社会開発調査部報告書

Japan International Cooperation Agency (JICA) Centre for Earthquake and Environmental Studies of Tehran (CEST) Tehran Municipality

The Study on Seismic Microzoning of the Greater Tehran Area in the Islamic Republic of Iran

Final Report Appendix 1: Data for Natural Conditions



-

• . .

Japan International Cooperation Agency (JICA) Centre for Earthquake and Environmental Studies of Tehran (CEST) Tehran Municipality

The Study on Seismic Microzoning of the Greater Tehran Area in the Islamic Republic of Iran

Final Report Appendix 1 : Data for Natural Conditions

November 2000

Pacific Consultants International OYO Corporation



Appendix 1 : Natural Conditions

Appendix IGeological Site InvestigationAppendix IILiquefaction Analysis Data1.Soil Properties2.Liquefaction Judgement ChartAppendix IIIAmbient Vibration Measurement

Appendix I: Geological Site Investigation

Geological Site Investigation

1. Boring Investigation and PS Logging

1.1. Contents of Investigation

Geological site investigation is undertaken during the project. The following items are especially taken into account.

- geological conditions covering whole the Study Area;.
- deep geological conditions down to 200m in depth;
- shear wave velocity of the ground.

The contents and quantities are as follows:

- Boring: 50 locations
- Total drilling depth: 2822 m
- Standard penetration test: 1186 tests
- PS Logging: 20 locations, Maximum depth of 200m
- Grain Size: 93 samples
- Atterberg Limits: 84 samples
- Specific Gravity: 21 samples
- Moisture Contents :284 samples
- Unconfined Compression Test: 19 samples
- Triaxial Compression Test: 17 samples

Details of contents and quantities are summarised in Table 1. Locations and elevations of the investigation site are summarised in Table 2. A location map of the investigation is shown in Figure 1.

PS logging works were undertaken with technical cooperation of Exploration Division, Institute of Geophysics, University of Tehran.

1.2. Outline of the Results

Results of the investigation are summarised in the *Field Report* which was submitted last November 1999. Characteristics of geological condition and ground properties are summarised in detail in Chapter 3.2 "Ground Classification". Soil property charts at some representative location are shown in Figure 2, Figure 3 and Figure 4. Typical geological cross section is shown in Figure 5.

It is the first time in Tehran City to undertake a boring investigation down to a depth of 200m with standard penetration tests and PS logging. In the southern part of Tehran, overconsolidated and stiff clayey soil is distributing. Thickness of the clayey soil exceeds 200m. Shear wave velocity of this clayey soil shows 300 to 800 m/sec.

Grain Size (Sieve/Hydrometer). Unconfined Compression Test Triaxial Compression Test **Drilling Depth** (m) Moisture Content. Ξ Atterberg Limits Specific Gravity Borchole No. PS Logging νo. SPT Nominal Actual C17 50 50 1 23 1 1 1 -• • 1 2 E09 15 15 8 _ -. • -• • 3 E11 done 15 21 8 -• --• • 4 E13 15 15 8 • -• -• • 5 E17 21 7 15 done --• -٠ • 6 E19 15 15 8 -• • -• • 7 F16 50 57 26 done --• -• -8 G01 15 15 8 ---• • -. 9 G04 15 15 8 40 -• • -• • 10 G07 15 8 15 . -• ٠ ٠ • 11 G11 15 15 8 -. . ---12 G13 50 56.75 26 done -. . -• • 13 G17 15 15 10 --Ξ. • -• -14 G19 15 15 8 -----15 G21 15 15 8 --• ----16 H07 15 15 8 --• -• --17 H09 15 15 8 -• --• ٠ -18 103 15 15 8 -. ----19 105 15 15 8 ---. --20 I13 15 21 8 done • • * ---I15 21 15 15 8 • • -٠ • -22 117 15 15 7 --. • -. 23 119 15 15 8 ---• --• 24 J17 50 50 25 •• • -• -• -50 25 K07 50 25 -• -• • -٠ 26 K09 100 106.5 39 done . . -. _ . 27 K11 50 50 25 -2 2 1 4 • 28 K13 50 50 25 32 23 1 1 -1 32 29 K14 25 50 50 2 . 2 1 6 • 30 K15 100 106 48 done з 3 2 1 10 -31 K17 50 50 25 2 2 -2 2 -• 32 L09 50 1 2 50 26 -1 1 6 --L11 33 100 106 4] done 2 1 -Ĥ L17 34 50 56 26 done 1 1 1 1 1 8 35 M09 25 50 50 3 3 2 1 • 9 36 M11 200 206 65 done 3 3 1 2 24 1 37 M13 100 106 40 4 4 1 done 1 2 16 38 M14 50 50 24 1 1 • 1 8 1 39 M15 100 106 43 done 1 1 3 • 12 -40 M17 50 5 2 50 25 5 2 1 9 ٠ • 41 N09 100 106 40 2 1 done . . 10 42 N13 100 206 65 done 6 6 1 -18 43 N15 50 50 25 2 2 2 ٠ --10 44 013 100 106 40 done 4 4 1 1 3 20 45 014 50 3 56 25 3 1 done . 2 10 46 015 200 206 76 done 2 2 1 1 19 -47 016 100 106 40 done 3 3 1 • 1 11 P15 48 50 50 22 1 1 1 --5 • 49 P17 50 56 26 3 3 1 done 1 . 7 Q17 50 100 106 40 done 4 4 1 1 1 16 Total 50 2600 2822.25 1186 93 84 21 20 19 17 284

Table 1 Contents of Boring Investigation and PS logging

٠

.

Borehole	Drilling	PS	Latitude		Latitude		Altitude
	Length (m)	Logging	Degree	Minute	Degree	Minute	(m)
C17	50	-	35	48.79	51	28.48	1664.3
E09	15	•	35	46.94	51	17.68	1560.6
E11	15	Done	35	46.86	51	20.51	1555.0
E13	15	-	35	46.79	51	23.10	1550.5
E17	15	Done	35	46,68	51	28.74	1472.5
E19	15	-	35	46,61	51	31.04	1525.5
F16	50	Done	35	45.78	51	27.05	1461.5
G01	15	-	35	44.29	51	7.16	1213,5
G04	15	•	35	44.45	51	11.05	1267.8
G07	15	-	35	44.92	51	15.27	1320.3
G11	15	-	35	44,58	51	20.30	1363.5
G13	50	Done	35	44.47	51	23.03	1350.0
G17	15	-	35	44.76	51	28.31	1225,0
G19	15	•	35	44.68	51	30.97	1340.7
G21	15	-	35	44.58	51	33.61	1662.9
H07	15	-	35	43.49	51	14.92	1272.6
H09	15	-	35	43.49	51	17.56	1263.3
103	15	-	35	42.51	51	9,98	1183.0
105	15	-	35	42.46	51	12.50	1205.7
I13	15	Done	35	42.71	51	22.65	1246.6
I15	15	-	35	42.50	51	25.18	1210.0
117	15		35	42.57	51	28.30	1224.9
I19	15	-	35	42.88	51	30.64	1350
J17	50	-	35	41.18	51	28.24	1174.8
K07	50		35	40.21	51	15.35	1160.0
K09	100	Done	35	40,59	51	17.20	1167.2
K11	50	•	35	40.35	51	20.30	1140.1
K13	50	-	35	39.95	51	22.74	1131.3
K14	50		35	40.19	51	24.41	1126.3
K15	100	Done	35	40.01	51	26.16	1132.0
K17	50	-	35	40,36	51	28.39	1152.4
1.09	50		35	39.36	51	17.97	1129.8
L11	100	Done	35	38.83	51	20.29	1125.5
L17	50	Done	35	39.27	51	28.25	1127.2
M09	50	-	35	38.46	51	17.84	1117.2
M11	200	Done	35	38.33	51	20.71	1110.0
M13	100	Done	35	38,00	51	22.85	1097.6
M14	50	-	35	38.11	51	24.11	1098.6
M15	100	Done	35	38.25	51	25,43	1094.2
M17	50	-	35	37.93	51	27.79	1104.3
N09	100	Done	35	37.00	51	17.84	1098.2
N13	200	Done	35	37.28	51	23,21	1090.2
N15	50	-	35	36.89	51	25.71	1073.3
013	100	Done	35	36.15	51	23.41	1065.5
014	50	Done	35	35.79	51	24.43	1056.7
015	200	Done	35	35.56	51	25.28	1052.8
016	100	Done	35	35.82	51	27.04	1062.1
P15	50	-	35	34.95	51	25.64	1046.4
P17	50	Done	35	35.14	51	28.01	1044 2
Q17	100	Done	35	33.69	51	28.30	1026.5

 Table 2
 Location of Boring Investigation



m/sec 1 Downhole method Geology: D2 and C fm. i ----------Vp. Vs 2000 <mark>م</mark> <u>00</u> -s i ŧ Ĩ. * Grain Size Distribution 20 Water Contents % -----I 22 30cm penetration) 3 ł Neq (equivalent to 8 ន ŧ 1 l 8 z 35 1 ŧ 1: Gravelly soil 2: Sandy soil 3: Clayey soil . i 1 -i : 1 : 1 . 3 Ţ ł l 1 ÷ ļ . i : . Soll Type ļ 1 ł ł ł 1
 10
 0.000

 20
 0.000

 30
 0.000

 0.000
 0.000

 10
 0.000

 00
 0.000

 00
 0.000

 10
 0.000

 10
 0.000

 10
 0.000

 10
 0.000

 10
 0.000

 10
 0.000

 11
 0.000

 120
 0.000
 1 160-170-180-190-Depth m

-

Figure 2 Soli Property Chart (Location G13)

Boring G13



Figure 3 Soil Property Chart (Location K13)



....

