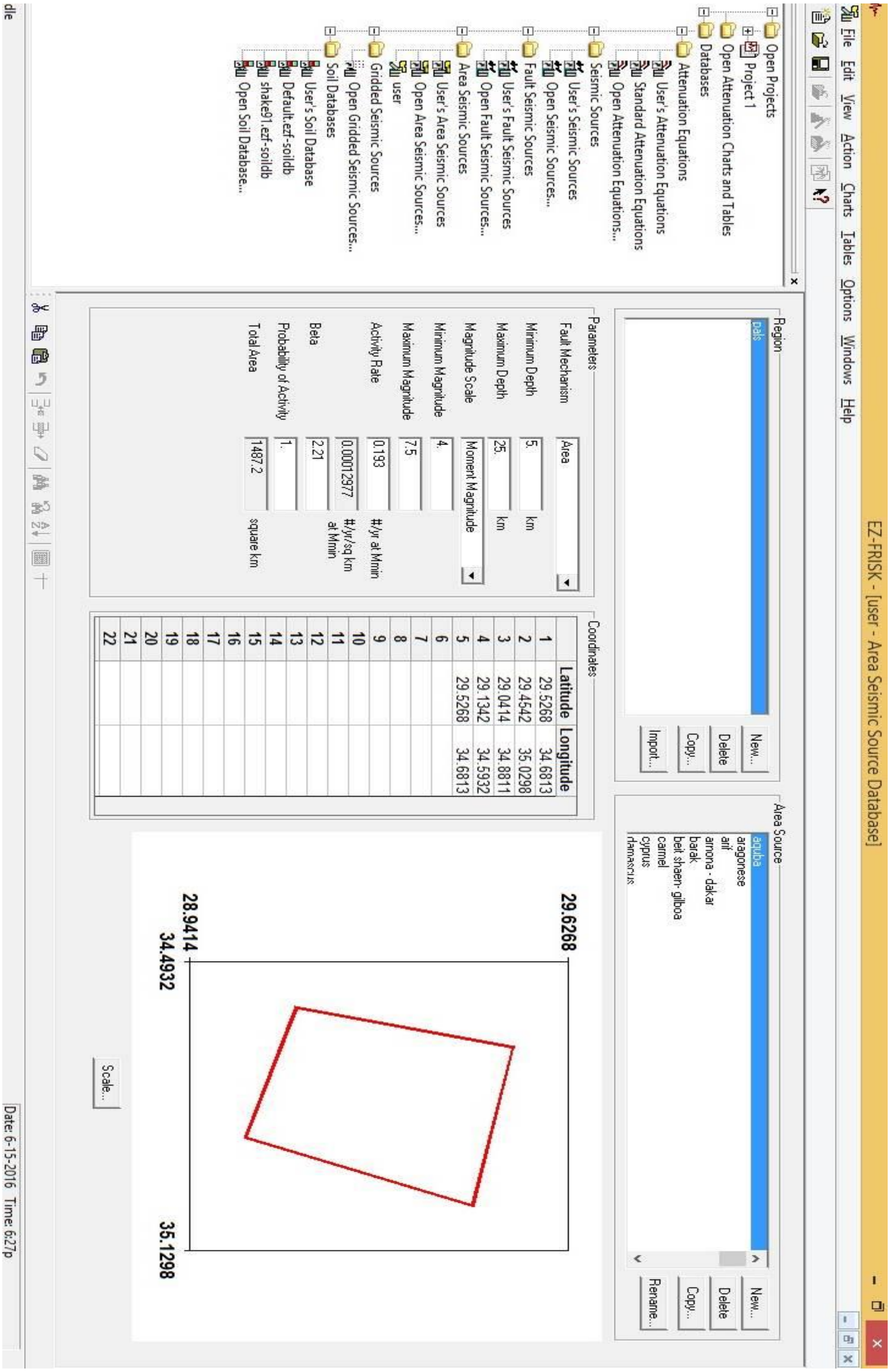


Figure (5.3): User seismic source window

4) The Boore-Joyner-Fumal (1997) attenuation relationship equation was selected from the select attenuation equation window as show in Figure 5.4.

5) The other calculation parameters for analysis have been selected before the analysis from the calculation parameter window as show Figure 5.5. From area source box the maximum inclusion distance has been used is 1000 km to ensure that all area sources effect in all points of region grid. The incremental of vertical distance from maximum to minimum depth has been chosen 0.5 km. 0.05 km and 0.06 km have been chosen as minimum and maximum distance integration increments. This limitation was used to define a small divide subarea in area source with maximum subarea dimension (0.06km*0.06km), so this small subarea can represent as point source in central of subarea. Default number of rupture azimuths can be effect when the subarea divided is large subarea (more than $0.25km^2$), while the maximum subarea has been defined was $0.0036km^2$. Also the incremental of earthquake magnitude was defined in this window and its 0.1 Moment magnitude.

6) The analysis has been run after complete all need input data and parameter from the analysis icon as shown in Figure 5.5.

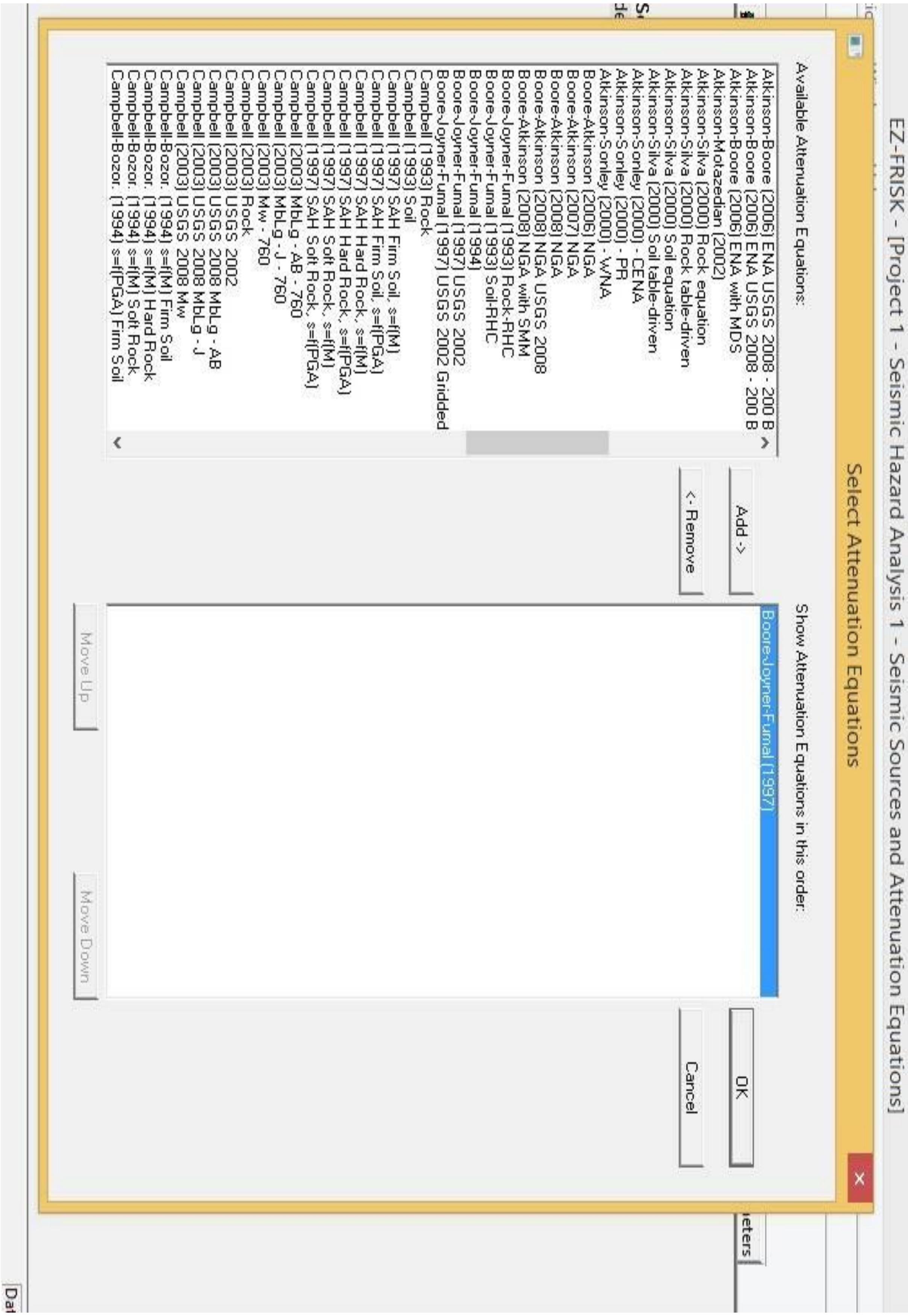


Figure (5.4): Select attenuation equations window

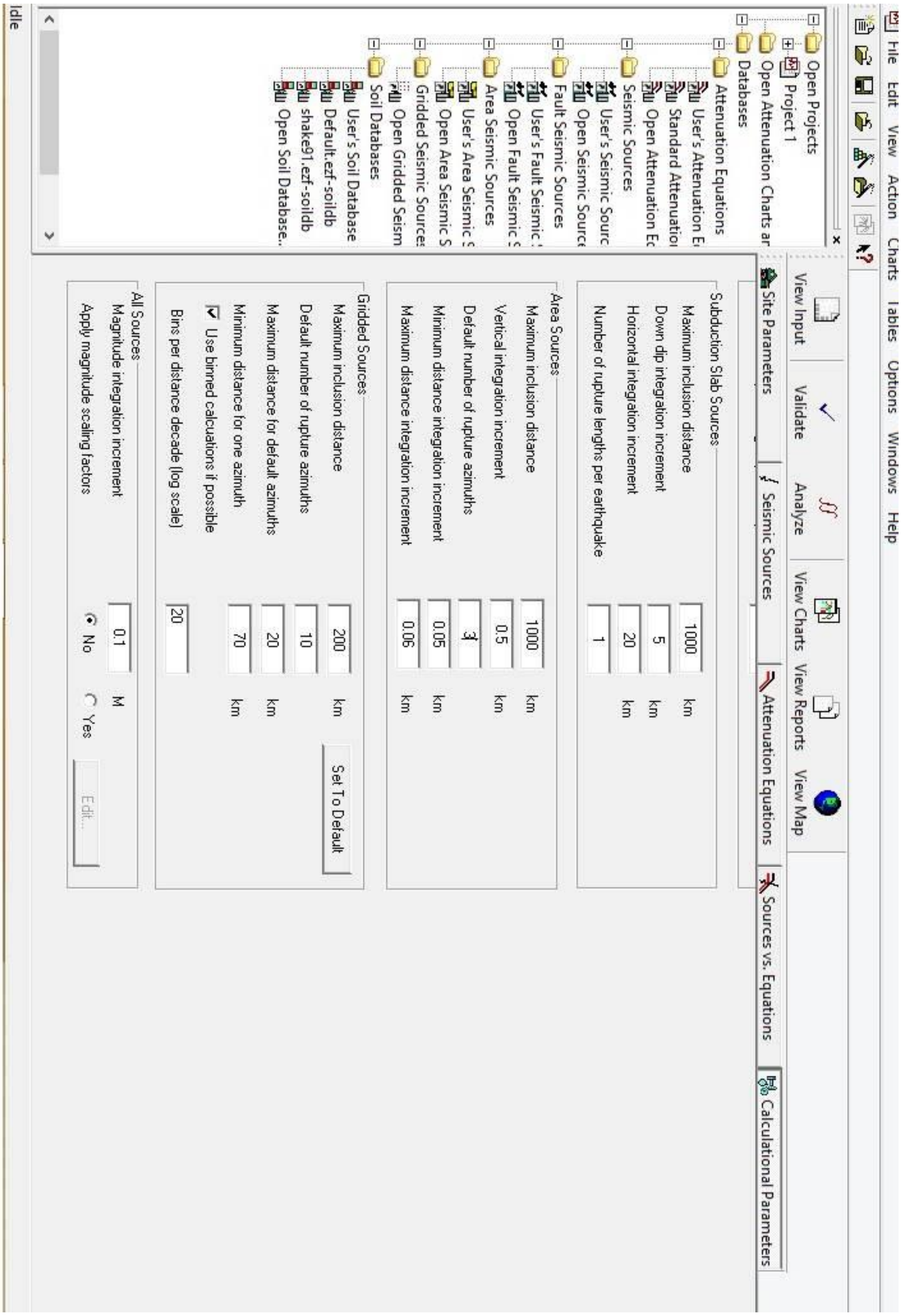


Figure (5.5): Calculation parameter window

5.3 Results

5.3.1 The spectral acceleration maps

EZ-FRISK program present the result of the analysis in table form as shown in Figure 5.6 and in ANNEX 1. The table shows the maximum considered earthquake ground motion for each point in the grid at different period (T=0.1, 0.2 and 1.0 seconds) with respect to 2% and 10% probability of exceedance in 50 years with return period 2475 year and 475 year respectively. The Arcmap program has been used to convert the results from table form to the maps form as follow:

1. The table has been copied to excel file and then the excel file added to Arcmap program
2. Add x y data tool has been used to convert the excel file to point shape file as shown in Figure 5.7.
3. IDW interpolation from spatial analysis tools was used to convert the point shape file to map form as shown in Figure 5.8. The final maps shown in Figures 5.9 and 5.10.

