Assessment of Seismic Site Effect for Rawabi First Palestinian Planned City

Global Platform for Disaster Risk Reduction

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Nablus - , Palestine

Geneva, 09-13 May 2011

Risk Assessment

$$\text{Risk} = \frac{\text{Hazard} * \text{Vulnerability}}{\text{Capacity}}$$

[R] = [H] * [VUL]


PEPSI
صورة 5

Jalal Al Dabbeek

IZMIT, TURKEY, 1999

IZMIT, TURKEY, 1999




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1. INTRODUCTION

Background

Rawabi is a new Palestinian planned city to be located north of Ramallah as shown in Figure 1.1.

Upon completion, Rawabi will have a population of 40,000 with an extent of 6,300 dunums (630 hectare).

Geographic setting of Rawabi in the West Bank (Source: www.rawabi.ps)




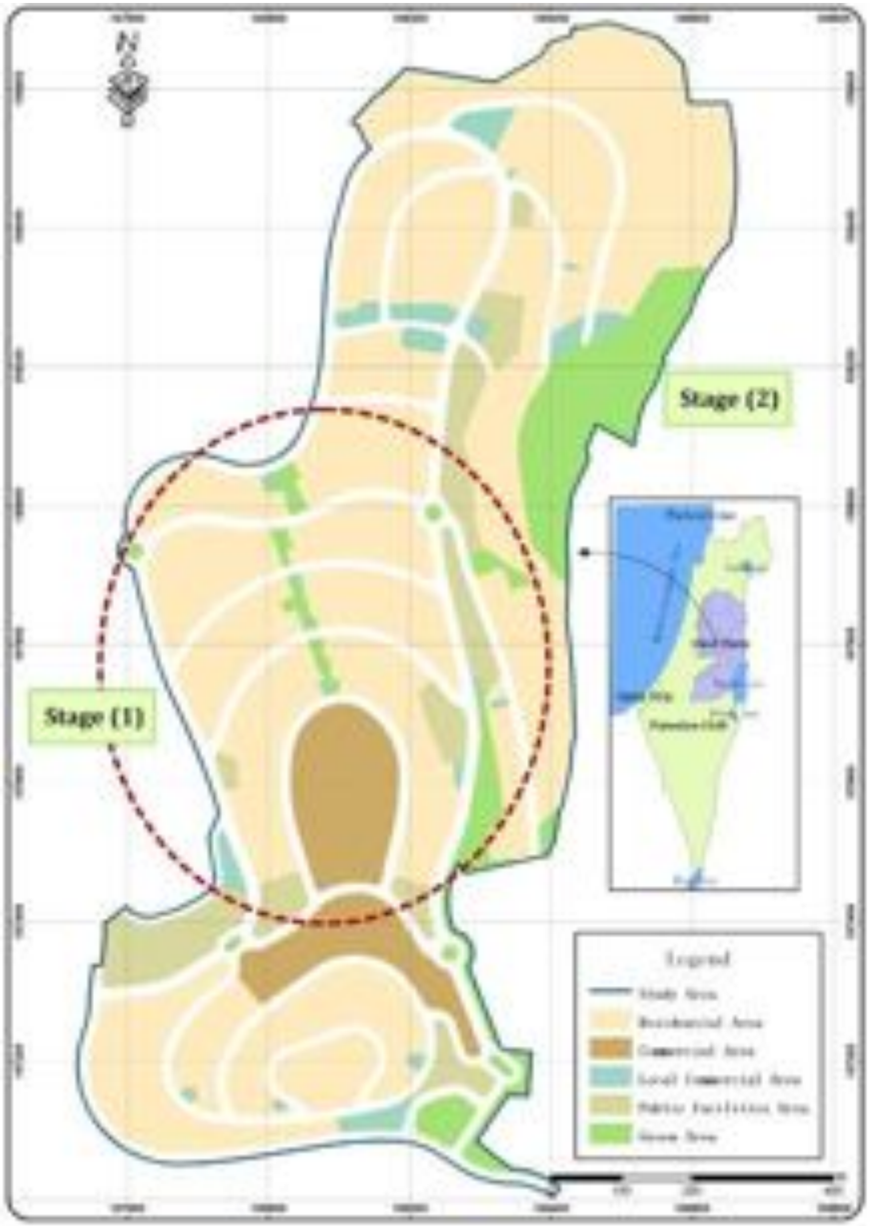

Figure 1.4: Rawabi Site Plan and the study area (Stage 1 and Stage 2).

1.2 The scope of Assessment of Seismic site effect (ASSE)

Earth Sciences and Seismic Engineering Center (ESSEC) at An-Najah National University (NNU), was approached by Bayti Real Estate Investment Company, to conduct an assessment of seismic site effect. This ASSE investigation provides engineering data and recommendations to mitigate the seismic site effect.

1.3 Problem Statement

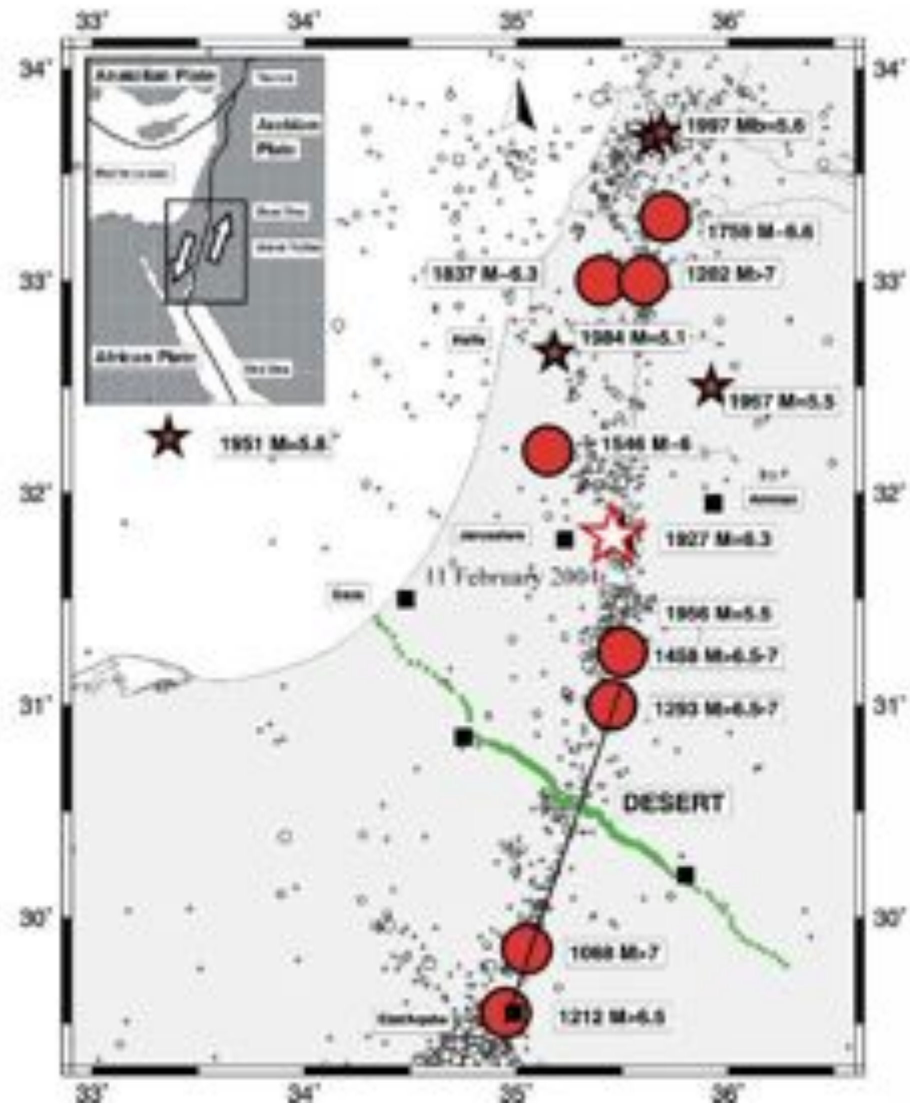

Figure 1.2: Seismic activity in the Dead Sea Transform region; the map shows locations of historical earthquakes [11-14 and others]. Also shown is the most recent earthquake of 11 February 2004, ML 5.2.