Boring N13

Figure 4 Soil Property Chart (Location N13)

ر



2. Microtremor Measurement

2.1. Contents of Investigation

Microtremor measurements are undertaken during the project. Total of 21 sites is selected to identify changes of properties depending on soil and rock distribution. Major observational lines and points are set as follows:

- North-South direction (variation for rock to thick quaternary soil)
- East-West direction (variation for fan sediments)
- On Rock (for reference as basement property)

The location and measurement dates/times are summarised in Table 3. A location map of the measurement is shown in Figure 1.

2.2. Outline of the Results

Results of the measurement are summarised in the Field Report which was submitted last November 1999. Power spectra diagrams at some representative location are shown in Figure 6. Characteristics of results are noise (spikes at about 1.2Hz), noise (high frequency level) and non-outstanding predominant frequencies.

2.2.1. Noise (Spikes at about 1.2Hz):

Nearly all power spectra show narrow spikes at about 1.2Hz. These spikes are clearly of instruments origin. This signal is the "beating" frequency between the seismometer and the 50Hz sampling frequency used during the measurements and the main power line frequency. Those noises are neglected.

2.2.2. Noise (High frequency level)

The measurements were taken from midnight to 5:00 a.m. to avoid artificial seismic noise. However, there were still heavy traffic and construction works during the measurement time. Some random noise signal is observed in frequency of over 5Hz. Those are considered to artificial seismic noise and those are also neglected.

2.2.3. Characteristics of predominant frequencies

Non-outstanding predominant frequencies are observed in power spectra diagrams for almost all the locations. There are very little directional variation, vertical, northsouth and east-west. Results of PS logging indicates a very simple layered structure for shear wave velocity. Non-characteristic predominant frequency is considered as an effect of the simple layered structure. Amplification properties of ground are described in Chapter 3.5.2 "Amplification of Subsurface Ground". Amplification functions are defined for each type of modelled ground. Characteristics of results of microtremor measurement agree with those of amplification functions.

No	Site code	Date	Time	Latitude	Longitude	Elevation
				Degree	Degree	(m)
				Minute,	Minute,	
		<u> </u>		Second	Second	
1	C17	12-Sep-99	22:34 UTC	N35, 49, 21.8	E51, 28, 55.6	1870
2	D11	13-Sep-99	22:12 UTC	N35, 48, 05.7	E51, 20, 23.3	1729
3	E17	12-Sep-99	23:39 UTC	N35, 46, 33.6	E51, 28, 50.0	1667
4	F16	12-Sep-99	01:28 UTC	N35, 45, 50.9	E51, 27, 05.2	1507
5	G11	13-Sep-99	00:48 UTC	N35, 44, 35.4	E51, 20, 19.0	1435
6	111	13-Sep-99	02:03 UTC	N35, 42, 35.5	E51, 20, 35.2	1241
7	l17 ·	17-Sep-99	23:47 UTC	N35, 42, 44.7	E51, 28, 19.8	1451
8	K07	06-Sep-99	23:11 UTC	N35, 40, 09.4	E51, 15, 23.3	1166
9	K09	06-Sep-99	00:31 UTC	N35, 40, 07.5	E51, 17, 17.7	1228
10	K11	06-Sep-99	02:00 UTC	N35, 40, 24.6	E51, 20, 18.4	1247
11	K13	07-Sep-99	23:34 UTC	N35, 40, 24.5	E51, 22, 40.9	1276
12	K15	07-Sep-99	00:30 UTC	N35, 40, 58.5	E51, 26, 07.1	1202
13	K17	07-Sep-99	02:47 UTC	N35, 40, 31.6	E51, 28, 36.7	1150
14	M11	15-Sep-99	00:22 UTC	N35, 38, 18.9	E51, 20, 42.0	1095
15	M15	16-Sep-99	23:02 UTC	N35, 38, 12.4	E51, 25, 27.5	1178
16	M19	09-Sep-99	21:17 UTC	N35, 38, 03.8	E51, 30, 43.4	1195
17	011	15-Sep-99	22:35 UTC	N35, 35, 58.1	E51, 20, 31.7	1091
18	P18	17-Sep-99	21:51 UTC	N35, 35, 25.9	E51, 29, 38.8	1196
19	Q15	09-Sep-99	23:50 UTC	N35, 40, 58.6	E51, 25, 37.5	1201
20	Q17	09-Sep-99	01:55 UTC	N35, 33, 37.7	E51, 28, 23.2	1039
21	HS	16-Sep-99	22:07 UTC	N35, 32, 39.5	E51, 22, 20.1	1069

Table 3 Location and Measurement Date/Time of Microtremor Measurement



Figure 6 Example of power spectra density

Appendix II: Liquefaction Analysis Data

-

,

•

د د و ه

1. Soil Properties







2. Liquefaction Judgement Chart

•

Tehran Seismic Microzoning Boring No PK-15 Khc=0.42

~		-1		ö	0		1	0	~	ō			, ''	···· · · ·	-	· ····	_
	Fw(z)		Š	8	0.0	0.0	0	00	121	8	000	036			8		
	5 9	,	ļ												8		
ſ	o tribute	·							• ••••						ŝ		
ļ	بر یو	·															
L		_	ļ					- 1 1	•			••	••••	-	ī		
L	Depth (m)	Ľ	。 					₽ 		15			8				
┝	Judgement	┢						·	<u> </u>			<u> </u>	0		-		
L	F	L	ļ						0.65			53	0.52				
Sł	xear stress ratio L		1						0483			171.0					
5	liess reduction	Γ					1		5			2					
┝		┢							<u>ة</u>			<u>-</u>	5		-	ę	
ł	<u>к</u>								0.31			0,20	ä		4	thquai	
	RL		1						91C.O			0.204	0.241			1° ear 6 Ioqu	
8	Na								20.7			115	2,736			Type of to b	
stance		-							658			185	1			ea) ase for X:r	
50.55		┝							<u>8</u>			3	33 12		-	x for ar ed on c squified	
O.		┢			-							14 07	× 03		-	on fact v is bas to be k	
		_							0			0 1.01	101		-		
_	CW							<u>.</u>	1 20			1 50	8			dgemer	
	Fc (%)		182	79.1	182	2	រ	Ĩ	2	191	Ē	3	142			884ii	_
	Ye (11/m3)				2,00		2.20	2.00	2.10	200		- 10					
	γ _n (t/m³)			0	20		2.20	20	2.10	50					╞		
	ip		25 0	25.0	25.0	25.01		25.0		25.0	25.DI				_		_
	D10 (mm)						5.00										
sic Data	D50 (mm)		0.005	0.005	0.005	0.005	5.000	0.005	2.100	0.005	0.005	2100	2100				
Ba	σ, *(kgl/cm²)		Q,130	0.530	0.930	1 165	1,368	1 815	1.826	2.035	2235	246	2.611				
	o _v (kgl/cm²)		0 130	0.530	0 830	1,330	1753	2,180	2.591	3.000	3 400	118.6	4,128				
	N value		8 E	22	11	33	5	27	31	2	4D	:	25		Τ		
	Vsi (m/sec)				Bor		295	B	251	200			T				
	Ground Type				1												
С	Depth of alculation m		0 65	2.65	4 65	6 65	8 65	10 65	12.65	14 65	18 65	18.65	20.15		1		
	Le vel So So	_			<u>-8</u> -												4
	N valt vater	_	~		- 121-	~	\sim										7
	SPT Bund	_		2				9				-	۵				-
	୍ତି ହ Geology	-					<u> </u>						1				-
	Depth (m)	80	шШ			uuud S	<u>eo eo</u> g	11111 2	 8		uuu si		 AN:A				┥
E	levation (m)								-7		\neg						-
	Scale (m)	-	····		1	, <u> </u>	 =		,ł	. <u>.</u>	l_	 ;	. ₿	·	-		┥