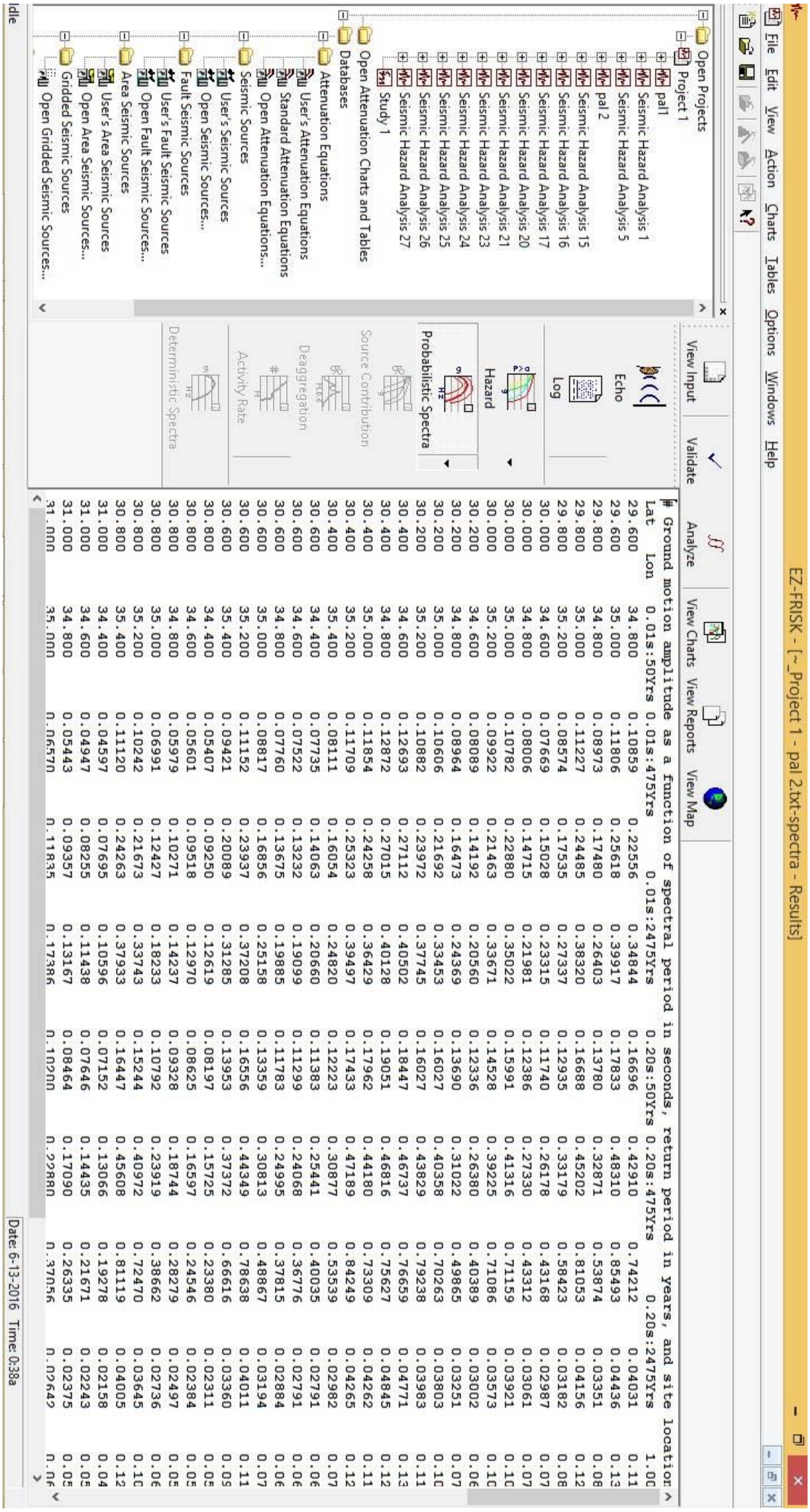


Figure (5.6): Result windows

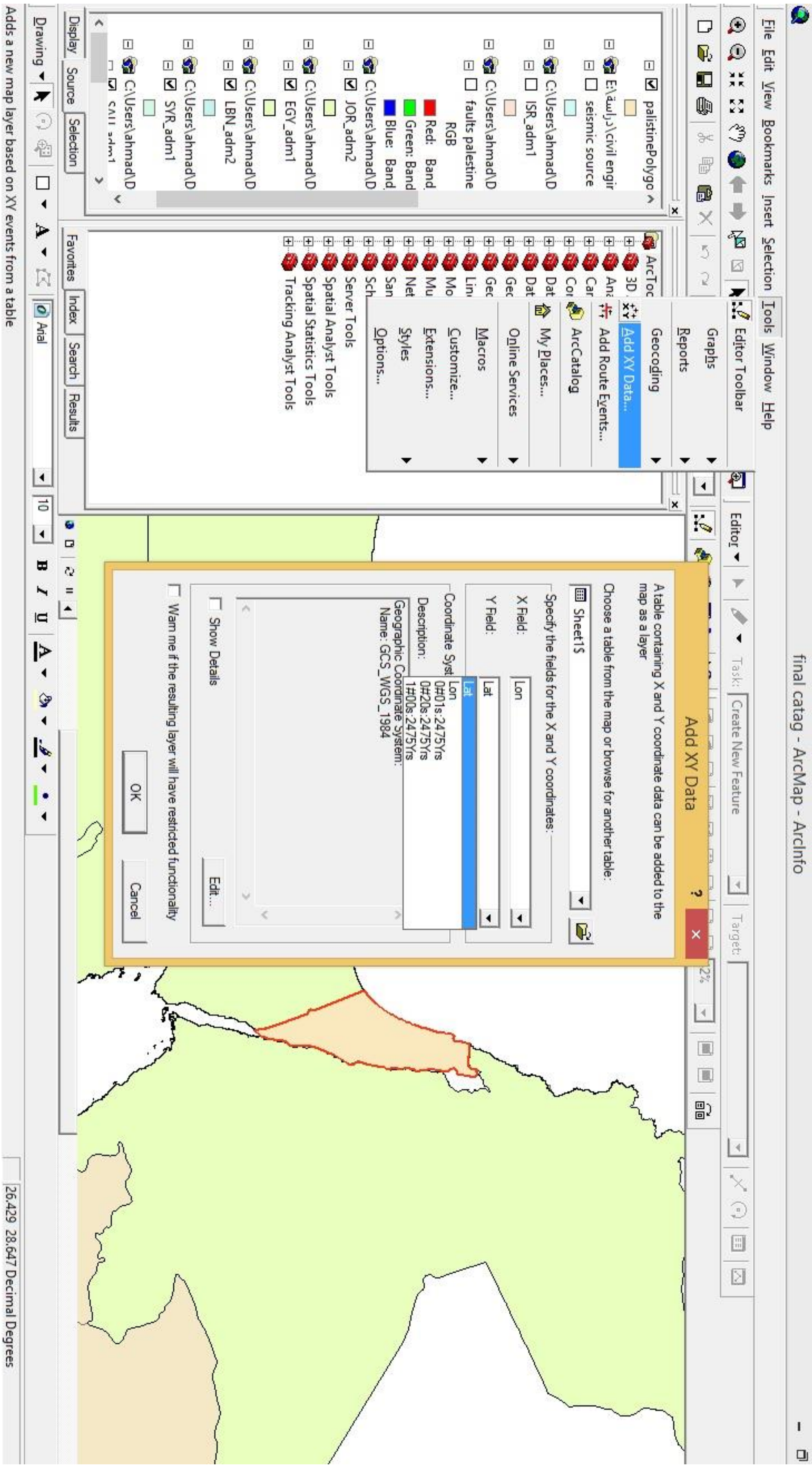


Figure (5.7): Convert excel file to shape file by Arcmap program

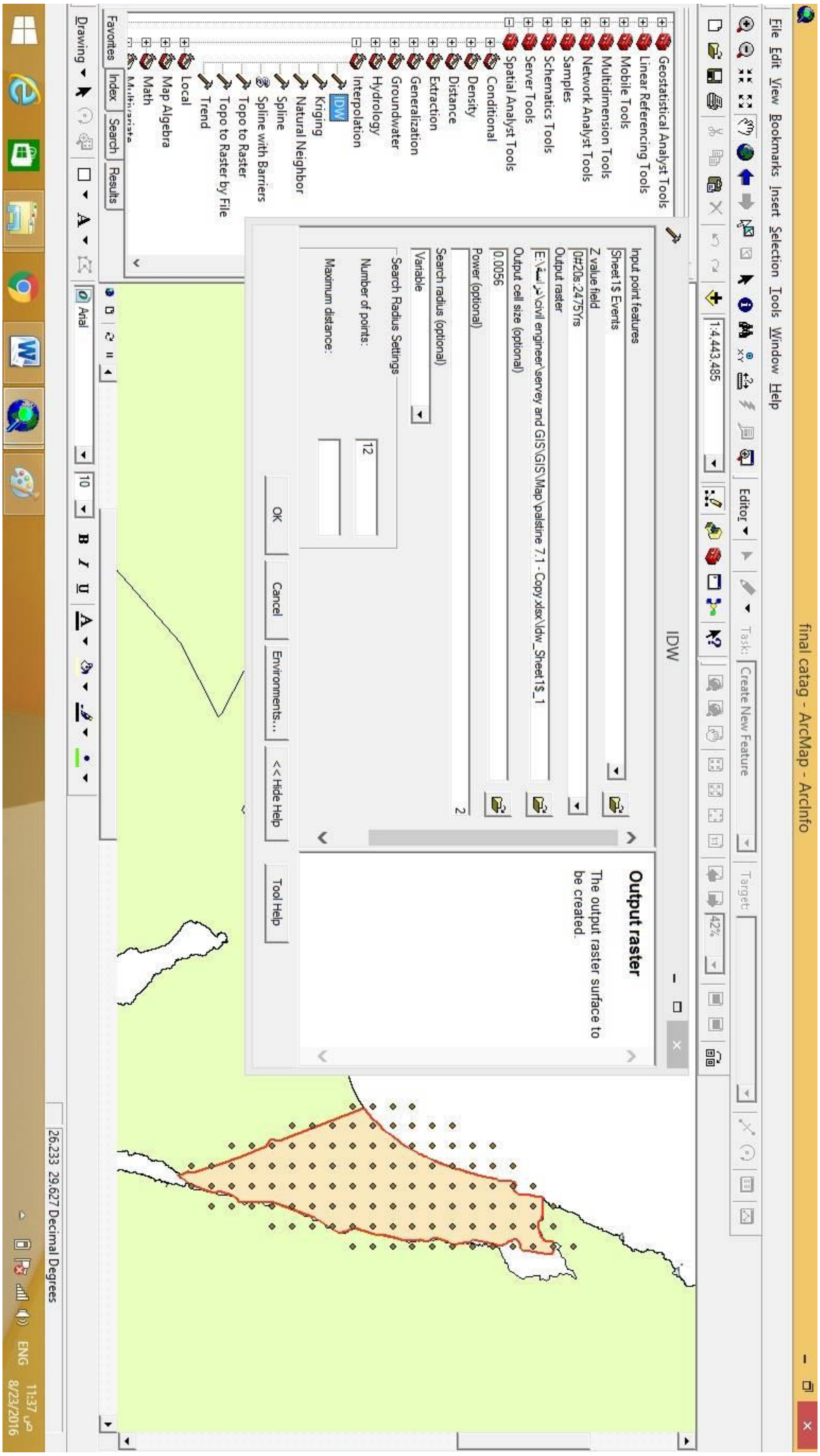


Figure (5.8): Convert point shape file to maps by Arcmap program

The maps in Figures 5.9 and 5.10 show that the region along the Dead Sea Fault from the west has a maximum value of S_S and S_1. The value of S_S decreases from west to east with a value of 0.83g to 0.14g and S_1 decreases from 0.06g to 0.23g. The east to west pattern of S_S and S_1 distributions reflects to the influence of the seismicity of the Dead Sea Basin, Jordan Valley, Hula, Yammouneh and Roam which are more active seismic sources compared to the farthest western sources; i.e. the Mediterranean and Cyprus sources. The S_S value at the northeast of Palestine is higher than Dead Sea region that because Yammouneh seismic source in the north Palestine have α value 0.9144 and maximum earthquake magnitude 8 while the maximum α value at seismic sources along the Dead Sea Fault (Dead Sea, Jordan Valley and Hula sources) 0.3729 and maximum magnitude 7.5 as shown in Table 3.1, and S_1 value in northeast of Palestine is the highest due to the high activity of Yammouned seismic source. In the south there are interior branch with high spectral seismic value comparison with it's around area. This seismic hazard is a result of the east Sinai and Paran seismic sources.

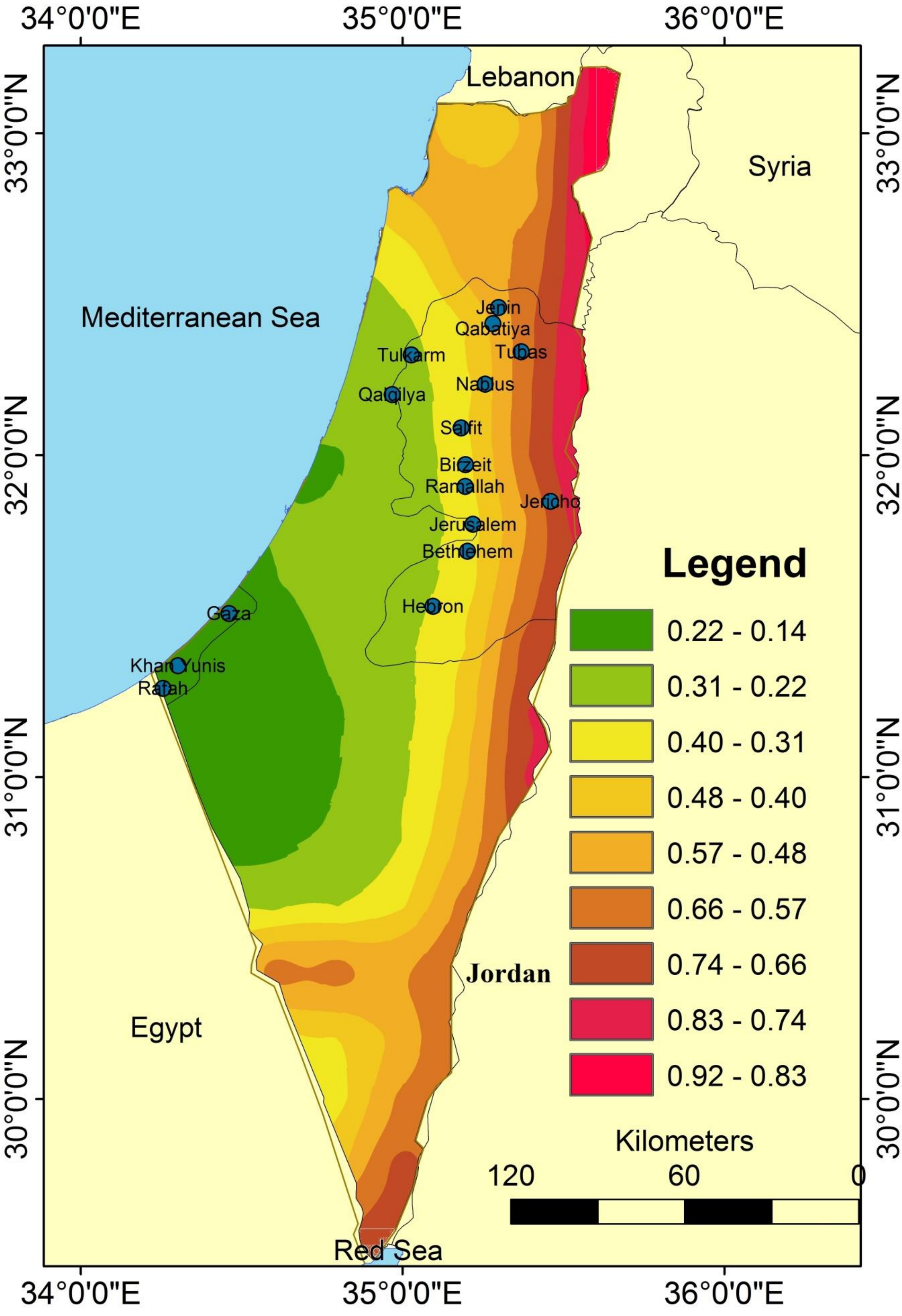


Figure (5.9): Maximum considered earthquake ground motion for Palestine of 0.2 sec spectral response acceleration with 5% damping and site class B

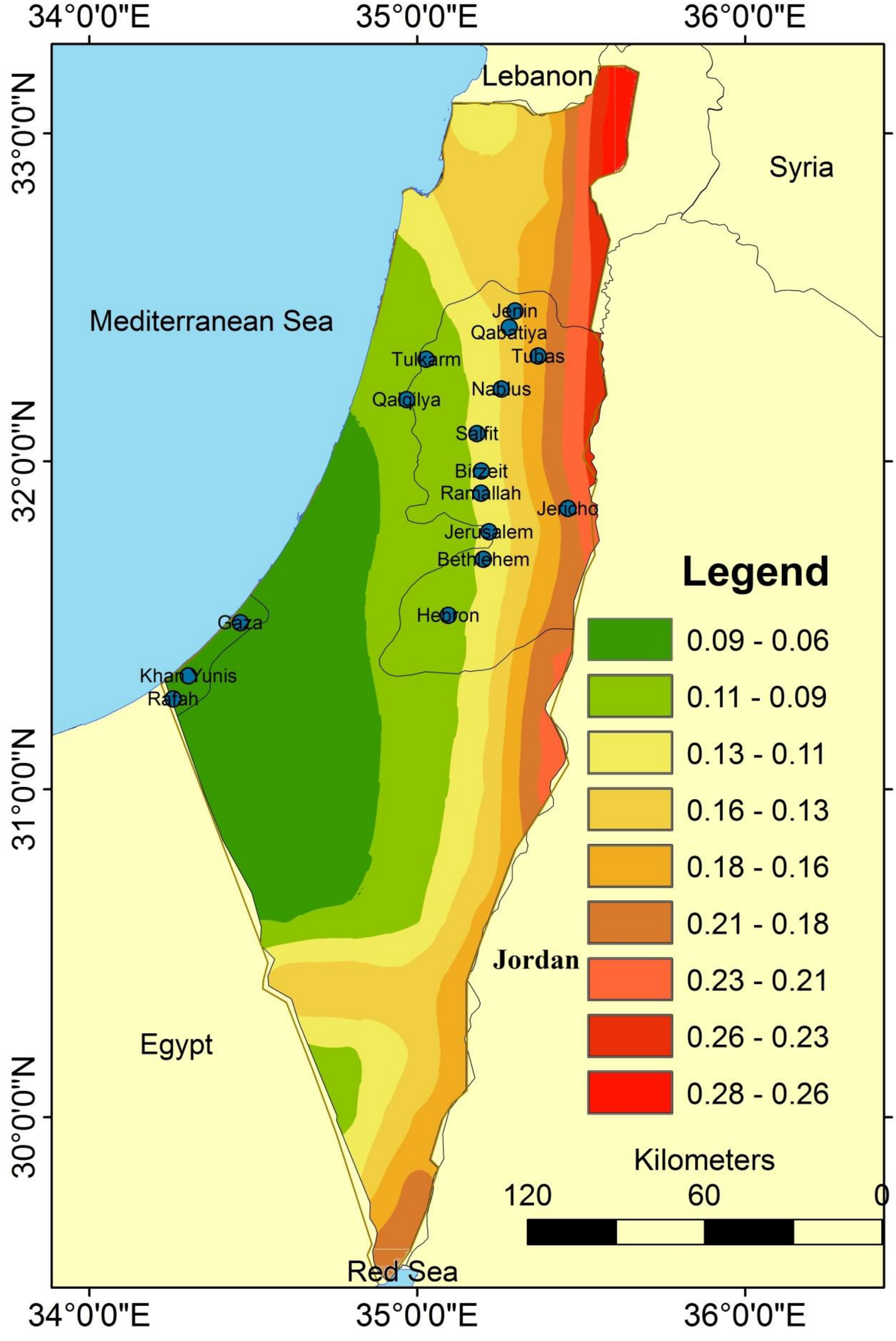


Figure (5.10): Maximum considered earthquake ground motion for Palestine of 1 sec spectral response acceleration with 5% damping and site class B

5.3.2 The risk coefficient maps

EZ-FRISK program has been used to compute the hazard curves for 18 points around Palestine. These points present the main cites of Palestine Figure 5.11 shows the hazard curve for Jerusalem. The risk coefficient has been computed by add the hazard curve for each point at the online site (http://earthquake.usgs.gov/designmaps/rtgm/) as shown in Figure 5.12. Table 5.1 lists the risk coefficient for the 18 points. Arcgis program has been used to convert Table 5.1 to contour maps as shown in Figure 5.13 for short period and Figure 5.14 for long period.