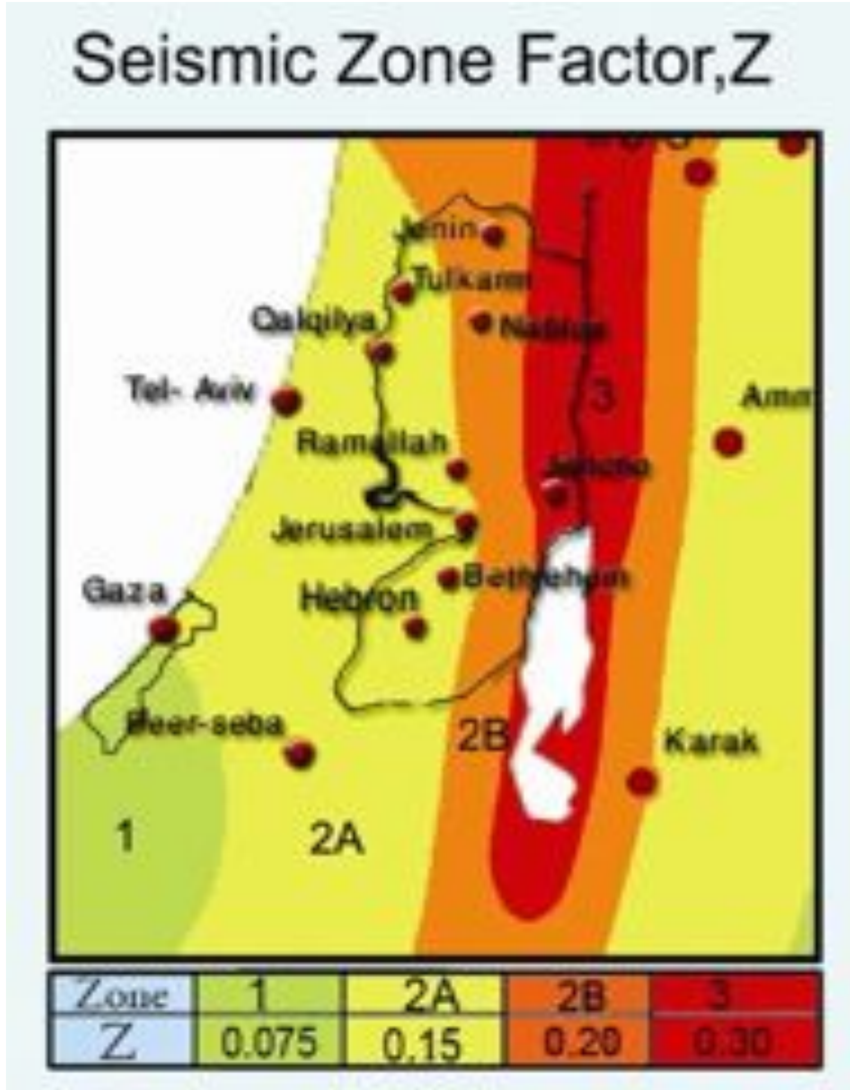

Figure 1.3: Seismic Hazard Map and Seismic Zone Factor (Source ESSEC)

2. GEOPHYSICAL SEISMIC STUDY: Site Investigations

2.1 Local Geology

2.2 Cavities in Rock

2.3 Methodology and Data Analysis

2.3.1 Geophysical experiment

2.3.2 Detection of Seismic Waves

2.3.3 Data Acquisition and Analysis

Site Effect: Fault Rupture

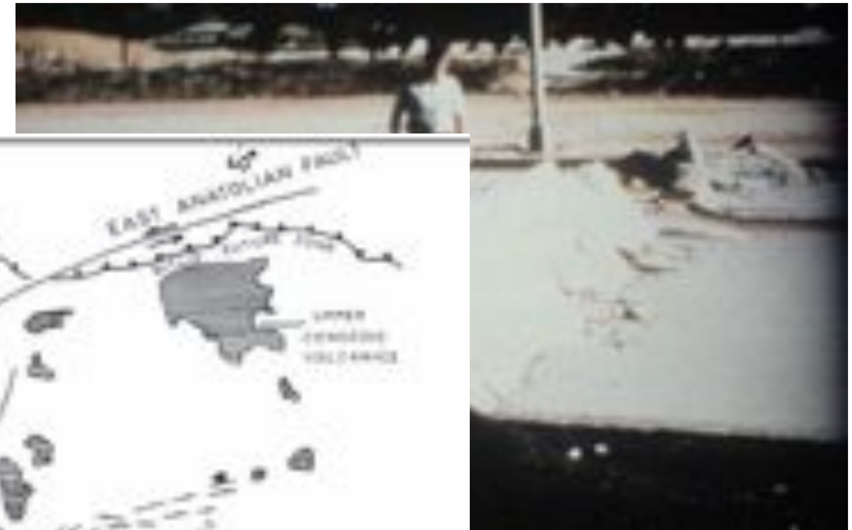

Figure 2.1: Sketch location map of the study area, also shown are the distribution of the seismic profiles.