1		Ξ	1	8	8 8	1	2 2	2 2	9			· · · · ·		~ <u>_</u>	·
	FW(2)			<u>ŏ</u>	6 6		5 5			8	8			000	
ſ	, voj	~ ~												Ê	
	stribut	~ }			- <u></u> .										
	. ٿ	-					<u> </u>							2	
╞	Death (-)		<u> </u>		·		<u></u>	•		<u></u>	••	•		БГ	
┟	Depth (m)	4			ю 		¥			<u></u>		- 20			
ŀ	F	┢	-					<u> </u>				<u> </u>		-	
	'L	1	_		<u> </u>			3				0.48			
Ľ	L	<u> </u>	_		0.55			0.612	_		0.592	0.576			
	Stress reduction factor r.	"			1908			818			328	849		7	
	R	┢			6	1	<u> </u>	<u> </u>			0	<u> </u>		-	÷
		╬	_								3	0.2		4	thqua
		┢	_		1 80			0.300			0.213	0.280			1°eau de lequ
	Na				15.224			1308			156.	6117		1	1.70 01 15 15
-united	NI	1	-		1			+28 \$2			100	1		- -	e se X Ze ze
a si		╀						<u>*</u>			=	<u> </u>		-	
ð	c2	╞			0.0	ļ		623			0.000	0.00			based besed belegi
1	c1				1.000			1.084			1000	80.1			n =
	CW				8	 		8			8	8			
┢		┢	+								<u> </u> =	<u> </u>			
	FC (%)	┦─		<u>្រុះ</u>		ສ	, i	2	, į	2	្ព	2			3056
	Y ₁₂ (tt/m3)	-	5		52		500	2.10		2002			2.20		
	Y ₍₁ (0/m²)	┢	<u></u>		2.2(·	<u></u>	2.10		3			220	L	<u> </u>
Ĺ		┢	251	8			25.0		25.0	25.0					
	U10 (mm)	╞	<u> </u>	X	<u> </u>	20			•		8	<u></u>			·
1 2 2 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	D50 (mm)		8	500	5.000	5.000	003	2.100	0.005	0.005	1000	5.000		Í	
Ba	o,'(kgl/cm²)	ĺ	130	858.0	870.	318	515	111	355	155	14	818			
	σ (kat/cm ³)		8		8	2	 8			89	12				
		┝	6	3			4	52	2.8	2 2	1	<u>.</u>			
	N value		=		5	5	3	2			~			!	
	Vsi (m/sec)		223		291		317	543	241	: 1					
	Ground Type			1											
C	Depth of aculation m		2.15	115	8.15 2	315	0.15	215	112	515_ 385_	2.15	0.15			
F	la 3	_				<u> </u>				22	<u> </u>	50			
	V valu ater le 40 50				~~	~									
	SPT J SPT J	_		<u></u>				-		 	~				
	Ö 2 Geology	_	 111111111	222	0 20 20			নিংনা		<u></u> त्यागाग	0000	0000	0.00		
	Death ()				0.000	80°.0	யாட	<u>::::</u>]		ШĘ	0101	0.0		0,0	<u> </u>
	rehn (uu)	0.0			- <u></u>	80		13.00		12,00				2	3
E	ievation (m)								_						
	Scale (m)		· · · · · · · · · · · · · · · · · · ·	1	· · - • - • · · ·	·	₽						.		<u>↓</u>
		_									_				1

Tehran Seismic Microzoning Boring No PL-17 Khc=0.51

1

Tehran Selsmic Microzoning Boring No PM-13 Khc=0.48

1		_															
	Fw(z)	_	_	00	2					2					00		
I	8														0 10		
	thbub	~	_										_		Ĭ		
	ъ Г	-	_												8		
ļ		_	_			-,	 								E F		
	Depth (m)		°					2			ţį.		20.	• •			
ŀ	Judgement	-	-		····								_				
L	F.	_			_												
ľ	Shear stress rai L	100															
ſ	Stress reductio	n													-		
┟		┥	+	<u> </u>	<u> </u>		-{				. <u> </u>				-	ai	
ļ	~~~~~	_	_ _													hquak	
ļ	RL															1" eart	
le	Na									-					1	Type	
ietanci	N1	┢	-			<u> </u>	-								-	× se	
la di		╇	┿		<u> </u>										-	for are on ca	
ð	⁶²	1					<u> </u>							-		factor based De lequ	2
	c1] ;	for s	i
	CW	Τ	Τ											••••••	1.		1
_	Ec (%)	╋	╈				<u> </u>									⇒ akculat bogen Oen at)
		-	-		2	78.	1	<u> </u>	2	79.1	2	1,87	5		Ľ	во-5 ш ————	
	Υ _α (Wm3)	╞	-					0 50	••					ļ	_	··· ··- <u>-</u>	
	Υ _μ (ωπ*)	╀		8	8	8	1 8	<u>5</u>									
		╞		25.	2	75	25.	25.0	25.0	25.0	25.0	25.0	25.0				
ā		┼	+	5	~		<u> </u>										
sic Dal	D50 (mm)			ŝ	6.0	0,0	8	0.00.	Ö	0.001	0.005	0.005	0.005				
B	a [*] (käl/cm ₃)	1	ł	0 430	0.830	1,230	1 630	1 915	2115	2315	2515	2715	21615				
	o, (kgl/cm²)	Γ	1	\$	830		8	ĝ	8	8	8	8					
	Nuclus	┢	┞				=		<u> </u>	- 		ที	4				
		<u> </u>	ļ		13		25		Ê	<u> </u>	33	0 6	5				
	Vsi (m/sec)							314									
	Ground Type	L															
Ci	Depth of alculation m			2.15	4 15	6.15	8,15	10 15	12,15	115	6,15	18,15	0.15				
	level o 60	-															
	N valı water 0 40 5			- a			?	· · · ·	_	\sim		~	0				
	F az o				0-		<u> </u>										=1
	Geology Geology	_							mm				IIIIII				4
_	Depth (m)	8	ш										<u> </u>				
													21.0				
8	evation (m)																
5	Scale (m)	0			, <u>,</u>		·····	ę.,		15-	-, ,		2			5	4

	Fw(z)]_		0.00	0.0	80	000	0.00	80	80	0.0		00	
Γ													д. 10.	
	s thete	_												
										_			8	
		-	 	, , , , , ,		 .		, , _					ت	
	Depth (m)	Ĺ	> ,	دن 			2			2		8		
-	Judgement	╢		·····	· · · ·				<u></u>				_	
	FL					<u> </u>								
51	L	Ľ												
S	iress reduction factor r _e													
	R]												tuake
	RL,													1" earthc e lequifie
500	Na													r Type not to b
esistanc	NI				· · · · -				•				_	area) icase fo d X:
Cyclic	c2													ictor for assed or sequifie
	ci													station fa ≦ cwist ● ±1 b
	CW													0 (com tatuon c ment. O<1.0
	Fc (%)			182	79 1	1.87	ie.	73.6	79.1	79.1	i.e	78.1		Calcu Sedor Fr:
	γ _e (il/m3)										50	L.,		
	γ _{ri} (Шm ³)										2.00			
	lρ			25 00	25.00	25.00	25.00	25.00	25.00	25.00	25.00 25.00	25.00		
	D10 (mm)													
sic Data	1050 (mm)			0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005		
Ba	a" (köl/cm ₅)			0.830	1.115	1.315	1.515	1715	1.915	2115	2365	2.515		
	a, (kgi/cm²)			0.830	1.230	1.630	2.030	2430	2.830	3230	3.820	4.030		
	N value			5	2	3	37	35		5	50 (17)	35		- -
	Vsi (m/sec)										304			i
	Ground Type			н									Τ	, i i i i
С	Depth of alculation m			4,15	6 15	8.15	10 15	12,15	14 15	16,15	18 10 18 65	20.15		
┝	e evel			- 8	I		-			-				
	V valu rater k 40 S			<u></u>							\nearrow	~		
	i 142 Whut Be as					_8	<i></i>						_	
	<u>មី មី</u> ទំ				mm	innin				mm			11111	<u> </u>
	Geology	⊢												₩
_	uepin (m)	00												25.04
E	levation (m)				· • · • •		i-	_,_,						
	Scale (m)	۰		5			2		15			ຊີ່		52

Tehran Seismic Microzoning Boring No PM-14 Khc=0.47 •

000 0.0 0.0 80 0.0 Fw(z) 0.0 8 000 88 œ0, 000 F_L Distribution C, N -PL=00Depth (m) ò w. 5 ģ 2 Judgement Fι Shear stress ratio L Stress reduction lactor r_d α ^{z=1}0 (correlation factor for area) Calculation of ow is based on case for Type 1* earthquake Judgement. O* to be lequified X* not to be lequified F_t : O<1.0 ● ≥1.0 R RL Cyclic resistance raio Na Nt c2 **c1** CW Fc (%) 14.2 78.1 79.1 182 Ē 781 78.1 192 210 γ_a (ti/m3) 28 25.00 2.00 2 γ_n (ຟ/៣³) 2.10 25.00 25.00 25.00 25.00 25.00 25.00 25.00 İρ Ð10 (mm) 210 0.005 0.005 Basic Dat D50 (mm) 0.005 0.005 0.005 0.005 0.005 0,005 3.860- 2.195 0.745 0,452 1.245 2.045 o, (kgi/cm²) 0.945 1465 1 645 1.045 0 452 0,660 2.260 3460 α, (kgl/cm²) 1.260 1660 2.660 3.060 기 N value 38 2 5 30 Ş 2 Ŷ Ę Vsi (m/sec) 243 321 Ground Type -Depth of Calculation m 19.15-4 15 2.15 11.15 15 15 17 15 9.15 13.15 6.15 SPT N value Groundwater level 10 20 20 40 20 60 8 • X Geology 000 Depth (m) 8 25.00 Elevation (m) Scale (m) ò n, **5**. 5 20-8

Liquefaction Potential Analysis

Tehran Seismic MicrozonIng Boring No PM-15 Khc≒0.47

...