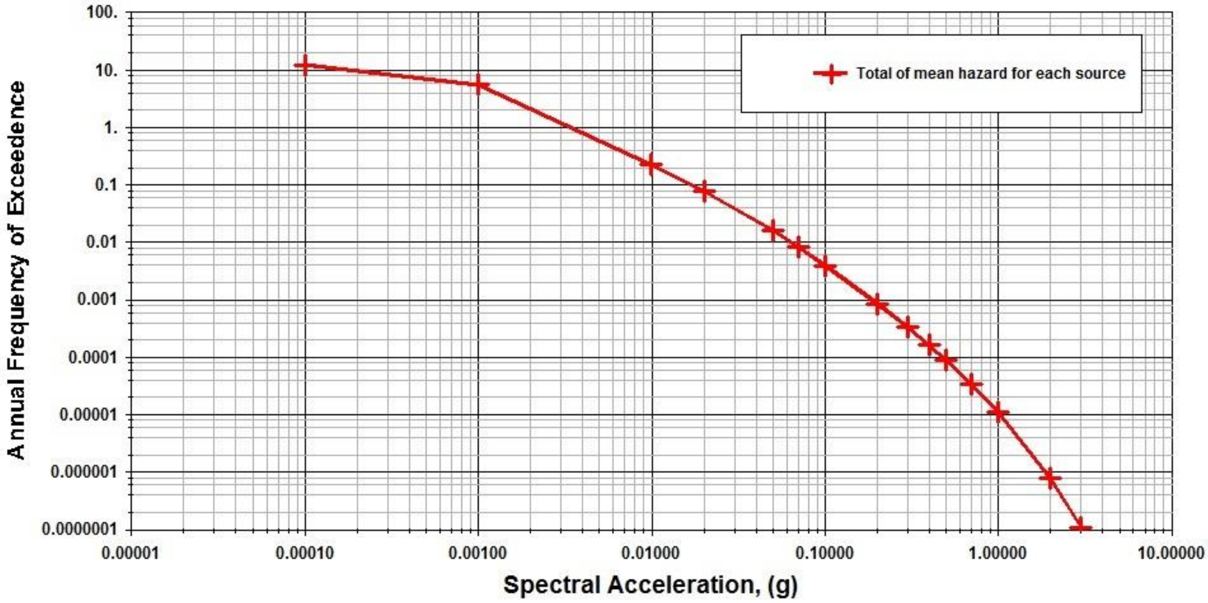


Figure (5.11): Hazard curve for Jerusalem

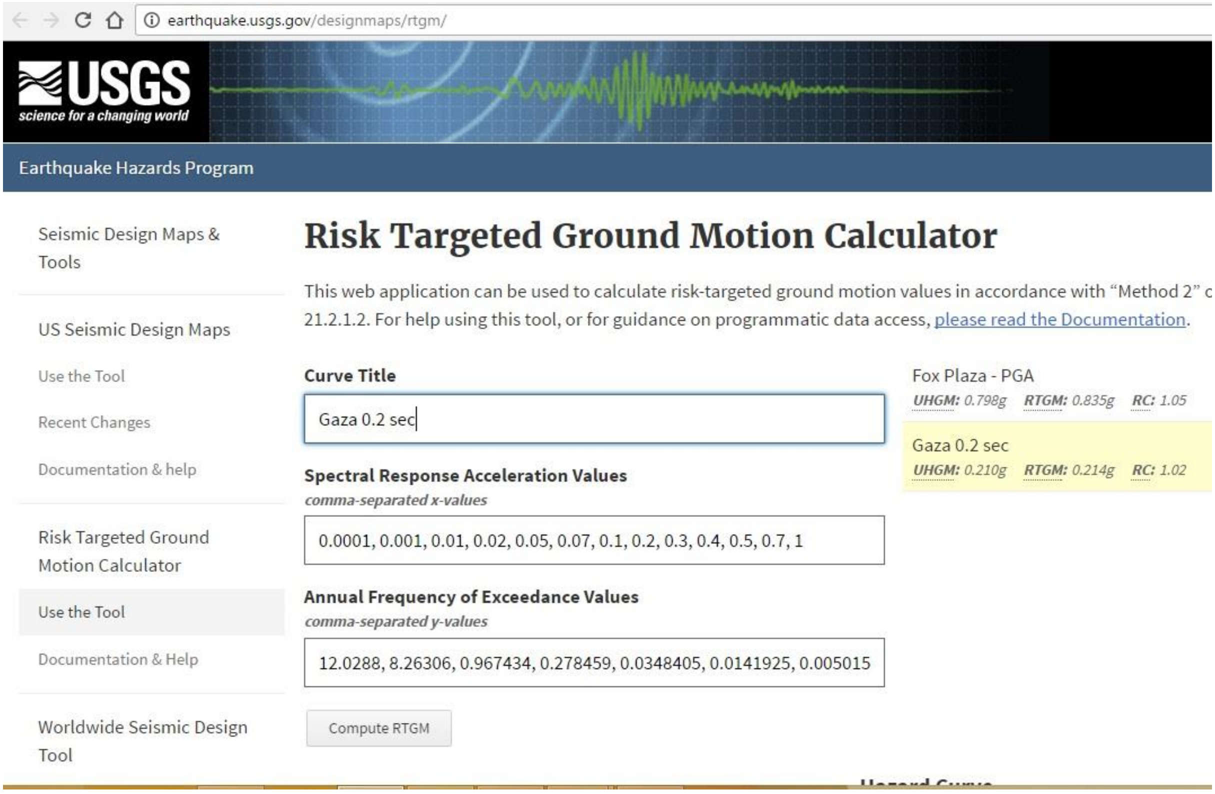


Figure (5.12): Online risk coefficient calculator

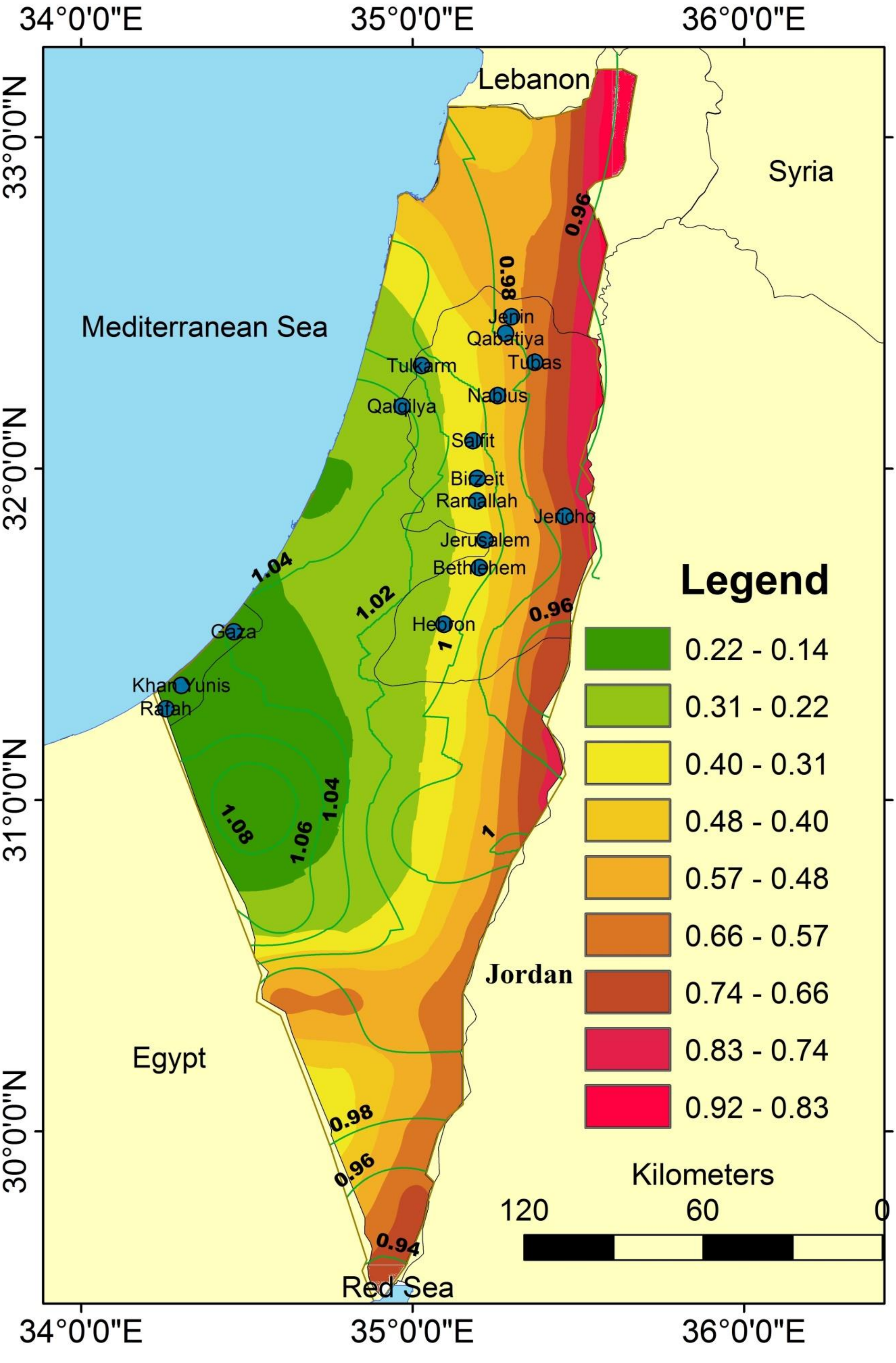


Figure (5.13): Mapped risk coefficient at 0.2 s spectral response period, C_{RS}

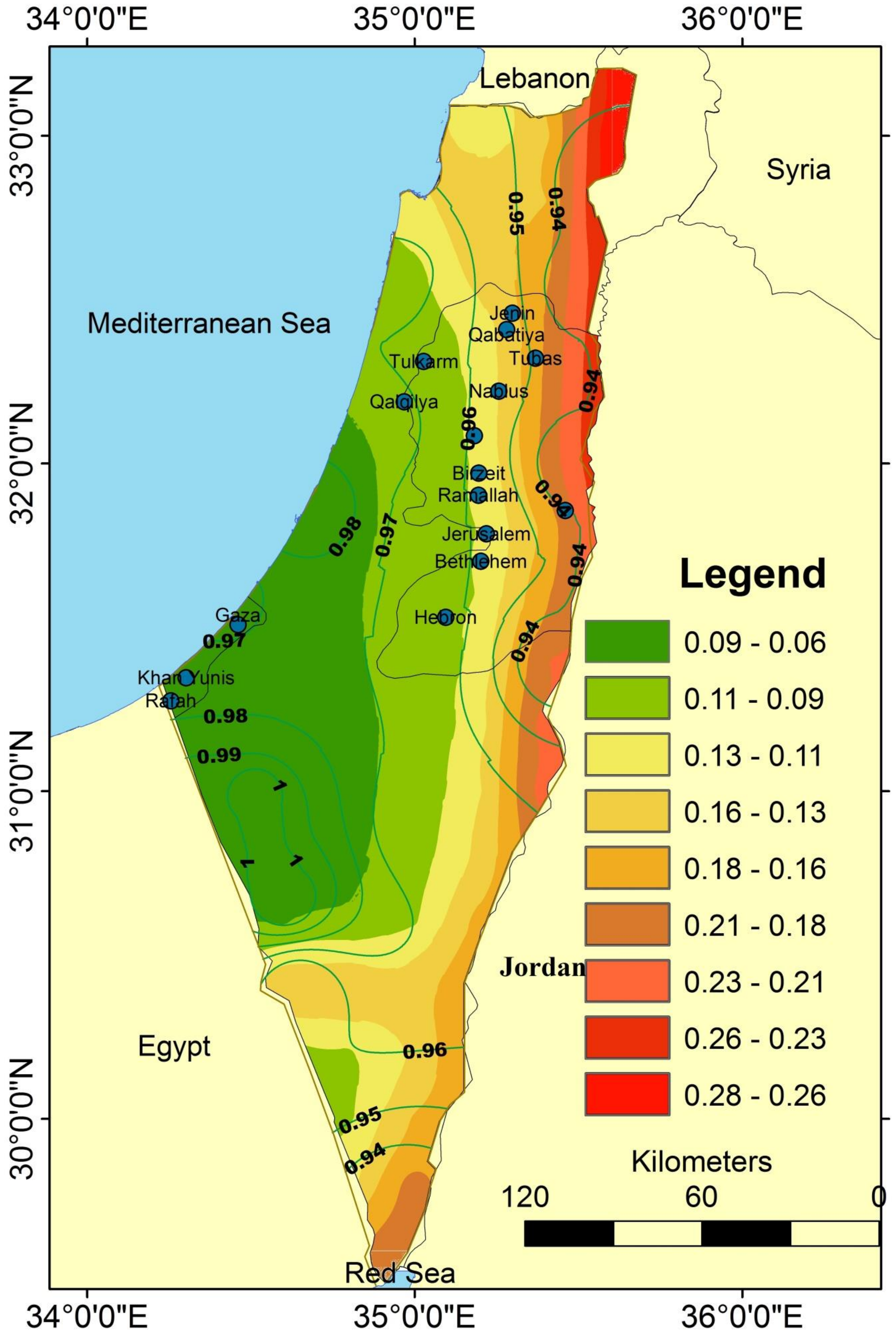


Figure (5.14): Mapped risk coefficient at 1 s spectral response period, C_{R1}

Table (5.1): Risk coefficient for main cities in the Palestine

latitude	longitude	***UHSA***	***RTSA***	***RC***	***period***
32.846	35.59	0.998g	0.957g	0.96	0.2
32.87	35.07	0.588g	0.575g	0.98	0.2
29.717	34.96	0.784g	0.746g	0.95	0.2
31.4	35.44	0.884g	0.840g	0.95	0.2
33.24	35.6	0.852g	0.823g	0.97	0.2
31.86	34.69	0.238g	0.251g	1.05	0.2
32	35.5	0.985g	0.945g	0.96	0.2
31.5	34.5	0.210g	0.214g	1.02	0.2
31.5	34.9	0.294g	0.300g	1.02	0.2
32.49	35.15	0.567g	0.558g	0.98	0.2
32.537	35.516	0.961g	0.922g	0.96	0.2
30.9648	34.5174	0.197g	0.216g	1.1	0.2
30.6694	34.6054	0.287g	0.306g	1.07	0.2
32.1086	34.8537	0.269g	0.284g	1.06	0.2
32.5581	34.9614	0.394g	0.398g	1.01	0.2
31.8096	35.1178	0.389g	0.395g	1.01	0.2
30.899	35.0396	0.396g	0.392g	0.99	0.2
30.4018	34.643	0.727g	0.713g	0.98	0.2
32.846	35.59	0.322g	0.300g	0.93	1
32.87	35.07	0.166g	0.159g	0.96	1

Table (5.1): Risk coefficient for main cities in the Palestine (continued)

latitude	longitude	***UHSA***	***RTSA***	***RC***	***period***
29.717	34.96	0.233g	0.218g	0.93	1
31.4	35.44	0.276g	0.256g	0.93	1
33.24	35.6	0.264g	0.247g	0.94	1
31.86	34.69	0.082g	0.081g	0.99	1
32	35.5	0.317g	0.295g	0.93	1
31.5	34.5	0.079g	0.077g	0.97	1
31.5	34.9	0.095g	0.091g	0.97	1
32.49	35.15	0.160g	0.154g	0.96	1
32.537	35.516	0.310g	0.289g	0.93	1
30.9648	34.5174	0.072g	0.072g	1	1
30.6694	34.6054	0.084g	0.085g	1.01	1
32.1086	34.8537	0.091g	0.089g	0.98	1
32.5581	34.9614	0.111g	0.109g	0.98	1
31.8096	35.1178	0.117g	0.113g	0.96	1
30.899	35.0396	0.114g	0.109g	0.96	1
30.4018	34.643	0.212g	0.201g	0.95	1

5.4 Comparison Between the Develop Maps with Other Available Maps

5.4.1 IBC – Jordan proposed maps

Figures 5.15 and 5.16 show the spectral acceleration for Palestine and Jordan for short and long period respectively (Jaradat, et al., 2008). The Jordan maps were developed by using Probabilistic Seismic Hazard Analysis (PSHA) approach to calculate the spectral acceleration at

0.2 and 1 second period of 2% probability of exceedance in 50 years. As shown in Figures 5.15 and 5.16 the Jordan maps are similar in shape with the developed maps but there are some differences between the develop map and Jordan map in the magnitude.

In the short period developed map at the south of Palestine (middle of Al-Naqab desert) there is a different pattern; the value of S_s decrease from center of this branch to outside with S_s value at west 0.66g and the same value in the east while the Jordan map this region has the same pattern along Palestine decrease from east to west with S_s value 0.17g at the west and 0.61g at the east. The reason for this difference is the difference between the seismic sources used to develop the seismic map, the increase of the S_s is due to use Thamad, east Sina and Paran seismic sources in this study while in Jordan analysis this source did not use as shown in Figure 5.17. The historical and geologic studies for this zone show that there are about five earthquakes occurred with magnitude more than 4.5 moment magnitude as shown in Figure 3.2 and this zone has an active fault as shown in Figure 3.2. So the used of the three seismic sources is more accurate and compatible with seismic characteristic and historic and geologic of this zone. This difference appear in S_1 maps as shown in Figures 5.10 and 5.16, this difference result for the same reasons dissected for S_s maps.

In the Dead Sea basin and the north of Palestine the Jordan map have S_1 values higher than the developed maps by about 30% with Jordan S_1 value about 0.4g, while in the developed map the S_1 for this regions are change from 0.21g to 0.28g, also in the north there is a difference in the interval rise value from the Mediterranean Sea to the east boundary of Palestine. In Jordan map the S_1 increase from 0.26g at the west boundary to 0.53g at the east while the value in this study map it increase from 0.16g to 0.28g at the same zone. There are two reasons for this difference the first is the shape of seismic sources for this zone in Jordan map the seismic sources were used to develop the map was 4 seismic areas sources as shown in Figure 5.17 while in this study 7 seismic sources was used as shown in Figure 3.2. According to the historical and geological studies the 7 sources have been used simulate the seismic parameters in the seismic model with accuracy more than 4 sources, In the Jordan map the b-value used the 4 sources Jordan Valley, Palmiride, Roam and Yammuneh are 0.60, 0.34, 0.35 and 0.20 respectively and the alfa value are 0.233, 0.173, 0.167 and 0.149 respectively. On the other side the b-value used in the study for Jordan Valley, S-Lebanon, Roam, Sergayha, Hula and Yammuneh are 0.96, and b-value for Sirhan is 0.71 and the alfa value are 0.3729, 0.0364, 0.2887,0.0820, 0.2526, 0.9144 and 0.0500 respectively. As dissection before the b-value should be around 1 so use the 7 seismic sources is more accurate. And the alfa values of seismic sources have been used in the study decrease from east to west and that compatible with results maps.

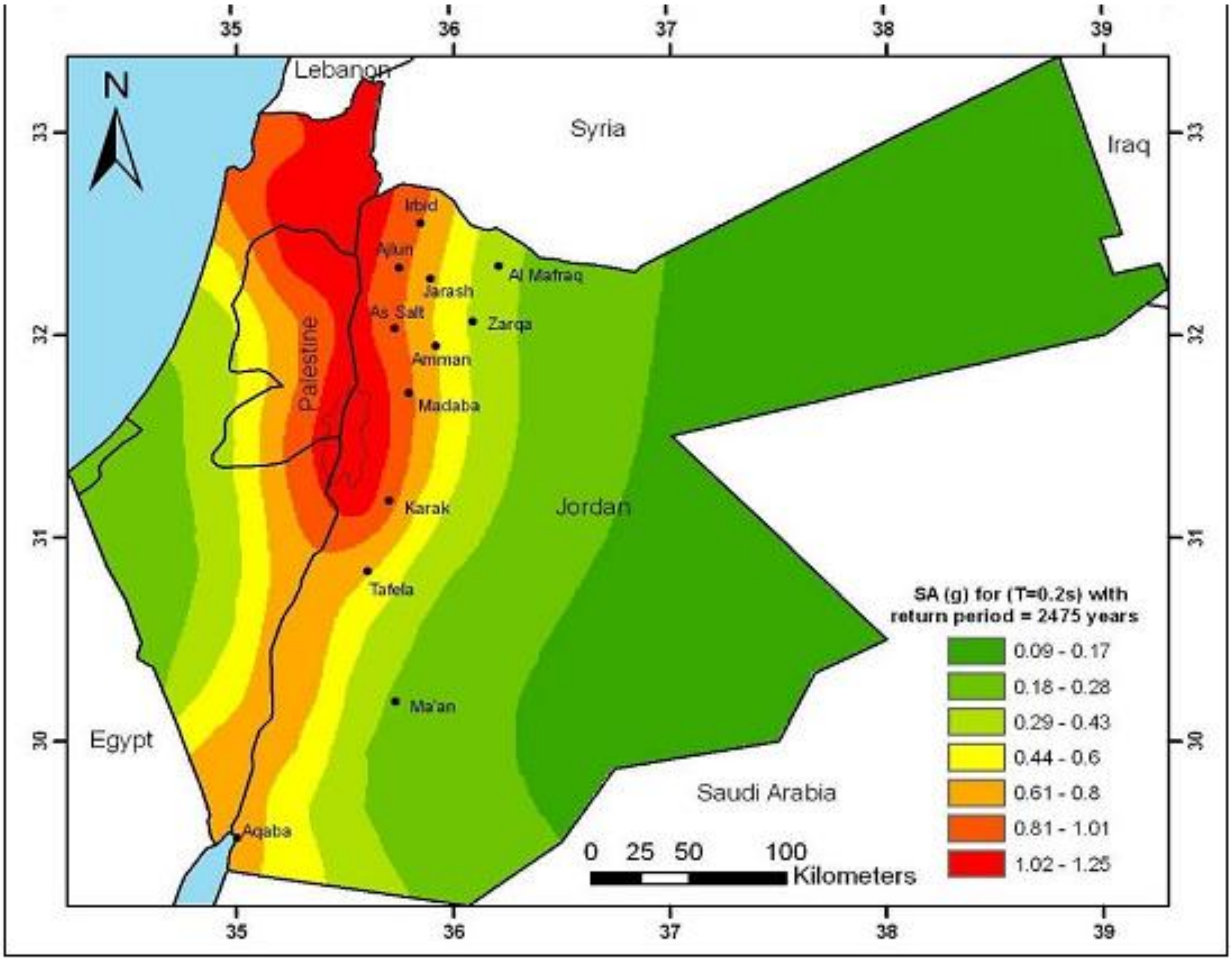


Figure (5.15): Jordan map of maximum considered earthquake ground motion of 0.2 sec spectral response acceleration with 5% damping and site class B