Seismic Detection

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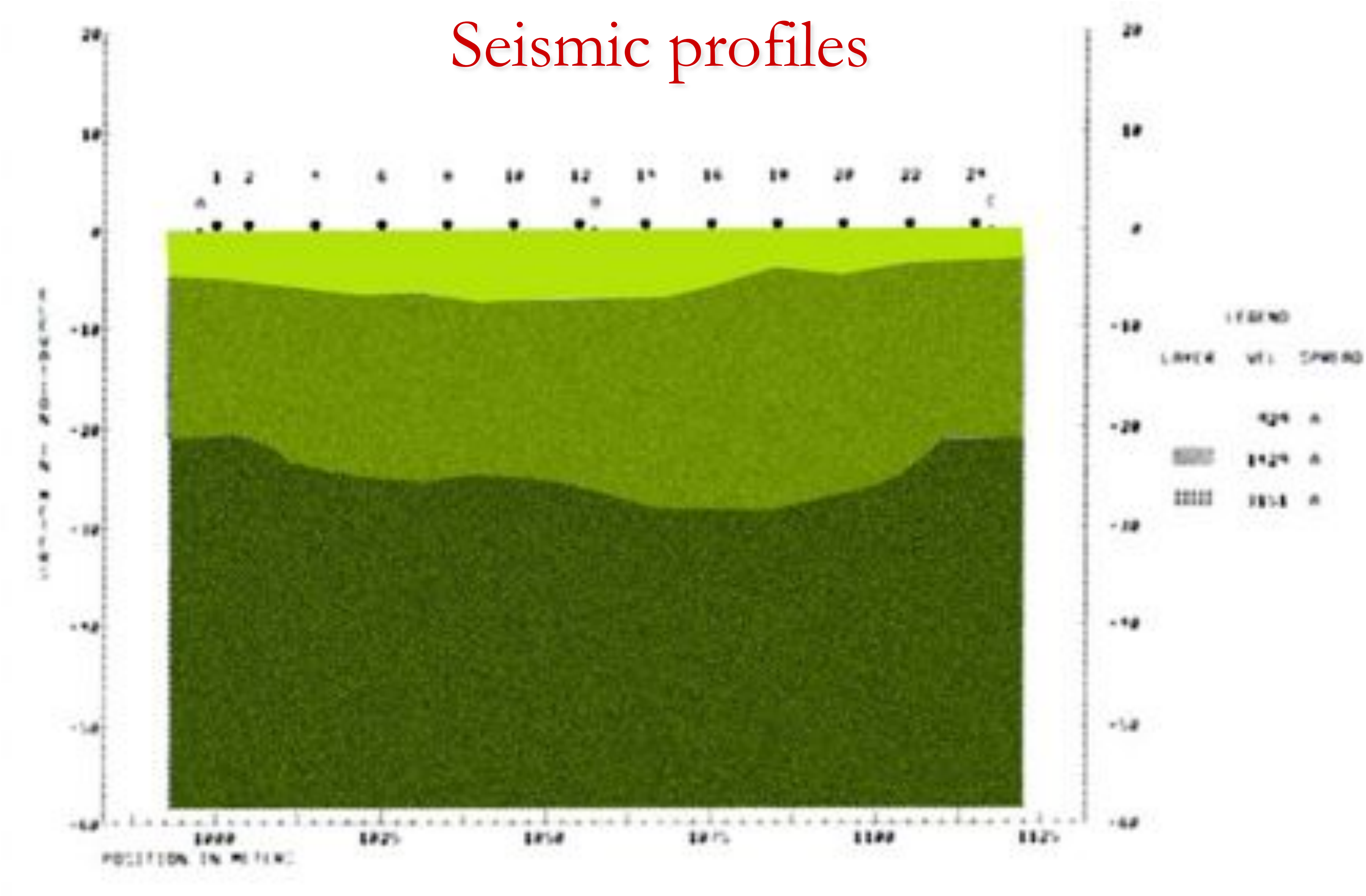
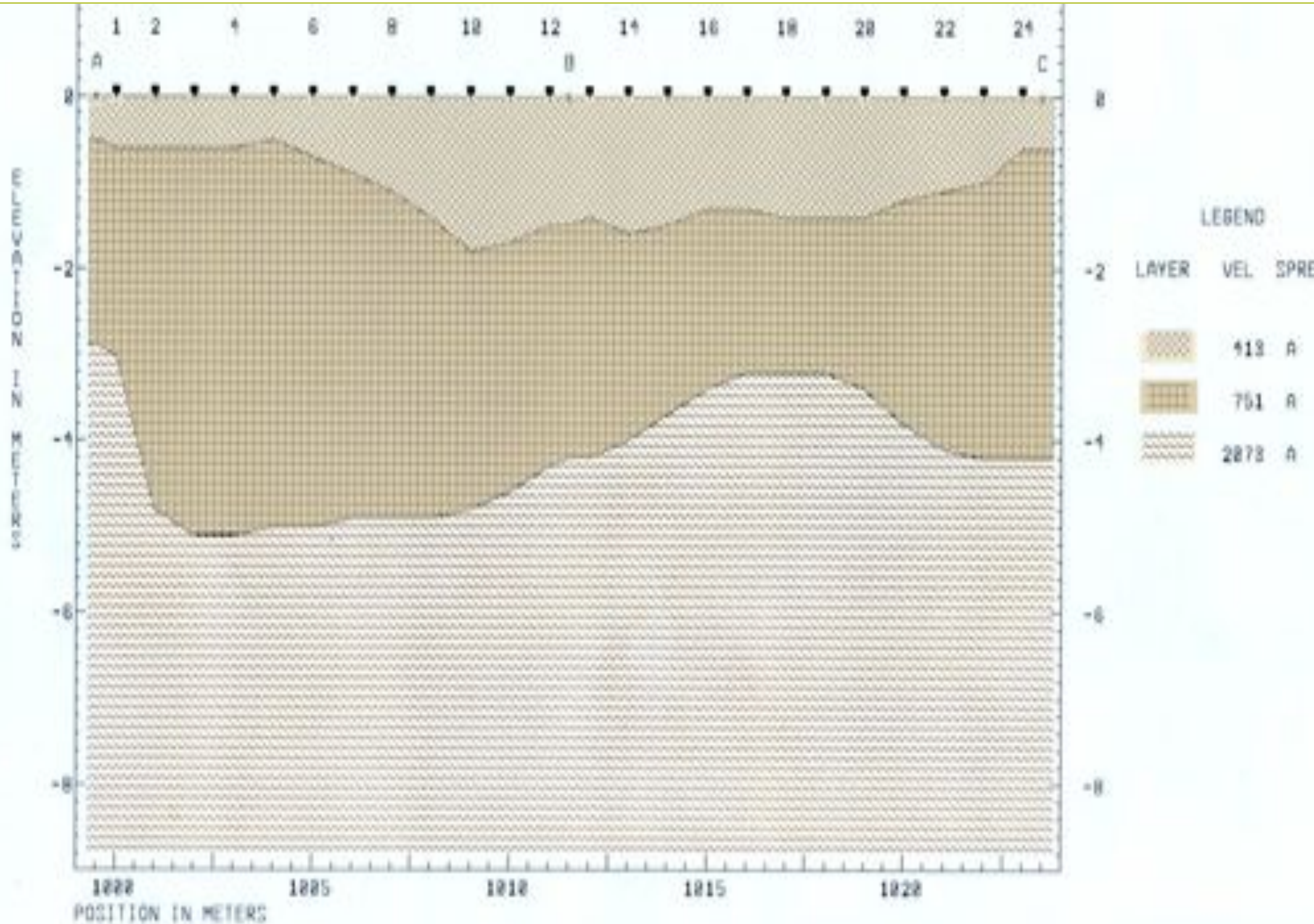
Seismic profiles





1 2 4 6 8 10 12 14 16 18 20 22 24
A
B
C
ELEVATION IN METERS
0
-2
-4
-6
-8
1000
1005
1010
1015
1020
POSITION IN METERS
LEGEND
LAYER VEL SPREA
413 A
751 A
2073 A

Table 2.1: Summary of results obtained from the seismic profiles

Line 1	Layer 1			Layer 2		Thickness (m)
	V m/sec	Thickness (m)	V m/sec	Thickness (m)	V m/sec	
Line 1-1	614	0.3 - 1.5	1505	7 - 9.5	4106	
Line 1-2	615	0.0 – 2.5	1377	1 - 8	2401	
Line 1-3	693	1 - 4	2042	7.5 - 10	3247	
Line 2-1	803	0.5 - 5	1819	∞	-------	
Line 22-33	919	3.5 - 5	2867	∞	-------	
Line 4-1	305	0 – 0.5	1306	9 - 15	2262	
Line 4-2	864	0 - 6	1207	5 - 9	2531	
Line 4-3	582	3.5 - 5	2027	9 - 10	3365	
Line 4-4	305	0 – 1.5	1863	17.5 - 21	3333	
Line 5-5	772	0.5 - 2	1422	∞	------	
Line 6-1	930	0.6 - 1	2555	0 - 1	2674	
Line 6-2	1689	5 - 7	2009	12.5 - 20	4241	
Line 6-3	305	0 - 1	1660	11 -12.5	3125	
Line 7-7	455	0.1 – 2.5	2144	20 – 22.5	3333	
Line 8-8	920	2.5 - 7	1420	12.5 - 20	3151	

Table 2.1: Summary of results obtained from the seismic profiles

Line 1	Layer 1		Layer 2			Thickness (m)
	V m/sec	Thickness (m)	V m/sec	Thickness (m)	V m/sec	
Line 9-9	385	0.3 - 1	1193	5.5 – 7.5	3413	∞
Line 10-10	597	2.5 – 2.65	1953	10 – 10.5	3859	∞
Line 11-11	522	1.5 – 1.6	1564	7.5 - 10	3208	∞
Line 12-12	1465	15 – 17.5	2275	∞	-----	∞
Line 13-13	1200	0.25 – 2.5	1952	15 – 16.5	4000	∞
Line 14-14	587	1 - 2	1414	2 - 5	1868	∞
Line 15-15	1003	0 – 3.5	1229	2.5 - 15	2852	∞
Line 16-16	851	1.5 – 2.5	2050	15 – 17.5	4268	∞
Line 17-17	879	2.5 - 3	1485	12.5 - 15	4308	∞
Line 18-18	1001	2 – 2.7	1579	3.5 – 6.5	2461	∞


2.5 Conclusions

Based on the outcropping geological cross-section in the study area and the ground velocity models deduced from the P-waves velocities of this study/

The subsurface geological formations beneath the seismic profiles are interpreted as:

- Soil cover of soft weathered material (clay and marly-clay materials) which forms the first layer in several sites in the studied area, with a maximum depth of 5 meters.