Tehran Seismic Microzoning Boring No PM-17 Khc=0.52

ſ		_			19	i i	<u> </u>							<u></u>	- <u>r</u>	
ļ	Fw(z)				6									8		
ļ	5	с)	_		\downarrow											
ĺ	stribul	~	_													-
	r L	-	_	·										_	- 0	
┟			_		1				·	- 	· • • • •	•			<u>"</u>	
╞	Depth (m)	_	。 —			· _ · -			2			12 		ິຊ		
┢	Judgement		-		┼─	+					<u> </u>	0	<u>'</u>			
ŀ	r <u>ı</u>	_										657		<u> </u>		
ľ	L	10										0,700				
	Stress reductio	n			Γ					1-		5	·			
┢		╉	+			+				+		<u> </u>				e
	ļ	_	╞													thqua
	RL											0.405		ļ		e ear e lequ
	Na											708		1		Type of to b
stance	N1	╈	╈		┢	-		+	······································	+	<u> </u>	<u>3</u>				a) X:n X:n
tic rest		╉								-		24.8				or are Toor are Thed
S												0233	1			lactor l based De lequ
	c1											284				
	CW CW	┮	┢												-	(corre tuon o ent : (
-		╋	╢									9				이 물 물 이
	Fc (%)		1.		791	1 82	791	79.1	78.1	70.1	162	142	791-			೮೮-೯೩
	Υ ₀ (Wm3)							2.00				2.10		200		
1	Y _{r1} (ti/m³)		╞	··				5.0				2.10		2.00		
	lρ		1		25.0	25.00	25.00	25.00	25.00	22.00	\$2,00		25.00			
	D10 (mm)	_	1_		-			 								
c Data	D50 (mm)				0.00	0.005	0.005	0.005	0.005	0.005	0.005	2100	0.005			
Bası	o_*(kgt/cm²)	Γ			Ę	515	8:5	015	512	3	-	326	58		- -	
	a hollomb	┢	┢		<u>e</u> g	<u> </u>	 	-					22			
	o [*] («Bacelt)	_			3	5	12		503	2	52	326	3.65			
	N value				2	15	23	2	21	\$	5	3.7	22		ľ	
	Vsi (m/sec)		1					Ξ				5		24	_	<u> </u>
	Ground Type		1			11					_,	<u> </u>		<u></u>		
	Depth of	1	1-		2	13	5	15	.15	£.	15	13	55		{	
<u> </u>	ເ ຊິ່ງຊີ ຊີ		E		~	-	9	æ	2	12	_ <u>∓</u>	<u> </u>	88			
	i value ater lev 40 50									0	-~		<u> </u>			
	N Tels			_ <u>µ</u>	<u></u>		2-	-0				8		·		
						<u> </u>										
	Geology		Ш													
Ľ	Depth (m)	000				_					15.00	021			24.00	
E	evation (m)					<u> </u>										
5	icale (m)	C	 	-1		 -			<u>0</u>			 [.		~ ~~~	-,	

Tehran Seismic Microzoning Boring No PN-13 Khc=0.54

	Fw(z)		r—	00,0	00.0	8	80	8.	8	8	8	8	<u> </u>		<u></u>	.
	5	- ო					I.,,			<u> </u>	<u> </u>	<u> </u>			00		
	othdiata	N	Ц									··			8		
	6		$\left - \right $											_	0		
	Depth (r	a)	╞		-, -,	ر 		,, 2			<u> </u>	_		- -	Ē		
	Judgema	nt															
	F_			- <u></u> .		_										Ţ	
	Shear stress	tabo															
	Stress reduce factor r	tion											•		-		
	R								<u> </u>				·		-	uake. 1	
	RL	-	1	·			+								-	earthq Iequifier	-
	R Na	-	+					·			·				-	Type 1 I to be	
	N1														-	sa) X:rr	
	2000 2000 2000 2000 2000		┽												- .	r for an ed on c quified	
ľ		╉							<u> </u>			<u> </u>				on facto vis basi to be le	ē1.0
			- -		- <u>. </u>						·			_			•
																Joulatu Joenen Joenen	Š
	Fc (%)			791	78.1	78.1	79.1	Ā	781	78.1	79 [162	181] {	3051	Ľ,
	Υ ₂ (ti/m3)							0 200		_							
	ip	╋	+	80	00.5	00	8		8	8	8		8	<u> </u>	<u> </u>		
	D10 (mm)	╀		<u> </u>	<u> </u>	<u> </u>	<u></u>		<u>X</u>	22	<u></u>	25	25.				
Data	D50 (m/n)			5001	0.005	1005	500	500	505			ŝ	002				
Base	a, '(kgl/cm²]	1-	0.430	830		815 0	815	015		115 0		- 				<u> </u>
	a, (kgl/cm²		1-		830	82			30 21		8	32	30 2.8				
	N value	┢	<u> </u>	ы м	- <u>-</u>				2	2.8	33		9				
	Vsi (m/sec)	+				-	+			~			÷		-		
	Ground Type							ġ			<u> </u>		l				
	Depih of	11		5	12	÷	15	5	15	12	12	-	5		_		
F					••	ۍ ا	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	<u> </u>	12	<u>.</u>	<u> </u>	8	50				
	N valu Water k 0 40 50	E	_	9			- <u>₹</u> 7111-7				~		م				
	SPT Ground 10 20 3	╞┼			8	7		5		8							
	Geology																-
	Depth (m)	80											8				-
Ek	evalion (m)																-
s	cale (m)			·,,	- <u></u>	- 	-, ,-	<u>e</u>	- r	15		,			ي تـــل	· - · - •	-

~		_										•		
	Fw(z)		ŏ	ă	ő	0.0	20	Š	0.0	8	80		8	
	5 .	\downarrow	<u> </u>						• • • • • • • • • • • • • • • • • • • •					
	stribut	ᆉ												
	Ö L	- -												
┝		_	<u> </u>	- , - , - , ,				····				<u></u>		
┝	Depth (m)	4	°		^ 		<u> </u>			? 		50		-
┢	F	┽			···· ··									
C 1	L	+				·	,							
Ĭ	L	1												
S	iress reduction factor r ₄					1								
F	R	ϯ												ake
		┢╴												arthqu quified
Ĺ	KL.	-				.	_							6 4 6 4 6 4
ce raio	Na													for "Tyr
esistan	וא													area) d X
Cyclic n	c2	1-												actor for based on e lequifie 0
	c1	-												elation f: of cw ts I ● to b ≥1.
	CW													1.0 (con culatituon perment. Oct 0
	Fc (%)		1.eT	79.1	1.62	78.1	78.1	39 6	1.67	1 62	1 62	101		in Sec.
	γ ₀ (il/m3)	L							2.00					
	Υ ₁₁ (ຟ/m³)								58					
	Ιρ 	ļ	25.04	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00		
	D10 (mm)	_												
isic Dat	D50 (mm)	ĺ	0.005	0.005	0,005	0.005	0.005	0,005	0.005	0.005	0.005	0.005		
ä	o _v *(kgl/cm²)	_	0.406	0 505	0.815	1.015	1.215	1.415	1 615	1.815	2,015	2.215		
	σ, (kgl/cm²)		0.412	0.812	1.230	1.630	2,030	2430	2.830	3.230	3 630	4.030		
	N value		2	20	12		30	45	25	9 7	25	÷.		
ĺ	Vsi (m/sec)								314					
	Ground Type			н					_					
Ca	Depth of Iculation m		2.05	4,06	6 1 S	8,15	10 15	12.15	14 15	16 15	1815	2015		
	e evel 8 erel	_								·			i.	
	N vai Water 0 40 5			1	· · · · · · · · · · · · · · · · · · ·					<u>.</u>	-	~		
	Las a				6				8	-0	-0			
	Geology									ΠΙΙΠ				
 I	Depth (m)	8		mmn	шшп	uuuuu	ишш			111(11)				8
B	avation (m)	-												
S	icale (m)			-, -, w	• •		<u>.</u>					<u>.</u>	·	
_							-		-			~		N