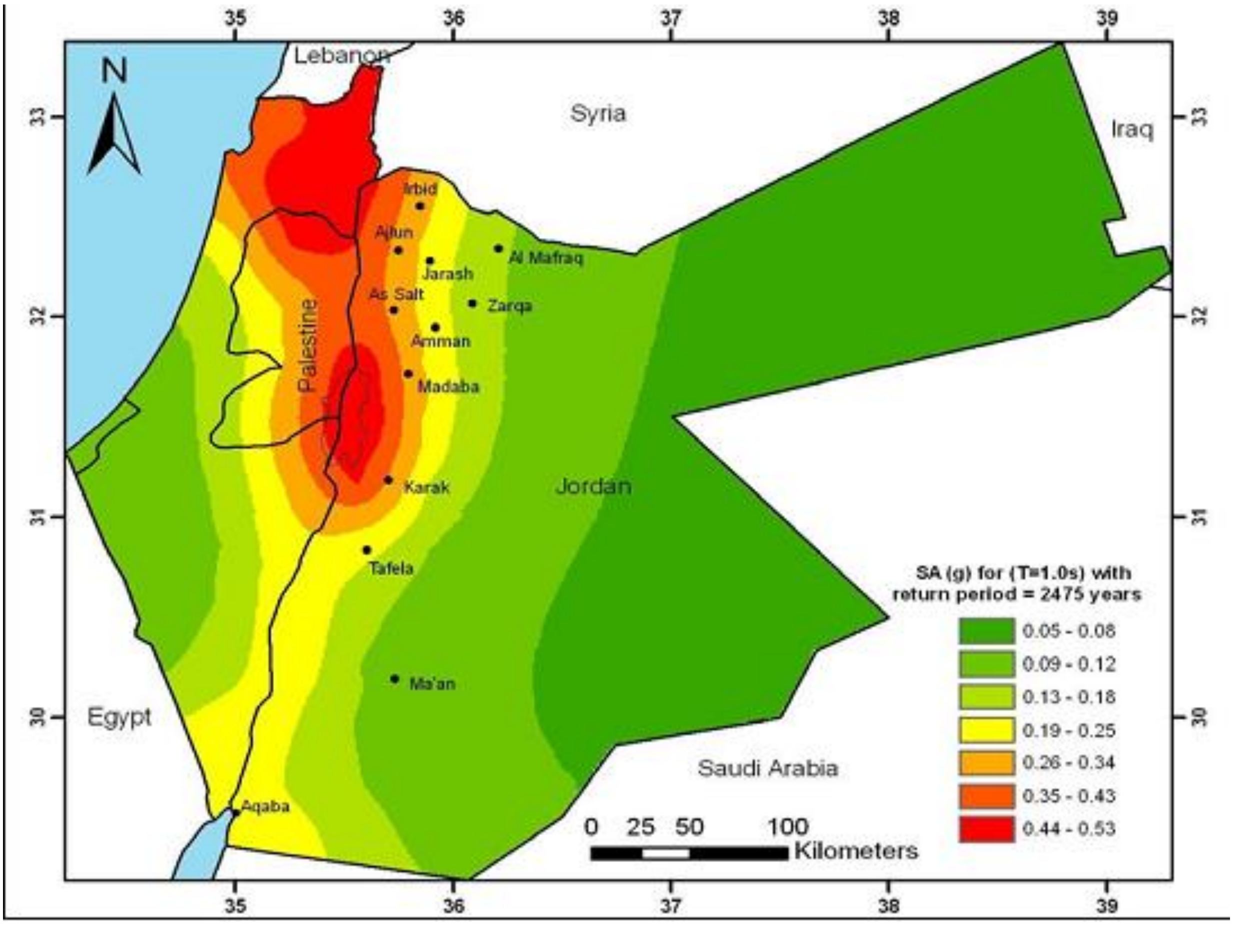


Figure (5.16): Jordan map of maximum considered earthquake ground motion of 1 sec spectral response acceleration with 5% damping and site class B

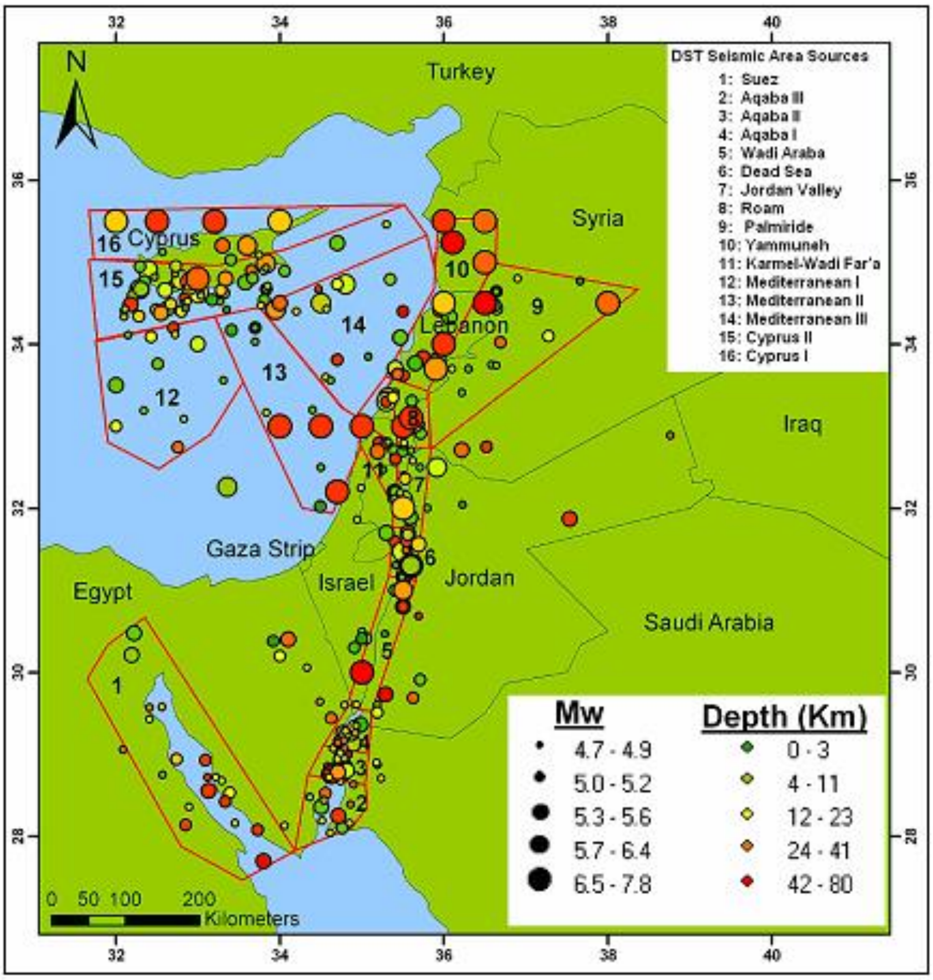


Figure (5.17): Seismicity map of the Dead Sea Transform region including historic and sources used in Jordan maps

5.4.2 Israel maps

The Israeli seismic maps and the study maps for short and long period are similar in the shape and magnitude with some difference in the values as shown in Figure 5.18. In general the seismic sources used in the Israeli maps and Palestinian are similar. This similar in seismic sources and the same parameter for the seismic sources led to similar in shape and magnitude. The differences in values referred to use difference attenuation relationships, the Israeli maps used the Campbell and Bozorgnia 2008 equation and the equation has been used to develop the study maps was Joyner and Boore 1997 (A. Klar el al., 2011).

1. Short period maps

In the south of Palestine (middle of Al-Naqab desert) there is a difference between the Israeli map and the study map values of S_s, in the Israeli map the value of S_s at the west boundary of the branch is 0.3g and increase dramatically to 0.8g at the east boundary of Palestine while in the study map the value of S_s along the branch 0.66g except the middle of branch is 0.57g. This difference results from use difference equations in each study. In the northeast of Palestine the S_s value in the Israeli map is 1.2g also the value along the east boundary of Palestine is around 1g. On the other hand, in the study map the S_s value in northeast Palestine is 0.92g and the S_s value along the east boundary is around 0.83g. The different between the S_s values in the two maps result from the different in the seismic area sources has been used at the region next to east boundary of Palestine as shown in Figure 5.19. Palmera seismic source with alfa and b values 0.1189 and 0.96 respectively used in the Israeli maps but in this study two seismic sources with small area have been used to represent the historical seismic of the region Damascus with alfa and b values 0.0641 and 0.96 respectively and Sergayha with alfa and b values 0.0820 and 0.96 respectively. The historical seismic active for this region is low, the earthquakes density is low and there is no active fault in the region so the two seismic areas have been used with small alfa value is more accurate. Jordan north defined as seismic area source in the Israeli maps along the east boundary with alfa and b values 0.1044 and 0.96. The historical earthquakes in this region was randomly with magnitude less than 4 so use area source in this region doesn’t make sense.

2. Long period map

In the long period the two maps are similar in shape and value of S_1 but there is a difference between the Israeli map and the study map in the branch at the south of Palestine, in the Israeli map the value of S_1 at the west boundary of the branch is 0.08g and increase dramatically to 0.18g at the east boundary of Palestine while in the study map the value of S_1 along the branch 0.16g. This difference results from use difference equations in each study.

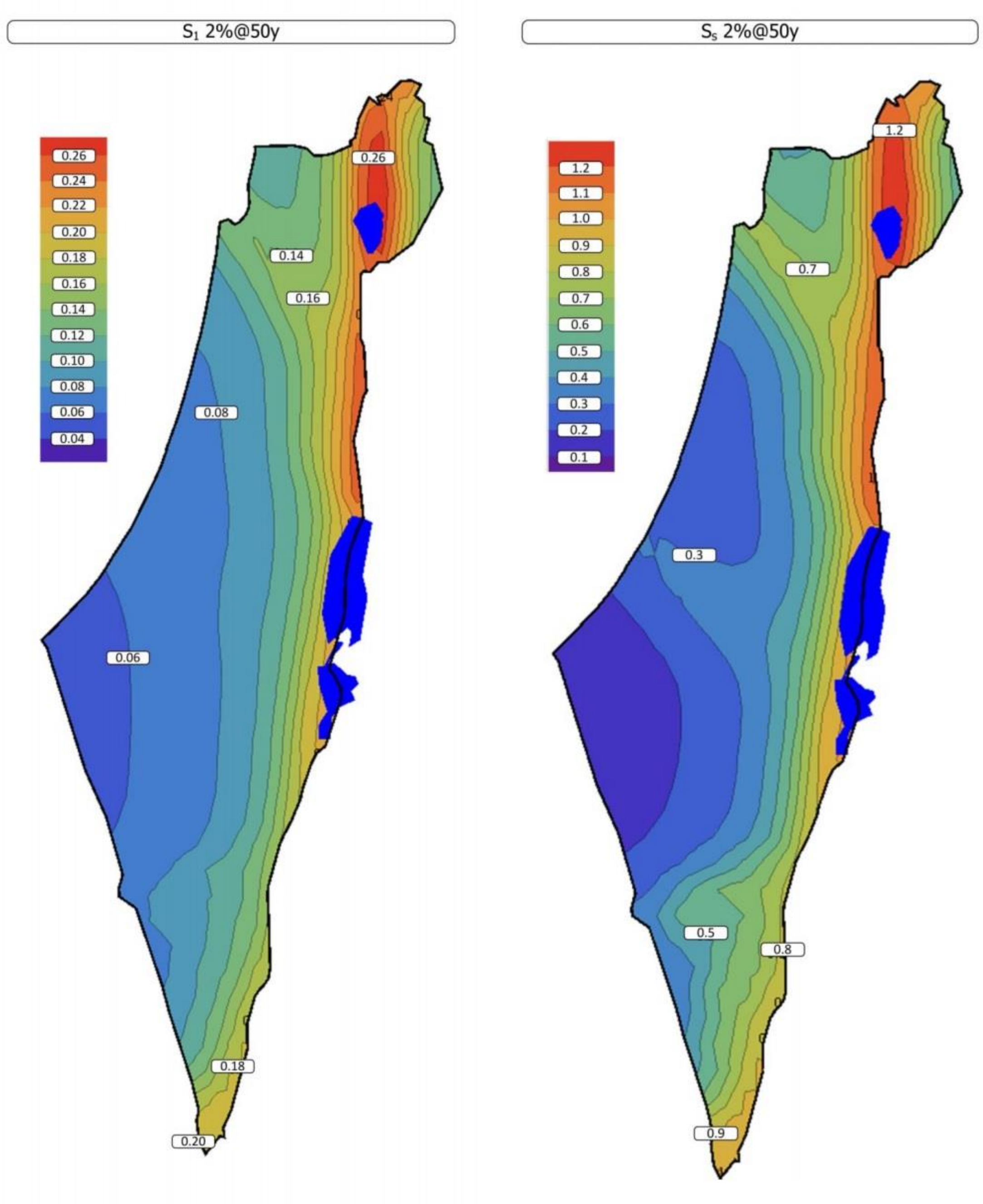


Figure (5.18): Israeli seismic maps of maximum considered earthquake ground motion with 2% in 50y and 5% damping and site class B, the right map for short period and the left map for long period

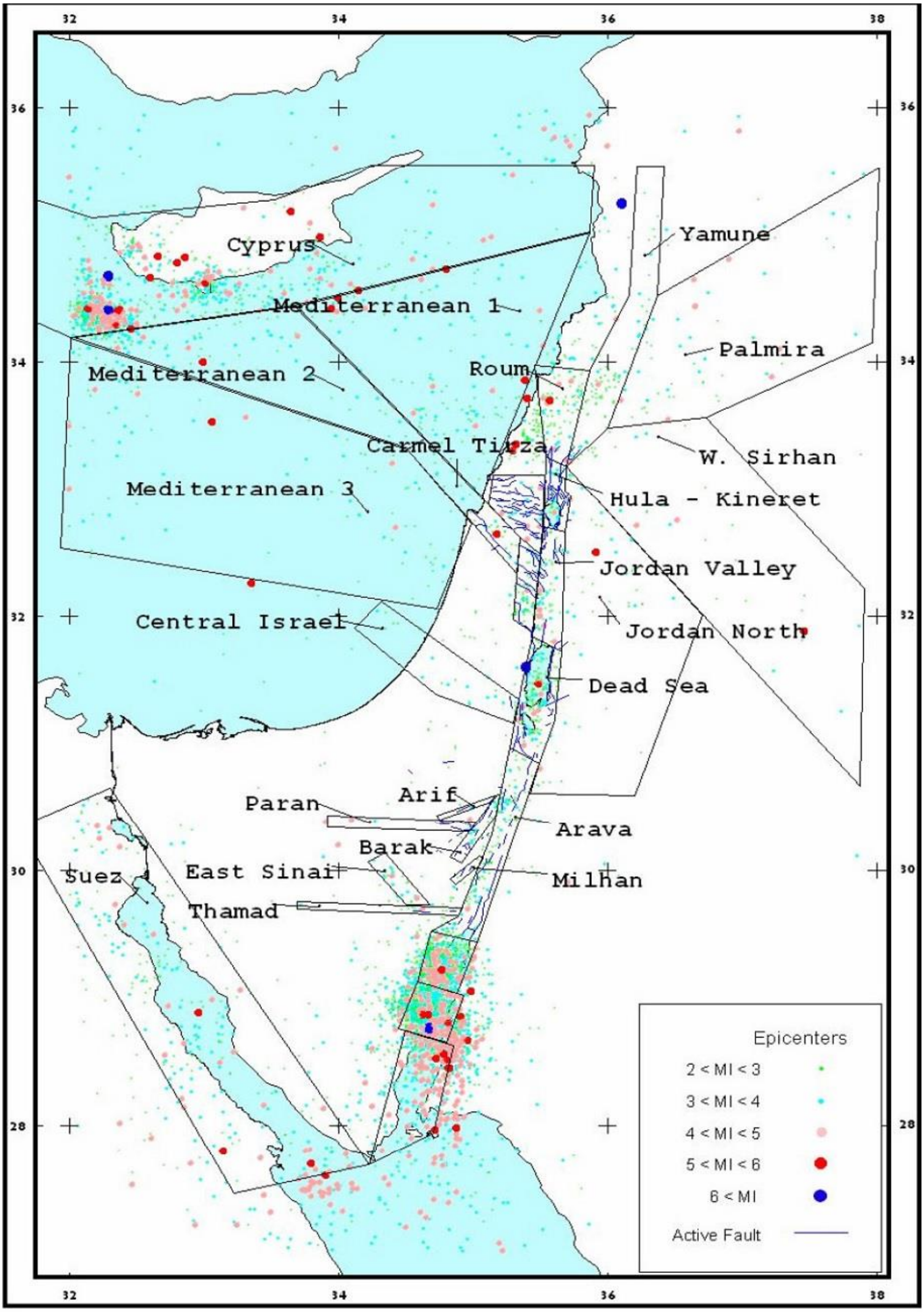


Figure (5.19): Israeli seismic source which used to develop Israeli seismic hazard maps (A. Klar el al., 2011)

5.5 Conclusion

The differences between the Jordan maps and the developed maps in the east of Palestine result from the differences in the seismic source, while in the west of Palestine the spectral acceleration are same due to use the same seismic source to develop the Jordan and Palestine maps.

The seismic sources have been used in this study are similar to seismic sources used to develop the maps for the Israeli code (SI413 2013), so the Israeli spectral acceleration maps and the developed maps are similar in shape and magnitude. But the Israeli code and IBC (IBC2012) used difference approaches to calculate the seismic forces, the Israeli code use difference probability of spectral acceleration maps (10%, 5% and 2% in 50 years) to calculate the seismic forces without use risk coefficient, while IBC2012 code use probability of 2% in 50 years multiplied by risk coefficient to calculate the seismic forces.

The risk coefficient maps developed based on uniform risk with probability of collapse 1%in 50 years. The values of risk coefficient indicate that the probability of collapse in Palestine is around 1% in 50 year.

Chapter 6

CASE STUDY

CHAPTER 6 CASE STUDY

6.1 Introduction

The use of the developed maps has been verified using a case study. For this purpose an existing buildings has been considered for comparison the seismic force result from the develop maps with calculation according IBC2012 code and the Israeli code maps, Jordan with calculation according IBC2012 code maps and UBC97 Palestinian map. The selection and description of the case are included in this chapter.

Two types of building have been chosen the first is residential building with 21 m high (6 floors) and the second is multistory building with 45m in high (15 floors). Each building has been calculated its seismic force in two places, in Gaza and West Bank. The two buildings have been chosen regular according the difference codes to avoid the effect of the irregularity at the seismic forces calculation.