- The second layer is explained as non consolidated carbonates of marly sediment materials in the southern part of studied area (upper part and city center), as well as consolidated carbonates in the northern part.

- Whereas the third layer is interpreted as consolidated carbonate materials of limestone, chalky limestone, and dolomite limestone.

The soft weathered material and most of clay- marly sediment materials recommended to be totally removed, and the excavation should reach the consolidated carbonate materials (limestone, chalky limestone, and dolomite limestone). And consequently this leads to harmonic and more less a homogeny in the physical properties of the engineering soil.

Based on the values of P- wave velocities in the two or three layers and using the approximate values of the Poisson's Ratio for each layer (v = 0.25, 0.30 and 0.35), the value of shear wave velocity (Vs) will be as follows:

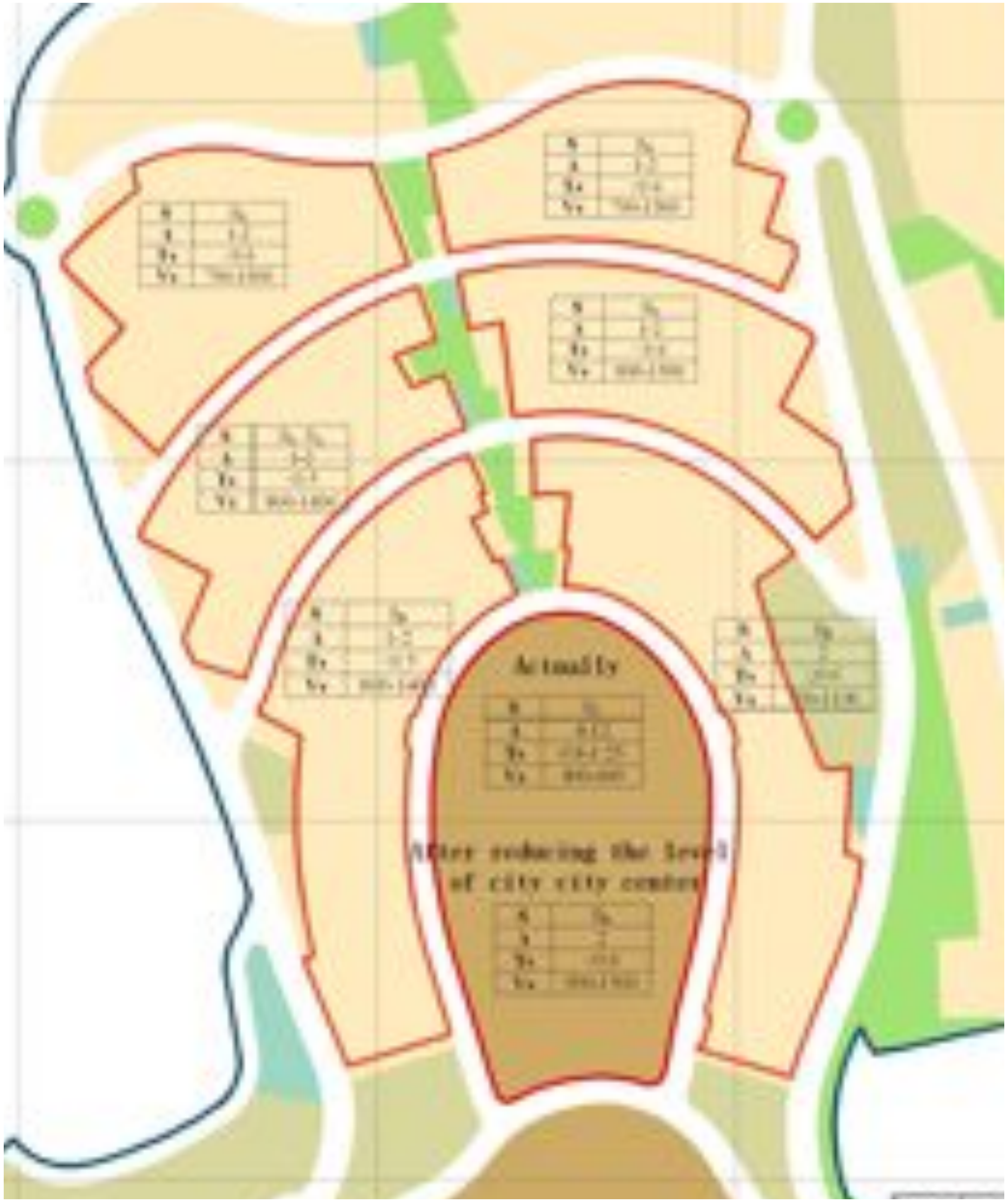
- **Vs** = 250 – 695 m/sec for the first layer
- **Vs** = 495 – 1590 m/sec for the second layer
- **Vs** = 934 – 2390 m/sec for the third layer

The values of shear wave velocities (Vs) at the proposed foundation levels will be around between 500 m/sec and 1500 m/sec. Based on international and regional seismic design codes, such as: Uniform Building Code 97, International Building Code IBC, Jordanian Building Code 2005 and Arab Uniform Building Code 2006 the type of soil profile for the shear wave velocities mentioned above (500 m/sec and 1500 m/sec) will be S_C and S_B. In design it's recommended to use:

- **S_B** for most of the buildings in studied area in Stage 1 and Stage 2.

- **S_C** for the buildings founded on marly-limestone soil foundations.

For more details about the type of soil profiles and the shear wave velocities (Vs) in the studied area, see the microzonation map presented in appendix no. 5.



S	Soil Profile
A	Amplification Factor
T_s	Dominant Natural Period (sec)
V_s	Shear Wave Velocity (m/sec)

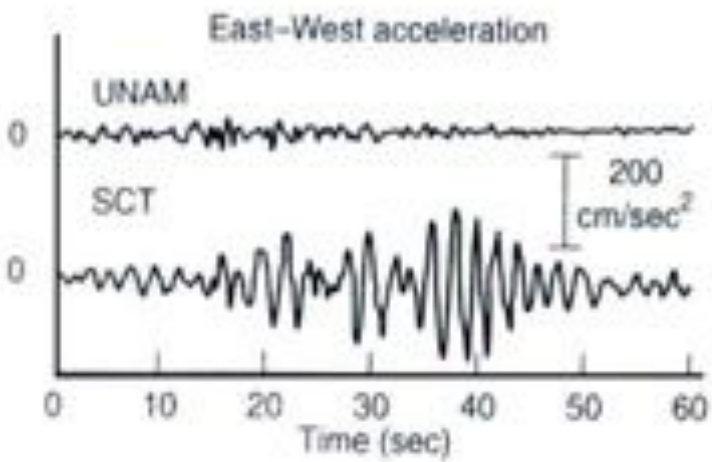
Appendix 5.1: Fundamental nature frequency (Ts), soil profiles type and shear wave velocity map.