Tehran Seismic Microzoning Boring No PN-15 Khc=0.49

Į

Tehran Seismic Microzuning Boring No PO-13 Khc=0.61

F			·									_,			<u></u>
┟	Fw(z)	_	_					<u> </u>	800			3	8		00
	stribution	8		_	\										
	ی م	-													- - - - -
┢	Depth (m)			┯┷┯	· · · ·		·		···· ··	-11		 ,		<u> </u>	Ĩ
E	Judgement	1		1	1					<u> </u>	-	-1	<u> </u>		
1	FL										-				4
s	hear stress rat	20	1		1		-	··					-		-
s	itress reduction factor r ₄	7			+							-			1
	R		1												d uake
Í	RL.	Γ					1				1	1	1		e eartho lequifie
	Na	1		-	1							-			Type 1 of to be
resistan	N1								-		1		·		arrea) : case for d X:r
l B S	c2											1			ctor for a ased on ased on ased on
	cì	ſ							1					••••	ficwist ficwist €tots tots
	CW	Γ							1		1	1			(corre abtron o ment · (
	Fc (%)			I.	Ĩ	Ĩ	L'ar		E	Ē	i i i	Ē			Calcul Ludge
	Y ₁₂ (W/m3)			.1	1		<u> </u>		1	1	<u> </u>	8	I		••••••••••••••••••••••••••••••••••••••
	ץ _{וו} (נו/m ³)											8			
	lp			25.00	25.00	25.00	25.00	ž,	25.00	25.00	25.00	25.00			
	D10 (mm)														
isic Data	D50 (mm)			0.005	0.005	0.005	0,005	500	\$00'0	0.005	0.005	0.005			
â	σ, *(kgl/cm²)	[0.430	0.828	1,230	1.015	1915	2015	2214	2.413	2.612			
	σ, (kgl/cm²)			0.430	0.828	1.230	1.630	2,230	2.430	2.828	3.226	3624			
	N value			ñ	23	26	38	87	36	50	50	50			
	Vsi (m/sec)											 88	-		
ľ	Ground Type				H										·
Ca	Depth of culation m			2.15	4 14	6.15	8 15	11.15	12.15	14.14	16 13	18.12			
	tievel So 80	_	_				-8				·1				
:	N V2 dwate	_		9			*		18						
Ì	17 B B B B B B B B B B B B B B B B B B B				<u></u>										
(Geology										TITL		11111111		<u> </u>
D	epih (m)	80	11111				111111				111111	111111		111111	8
Ele	valion (m)		-					·							
Se	cale (m)	0						6		<u></u>	• •		8	· · · ·	·!

Fw(t) 000 </th <th>- -</th> <th></th> <th></th>	- -		
Obstatistical O Statistical O Statistical O Statistical O Statistical St	00 00 00 00 00 00 00 00 00 00 00 00 00	0.00 0.00 0.00 0.15	0
Ma O Shear stress ratio O Stress reduction a O a O a			
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		······································	
Depth (m) o <tho< th=""> <tho< th=""> <tho< t<="" td=""><td></td><td></td><td> •</td></tho<></tho<></tho<>			•
Deput (m) C G <thg< th=""> <thg< th=""> <thg< t<="" td=""><td></td><td>······································</td><td></td></thg<></thg<></thg<>		······································	
Fill O Fill 650 Shear stress ratio 650 L 650 Stress reduction 650 R 900 RL 910 Na 917 Na 600 N1 72		<u> </u>	
R Stress reduction RL Stress reduction Na Stress reduction V Stress reduction RL Stress reduction V Stress reduction			
L Image: Constraint of the state of the sta	· · · · · · · · · · · · · · · · · · ·		
Stress teorection Na Club and		0238	
K Na Na 1349 Na 1349 Na 1349 Andread 1349 Andread 1349 Andread 1349 Andread 1349 Andread 1349		50	
RIT Na Na Na Na Na Na Xis 2.13 Na 2.14 2.14			d take
Ydfc resstance rao N N IN			earthq equifie
NT N N IN IN IN			to be 1
NI NI 8,743 8,743 0 8,743 0 0,000		7.0	t for T
		8.743	r area) n case ed
		000	ctor fo assed c
			thon fa ∼to be
	<u> </u>		
	<u> </u>		0 5 5 5
	1 er 2.2 1.er 1.er 1.er		రరశిచి
Y ₂ (1/m3) 8 8 8 8	2.20	2.00	
	5 5 5	2.20	
32 32 32 32 32 32 32 4	25.00	25.00 25.00 25.00 25.00	
	<u> </u>	6	
120 000 100 <td>0.001 5.000 0.005</td> <td>0.005 5.000 5.000</td> <td></td>	0.001 5.000 0.005	0.005 5.000 5.000	
a [*] (kg/cm ³) 85 85 85 85 85 85 85 85 85 85 85 85 85	0.430	2205 2405 2655 2655 2655 2655	
	430 870 070 070	22 22 28 22 28 22 28 22 28	
		<u> </u>	
	й н й н п	<u> </u>	
	33 39	39 39	
Depth of Contract Con	H		
Calculation m 21 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	2.15 4.15 6.05 8.15 10.15	13 65 15 65 18,15 18,15	
	8		
Geology Geology			
Depth (m) S S S	8 8	0.20	
Elevation (m)		······	{
	<u></u>		

Tehran Seismic Microzoning Boring No PO-14 Khc=0.54
-

Tehran Seismic Microzoning Boring No PO-15 Khc=0.61

-

ł			íΤ			2							<u> </u>		_	-,
	Fw(2)		\vdash	. <u></u>	6	ă			5 6	5 0	6			0		8
	, Se	3	┞┼												_ :	0
	kstribu	N	┝┼			<u> </u>									_	
	ت ت	-	┝╌╂												4	
$\left \right $	Death (m)				, , , , , , , , , , , , , , , , , , , 	-,,-		·	- <u></u>					, <u> </u>		
ł	Judgement	-	T				·		<u>ح</u>		*			រ ក		·-
ľ	 F _L		1		•••••											4 .
ŀ	Shear stress ra	itio	-		_ · _											-
ŀ	L.	-	4									_]
Ľ	factor r	<u></u>			·· -					_						
ļ	R	Ì													·	, iake.
	RL	ϯ	╧					+								sarthquifier
 ۱		╉	╀													
	1 Na	╀	_ -					.								for Ty (: not t
tesist:	NI						_									area) Kd X
Q Q Q Q	c2		T									•••				ctor for lased on 3 lequific
	c1	T	T													lation fa ficwis b O: to br ≥1.1
	CW]-	1) (corre latuon o ment: (O<1.0
	Fc (%)	T	1-		79.1	79.1	79.1	Ē	19.1	192	1 61	10				Calcul Judge
	Y _e (tl/m3)	T	1					.L	_						8	
	γ ₁₁ (Wm³)	Τ	Τ												8	,
i	lp		Τ		25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00			
	D10 (mm)															
XC Uata	D50 (mm)				0.005	0,005	0.005	0,005	0.005	0.005	0.005	0.005	0.005			
80	σ, (kgl/cm²)				0.63	1,030	1.315	1.515	1.715	1.915	2.11.5	2.315	2.465			
	σ _v (kgi/cm²)				0.63	1.030	1.430	1 830	2230	2,630	3 030	3.430	3.730			
	N value				27	ę	24	16	2 B	Ŧ	0	0 5	5		1	
l	Vsi (m/sec)		Γ												1-	
	Ground Type	Γ				•				_						<u></u>
Ca	Depth of liculation m	F			3.15	5.15	715	9.15	11.15	3 15	515	7 15	9 15-		+	
	evel evel	F				8	1									
	N valu vater 1 vater 1 vater 1					~		•		<u></u>	-0	~	~			
ļ	tds 8	 			0		<u>~</u>		-0-							
	<u><u></u></u>		http		птп	mm		mm	mm	TITITI	mm					
	Geology	_														
C	Jepth (m)	0.00														25.00
Ele	vation (m)			-	_											
s	cale (m)	-						- <u>e</u>	- 1 - 1 -							·

	Ĺ	Fw(z)						0.00	8	8	8	8	8			···-
	ſ		~								<u>- </u> _				0.0	
	ł	tbutor	с. 0									•			Ĕ	
			-				_				<u> </u>			_		
	L	- <u></u> -		$\left[\right]$					•						<u>-=0</u>	
		Depth (m)		•)))		- i 4	-		. .	15.		, . S		-	
	┝	Judgemen													-	
	L	F														
	S	hear stress ra L	ailo						•			<u> </u>				
ĺ	S	itess reduct	on												_	
1			-													
		R														juake K
		RL														earthc
	8	Na					• • • • • • • •				-	·	4 <u> </u>		-	to bei
	istance	N1	┥		· · · · · · · · · · · · · · · · · · ·					······					-	x: not 1
.			╉	-												r area) on cast
ŀ	<u>ל</u>	c2														ictor lo lased c e lequit
		cl				_					1-					ation fa cwist to be ≥1 (
		CW	7	1							+					
ŀ	+	Fc (%)	╞	╉				<u></u>						<u> </u>		o la
	}		-[-	┦			79.1	2	79.L	, at	162	79.1	79.1			8935
	ł	T ₂ (u/ni3)	╉	┦				·					2.00			
	ł	10 In		┥									<u>5</u>			
ł	ł			╉		,	25.0	25.0	25.0	25.0	25.0	15.0	25.00			
ata	ŀ	D50 (mm)	┢	╉		-				<u> </u>						
asic D:	┝			4			8	0.0	00'0	0.005	0.005	0.005	0.005			
Ē	Ľ	a, (kgl/cm²)			_		1.415	1,615	1,815	2015	8077	2415	2815			
		a" (kälicuus)	Γ	Γ			630	030	430	ŝ	8	 g				
	F	N value	1-	┢						<u>~</u>	H -		¥			
	┝	Vel Imlene)	-	╀─			N				- ⁶	20	<u> </u>			
			_	_					_				333			(
		enth of		╞	<u> </u>				·							
C	aic	ulation m					8 15	10.15	12.15	14.15	16 00	18,15	20,15			
	dille	19 8 8 6	_	<u> </u>		8								L		
	I N v:	dwate 30 45	_		t	<u>.</u>		~		<u> </u>	-0	-				
	5	20 20 20 20 20 20 20 20 20 20 20 20 20 2							\checkmark						_	
_	G	eology		Π			ШП		MAM	TITIT			IIIIII	ΠΠΠ	m	π
1	Dej	pth (m)	80	чu			шц		ЩШП	111111						 _
FL		alico (m)	-													<u> </u>
			_	-,	,,,,,	· · · · · · · · · · · · · · · · · · ·							_			
	xca	we (m)			<u>د</u>			2		. 5			8	11		<u>2</u>