6.2 Seismic Force Calculation According to Difference Codes

Figure 6.1 and Figure 6.2 shown plan view and the elevation for the multistory building used in the case study. Figure 6.3 and Figure 6.4 shown plan view and the elevation for the residential building used in the case study. The parameters and properties for each case in case study explain in Table 6.1

Table (6.1) : summary of cases used in case study

No.	Building type	Location of building	Type of soil	Importance of building	Code used
1	multistory building	Gaza	D	1	IBC 2012 with developed maps
2	multistory building	Jericho	E	1	IBC 2012 with developed maps
3	multistory building	Gaza	D	1	IBC 2012 with Jordan maps
4	multistory building	Jericho	E	1	IBC 2012 with Jordan maps
5	multistory building	Gaza	D	1	SI413 2013 (Israeli code)
6	multistory building	Jericho	E	1	SI413 2013 (Israeli code)

Table (6.1) : summary of cases used in case study(continued)

7	multistory building	Gaza	S_D	1	UBC 97 with Palestinian map
8	multistory building	Jericho	S_E	1	UBC 97 with Palestinian map
9	residential building	Gaza	D	1	IBC 2012 with developed maps
10	residential building	Jericho	E	1	IBC 2012 with developed maps
11	residential building	Gaza	D	1	IBC 2012 with Jordan maps
12	residential building	Jericho	E	1	IBC 2012 with Jordan maps
13	residential building	Gaza	D	1	SI413 2013 (Israeli code)
14	residential building	Jericho	E	1	SI413 2013 (Israeli code)
15	residential building	Gaza	S_D	1	UBC 97 with Palestinian map
16	residential building	Jericho	S_E	1	UBC 97 with Palestinian map

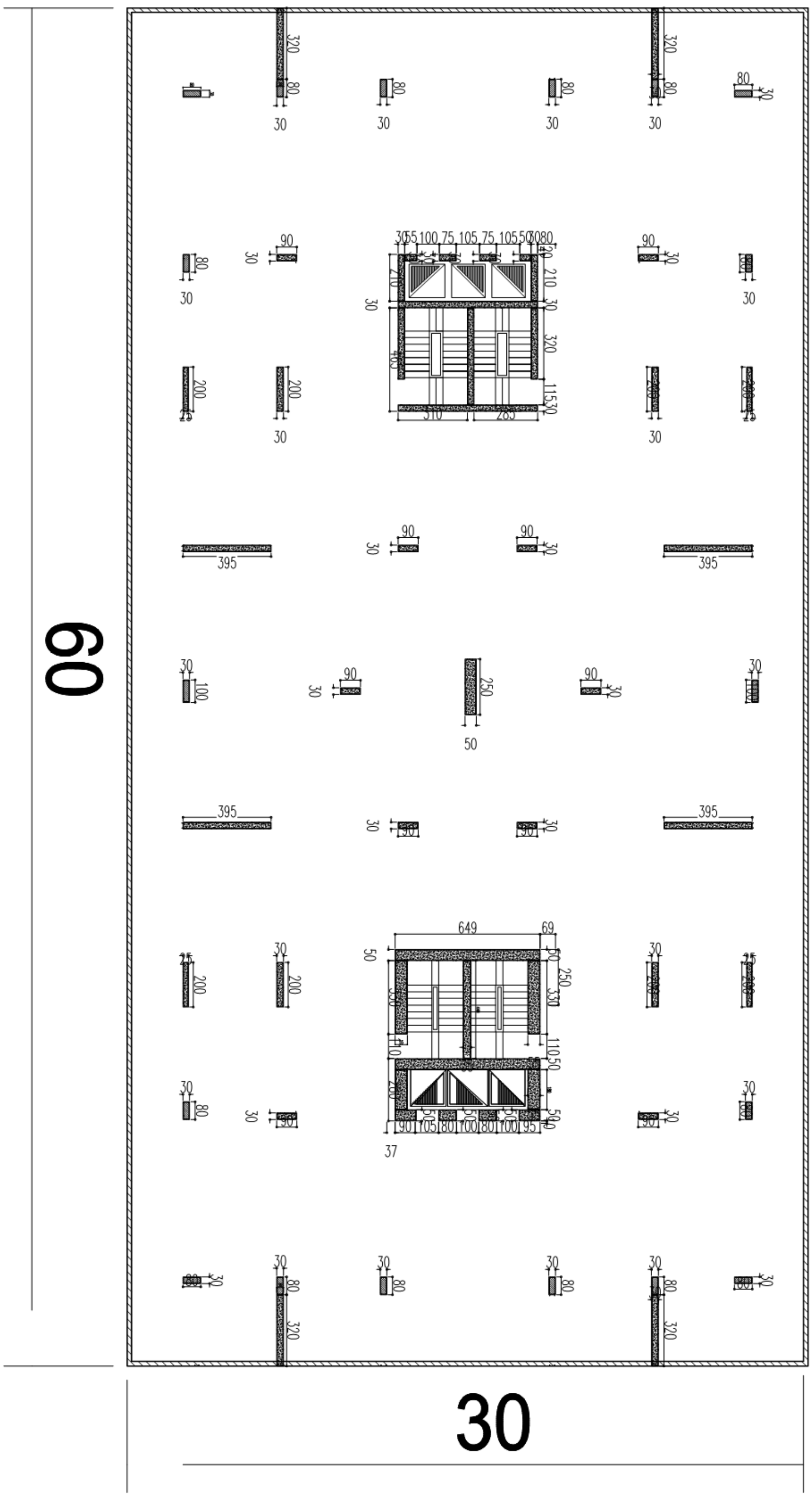


Figure (6.1): Plan view for the multistory used in the case study

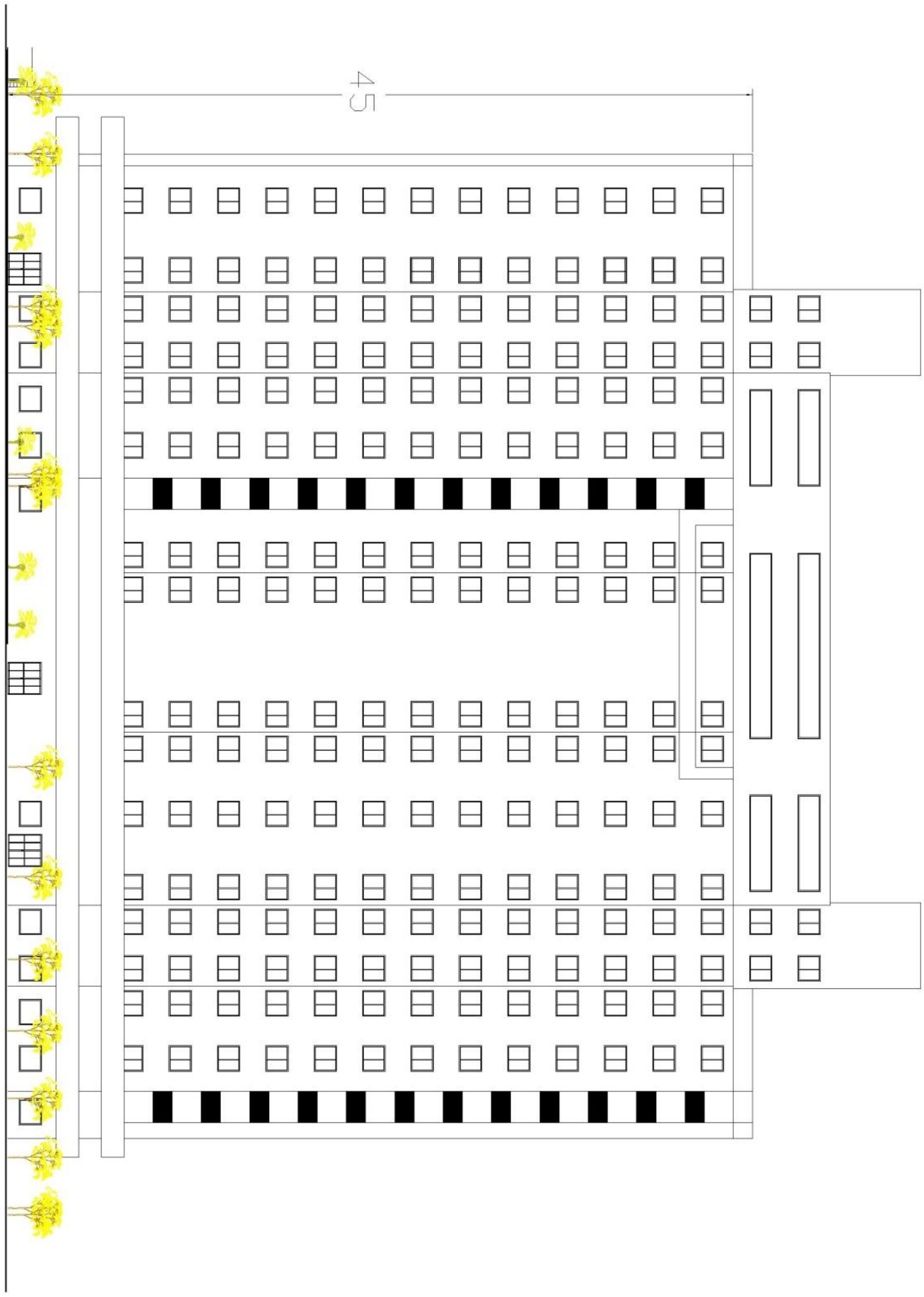


Figure (6.2): Elevation for the multistory used in the case study

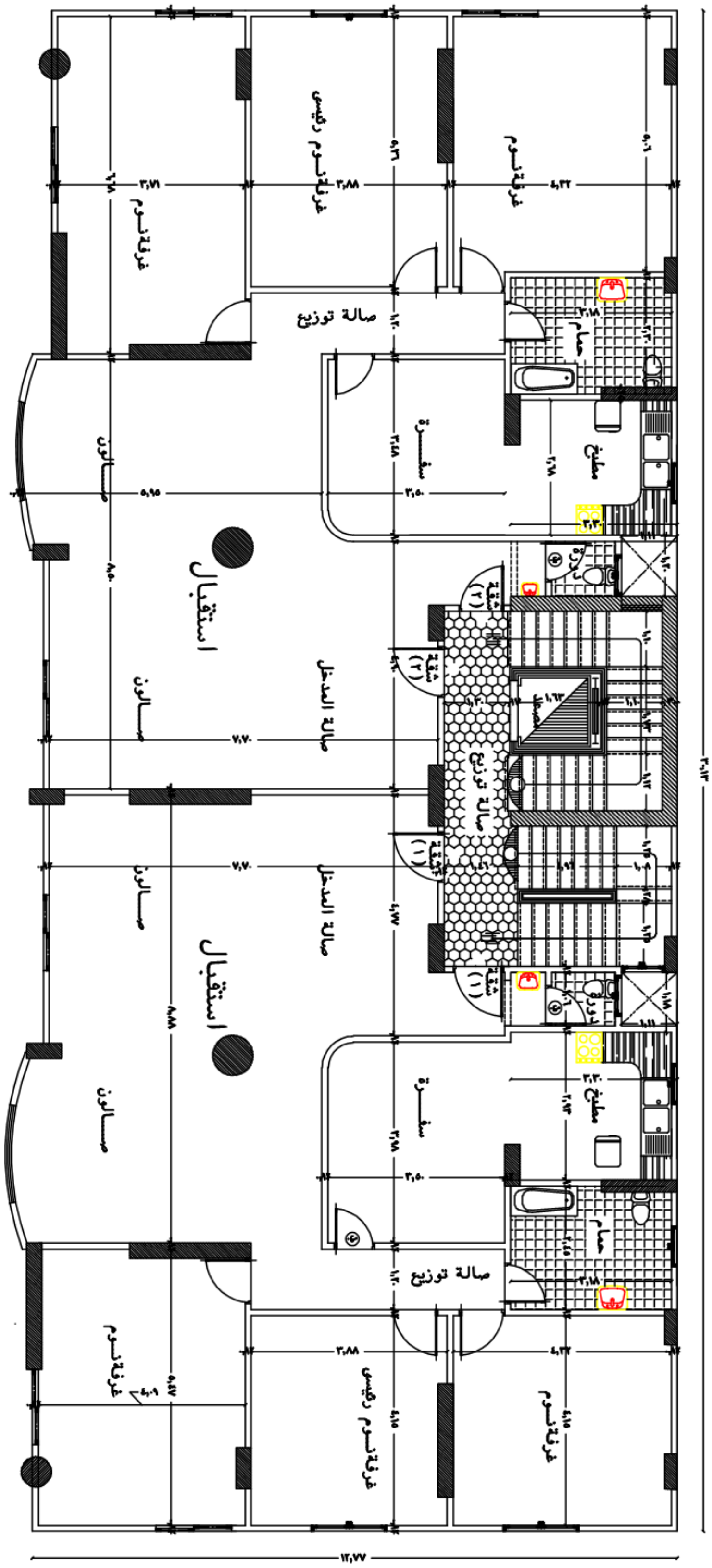


Figure (6.3): Plan view for the residential building

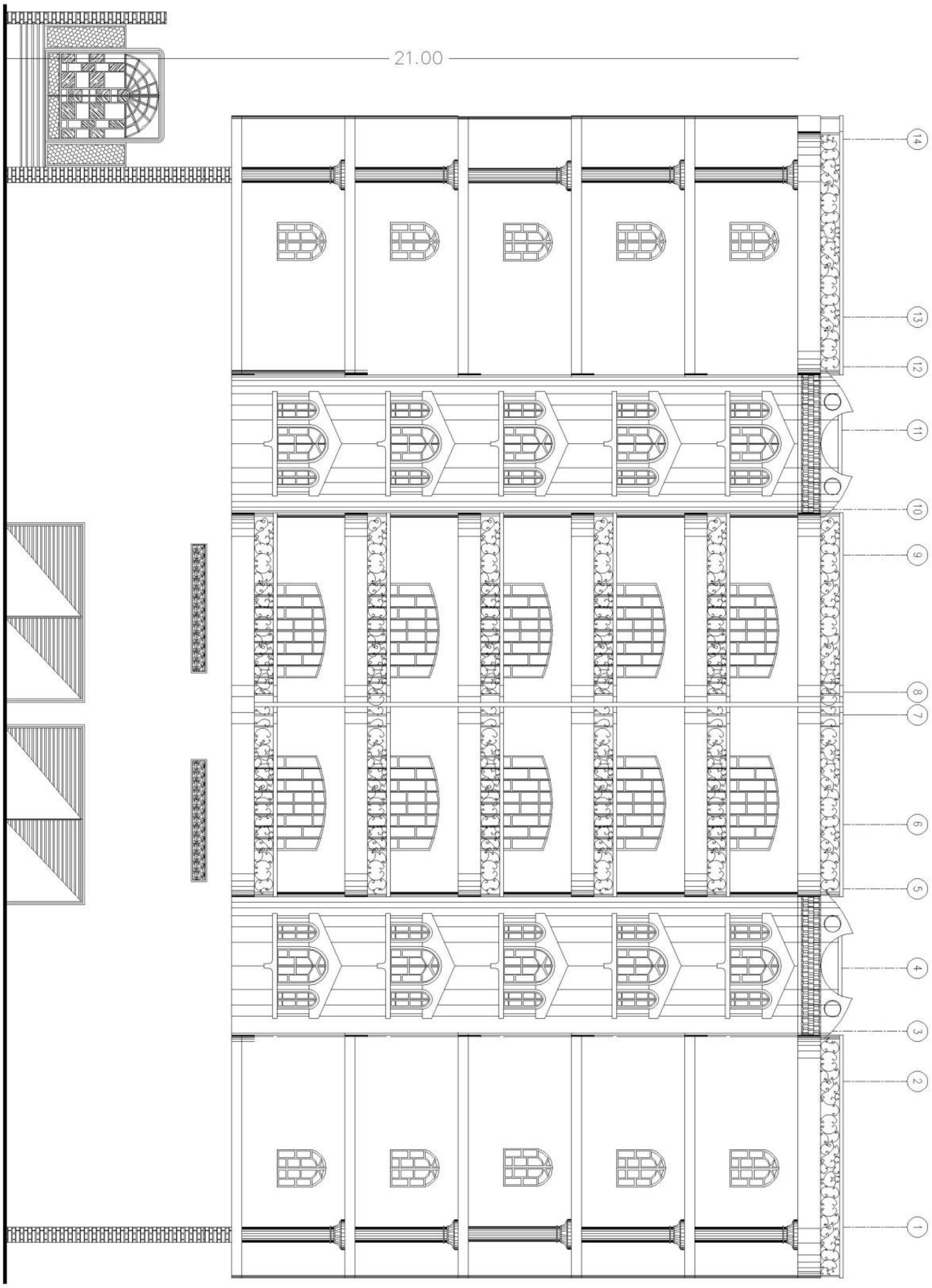


Figure (6.4): Elevation view for the residential building

6.2.1 Multistory building design by IBC 2012 with maps have been developed

The Figure 6.1 shown plan view for the multistory building with dimension (60*30 m), the building contains with 15 floors (45m) and the slab thickness is 0.27 m. The hollow area for lifts is 132 m^2; the total portion wall length is 750 l.m and the external wall 180 l.m.

1. Site in Gaza

Table 6.2 shows the summary of seismic calculation for the multistory in Gaza city. The D soil type was assumed in Gaza.

Table (6.2): Summary of seismic calculation for multistory in Gaza according to IBC 2012 with developed maps

The parameter	The value	The source of value
W	299340KN	hand calculation
S_s , C_{Rs}	0.22 , 1.04	Figure 5.9, Figure 5.13
S_1, C_{R1}	0.09 , 0.97	Figure 5.10, Figure 5.14
F_a	1.6	Table 1613.3.3(1) IBC2012
F_v	2.4	Table 1613.3.3(2) IBC2012
S_{DS}	0.2441	$=(2/3)F_aS_s\ C_{Rs}$, Equation2.9
S_{D1}	0.1397	$=(2/3)F_vS_1C_{R1}$, Equation2.10
risk category	II	Table 1604.5 IBC2012
Importance factors I_e	1	Table 1.5-2 ASCE7-10
seismic design category 0.2 sec	B	Table 1613.3.5(1) IBC2012
seismic design category 1 sec	C (control)	Table 1613.3.5(2) IBC2012

Table (6.2): Summary of seismic calculation for multistory in Gaza according to IBC 2012 with developed maps (continued)

response modification factor R	4	Table 12.2-1 ASCE 7-10
Type of seismic resistance	Ordinary shear wall	Table 12.2-1 ASCE 7-10
T_L	12	T_L Israeli map SI413 2013
C_w	0.011886	Equation 2.12
T_a	0.7842 sec<12	$=0.0019h_n/\sqrt{C_w}$, Equation 2.11
C_s	0.061025	$=S_{DS}/(R/I_e)$, Equation 2.6
$C_{s\ max}$	0.044530 control	$=S_{D1}/T(R/I_e)$, Equation 2.7
$C_{s\ min}$	0.01074	$=0.044S_{DS}I_e > 0.01$
Base seismic force V	0.044530*299340=13329.61KN	$= C_sW$, Equation 2.5

2. Site in Jericho

Calculate the seismic force act in the multistory in Jericho, Table 6.3 shows the summary of the parameters have been used in calculation. The E soil type was assumed in the calculation.

Table (6.3): Summary of seismic calculation for multistory in Jericho according to IBC 2012 with developed maps

The parameter	The value	The source of value
W	299340KN	hand calculation
Ss , C_{Rs}	0.74 , 0.97	Figure 5.9, Figure 5.13
S_1, C_{R1}	0.21 , 0.94	Figure 5.10, Figure 5.14
Fa	1.2644	Table 1613.3.3(1) IBC2012

Table (6.3): Summary of seismic calculation for multistory in Jericho according to IBC 2012 with developed maps (continued)

F_v	3.2078	Table 1613.3.3(2) IBC2012
S_{DS}	0.60506	$=(2/3)F_aS_s\ C_{Rs}$, Equation2.9
S_{D1}	0.42215	$=(2/3)F_vS_1C_{R1}$, Equation2.10
risk category	II	Table 1604.5 IBC2012
Importance factors I_e	1	Table 1.5-2 ASCE7-10
seismic design category 0.2 sec	D	Table 1613.3.5(1) IBC2012
seismic design category 1 sec	D	Table 1613.3.5(2) IBC2012
response modification factor R	5	Table 12.2-1 ASCE 7-10
Type of seismic resistance	Special shear wall	Table 12.2-1 ASCE 7-10
T_L	6	T_L Israeli map SI413 2013
C_w	0.011886	Equation 2.12
T_a	0.7842 sec<6	$=0.0019h_n/\sqrt{C_w}$,Equation 2.11
C_s	0.121012	$=S_{DS}/(R/I_e)$, Equation 2.6
$C_{s\ max}$	0.107664 control	$=S_{D1}/T(R/I_e)$, Equation 2.7
$C_{s\ min}$	0.026622	$=0.044S_{DS}I_e > 0.01$
Base seismic force V	0.107664*299340=32228.14KN	$= C_sW$, Equation 2.5

6.2.2 Multistory building design by IBC 2012 with Jordan maps

1. Site in Gaza

Table 6.4 shows the summary of seismic calculation for the multistory in Gaza city.

Table (6.4): Summary of seismic calculation for multistory in Gaza according to IBC 2012 with Jordan maps

The parameter	The value	The source of value
W	299340KN	hand calculation
S_s	0.28	Figure 5.15
S_1	0.12	Figure 5.16
F_a	1.576	Table 1613.3.3(1) IBC2012
F_v	2.32	Table 1613.3.3(2) IBC2012
S_{DS}	0.29419	$=(2/3)F_aS_s$, Equation2.9
S_{D1}	0.1856	$=(2/3)F_vS_1$, Equation2.10
risk category	II	Table 1604.5 IBC2012
Importance factors I_e	1	Table 1.5-2 ASCE7-10
seismic design category 0.2 sec	B	Table 1613.3.5(1) IBC2012
seismic design category 1 sec	C (control)	Table 1613.3.5(2) IBC2012
Response modification factor R	4	Table 12.2-1 ASCE 7-10
Type of seismic resistance	Ordinary shear wall	Table 12.2-1 ASCE 7-10
T_L	12	T_L Israeli map SI413 2013

Table (6.4): Summary of seismic calculation for multistory in Gaza according to IBC 2012 with Jordan maps (continued)

C_w	0.011886	Equation 2.12
T_a	0.7842 sec<12	$=0.0019h_n/\sqrt{C_w}$, Equation 2.11
C_s	0.0735475	$=S_{DS}/(R/I_e)$, Equation 2.6
$C_{s\ max}$	0.059169 control	$=S_{D1}/T(R/I_e)$, Equation 2.7
$C_{s\ min}$	0.01287	$=0.044S_{DS}I_e > 0.01$
Base seismic force V	0.059169*299340=17711.65KN	$= C_sW$, Equation 2.5

2. Site in Jericho

Table 6.5 shows the summary of seismic calculation for the multistory in Jericho city.