3. SEISMIC SITE AMPLIFICATION

3.1 Introduction

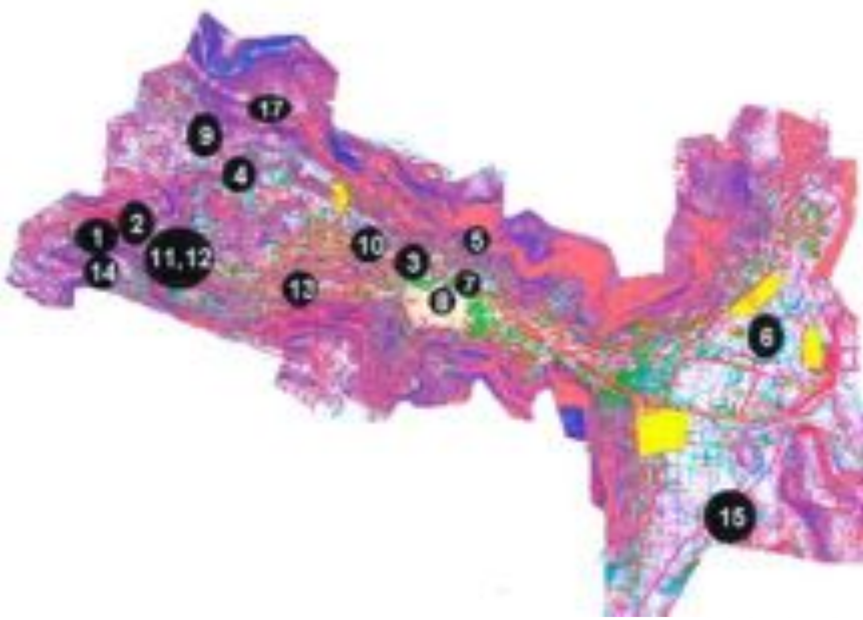
Recent studies of large destructive earthquakes have shown that damages during the earthquakes are often caused by the amplification of seismic waves in near-surface geology [15-20], where the post disaster damage assessment showed that the local site effect may have a dominant contribution to the intensity of damage and destruction.

Site Amplification



Soft Clay

(a) Time Histories



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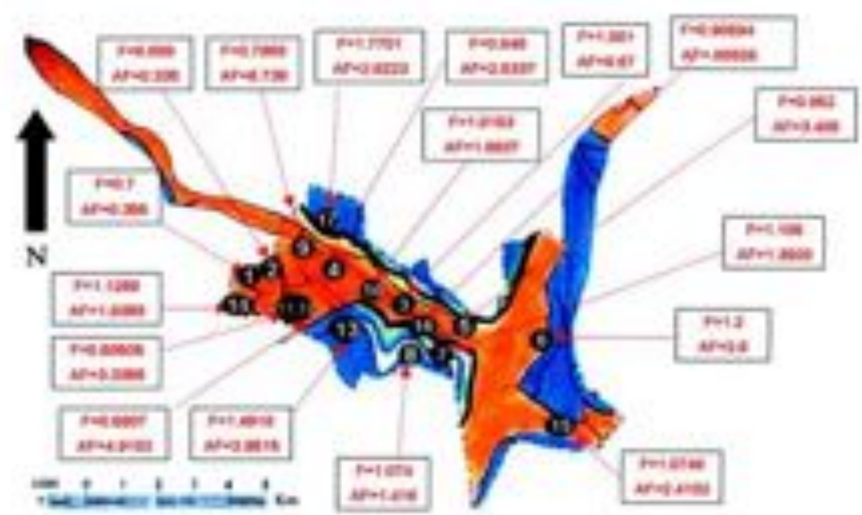


Values of dominant frequencies (DF) and amplification factors (AF) at all measured sites in Nablus City.

3.2 Methodology and Data Analysis

3.2.1 Nakamura's Technique

One of the most appealing techniques for estimating site response is Nakamura's method [25] since it only requires records from a single three-component station deployed at the site of interest and does not need a reference seismogram measured at the substratum bedrock. As introduced by Nakamura [25], the technique was intended to assess S-wave amplification from microtremor measurements.

3.2.2 Microtremor Measurements

Several points have been selected in different sites of Rawabi city (see Fig. 3.1). The criterion for each point is the variations in the geology as well in the topography, where points have been measured on rock cover of mainly limestone, chalk and marl (mountain areas), while other points selected to be on soil.

Microtremor measurements were carried out at 12 selected sites to represent different geological formations and to cover a comprehensive area in order to give a macrozonation general idea about the dominant frequency in the study area, see Fig 3.1.

The site effects have been investigated by taking measurements of ambient noise collected by short period seismic station and making the spectral analysis using the packages programs: SDA software for data acquisition and SEISPECT for data analysis (see appendix no. 3).

The measurements were made during the daytime (see photos – appendix 3.3), when the contaminating effects of traffic and industrial noise were significant.