٠

Liquefaction Potential Analysis

Tehran Seismic Microzoning Boring No PP-15 Khc≖0.50

:

Tehran Seismic Microzoning Boring No PP-17 Khc=0.51

1	5		ר		2	<u>_</u>	<u> </u>									
	FW(2)					8	8	8	2.9	507		8	8]	191	
	noir	5			۲										010	
	Distrib	~	$\left - \right $. <u> </u>			·····	<u> </u>				··			2	
	u."	-														
ľ	Depth (m)	<u> </u>			r	-,, 0				.		· · · · ·	_, _,		ā	
F	Judgement		\square	×				(0 0) ()	>	<		-	
L	F	_		3112						25		5			1	
15	hear stress ra L	alio		0.043					202					_	1	
	iress reducts	01							÷						-	
ŀ	R	-	+							2 0.7	_	207			4	ey.
		-		2 						5						rthquai
0	~~ 	_	_	583					5	0.412	·	0 807				be leg
NEL SOL	Na			C87.5				21 500	24,262	24.892		1 435]	rot to
resista	N1			38.126				1 765	4.448	5.084		676				
	c2	T		6233			1	 17	33	233 2	<u> </u>				tor for .	is ed on lequifier
	c1	T						180		<u> </u>					tion far	rtobe ≥105
	CW	- -		8			┢	 8		<u>~</u> 8		2			(correls	동이
	Fc (%)	╬	╧	 N			+			<u></u>		2			2=10	
	Υ., (U/m3)	╀	╀		 2	*	<u>^</u>	2	<u>-</u>		ដ តែរួច	1 7	<u></u>			<u> </u>
ļ	γ _n (ឃ៣ ³)	┼	┼	10 2	20 2		ਸ <u>਼</u> 8	12		<u>.</u>	0 2 2	51	50			
ł	<u>الم</u>	1-	┢	2		<u> </u>	<u>N</u>	<u></u>		J	22	<u>, 2</u>	8			
ĺ	D10 (mm)	1-	1		5.000		~				8		X			·
	D50 (mm)			2,100	5.000	0.005	2003	8	8	8	8	8	8			
ſ	a" (käljaurs)	1-	1	9520	468	1685	1984		316	2.	758	5	<u>.</u>			
ľ	 σ, (kgi/cm²)	1-	1-			300	898			 21	83 E.	1 1	8	_	<u> </u>	
f	N value		<u> </u>							<u>ה</u>	<u>ਜ</u>		<u>-</u>			
┢	Vsi (m/sec)		\vdash	<u></u>	<u></u>	 ~	 ,	~							<u> </u>	
6	iround Type			8	58	25		52	52		<u> </u>	295	314			
]]	epth of			15	- <u>-</u>	2	<u> </u>	5		2	<u>n</u>					
aic	1000 m 1000 m				*		8	ġ	5	X	2		50			
d value	우 <u>-</u>				Δ						~	~				
	N R	4	r			R				-0.			<u>\</u>			
G	<u>ci </u> ≘ eology			p	<u></u>					••••	eant.	•्र ना				
De	pth (m)	8	<u>····</u>	<u></u> 8	e e elle e e elle							<u> </u>	Щ			
		1					- 1				100	19.01	203			
a¥ De:		_	·		_ _	.	<u> </u>							_		
эCi	wa (m)	•	_		ю —			₽ [`]	•	15.		1	N N		25	

	Ew(z)	-	7	<u> </u>	8	3	8	8	65	2 1	<u>_</u>	<u></u>						_
			┦─		<u> </u>	; ;	<u> </u>	õ	č	3		<u> </u>	<u> </u>	8		- 8	2	
	5	3								<u> </u>							2	
	A Set	N								_								
	- -	*-							_							- 2		
	Depth (n	 n)	┟┤		··· • - •		, _ , _ ,	·	•			- <u>, </u> ,	- 1 - 1	—,,,,,,,,	<u> </u>			
j	judgeme	at			×			— T	0						J 			
	FL				8.127				167									
	Shear stress	rabo								┢	·							
	Stress reduc	lion				·			Ē							_		
ł	factor r	-	\dashv		0.93				0.84	<u> </u>	·							
	R		_		Ë				0.297								quake. ed	
	RL,				9,135				182.0								l" earth Hequifí	
	e Na				1453			-	8	<u> </u>					··	-	Type 1	
	2 2				*		·		12 13						·	_	×ē, ×g,	
			+		3 45.				8							_	for are for care	
	<u>م</u>	4			0.23				023								factor based be leg	
1	c1	_ _			1.084				1.084									
	CW				1.000				8					·			Con atton	
Γ	Fc (%)				4			=	~							-	Calcut Ludger	
	Y ₁₂ (ti/m3)		+	8			8	<u>= =</u> 	<u>=</u>	2	61	1	62	<u></u>				_
	۲ ₀ (ti/m³)		-	200	10		00							<u>ដ</u> ខ		+-		_
	lp	1		25.00		22.00	~	8 8		5.00	8.0	83	8	<u>2</u> 8		+-		_
	D10 (mm)									<u>N</u>	N		~~~~	<u> </u>		- -	<u> </u>	{
c Data	D50 (mm)			0.005	2,100	0.005	į	5	B	500	SOO	500	500	503				
Bask	σ, *(kgl/cm²	5	1-	215	÷	627			0	5	32			<u>6</u>			·	4
	o, (kajicm²		+	 8	-0 	5 0		3 ⊇: :	2	2		<u> </u>		۾ م				
		- -	+-	6	3	17			<u>;</u> -	543		375	3.65	4.05				
	IN VAIUE	-{			- <mark>8</mark> - 11			172		-	53	23	26	50		ŀ		
	Vsi (m/sec)		<u> </u>	267	- 1		271						296					
μ	Ground Type	'			-			_		_		_				1		-
Ca	Depth of siculation m			2.15	415	6 15	8.85	13 15		2.15	4.15	615	8.15	0.15		†-	<u> </u>	1
	lue level so so		6											~		. <u>. </u>		-
	N va dwater 80 to	Þ	F.											2				-
	s Gound			~	$ \geq $			-0	\leq	>	<u> </u>	-0	-0					
	Geology						IIIIIII						11111		mm	 111111	 	
C	Depih (m)	8			9 N	սաս		នី ន កាក	i II II	иЩ	шш						비	-
Ele	vation (m)	$ \overline{-} $			┦┦									· <u> </u>				
	cala (m)	┝┷	·	 -	ĻĻ	,	·	ļļ	·		.							
		<u> </u>						2			12	•	• • •	ຊື່			-,,-	1

•

Tehran Seismic Microzoning Boring No PQ-17 Khc=0.60

.

Tehran Seismic Microzoning Boring No S19-4 Khc=0.48

•

ļ	Fw(z)		_	0.0	8		000	3		8				8
	8	m-		·				_					•	
	stribut	~-				-								
	ی بر	- -	_											
		_ _												
	Depth (m)		•		ю. 		2		- 	5		20		
ŀ	Judgement	<u> </u>												
Ĺ	F	_ _												
5	ihear stress ra L	atio												
	Stress reducts	on [-{	·										
-	factor r	_ _	-	··		-								
	R													ad utake
	RL	ļ		_										earth
	Na		1		_									
ance		+-												- rot
C rests	N1													area) areas
Š	c2													
		1-											•	tis ba
							···							
	CW													
	Fc (%)		P.t	1.4		=		2			•			
	γ ₀ (il/m3)			~~~~	~	8							<u> </u>	
	γ., (ti/m³)		-			<u>5</u>								
	ip		8	8	8	8	8	8	8					<u> </u>
ł	D10 (mm)			<u>×</u>		2		<u></u>	<u>. 12</u>				. <u> </u>	·
ł	D50 (mm)	╏─┤		2			10							·
		╢┥	8	8		8 8	8	00	0.0					
ļ	σ, *(kgl/cm²)		0,414	0.707	0.907	1.107	נטבו	1.507	1.707					
ļ	σ _e (kgl/cm²)	Π	414	1	214	814	5		11			_		
ŀ	N value	┢┼				-	~		Ň					
┞		╟┼	ñ		Ň	50	20		50					
┞	vsi (m/sec)					368								
(Ground Type		·	<u> </u>										
ا al	Depth of culation m		2.07	4.07	6 07	8 07	0.01	2.07	4.07					
	e vei e vei			}		•		-	-			-		
Marrie M	water vater	-	n •— iki — −		-0		-0		-0					
		+	<u>×</u> #											
(ල ස Geokoov	-		ПШП		111111	ШШШ							
- 	coth (m)]								Щ			<u> </u>	
_	 	8								16.00				
eı	ration (m)						_							
Sc	ale (m)		1-1-1-1-	-11-	-,	· · · ·	2	· • • • •	<u>.</u>		····•	2		· - <u>-</u>