Table (6.5): Summary of seismic calculation for multistory in Jericho according to IBC 2012 with Jordan maps

The parameter	The value	The source of value
W	299340KN	hand calculation
S_s	1.25	Figure 5.15
S_1	0.43	Figure 5.16
F_a	0.9	Table 1613.3.3(1) IBC2012
F_v	2.4	Table 1613.3.3(2) IBC2012
S_{DS}	0.75	$=(2/3)F_aS_s$, Equation2.9
S_{D1}	0.688	$=(2/3)F_vS_1$, Equation2.10
risk category	II	Table 1604.5 IBC2012

Table (6.5): Summary of seismic calculation for multistory in Jericho according to IBC 2012 with Jordan maps (continued)

Importance factors I_e	1	Table 1.5-2 ASCE7-10
seismic design category 0.2 sec	D	Table 1613.3.5(1) IBC2012
seismic design category 1 sec	D	Table 1613.3.5(2) IBC2012
response modification factor R	5	Table 12.2-1 ASCE 7-10
Type of seismic resistance	Special shear wall	Table 12.2-1 ASCE 7-10
T_L	6	T_L Israeli map SI413 2013
C_w	0.011886	Equation 2.12
T_a	0.7842 sec<6	$=0.0019h_n/\sqrt{C_{w,}}$Equation 2.11
C_s	0.15 control	$=S_{DS}/(R/I_e)$, Equation 2.6
$C_{s\ max}$	0.175475	$=S_{D1}/T(R/I_e)$, Equation 2.7
$C_{s\ min}$	0.033	$=0.044S_{DS}I_e > 0.01$
Base seismic force V	0.15*299340=44901.0KN	$= C_sW$, Equation 2.5

6.2.3 Multistory building design by SI413 2013

The D soil type is assumed in Gaza and the E for Jericho. The multistory building has been chosen is regular according the Israeli code (SI413, 2013).

1. Site in Gaza

Calculate the seismic force act in the multistory in Gaza, Table 6.6 shows the summary of the parameters have been used in calculation. According to SI413 Table (4) the important factor of the structure (I) is 1 and it should design with probability 10 in 50 year.

Table (6.6): Summary of seismic calculation for multistory in Gaza according to SI413 code

The parameter	The value	The source of value
W	299340KN	hand calculation
S_s	0.15	Israeli code
S_1	0.05	Israeli code
F_a	1.6	Table (2) SI413 2013
F_v	2.4	Table (3) SI413 2013
S_{DS}	0.24	$=F_a*S_s$, Equation 2.20
S_{D1}	0.12	$=F_v*S_1$, Equation 2.21
T_0	0.08	$=0.16(S_{D1}/S_{DS})$
T_S	0.5	$=S_{D1}/S_{DS}$
T_L	12	SI413 2013
T	0.8687, $T_s < T < T_L$	$=0.050*H^{(3/4)}$
S_a	0.138137	S_{D1}/T , Equation 2.18
K	3	Table 5 SI413 2013
Z	0.05	Israeli code
C_d	0.0460457	$=S_aI/K$, Equation 2.13
$C_{s\ min}$	$0.01 < C_d$ O.K	=0.2ZI, Equation 2.14
$C_{s\ min}$	$0.015 < C_d$ O.K	=0.015I, Equation 2.15
Base seismic force V	0.0460457*299340=13783.32KN	V= CsW

2. Site in Jericho

Table 6.7 shows the summary of seismic calculation for the multistory in Jericho city. The E soil type was assumed in Jericho. According to SI413 table (4) the important factor of the structure (I) is 1 and it should design with probability 10 in 50 year.

Table (6.7): Summary of seismic calculation for multistory in Jericho according to SI413 code

The parameter	The value	The source of value
W	299340KN	hand calculation
S_s	0.55	Israeli code
S_1	0.1	Israeli code
F_a	1.6	Table (2) SI413 2013
F_v	3.5	Table (3) SI413 2013
S_{DS}	0.88	$=F_a*S_s$, Equation 2.20
S_{D1}	0.35	$=F_v*S_1$, Equation 2.21
T_0	0.0636	$=0.16(S_{D1}/S_{DS})$
T_S	0.3977	$=S_{D1}/S_{DS}$
T_L	4	SI413 2013
T	0.8687, $T_s < T < T_L$	$=0.050*H^{(3/4)}$
S_a	0.4029	S_{D1}/T , Equation 2.18
K	4	Table 5 SI413 2013
Z	0.2	Israeli code
C_s	0.1007	$=S_aI/K$, Equation 2.13
$C_{s\ min}$	0.04< C_d O.K	=0.2ZI, Equation 2.14

Table (6.7): Summary of seismic calculation for multistory in Jericho according to SI413 code (continued)

$C_{s\ min}$	0.015< C_d O.K	=0.015I, Equation 2.15
Base seismic force V	0.1007*299340=30151.09KN	V= CsW

6.2.4 Multistory building design by UBC97

1. Site in Gaza

Table 6.8 shows the summary of the parameters have been used in calculation. Figure 6.6 show the seismic Z factor for Palestine (Boore et al., 1997)

Table (6.8): Summary of seismic calculation for multistory in Gaza according to UBC97 map

The parameter	The value	The source of value
W	299340KN	hand calculation
Soil Profile Type	S_D	Table16-J UBC97 code
response factor R	5.5	Table 16-N UBC97
Seismic Zone	1	Figure 6.6
seismic zone factor Z	0.075	Table 16-I UBC97
Importance factors I	1	Table 16-K UBC97
combined effective area A_c	2.4515	$\sum A_i[0.2+(D_e/h_n)^2]$
T	0.824	Equation 2.4
C_a	0.12	Table 16-Q UBC97
C_v	0.18	Table 16-R UBC97

Table (6.8): Summary of seismic calculation for multistory in Gaza according to UBC97 map (continued)

Base seismic force V	11889.04KN	$=C_vWI/RT$, Equation 2.1
V_{max}	16326KN	$= 2.5C_aIW/R$, Equation 2.2
V_{min}	3950KN	$=0.11C_aIW$, Equation 2.3

2. Site in Jericho

Table 6.9 shows the summary of seismic calculation for the multistory in Jericho city. The S_E soil type was assumed in Jericho.

Table (6.9): Summary of seismic calculation for multistory in Jericho according to UBC97 map

The parameter	The value	The source of value
W	299340KN	hand calculation
Soil Profile Type	S_E	Table16-J UBC97 code
response factor R	5.5	Table 16-N UBC97
Seismic Zone	3	Figure 6.6
seismic zone factor Z	0.3	Table 16-I UBC97
Importance factors I	1	Table 16-K UBC97
combined effective area A_c	2.4515	$\sum A_i[0.2+(D_e/h_n)^2]$
T	0.824	Equation 2.4
C_a	0.33	Table 16-Q UBC97
C_v	0.45	Table 16-R UBC97

Table (6.9): Summary of seismic calculation for multistory in Jericho according to UBC97 map (continued)

Base seismic force V	29722.64KN	$=C_vWI/RT$, Equation 2.1
V_{max}	44901KN	$= 2.5C_aIW/R$, Equation 2.2
V_{min}	10866KN	$=0.11C_aIW$, Equation 2.3

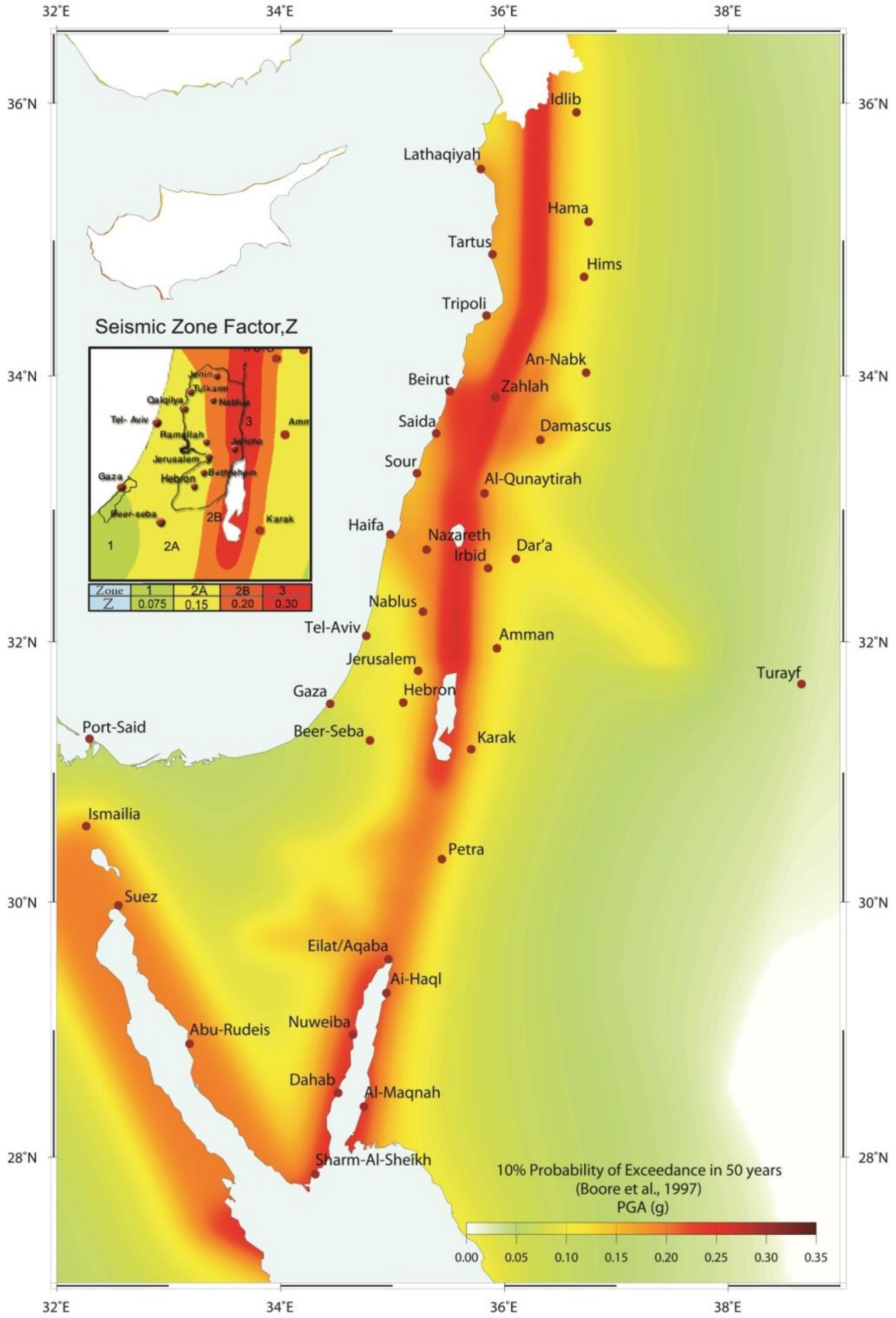


Figure (6.5): Z factor map according UBC97 (Boore et al., 1997)

6.2.5 Residential building design by IBC 2012 with maps have been developed

The Figure 6.3 shown plan view for the residential building with dimension (30*12.5 m), the building has 6 floors (21m) and the slab thickness is 0.25 m. The total portion wall length is 88 l.m and the external wall 85 l.m. the D soil type is assume in Gaza and E in Jericho. The building has been chosen regular according the difference codes to avoid the effect of the irregularity at the building.

1. Site in Gaza

Table 6.10 shows the summary of the parameters have been used in calculation.

Table (6.10): Summary of seismic calculation for building in Gaza according to IBC 2012 with developed maps

The parameter	The value	The source of value
W	35548KN	hand calculation
S_s , C_{Rs}	0.22 , 1.04	Figure 5.9, Figure 5.13
S_1, C_{R1}	0.09 , 0.97	Figure 5.10, Figure 5.14
F_a	1.6	Table 1613.3.3(1) IBC2012
F_v	2.4	Table 1613.3.3(2) IBC2012
S_{DS}	0.2441	$=(2/3)F_aS_s\ C_{Rs}$, Equation2.9
S_{D1}	0.1397	$=(2/3)F_vS_1C_{R1}$, Equation2.10
risk category	II	Table 1604.5 IBC2012
Importance factors I_e	1	Table 1.5-2 ASCE7-10
seismic design category 0.2 sec	B	Table 1613.3.5(1) IBC2012
seismic design category 1 sec	C (control)	Table 1613.3.5(2) IBC2012

Table (6.10): Summary of seismic calculation for building in Gaza according to IBC 2012 with developed maps (continued)

response modification factor R	4	Table 12.2-1 ASCE 7-10
Type of seismic resistance	Ordinary shear wall	Table 12.2-1 ASCE 7-10
T_L	12	T_L Israeli map SI413 2013
C_w	0.009949	Equation 2.12
T_a	0.40 sec<12	$=0.0019h_n/\sqrt{C_w}$, Equation 2.1
C_s	0.061048 control	$=S_{DS}/(R/I_e)$, Equation 2.6
$C_{s\ max}$	0.08731	$=S_{D1}/T(R/I_e)$, Equation 2.7
$C_{s\ min}$	0.010712	$=0.044S_{DS}I_e > 0.01$
Base seismic force V	0.061048*35548=2170.13KN	$= C_sW$, Equation 2.5

2. Site in Jericho

Calculate the seismic force act in the Residential in Jericho, Table 6.11 shows the summary of the parameters have been used in calculation.

Table (6.11): Summary of seismic calculation for residential building in Jericho according to IBC 2012 with developed maps

The parameter	The value	The source of value
W	35548KN	hand calculation
Ss , C_{Rs}	0.74 , 0.97	Figure 5.9, Figure 5.13
S_1, C_{R1}	0.21 , 0.94	Figure 5.10, Figure 5.14
F_a	1.2644	Table 1613.3.3(1) IBC2012

Table (6.11): Summary of seismic calculation for residential building in Jericho according to IBC 2012 with developed maps (continued)

F_v	3.2078	Table 1613.3.3(2) IBC2012
S_{DS}	0.60506	$=(2/3)F_aS_s\,C_{Rs}$, Equation2.9
S_{D1}	0.42215	$=(2/3)F_vS_1C_{R1}$, Equation2.10
risk category	II	Table 1604.5 IBC2012
Importance factors Ie	1	Table 1.5-2 ASCE7-10
seismic design category 0.2 sec	D	Table 1613.3.5(1) IBC2012
seismic design category 1 sec	D	Table 1613.3.5(2) IBC2012
response modification factor R	5	Table 12.2-1 ASCE 7-10
Type of seismic resistance	Special shear wall	Table 12.2-1 ASCE 7-10
T_L	6	T_L Israeli map SI413 2013
C_w	0.009949	Equation 2.12
T_a	0.40 sec<6	$=0.0019h_n/\sqrt{C_w}$, Equation 2.1
C_s	0.121012 control	$=S_{DS}/(R/I_e)$, Equation 2.6
$C_{s\ max}$	0.21108	$=S_{D1}/T(R/I_e)$, Equation 2.7
$C_{s\ min}$	0.025648	$=0.044S_{DS}I_e > 0.01$
Base seismic force V	0.121012*35548=4301.73KN	$= C_sW$, Equation 2.5

6.2.6 Residential building design by IBC 2012 with Jordan maps

1. Site in Gaza

Table 6.12 shows the summary of the parameters have been used in calculation

Table (6.12): Summary of seismic calculation for building in Gaza according to IBC 2012 with Jordan maps

The parameter	The value	The source of value
W	35548KN	hand calculation
S_s	0.28	Figure 5.15
S_1	0.12	Figure 5.16
F_a	1.624	Table 1613.3.3(1) IBC2012
F_v	2.23	Table 1613.3.3(2) IBC2012
S_{DS}	0.30315	$=(2/3)F_aS_s$, Equation2.9
S_{D1}	0.1784	$=(2/3)F_vS_1$, Equation2.10
risk category	II	Table 1604.5 IBC2012
Importance factors I_e	1	Table 1.5-2 ASCE7-10
seismic design category 0.2 sec	B	Table 1613.3.5(1) IBC2012
seismic design category 1 sec	C (control)	Table 1613.3.5(2) IBC2012
Response modification factor R	4	Table 12.2-1 ASCE 7-10
Type of seismic resistance	Ordinary shear wall	Table 12.2-1 ASCE 7-10
T_L	12	T_L Israeli map SI413 2013
C_w	0.009949	Equation 2.12
T_a	0.40 sec<12	$=0.0019h_n/\sqrt{C_w}$, Equation 2.1
C_s	0.075787 control	$=S_{DS}/(R/I_e)$, Equation 2.6

Table (6.12): Summary of seismic calculation for building in Gaza according to IBC 2012 with Jordan maps (continued)

$C_{s\ max}$	0.1115	$=S_{D1}/T(R/I_e)$, Equation 2.7
$C_{s\ min}$	0.013338	$=0.044S_{DS}I_e > 0.01$
Base seismic force V	0.075787*35548=2694.08KN	$= C_sW$, Equation 2.5

2. Site in Jericho

Table 6.13 shows the summary of the parameters have been used in calculation.

Table (6.13): Summary of seismic calculation for building in Jericho according to IBC 2012 with Jordan maps

The parameter	The value	The source of value
W	35548KN	hand calculation
S_s	1.25	Figure 5.15
S_1	0.43	Figure 5.16
Fa	0.9	Table 1613.3.3(1) IBC2012
Fv	2.4	Table 1613.3.3(2) IBC2012
S_{DS}	0.75	$=(2/3)F_aS_s$, Equation2.9
S_{D1}	0.688	$=(2/3)F_vS_1$, Equation2.10
risk category	II	Table 1604.5 IBC2012
Importance factors I_e	1	Table 1.5-2 ASCE7-10
seismic design category 0.2 sec	D	Table 1613.3.5(1) IBC2012
seismic design category 1 sec	D	Table 1613.3.5(2) IBC2012

Table (6.13): Summary of seismic calculation for building in Jericho according to IBC 2012 with Jordan maps (continued)

response modification factor R	5	Table 12.2-1 ASCE 7-10
Type of seismic resistance	Special shear wall	Table 12.2-1 ASCE 7-10
T_L	6	T_L Israeli map SI413 2013
C_w	0.009949	Equation 2.12
T_a	0.40 sec<6	$=0.0019h_n/\sqrt{C_w}$, Equation 2.1
C_s	0.15 control	$=S_{DS}/(R/I_e)$, Equation 2.6
$C_{s\ max}$	0.344	$=S_{D1}/T(R/I_e)$, Equation 2.7
$C_{s\ min}$	0.033	$=0.044S_{DS}I_e > 0.01$
Base seismic force V	0.15*35548=5332.2KN	$= C_sW$, Equation 2.5

6.2.7 Residential building design by SI413 2013

1. Site in Gaza

Calculate the seismic force act in the Residential in Gaza, Table 6.14 shows the summary of the parameters have been used in calculation. According to SI413 table (4) the important factor of the structure (I) is 1 and it should design with probability 10 in 50 year.