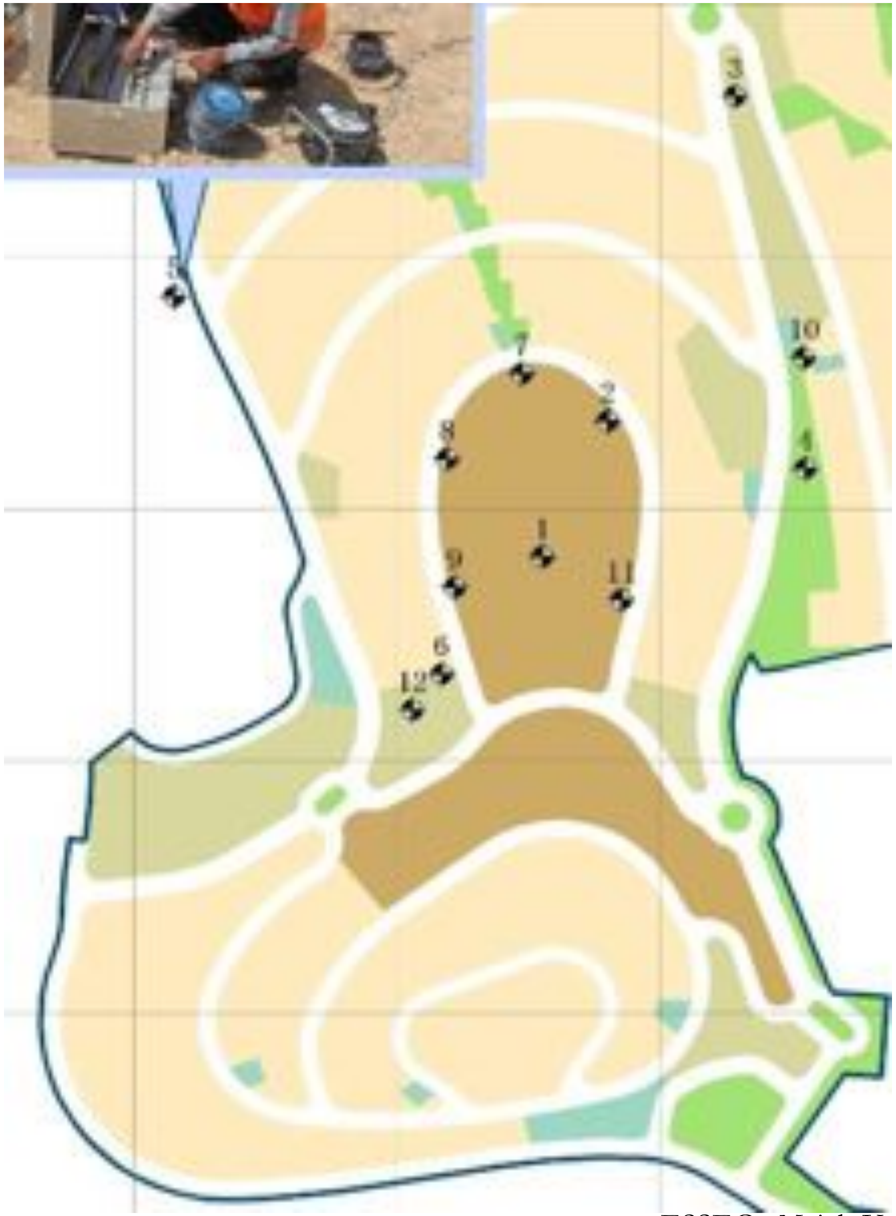


Figure 3.1: Locations of selected sites for microtremor measurements

3.2.3 Spectral Analaysis Results

The analysis of ambient vibration measurements developed a spectral ratio site response for each site, an example of average Fourier spectra for selected windows and the relation between dominant frequency at the site and the amplification factor (spectral ratio) is presented in Figures. 3.2 – 3.13 for the selected sites shown in Fig. 3.1. The dominant frequency (or period) and its amplification factor of all measured locations are presented in Table 1. The results showed obvious difference among the dominant frequencies even the studied area is small.

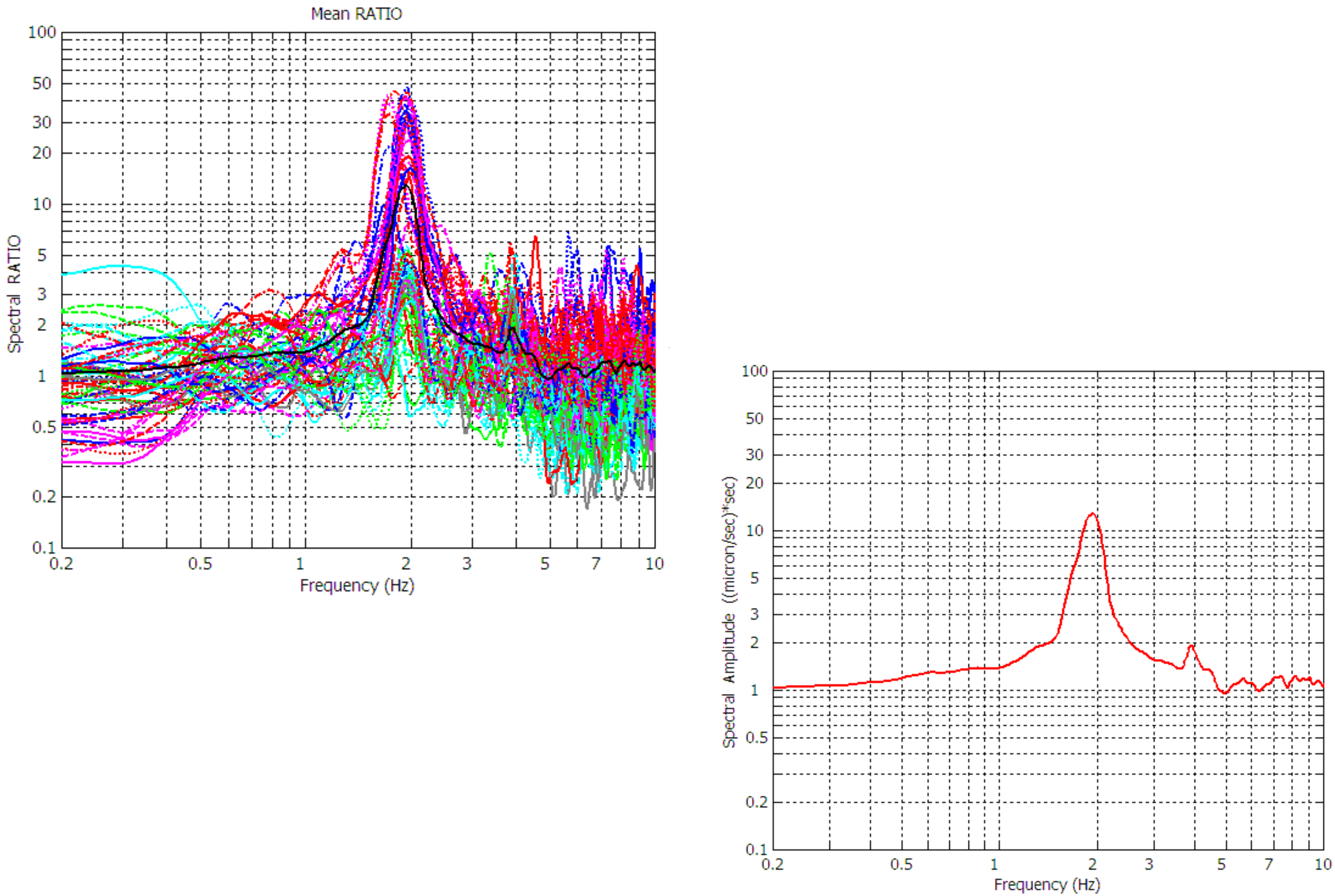


Figure 3.2: Spectral amplitude and spectral ratio for site 1.

TABLE 3.1: Results list of dominant frequencies, amplifications and natural periods.

Microtremor Measurements				Building Codes*
Site	**Dominant Frequency Hz**	**Amplification Factor**	**Natural period sec (Ts)**	**Natural period Sec (T_b)**
1	2	11-12	0.5	1.5
2	2.2	2-3	0.45	1.5
3	1.5 - 2	2	0.5 – 0.66	0.55 (0.455)
4	0.5 – 1	2 – 3	1- 2	0.55 (0.455)
5	1 - 2	2.5	0.5 - 1	0.55 (0.455)
6	0.8 - 2	7 – 9	0.5 – 1.25	0.55 (0.455)
7	1.8 - 2	3	0.5 – 0.55	1.5
8	1 - 2	4 - 5	0.5 - 1	1.5
9	1.5 - 2	4 - 5	0.5 – 0.66	1.5
10	1 - 2	2.5 - 3	0.5 - 1	0.55 (0.455)
11	1 - 2	4 - 8	0.5 - 1	1.5
12	2	1 - 2	0.5	0.55 (0.455)

* *According to Uniform Building Code (UBC97), International Building Code (IBC) and Jordanian Building Code (JBC).*
Att. the values between two brackets according to JBC

3.3 The Fundamental Natural Period of Proposed Buildings in Rawabi City (staqge 1 – phase 1)

The fundamental period of proposed buildings in Rawabi city (buildings which will be built in stage 1 – phase 1) were calculated by using Uniform Building Code (UBC 97), International building Code (IBC) and Jordanian Building Code (JBC), see Table (3.1) in the final report.

All the proposed buildings in the city center area have fundamental periods (Tb) more than the characteristic site period (Ts), this mean that the double resonance phenomena will be avoided in this area.

3.3 The Fundamental Natural Period of Proposed Buildings in Rawabi City (staqge 1 – phase 1)

Reducing the marly stratum level in city center area by 10 meters as proposed in the master plan, will affect positively in reducing the amplification factor mentioned above (see amplification factor for sites 1, 2, 6, 7, 8, 9 and 11 in table 3.1) and in this case expected to be less than 2, and it's relatively safe. In other words, the city center site resonance will be avoided. For the other areas (Hai 1 – 6), the amplification factor is relatively small.