-

Tehran Seismic Microzoning Boring No S207-1 Khc=0.55

						<u> </u>								_	
	Fw(z)		\square		<u> </u>	õ	ă		80'n	80	80	•	8		
	5	e	Ц										0.0		
	- tabet	N			-								6		
	 22	-									·				
						_							1		
ļ	Depth (m)	<u> </u>	•				. <u>.</u>	· · · · · ·	5	- +	20.	╎	-		
	Judgemen	t	-												
	۶ <u>ر</u>			_											
	Shear stress r L	atio										<u> </u>	4		
ľ	Stress reduct	юп			·	· · · · · · · · · · · · · · · · · · ·		<u>-,</u> .	<u> </u>				-		
ŀ	R		╈			· •							_	ke.	
ļ	RL								·····		·	• <u> </u>	-	earthqua squiñed	
	Na Na	╡					<u></u>						-	Type 1' Ito be k	
The retained	N1												1	raa) Seefor	
- Tool	c2	Ţ												tor for a ased on (lequified	
	c1										·		1	Lation fat	●21.0
	cw													(corre latiuon ol ment : (0.12 1
	Fc (%)			181	167		79.1	78.1	1.47	79.1	70.1		1	Lage 1.	۔ س
	Υ ₀ (t/m3)						2 00						┢		<u> </u>
	ץ _{נו} (ג/m³)			_			2.00						┢		
	lp			25.00	25.00		25.00	25.00	28	8	8		┢		
	D10 (mm)								N			. <u> </u>	┢	··	
sic Data	D50 (mm)			0.005	0.005		0.005	0.005	0,00S	0.005	500.0				
ŝ	σ, '(kgl/cm²)			0 430	1 030		1,815	2.115	2.415	2.015	2.015				
	o _r (kgl/cm²)		<u> </u>	0 430	1 030		2.030	2,630	3,230	3.630	4.030				
	N value		 	a 		-,	5	Ŧ	=	16	20		•		
	Vsi (m/sec)						304							-	
	Ground Type				-										
Ca	Depth of liculation m			2.15	5 15		10.15	13.15	1615	18 15	20.15				
	situe Sitevel Si Si Si		<u> </u>						·····						
	d wate d wate							~		8					
	Cround Cr								\checkmark						
	Geology		Ш							111111		m –	_		
1	Depth (m)	000	uu								4111111	비 왕			-
Ek	vation (m)							<u> </u>		·		<u> </u>			
S	cale (m)	0		· · · ·	- <u>-</u>		2	_ ,_,_	-,,,- 2			+			-
							_								

٠

•

Tehran Seismic Microzoning Boring No S207-2 Khc=0.55

:

	Г	E (1)		7	·	8							<u> </u>				
	\vdash	FW(Z)		┟╴┼╴		<u>ĕ</u>	8		8	ő	2	5	8.0		8		
		F _t Distribution	123						. <u></u>						<u>00, æ0, 0</u>		
		Depth (m)			 -		·		-,	- -	•0 • • • • • • •				Ē		
	-	Judgemen	t	T									~~~		4		
		F,	_		·										-		
	She	ar stress r	alxo								<u> </u>				-		
	Stre	ess reducti factor r.	00		·	<u> </u>		·							-		
ľ	Τ	R	1	-†						<u>.</u>	•				-	ake	
	ſ	RL		-							·					earthqu Iequified	
		Na													{	Type 1 of to be	
		N1						••••••			<u> </u>					area) case for d X·r	
142	2	c2							·						1	ctor for a lased on e lequifie	
		c1						<u> </u>						,			
		CW														Delo Satuon com Ment : Orio	
		Fc (%)			791	,		102	;	ž	187	79.1				103 103 103 103 103 103 103 103 103 103	•
	Ľ	Y _e (II/m3)	L						500								
	Ŀ	Y ₁₁ (tt/m ³)							8							<u> </u>	
		lp			25.00	25.00		8			2:00	8	·			——	
		010 (mm)						<u>N</u>		·	~ ~	N					-
ic Data)50 (mm)			0.005	0.005		0.005	500.0		0.005	0.005					-
Bas	σ,	(kgl/cm²)			0.63	1,230		1 865	2115		2.415	2865		-		<u> </u>	-
	α,	(kgi/cm²)			0.63	1.230		2130	2,630		3230	3.730				·	-
	1	N value			28	21		2 8	26		23						1
11	Vs	i (m/sec)							8					-			
	Gro	und Type													_		-
r -	Dep	oth of			15	15	·- <u></u> .	65	3		5					<u> </u>	-
	iouit 1	ē 3				<u> </u>		<u></u>				<u> </u>					
	value	9 9 9 9								_							
		8 R	-					0			-0						-
						_											-
	Geo	logy							ΠΠΠΠ	ΠΠ		TATAAN	TIIIITT	IIIIII			-
C	lepth	ו (חו)	800						40000		mutul	*11111	mmili	<u>111111</u>	RTTT CTTTT		-
Ele	vabo	on (m)	╡											<u> </u>	25.1		-
S	cale	(m)	T o	·	- 1 1	, , , , s		5	1 	15		50 	-,-,		,	,,_	-

Tehran Seismic Microzoning Boring No S207-3 Khc=0.55

	Fw(z)		1		00.0	8	80	8	8.0	8			<u> </u>
							·					-	
	-putrol	ເນ ເປ									<u> </u>	- 8	
	г, D _{ist}												
				· · · · · · · · · · · · · · · · · · ·			_					- º: -	
ļ	Depth (m))	°		·		5		5		30	-1.=	
}	Judgemen	<u>.</u>											
ļ	F ₁												
Į	Shear stress r L	atxo											
ſ	Stress reduct	ion i							···			{	
ļ	R			<u> </u>									ake
	RL	-									··	-	earthqu
	Na Na	Ť	- -						- •				Type 1" st to be l
	N1						<u> </u>					-	rea) Lase for ' X:nx
	c2	1			<u> </u>				·	·			tor for an ised on c lequified
	c1							<u> </u>					abon fac cw is ba ↓ to be ∞1 0
	cw	- -										-	abuon of abuon of Trent: O
ſ	Fc (%)	-		192	1.47		Ĩ	19.1			5		Calculi Judgei Fr:
ļ	Υ ₁₂ (Wm3)					Ę	3						
	Y ₁₁ (ti/m³)					Ę	3						
	!p		_	25.00	25.00	25.00	25.00	25.00	25.00				
	D10 (mm)							_					
Isic Data	D50 (mm)	┥		0.005	0.005	0.005	0.005	500.0	0.005		0.005		
ä	σ, '(kgl/cm²)		_	0.830	1.230	1.765	1965	2,855	2365		2,815		
	σ _v (kgi/cm²)	_		0.830	1,230	1.930	2,330	2.730	3.130		4.030	T	
	N value	_		==	:		8	32	2		5		
	Vsi (m/sec)	_	<u> </u>			280						T	
	Ground Type	 											
Cá	Depth of alculation m			4 15	6.15	9 65	11.65	13 65	15 65		2015	1	
	atue rievel so so					- 8							
	T N V Movale 30 45					M	2			~			
	5 Ground 19 19	<u> </u>			- 0				>₀<				
_	Geology										 		
(Depth (m)	00.0						u <u>III</u>			8		
Ek	evation (m)					·						·	{
S	cale (m)	0			·····	2	1-1-		Ê	··	8 8	7	÷