Table (6.14): Summary of seismic calculation for building in Gaza according to SI413 code

The parameter	The value	The source of value
W	35548KN	hand calculation
S_s	0.15	Israeli code
S_1	0.05	Israeli code
F_a	1.6	Table (2) SI413 2013

Table (6.14): Summary of seismic calculation for building in Gaza according to SI413 code (continued)

F_v	2.4	Table (3) SI413 2013
S_{DS}	0.36	$=F_a*S_s$, Equation 2.20
S_{D1}	0.12	$=F_v*S_1$, Equation 2.21
T_0	0.0533	$=0.16(S_{D1}/S_{DS})$
T_S	0.3333	$=S_{D1}/S_{DS}$
T_L	12	SI413 2013
T	0.4905, $T_S < T < T_L$	$=0.050*H^{(3/4)}$
S_a	0.24465	$=S_{D1}/T$, Equation 2.18
K	3	Table 5 SI413 2013
Z	0.05	Israeli code
C_d	0.08155	$=S_aI/K$, Equation 2.13
0.2ZI	0.01	=0.2ZI, Equation 2.14
0.015I	0.015	=0.015I, Equation 2.15
Base seismic force V	0.08155*35548=2898.93KN	V= CsW

2. Site in Jericho

Calculate the seismic force act in the Residential in Jericho, Table 6.15 shows the summary of the parameters have been used in calculation. According to SI413 table (4) the important factor of the structure (I) is 1 and it should design with probability 10 in 50 year.

Table (6.15): Summary of seismic calculation for building in Jericho according to SI413 code

The parameter	The value	The source of value
W	35548KN	hand calculation
S_s	0.55	Israeli code
S_1	0.1	Israeli code
F_a	1.6	Table (2) SI413 2013
F_v	3.5	Table (3) SI413 2013
S_{DS}	0.88	$=F_a*S_s$, Equation 2.20
S_{D1}	0.35	$=F_v*S_1$, Equation 2.21
T_0	0.064	$=0.16(S_{D1}/S_{DS})$
T_S	0.3977	$=S_{D1}/S_{DS}$
T_L	4	SI413 2013
T	0.4905, $T_S < T < T_L$	$=0.075*H^{(3/4)}$
S_a	0.7136	S_{D1}/T , Equation 2.18
K	4	Table 5 SI413 2013
Z	0.2	Israeli code
C_d	0.1784	$=S_aI/K$, Equation 2.13
0.2ZI	0.04	=0.2ZI, Equation 2.14
0.015I	0.015	=0.015I, Equation 2.15
Base seismic force V	0.1784*35548=6341.76KN	V= CsW

6.2.8 Residential building design by UBC97

1. Site in Gaza

Calculate the seismic force act in the Residential in Gaza, Table 6.16 shows the summary of the parameters have been used in calculation

Table (6.16): Summary of seismic calculation for building in Gaza according to UBC97 map

The parameter	The value	The source of value
W	35548KN	hand calculation
Soil Profile Type	S_D	Table16-J UBC97 code
response factor R	5.5	Table 16-N UBC97
Seismic Zone	1	Figure 6.2
seismic zone factor Z	0.075	Table 16-I UBC97
risk category	II	table 1604.5 IBC2012
Importance factors I	1	table 16-K UBC97
combined effective area A_c	0.9513	$\sum A_i[0.2+(D_e/h_n)^2]$
T	0.747	Equation 2.4
C_a	0.12	Table 16-Q UBC97
C_v	0.18	Table 16-R UBC97
Base seismic force V	1457.45KN	$=C_vWI/RT$, Equation 2.1
V_{max}	1938KN	$= 2.5C_aIW/R$, Equation 2.2
V_{min}	469KN	$=0.11C_aIW$, Equation 2.3

2. Site in Jericho

Calculate the seismic force act in the Residential in Jericho, Table 6.17 shows the summary of the parameters have been used in calculation.

Table (6.17): Summary of seismic calculation for building in Jericho according to UBC97 map

The parameter	The value	The source of value
W	35548KN	hand calculation
Soil Profile Type	S_E	Table16-J UBC97 code
response factor R	5.5	Table 16-N UBC97
Seismic Zone	1	Figure 6.2
seismic zone factor Z	0.075	Table 16-I UBC97
risk category	II	table 1604.5 IBC2012
Importance factors I	1	table 16-K UBC97
combined effective area A_c	0.9513	$\sum A_i[0.2+(D_e/h_n)^2]$
T	0.747	Equation 2.4
C_a	0.09	Table 16-Q UBC97
C_v	0.13	Table 16-R UBC97
Base seismic force V	3643.62KN	$=C_vWI/RT$, Equation 2.1
V_{max}	5332KN	$= 2.5C_aIW/R$, Equation 2.2
V_{min}	1290KN	$=0.11C_aIW$, Equation 2.3

6.2.9 Summary and Conclusion

Table 6.18 shows the summary of the base shear forces have been designed according the difference codes.

In general, In Gaza city the seismic forces calculate for the two building according the different codes are relatively equal. The forces calculated according to develop maps, UBC97 and the Israeli code for the multistory building are relatively equal, while the forces calculated according to Jordan maps is more by 22%. The difference between the forces according to developed maps and Jordan maps refer to the difference in S_1 values which control the seismic forces calculation in the two cases. The Jordan S_1 value is more than the Palestinian value by 27%. In the residential building the force calculated according to Israeli code more than the other cases by about 25%. This difference may refer to use a different approach in the Israeli code for calculate the seismic force.

In Jericho there are differences in the seismic forces value in the residential, Israeli code value computes seismic force higher than the force calculate according the develop maps by about 32%, while in Jordan maps case the force more than the developed maps case by 19%. The different between the seismic forces according Jordan maps and the developed maps resulted from the difference between the values of spectral acceleration S_S which increase by about 40%. The Israeli code used the spectral acceleration for return period 475 years (10% in 50 years). In the multistory building the Jordan maps value computes seismic force higher than the force calculate according the develop maps by about 29%, while the other cases are relatively similar to the developed maps force value.

There is no general conclusion due to variation of the seismic forces value in the cases. The codes have been used in the case study used different approach to calculate the seismic forces, and these codes used different approach for the concrete design, so the final concrete design may be similar in the different codes.

Table (6.18): Summary of the seismic forces calculation according to difference codes

location	The code	multistory	Residential
Gaza	IBC2012 (Developed maps)	13329.61KN	2170.13KN
	SI413 2013 (Israeli code)	13783.32KN	2898.93KN
	IBC2012 (Jordan maps)	17711.65KN	2694.08KN
	UBC 97	11889.04KN	1457.45KN
Jericho	IBC2012 (Developed maps)	32228.14KN	4301.73KN
	SI413 2013 (Israeli code)	30151.09KN	6341.69KN
	IBC2012 (Jordan maps)	44901.0KN	5332.2KN
	UBC 97	29722.64KN	3643.62KN

Chapter 7

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Based on the seismic analysis for Palestine in this study, the following conclusions regarding the seismic hazard maps and the seismic codes used in Palestine were reached:

1. The eastern boundary of Palestine have higher ground spectral acceleration in Palestine and the highest value for ground spectral acceleration are in the east-north of Palestine.
2. The developed maps for Palestine are similar to developed for the around countries, such as Jordan and Israeli maps.
3. Due to limited ground motion record result from the strong earthquakes, an empirical equation (Boore-Joyner-Fumal 1997 equation) has been used to determine the spectral ground acceleration for Palestine.
4. In the case study the values of seismic forces calculated according to IBC2012 developed maps are in rang with the forces according to other different code.
5. The result of the case study for each code can't be generalized in the code because the calculation depends on the characteristic of the building.
6. The seismic force calculation and the seismic resistance concrete design should be according to same version of code, because the codes use different approach in the seismic calculation and in the concrete design.

7.2 Recommendations

1. Create Palestinian seismic code to unify the seismic design in Palestine based on the developed maps or use the modern codes in seismic design.
2. Increased communion between institutions working in the field of building to improve the seismic resistance of the building according to modern codes.
3. Adoption the seismic design according to modern codes in the engineers syndicate and the other related institutions.
4. Make workshops about the seismic codes and the earthquakes hazard to increase the understanding of seismic hazard between Palestinian people.

5. Create recording seismic centers in Palestine to determine the exact ground motion equation, so that increase the accuracy of spectral acceleration value.

6. Update the geological data for the faults system in Palestine to increase the understanding of the activity seismic and make a real simulation for seismic fault system.

REFERENCES

REFERENCES

Al-Dabbeek, J.; El-Kelani, R., (2004). Local Site Effect in Palestinian Cities: A Preliminary Study Based on Nablus Earthquake of July 11, 1927 and the Earthquake of February 11, 2004. The 1st Conference of Applied Geophysics for Engineering.

Al-nimry, H., (2008). Seismic Hazard Assessment for Jordan and Neighboring Areas. *Bollettino di Geofisica Teorica ed Applicata*. Vol.49, pp.17-36.

AMBRASEYS, N., SIMPSON, A., BOMMER, J., (1996). Prediction of horizontal response spectra in Europe. *Earthquake Engineering and Structural Dynamics*. Vol. 25, 371-400.

ASEP Inc., National Structural Code of the Philippines(C101-10), (2010). *Buildings, Towers and Other Vertical Structures*. ASEP Inc., Philippines, pp. 758.

Bachmann, H., (2003). *Seismic Conceptual Design of Buildings – Basic principles for engineers, architects, building owners and authorities*. Federal Department of Foreign Affairs.

Baker, J.W., (2008). *An Introduction to Probabilistic Seismic Hazard Analysis (PSHA).* report for the US Nuclear Regulatory Commission.

Barker, R. Kirk, J. and Munday, R.J., (1988). *Narrative analysis*. 3rd ed. Bloomington: Indiana University Press.

Benjamin, J.R. and Cornell, C.A., (1968). *Probability, Statistics and Decision for Civil Engineers.* McGraw-Hill Book Inc., New York.

Boore, M., Joyner, B., Fumal, E., (1994). Estimation of response spectra and peak accelerations from western North American earthquakes: An interim report part 2. *U.S. Geological Survey Open-File* Report 94-127,40pp.

Boore, M., Joyner, B., Fumal, E., (1997). Equations for estimating horizontal response spectra and peak acceleration from western North American earthquakes: A summary of recent work. *Seismol. Res*. Lett. 68,128–153.

Boughton, J.M., 2002. The Bretton Woods proposal: an indepth look. *Political Science Quarterly*, 42(6), pp.564-78.

Bozorgnia, Y., Bertero, V., (2006). *Earthquake Engineering From Engineering Seismology to Performance-Based Engineering*. the Taylor & Francis e-Library.

Budnitz, R., Apostolakis, G., Boore, D., Cluff, L., Coppersmith, K., Cornell, C., Morris P., (1997). *Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts*. Senior Seismic Hazard Analysis Committee (SSHAC).

CEN. (2004). *Draft European Standard prEN 1998-3: Eurocode 8: Design of structures for earthquake resistance. Part 3: Assessment and retrofitting of buildings*. Draft No.5. Doc CEN/TC250/SC8/N388, Brusells: Comite Europeen de Normalisation.

Central Bureau of Statistics (CBS), (2012). *Nepal Housing and Population Census. National Planning Commission*. Government of Nepal

Chopra, A.K. (2001). *Dynamics of Structures: Theory and Applications to Earthquake Engineering*. Prentice Hall: New Jersey.

Commercial Structures Code Specialist, (2012). *A Summary of Requirements in the State of Oregon.* Building Codes Division.

Committee on the Science of Earthquakes (2003). *Living on an Active Earth Perspectives on Earthquake Science*. National research council of the national academies.

Dhaka, R P.; (2011). *Structural design for earthquake resistance: past, present and future*. Report to the Canterbury Earthquake Royal Commission.

Earthquake Engineering Research Institute (EERI) (2006). *Risk Management Series Designing for Earthquakes.* Federal Emergency Management Agency of the Department of Homeland Security.

Earthquake Van – Ercis, Turkey. Retrieved 30 October 2015. http://earthquake-report.com/2011/10/23/very-strong-dangerous-earthquake-in-eastern-turkey/.

Frankel, A., Petersen, M., Mueller, C., Haller, K., Wheeler, R., Leyendecker, E., Wesson, R., Harmsen, S., Cramer, C., Perkins, D., Rukstales, K., (2002). Documentation for the 2002 Update of the United States National Seismic Hazard Maps. *U.S. Geological Survey Open-File* Report 02-420 http://pubs.usgs.gov/of/2002/ofr-02-420/. USGS, Golden, Colorado.

Genc, G., (2004). *Probabilistic Seismic Hazard Assessment for ESKİŞEHİR*. Middle East Technical University.

Ghosh, B., (2002) "Seismic Design Provisions in U.S. Codes and Standards: A Look Back and Ahead. *Precast/Prestressed concrete institute PCI Journal*.

Godinho, J., (2007). *Probabilistic Seismic Hazard Analysis an Introduction to Theoretical Basis and Applied Methodology*. A Dissertation Submitted in Partial Fulfillment of the Requirements for the Master Degree in University of Patras, Greece.

Hobbs, D., (2013). *Development of a joint seismic hazard curve for multiple site seismic hazard*. A Master's Report submitted to the Faculty of the Graduate School of the University of Colorado.

Husein, A., AI-Homoud, A., Liang, R., (1995). Seismic Hazard Mapping of Jordan. *Quarterly J. of Engineering Geology*, 28, pp. 75-81.

International Code Council, Inc., (2012). *International Building Code (IBC)*. Falls Church, VA, USA.

International Conference of Building Officials, (1997) *Uniform Building Code (UBC)*, Volume 2,2-1, 2–38.

Jaradat, R., Nusier, O., Awawdeh, M., Al-Qaryouti, M., Fahjan, Y., Al-Rawabdeh, A., (2008). Deaggregation of Probabilistic Ground Motions for Selected Jordanian Cities. *Jordan Journal of Civil Engineering*, Volume 2, No. 2.

Jardaneh, I., (2004). Evaluation of ground response due to earthquake. *journal of applied sciences* 4(3), p364-368.

Jreisat, K., Yazjeen, T., (2013). A Seismic Junction. *ATLAS OF JORDAN*, Presses de l'Ifpo, Institut français du Proche-Orient, p. 47-59.

Kenny, C., (2009). *Why Do People Die in Earthquakes? The Costs, Benefits and Institutions of Disaster Risk Reduction in Developing Countries*. The World Bank, Sustainable Development Network, Finance Economics & Urban Department.

Klar A, Meirova T, Zaslavsky Y, Shapira A (2011). *Spectral acceleration maps for 817 use in SI 413 amendment No. 5*. GII Report No. 522/599/11 and NBRI 818, Report No. 2012938, 74 pp

Leonov, J. (2000). Horizontal Peak Ground Acceleration Attenuation Relationship Way and Argumentation of its Choice. available on site http://earthquake.co.il/heb/hazards/docs/Leon_doc.pdf [Accessed 15 January 2016].

Levi, T., Tavron, B., Katz, O., Amit, R., Segal, D., Hamiel, Y., Bar-Lavi, Y., Romach, S., Salamon, A., (2010). Earthquake loss estimation in Israel using the new HAZUS-MH software: preliminary implementation. *Geological Survey of Israel*, Report GSI/11/2010.

Luco, N., Ellingwood, B., Hamburger, R., Hooper, J., Kimball, J., Kircher, C., (2007). Risk-Targeted versus Current Seismic Design Maps for the Conterminous United States. *Structural Engineers Association of California*, SEAOC 2007 Convention Proceedings: September 26-29, 2007, Squaw Creek, California.

Main, I., Naylor, M., Greenhough, J., Touati, S., Bell, A., McCloskey, J., (2011). Model selection and uncertainty in earthquake hazard analysis. *Applications of Statistics and Probability in Civil Engineering*, Taylor & Francis Group, London, ISBN 978-0-415-66986-3.

McGuire R. K., (2004). *Seismic Hazard and Risk Analysis*, EERI, MNO-10, Oakland, CA.

National Institute of Building Sciences, Building Seismic Safety Council (2012). *2009 NEHRP Recommended Seismic Provisions: Design Examples*. Federal Emergency Management Agency of the Department of Homeland Security.

NHS Evidence, 2003. National Library of Guidelines. [online] Available at: <http://www.library.nhs.uk/guidelinesFinder> [Accessed 10 October 2009].

Ozturk, N., (2008). *Probabilistic Seismic Hazard Analysis: a Sensitivity Study With Respect To Different Models*, Middle East Technical University.

Pradhan, P., Adhikari, R., Bhat, D., (2015). Assessment of Buildings after Gorkha-Eaethquake-2015: A Case Study of Central Buildings of Kathmandu University, Nepal. *Kathmandu University, journal of science, engineering and technology*, Vol. 11, No. II, pp 34-44

Reiter, L., (1990). *Earthquake Hazard Analysis*. Columbia University Press.

Richmond, J., 2005. *Customer expectations in the world of electronic banking: a case study of the Bank of Britain*. Ph. D. Anglia Ruskin University.

Risk Engineering, INC., (2011) *EZ-FRISK Version 7.52 Software for Earthquake Ground Motion Estimation*. Boulder, Colorado.

Risk Targeted Ground Motion Calculator, http://earthquake.usgs.gov/designmaps/rtgm/ [Accessed 9 August 2016], developed by United States Geological Survey (USGS).

Sbeinati, M., Darawcheh, R., Mouty, M., (2005). The historical earthquakes of Syria: an analysis of large and moderate earthquakes from 1365 B.C. to 1900 A.D. *ANNALS OF GEOPHYSICS*, VOL. 48, N.3

Shapira, A., Hofstetter, R., Abdallah, A.F., Dabbeek, J., Hays, W., (2007). Earthquake Hazard Assessments for Building Codes Final Report. *Submitted to the U.S. Agency for International Development*, Bureau for Economic Growth, Agriculture and Trade.

Shinozuka, M., (1995). Preliminary Reports from the Hyogo-ken Nambu Earthquake of January 17, 1995. *National Center for Earthquake Engineering Research*.

Solomos, G., Pinto, A., Dimova S., (2008). A Review of the seismic hazard zonation in national building code in the context of EUROCODE 8. *JRC scientific and technical report*, JRC 48352.

Standard of Israel (SI 413), (2013). *Design provisions for earthquake resistance of structures.* 2013 Edition.

Taranath, B., (2010). *Reinforced Concrete Design of Tall Buildings*. Taylor and Francis Group, LLC CRC Press is an imprint of Taylor & Francis Group, an Informa business.

Thomas, H., (2003). Living on an Active Earth: Perspectives in Earthquake Science. *R*eport by *Committee on the Science of Earthquakes*.

Tripathi, S., Pandey, B., (2016). Inner structure of the earth – relevance to earthquakes. *best International Journal of Management Information*, Vol. 4, Issue 3.

U.S. Geological Survey (2008). United States National Seismic Hazard Maps. Fact Sheet 2008–3017 available on site https://pubs.usgs.gov/fs/2008/3017/pdf/FS08-3017_508.pdf [Accessed 30 October 2015].

Wallace, E., (1968). Earthquake of August 19, 1966, Varto Area, eastern Turkey . *Bulletin of the Seismological Society of America*, issue 58 (1).

Working Group on California Earthquake Probabilities (WGCEP), Inc., (1999). Earthquake Probabilities in the San Francisco Bay Region: 2000 to 2030-A Summary of Findings. *U.S. Geological Survey, Open-File* Report 99-517.