3.4 Conclusions

The characteristic site period (or site dominant frequency **Ts**) which depends on the thickness (H) and shear wave velocity (Vs) of the soil provides, represent a very useful indication of the period of vibration at which the most significant amplification can be expected.

The site dominant natural period varies between 0.8 - 1.25 sec at city center area and between o.5 – 1 sec at the other areas.

Based on the effects of local geology, there is good correlation between the different values of the amplification factor and the changes in the lithology. Where in the most of the areas at Hai 1, 2, 3, 4, 5 and 6, consist of consolidated carbonates bedrock, slight amplification is expected in comparison with quite larger amplification factor was computed at the city center area consist of un consolidated carbonates bedrock (marly materials).

Reducing the marly stratum level in city center area by 10 meters as proposed in the master plan, will affect positively in reducing the amplification factor mentioned above (see amplification factor for sites 1, 2, 6, 7, 8, 9 and 11 in table 3.1) and in this case expected to be less than 2, and it's relatively safe. In other words, the city center site resonance will be avoided.

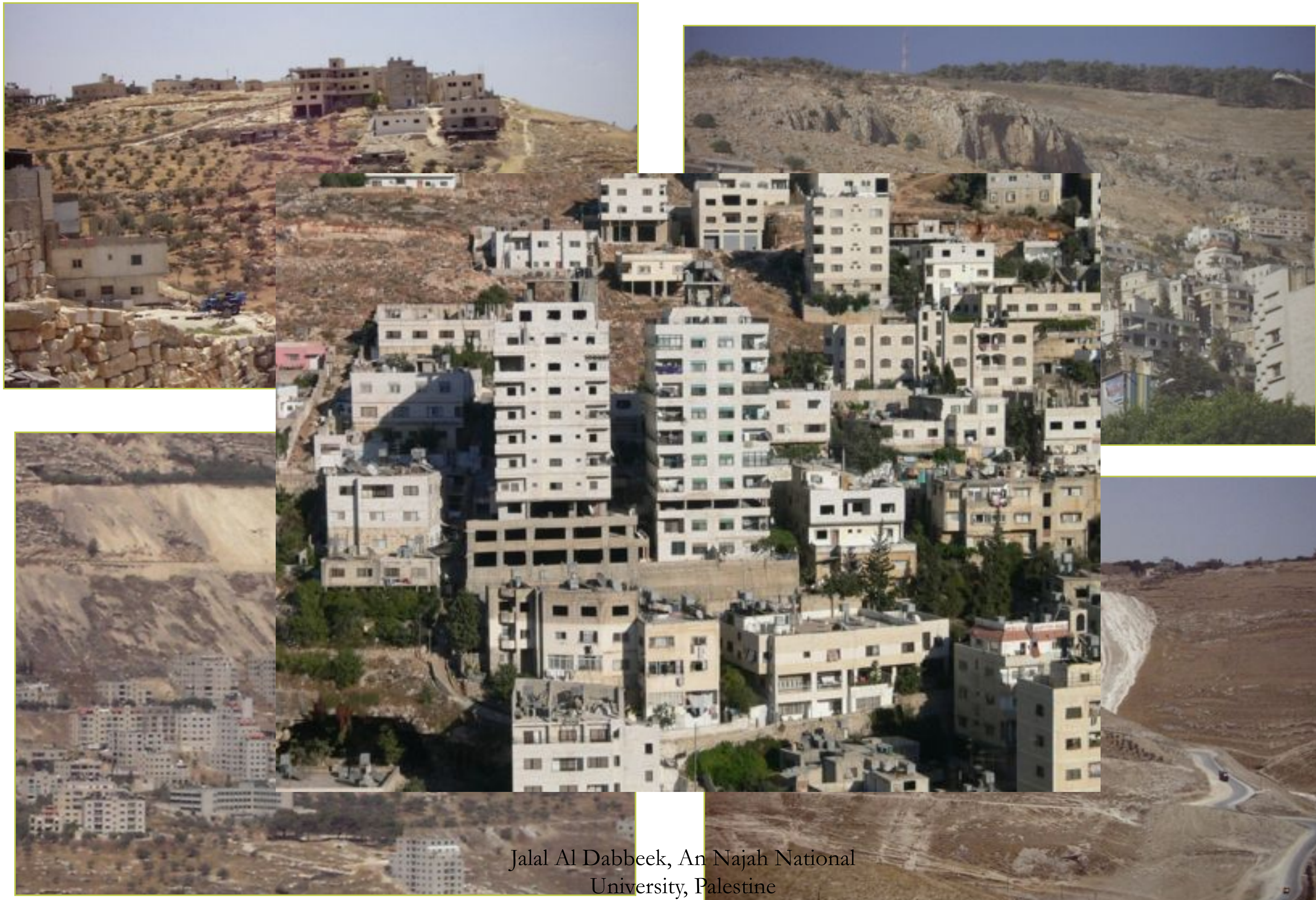
For the other areas (Hai 1 – 6), the amplification factor is relatively small.

S	Soil Profile
A	Amplification Factor
T_s	Dominant Natural Period (sec)
V_s	Shear Wave Velocity (m/sec)

Appendix 5.1: Fundamental nature frequency (Ts), soil profiles type and shear wave velocity map.

4. LANSLIDING AND SLOPE Stability ANALYSIS

Introduction



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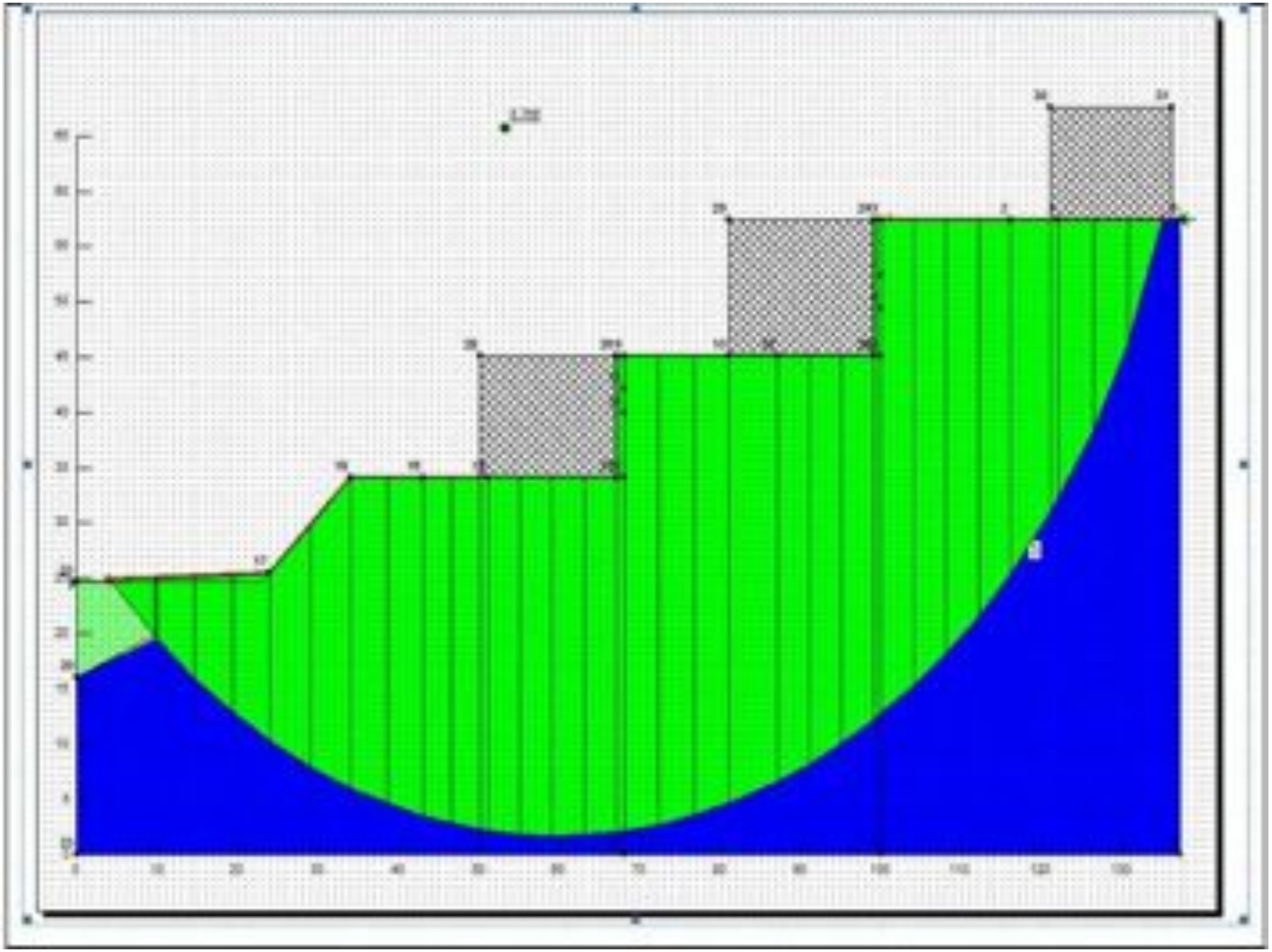
4. LANSLIDING AND SLOPE Stability ANALYSIS