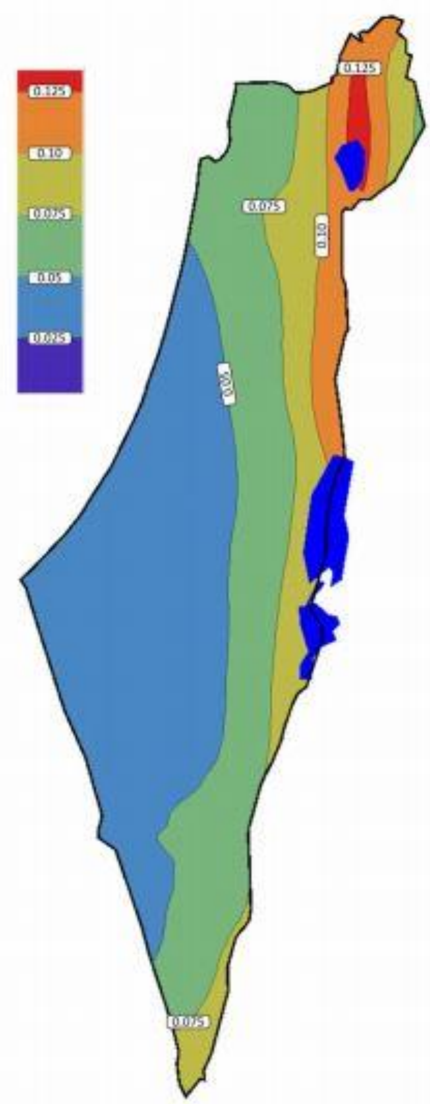
APPENDIX 1: TABLE OF THE SPECTRAL ACCELERATION RESULT FROM THE EZ-FRISK PROGRAM

FID	Lat	Lon	0.20s in 475 Y	0.2s in 2475Y	1s in 475Y	1s in 2475Y
0	29.6	34.8	0.37576	0.64314	0.09552	0.18426
1	29.6	35	0.40373	0.71578	0.10372	0.2081
2	29.8	34.8	0.27937	0.45396	0.07341	0.13054
3	29.8	35	0.38571	0.69685	0.09894	0.19969
4	29.8	35.2	0.28976	0.50827	0.07455	0.14126
5	30	34.6	0.21227	0.32346	0.0603	0.1002
6	30	34.8	0.23863	0.37112	0.0655	0.11194
7	30	35	0.34819	0.59834	0.08835	0.16646
8	30	35.2	0.34345	0.62467	0.0877	0.17601
9	30.2	34.6	0.24242	0.37266	0.06347	0.10296
10	30.2	34.8	0.26408	0.40608	0.06811	0.11199
11	30.2	35	0.32107	0.51431	0.08141	0.1427
12	30.2	35.2	0.37359	0.6847	0.09513	0.19362
13	30.4	34.6	0.37422	0.62128	0.09346	0.16395
14	30.4	34.8	0.37652	0.61329	0.09395	0.16155
15	30.4	35	0.34973	0.56184	0.08718	0.15118
16	30.4	35.2	0.37821	0.67051	0.09551	0.18963
17	30.4	35.4	0.28786	0.50834	0.07267	0.13884
18	30.6	34.4	0.19246	0.29252	0.05342	0.08488
19	30.6	34.6	0.19544	0.29258	0.0549	0.08839
20	30.6	34.8	0.20959	0.31306	0.0581	0.09581
21	30.6	35	0.2501	0.39053	0.06592	0.11271
22	30.6	35.2	0.3533	0.61603	0.08907	0.17267
23	30.6	35.4	0.35141	0.63534	0.08934	0.18037
24	30.8	34.4	0.13623	0.20331	0.04619	0.07454
25	30.8	34.6	0.14488	0.21592	0.04859	0.07945
26	30.8	34.8	0.16196	0.24493	0.05202	0.08767
27	30.8	35	0.20098	0.31756	0.0583	0.10341
28	30.8	35.2	0.30353	0.52812	0.07651	0.14691
29	30.8	35.4	0.40118	0.71829	0.10128	0.20644
30	31	34.4	0.11895	0.17178	0.04371	0.0718
31	31	34.6	0.12977	0.19431	0.04638	0.07713
32	31	34.8	0.14896	0.22902	0.05033	0.08571
33	31	35	0.18883	0.30172	0.0568	0.10139
34	31	35.2	0.28261	0.48106	0.07291	0.13751
35	31	35.4	0.43827	0.77244	0.11069	0.22576
36	31.2	34.2	0.105	0.14637	0.0408	0.06692
37	31.2	34.4	0.11286	0.162	0.04286	0.07097
38	31.2	34.6	0.12493	0.18694	0.04568	0.07642
39	31.2	34.8	0.14533	0.22408	0.04987	0.08494
40	31.2	35	0.18449	0.29184	0.05634	0.10003

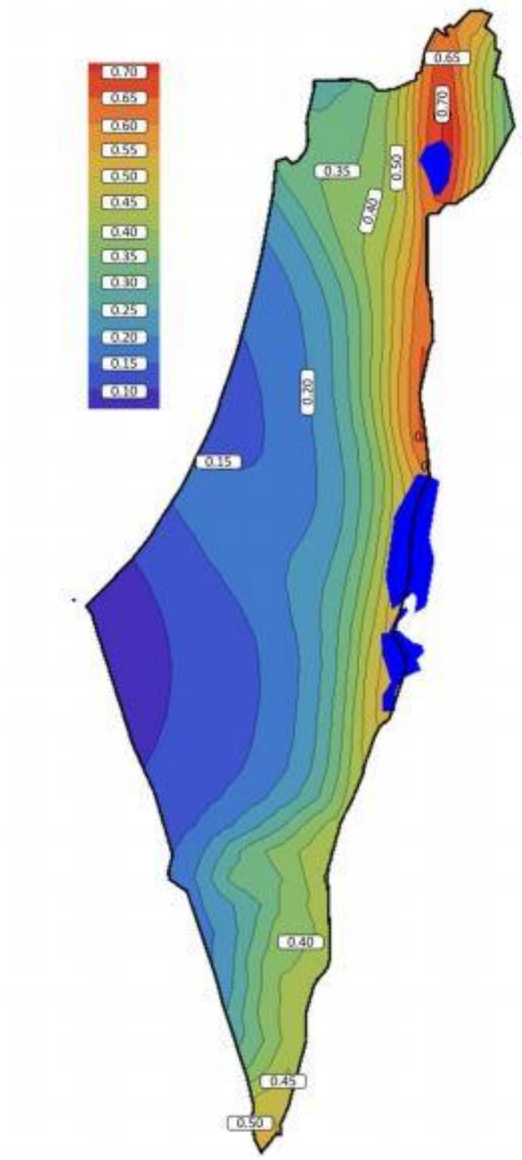
41	31.2	35.2	0.2644	0.43915	0.07065	0.1304
42	31.2	35.4	0.43358	0.76081	0.11046	0.22399
43	31.2	35.6	0.39273	0.69425	0.10085	0.2032
44	31.4	34.2	0.1031	0.14371	0.04057	0.06677
45	31.4	34.4	0.11214	0.16168	0.04276	0.07095
46	31.4	34.6	0.12747	0.19436	0.04598	0.07678
47	31.4	34.8	0.15427	0.24548	0.05147	0.08801
48	31.4	35	0.18915	0.30118	0.05762	0.10145
49	31.4	35.2	0.24761	0.40505	0.0686	0.12433
50	31.4	35.4	0.40685	0.71611	0.10482	0.21084
51	31.4	35.6	0.41606	0.73294	0.10713	0.21619
52	31.6	34.2	0.10483	0.14831	0.04086	0.06728
53	31.6	34.4	0.11797	0.17749	0.04354	0.07206
54	31.6	34.6	0.14042	0.22697	0.04837	0.08122
55	31.6	34.8	0.15893	0.25443	0.05233	0.08903
56	31.6	35	0.18175	0.28552	0.05703	0.09987
57	31.6	35.2	0.22817	0.36446	0.06563	0.11781
58	31.6	35.4	0.36716	0.63761	0.09425	0.1845
59	31.6	35.6	0.43103	0.75593	0.1111	0.22375
60	31.8	34.2	0.11239	0.17036	0.042	0.06925
61	31.8	34.4	0.13299	0.21883	0.0463	0.07726
62	31.8	34.6	0.14473	0.23486	0.04933	0.08239
63	31.8	34.8	0.15188	0.23614	0.05169	0.08714
64	31.8	35	0.17339	0.26514	0.05617	0.09737
65	31.8	35.2	0.22626	0.35657	0.06605	0.11724
66	31.8	35.4	0.35294	0.59191	0.08991	0.17055
67	31.8	35.6	0.48485	0.84053	0.12553	0.25436
68	32	34.4	0.13781	0.22836	0.04742	0.07899
69	32	34.6	0.1397	0.21855	0.04876	0.08063
70	32	34.8	0.14889	0.22681	0.05176	0.08679
71	32	35	0.17709	0.26974	0.05728	0.09877
72	32	35.2	0.23939	0.37995	0.06887	0.12078
73	32	35.4	0.39959	0.67206	0.10284	0.19595
74	32	35.6	0.51239	0.87589	0.13235	0.26646
75	32.2	34.4	0.14575	0.25157	0.04917	0.0832
76	32.2	34.6	0.15474	0.26288	0.05183	0.08828
77	32.2	34.8	0.16198	0.25865	0.0543	0.09233
78	32.2	35	0.18374	0.2784	0.05875	0.10053
79	32.2	35.2	0.24388	0.38309	0.07031	0.12171
80	32.2	35.4	0.39576	0.65846	0.10262	0.19261
81	32.2	35.6	0.51374	0.87645	0.13318	0.2668
82	32.4	34.6	0.16489	0.28236	0.05365	0.09131
83	32.4	34.8	0.17485	0.28474	0.0567	0.09678
84	32.4	35	0.19541	0.29705	0.06081	0.10303
85	32.4	35.2	0.25667	0.40654	0.07283	0.12509
86	32.4	35.4	0.39182	0.64888	0.1023	0.18974

87	32.4	35.6	0.51198	0.87371	0.1331	0.26582
88	32.6	34.6	0.17194	0.29052	0.05515	0.09339
89	32.6	34.8	0.18867	0.30745	0.05902	0.10042
90	32.6	35	0.21984	0.34823	0.06501	0.10954
91	32.6	35.2	0.3113	0.53104	0.08529	0.15325
92	32.6	35.4	0.37532	0.6122	0.09922	0.18078
93	32.6	35.6	0.50686	0.86576	0.13254	0.26459
94	32.8	34.8	0.20989	0.3447	0.06231	0.10539
95	32.8	35	0.27775	0.4841	0.07622	0.13414
96	32.8	35.2	0.31896	0.54079	0.08711	0.15558
97	32.8	35.4	0.34212	0.53804	0.09156	0.16218
98	32.8	35.6	0.53695	0.91856	0.14186	0.28548
99	33	35	0.30964	0.54765	0.08332	0.14995
100	33	35.2	0.27839	0.43713	0.07824	0.13183
101	33	35.4	0.32736	0.51408	0.08908	0.15726
102	33	35.6	0.52856	0.90353	0.13984	0.28087
103	33.2	35.2	0.27203	0.44418	0.0781	0.13509
104	33.2	35.4	0.32216	0.52221	0.08859	0.15884
105	33.2	35.6	0.5033	0.86786	0.13365	0.26783
106	33.4	35.6	0.44862	0.76994	0.11918	0.23401

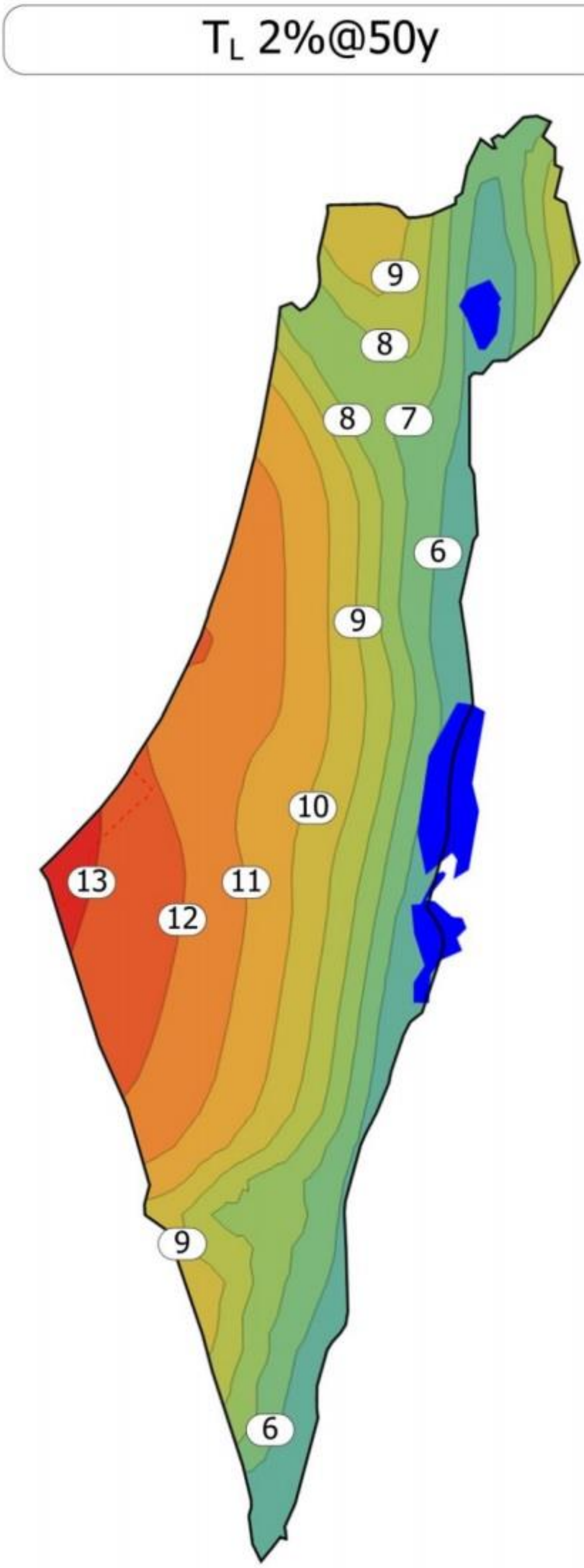
APPENDIX 2: ISRAELI CODE MAPS USED IN THE STUDY



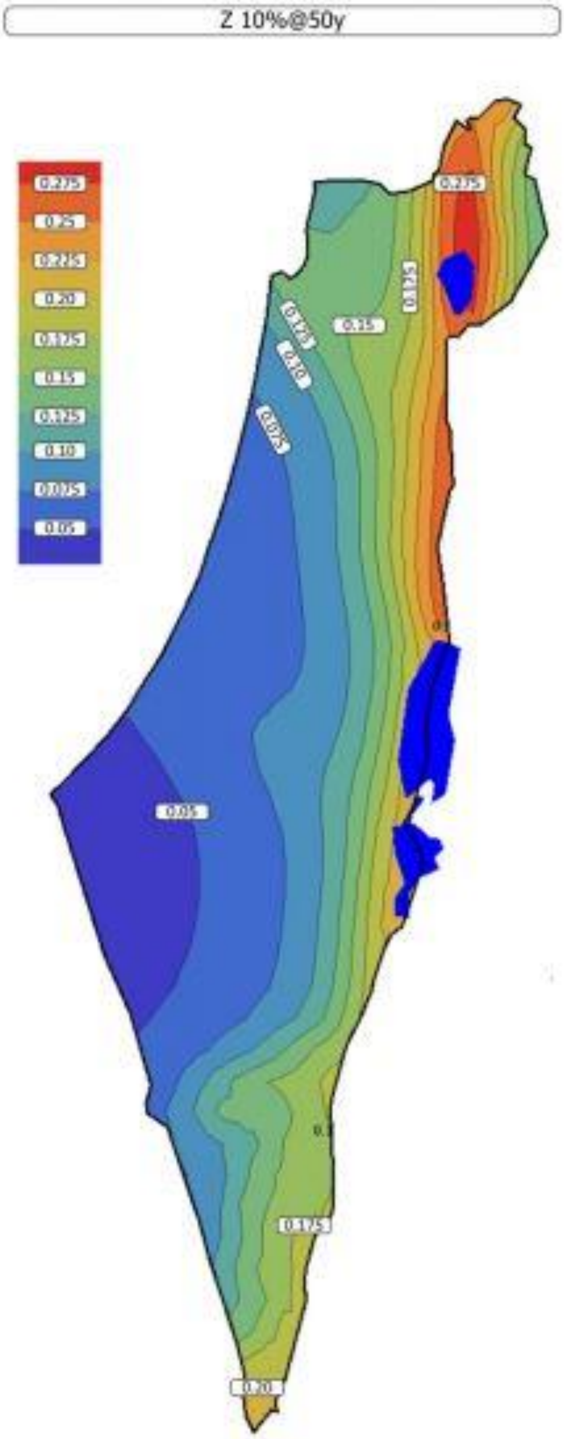
Israeli seismic maps of maximum considered earthquake ground motion with 10% in 50y and 5% damping and site class B, for long period



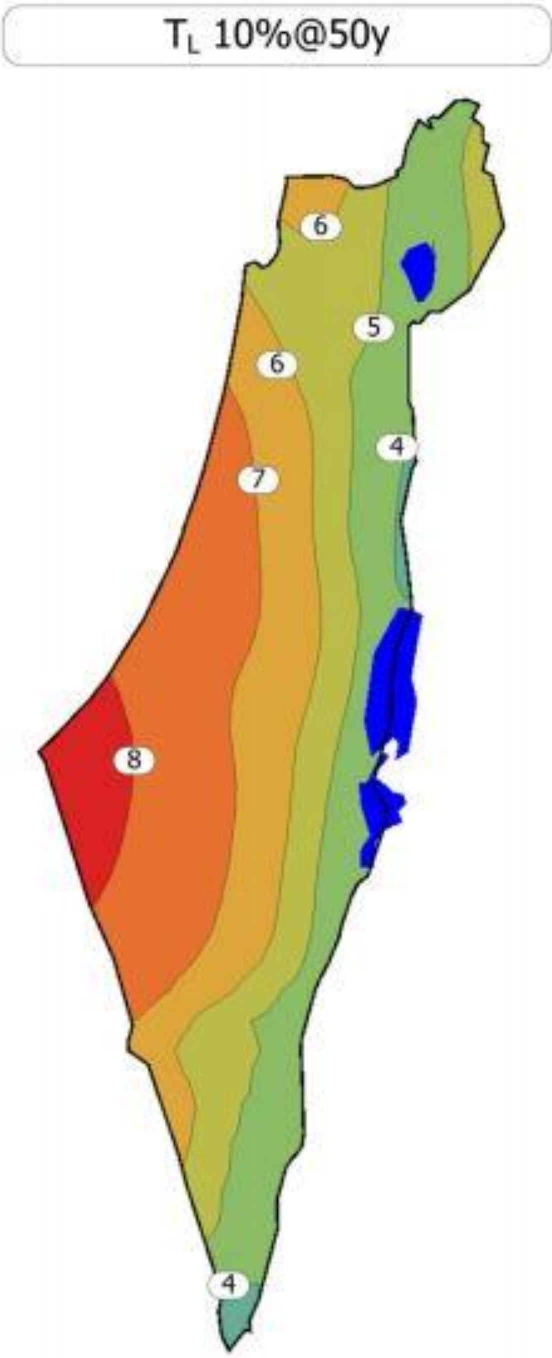
Israeli seismic maps of maximum considered earthquake ground motion with 10% in 50y and 5% damping and site class B, for short period



Map of T_L for return period of 2475 Years (2% @ 50y) SI413 2013



Map of Z for return period of 475 Years (10% @ 50y) SI413 2013



Map of T_L for return period of 475 Years (10% @ 50y) SI413 2013