4.3 Procedures

The procedures to carry this task are as follows:

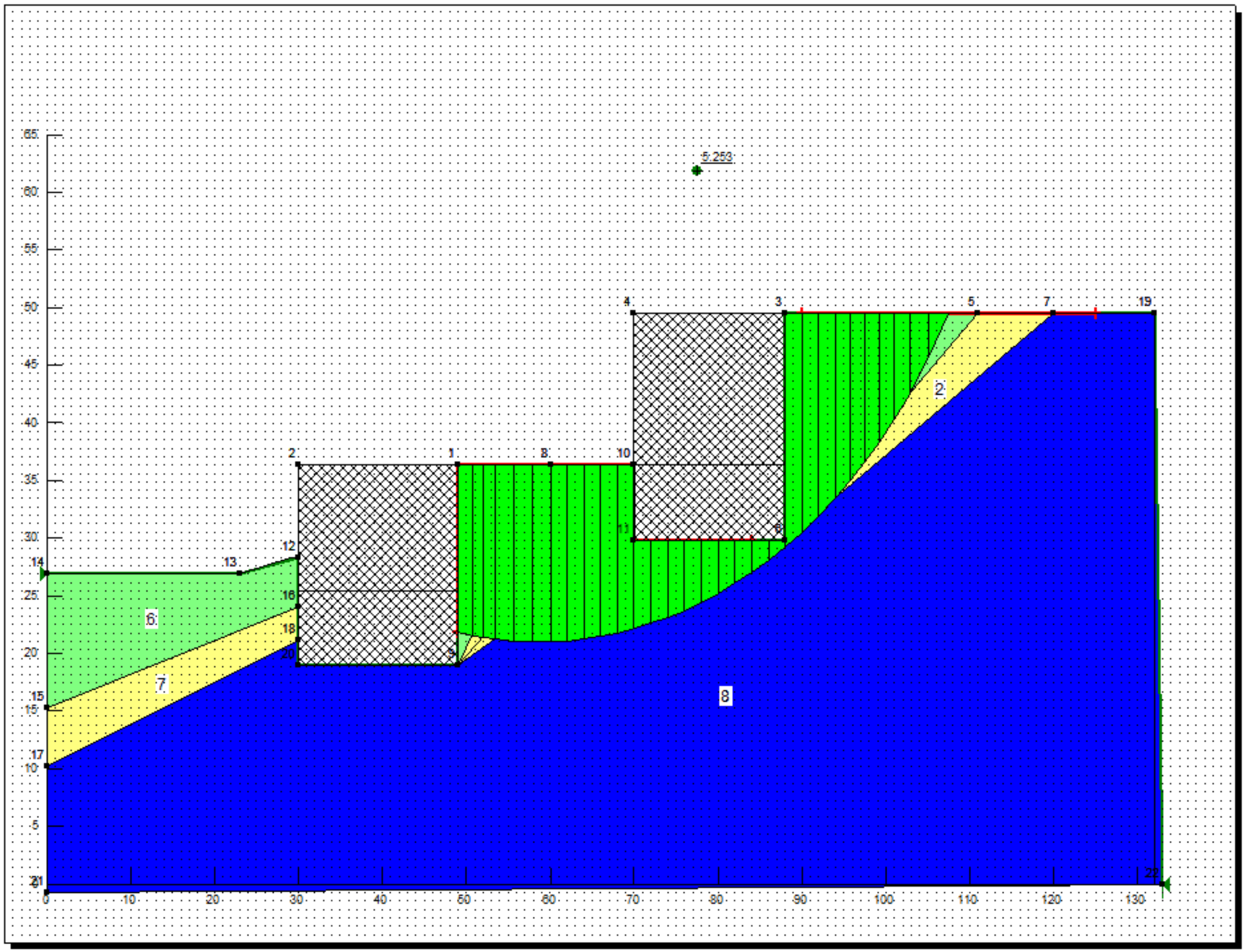
- Selecting of critical sections.
- Detailed geometric description and loads for buildings, excavations, backfilling behind retaining walls and embankments and expected seismic forces.
- Site visit and inspection of the site along the selected critical sections. This is to provide the required geotechnical conditions and any other missing parameters.
- Slope stability analysis software called GeoStudio 2004 (slope/w) was used to carry out detailed slope stability analysis for the critical sections.

Slope stability analysis for section 2 overall zone (Minimum factor of safety = 5.8)



Typical virtual section showing increases in the backfill materials and marl layer.

Slope stability analysis for basic load minimum F.S. = 7 and for basic loads and seismic loads minimum F.S. = 4.7 for 2-story extra excavations and loads for upper zone.



Results of slope stability analysis for the three selected sections through Hai No.1.

Section Name	Zone	Minimum Factor of Safety	Notes
Section # 1	Upper Building Zone	**7.6**	Safe, Stable Slope
	Lower Building Zone	**22**	Safe, Stable Slope
	Overall Stability	**7**	Safe, Stable Slope
Section # 2	Upper Building Zone	**10**	Safe, Stable Slope
	Lower Building Zone	**15**	Safe, Stable Slope
	Overall Stability	**5.8**	Safe, Stable Slope
Section # 3	Upper Building Zone	**8.3**	Safe, Stable Slope
	Middle Building Zone	**15**	Safe, Stable Slope
	Lower Building Zone	**18**	Safe, Stable Slope
	Overall Stability	**7.3**	Safe, Stable Slope

4.5.7 Analysis of the Results

- ✓ The results for Hai 1 are found utilizing the sections provided by the owner.
- ✓ Comparing the results with the minimum required factor of safety (1.3 for temporary structures and 1.8 for permanent structures); it is shown that the site is stable and the values of factor of safety for slope stability are higher than the limits for permanent structures.
- ✓ Slope stability analysis with basic loads plus seismic forces for critical cases were analyzed and shown that the factor of safety is above minimum.

4.7 Recommendations

- The recommendations regarding slope stability analysis for Rawabi City site are as follows:

- The site is safe regarding landsliding and slope stability.

- Any changes other than given or assumed regarding sections, loads, backfilling, etc. should be re-analyzed for slope stability.

- Backfill materials to be used behind retaining walls and as embankments for constructing roads should be selected according to standards of high quality backfill materials.

THANKS

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