Tehran Seismic Microzoning Boring No S207-4 Khc=0.55

1	r		1 1	— <u>—</u>			÷ T							•			
	Fw(z)		\vdash				8	õ	0.0	ő			3 5 5			8	
i	E																
1	ribut,	 N		_											7.		
ł	5	-															
											-						
ł	Depth (m)		0			<u>د</u>	-,		2		÷.	- 1 T		a,		7	
F	Judgemen	i I														1	
ł	FL																
ľ	Shear stress ra	atio			-									-		-	
ŀ	Stress reducts	on			·		╧							·		-	
ŀ	factor r _a	_				_											
l	R															duake.	ł
	RL															1" earlin e leonific	
A Tak	Na										_					r Type notio b	
retetan	NI															area) crase fo	
0 T C C C C	c2									-						actor for based or e legurific	
	c1							•							-	crist of crist	0 ≥1(
	cw															0 (corre tatuon c ment : - :	e S
	Fc (%)			181	141	78.1	, in the second	i g		142		1.8			\neg	Lako Judge	ů.
	Y _Q (W/m3)	1							8	<u> </u>				T	-+		
	Υ ₍₁ (t/m³)		1 -						8					+	-+		···
	lp	1	-[12:00	5.00	5.00	8	2.00		2,00	8	8		l	-+-		
	D10 (mm)	╧				~~~	<u> </u>	N	<u> </u>	~		<u>~~</u>				·	
313			1-	S	5	S	8	5	<u> </u>	8	8			··	-		
Dasic L	o, '(ka(/cm²)	-	+	 	<u> </u>	30	5	12	_	2: 	00	22				. <u> </u>	
	a (kal/cm²)	- -		2 8		30	2 2 2	=		<u>2</u>		0 25					
		╢		3	5	<u>1</u>		2			8						
	N value		<u> </u>				-	54		.		~					
	Vsi (m/sec)	 _						126									
	Ground Type	İ															
Ċa	Depth of loutation m			2.15	4,15	615	8.15	10.15	1 1 1	2	15,15	17 65			Τ		
	e erel		<u> </u>				-8-						_				
	N val- vater 1 40 5									_				··			
	Nudy 8				<u>~</u>	<u> </u>		×	_								
	. g =			<u>e</u> c													_
	Geology																
0)epth (m)	000											2	3			
Ek	rvation (m)																
s	cale (m)	0			м			6			15.	·	2	 	- r	 33	

•

	Endal				8	8	8	8	0		.			•	_	········
	····		┟╌┽		÷	ō	ă 	<u>ŏ</u>	<u> </u>		8	8	00	-		
	ş	e	┝─┼													2
	it/port	N]`	
	Č Ľ	-	\square								_				٦ ۽	2
													`		<u>ן</u>	2 1
1	Depth (a	1)	•	• •	• •	υ 	,	ê			15		20	·	1	1
ĺ	Judgeme	nt														·
	FL														_	
	Shear stress	ratio														ļ
	Stress reduc	ina i			<u> </u>											
ł	factor r															
	R		1										<u> </u>			ş
					<u> </u>										_	rified
1		_	_ _													ea lea
	Na R															Type
	N1	-1			· · · · ·										-1	× se for
						<u> </u>									_	or are fied
2	5 2							_							ł	actor f based e lequ 0
ł	c1														-1	stion fi Cwrs I ≥ to b
l	CW	- -	+-							•	-		•		-	
-		╺┼╴				·	<u></u> .									÷ a a bo
L	Fc (%)			181	79.1	۲. ور	79.1		ł	162	162		1.6		-	유율물뜻
1	γ_{ϱ} (il/m3)								8						╈	
ł	Υ _{ct} (t/m ³)		1						8						╌┼╴	
	lp			25,00	25.00	8.8	8	8	3	8.8	8		8		+-	
	D10 (mm)	Τ	1							~	~		Ň		┿	
Cata Data	D50 (mm)			58		5	 5	8	;	5				·	╋	
Jasic [<u>ë</u>			8	8		3	ð		5			
Ĩ	o" (köncu.) 	<u> </u>		0.83	27), the	2,265		2.515	2715		cinr			[
	o _n (kgi/cm²)			0430	0630	230	130	ĥ		830	230	1	2		1-	——————————————————————————————————————
	N value	-						<u> </u>					i 		╉	
		-	<u> </u>			~	~			~	<u> </u>					
	Vsi (nvsec)		<u> </u>						307							
	Ground Type														\uparrow	
Ca	Depth of loulation m			2.15	¢ 15	315	13	65		15	.15			<u> </u>	\square	
-	<u>a</u> 8										=				L	
	Value ater le 5 5										~					
	N Ldi				$ \geq $			NE.		$\overline{}$						
	0 ⁰ 5			<u> </u>				~								
	Geology	_								Ī			T			
0)epih (m)	8					-								111	8
Ele	vation (m)				·····			·····								- *
c	cala (m)			,	-, _,			·	_,,		-1 - 1 -					
3	casa fiith	°			5		2			15	·	- •	8		-	2 T

•

Liquefaction Potential Analysis

Tehran Seismic Microzoning Boring No S207-6 Khc=0.60

•

Tehran Seismic Microzoning Boring No S207-7 Khc=0.60

mid o		Г	Sw(+)	_	1	1 8	3	8	8	8	<u>e</u>		<u> </u>			
Start strate Start strate<		╞	rw(z)					8	ő	8	8	8	0.0	Ö.Ö		
Na Na Na Na Na R <td></td> <td></td> <td>Log</td> <td>3</td> <td>\vdash</td> <td> </td> <td></td> <td>_</td> <td>····-</td> <td></td> <td></td> <td></td> <td></td> <td>·</td> <td>_ :</td> <td></td>			Log	3	\vdash			_	····-					·	_ :	
Line -		ļ	hstribu	2	\vdash											
Deph (m) o o g Jagannenti			<u> </u>	-	\vdash		_									
Judgement Image: Construction of the second of		-	Depth (m)			- ,,	-,,	-, -, %				· ·····		···		1
Fi Image: State states Image: State state Image: State state <td></td> <td>_</td> <td>Judgement</td> <td>!</td> <td></td>		_	Judgement	!												
Shear Mress ratio			F.													
Stress rockston factor r, attor r, R R		Sh	near stress ra	atio			_									
Jackyr (, R R R R	ł	SI	L tress reduction	201	-								·			
R R	ļ		factor r _a	_							<u> </u>					
Rt Na Na Na N1 Na Na Na Na Colored (Mar) Na Na Na Na N1 Na Na Na Na Na Value (Mar) Na Na Na Na Na Value (Mar) Na Na Na Na Na Na Value (Mar) Na		ĺ	R					_							_	guake ed
Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na Na <			RL													earth
Start Start <th< td=""><td></td><td></td><td>Na</td><td>-1</td><td></td><td></td><td><u> </u></td><td></td><td></td><td>\neg</td><td></td><td></td><td></td><td></td><td></td><td>Type 1 (to be</td></th<>			Na	-1			<u> </u>			\neg						Type 1 (to be
Bac Date 0 <				╉	+		·									X:ro X:ro
Grad of all o	1000		 c2	╉												don care, utiled
Ci Ci <thci< th=""> Ci Ci Ci<</thci<>	ľ	"		╀							<u> </u>		<u> </u>			n factor is base o be let
Cw 0 0 0 123 Fc (%) iiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiii		ł		╉	+					4_	··					
Fc (%) R <td></td> <td>┦</td> <td>CW</td> <td>╀</td> <td>\downarrow</td> <td></td> <td>_</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>Definition (5)</td>		┦	CW	╀	\downarrow		_									Definition (5)
Ya (Um3) Solution	ļ		Fc (%)			181	791	79.1	le.	Ĩ	78,1		79.1	1 62		
Yn (t/t/m ³) OC IP 000000000000000000000000000000000000		ļ	Y ₂ (II/m3)								2 00					
Ip dist size D10 (mm) 000000000000000000000000000000000000		ŀ	γ ₀ (t/m³)						_		2.00					·
D10 (mm) S00 00 00 00 00 000 000 000 S00 00 000 000 000 S00 000 000 000 a, '(kgl/cm ²) S00 00 00 000 000 000 000 000 000 S11 117 000 S10 000 a, '(kgl/cm ²) S00 00 000 000 000 S11 117 000 S10 000 a, '(kgl/cm ²) S10 000 S11 117 000 S11 117 000 b, '(kgl/cm ²) S10 000 S11 117 000 S11 117 000 b, '(kgl/cm ²) S10 000 S11 117 000 S11 117 000 b, '(kgl/cm ²) S1 117 11 S1 117 11 S1 117 11 b, '(kgl/cm ²) S1 117 11 S1 117 11 S1 117 11 b, '(kgl/cm ²) S1 117 11 S1 117 11 S1 117 11 b, '(kgl/cm ²) S1 117 11 S1 117 11 S1 117 11 b, '(kgl/cm ²) S1 117 11 S1 117 11 S1 117 11 b, '(kgl/cm ²) S1 117 11 S1 117 11 S1 117 11 b, '(kgl/cm ²) S1 117 11 S1 117 11 S1 117 11 b, '(kgl/cm ²) S1 117 11 S1 117 11 S1 117 11 b, '(kgl/cm ²) S1 117 11 S1 117 11 S1 11 <td>ł</td> <td>ŀ</td> <td>lp</td> <td>╞</td> <td>1</td> <td>25.00</td> <td>25.00</td> <td>25.00</td> <td>25.00</td> <td>25.00</td> <td>25.00</td> <td></td> <td>25.00</td> <td>25.00</td> <td></td> <td></td>	ł	ŀ	lp	╞	1	25.00	25.00	25.00	25.00	25.00	25.00		25.00	25.00		
DS0 (mm) S00 000 <		L	D10 (mm)	Ļ	-					<u> </u>						
dial a, (kgl/cm²) ison in the second se	sic Data		D50 (mm)			0.005	0.005	0.005	0.005	0.005	0.005		0.005	0.005		
u, (kg/tcm²) St occurs	8	4	o, (kgi/cm²)			0.430	0.830	1.230	1.730	2.030	2415		2,715	3.065		
N value 1 2 1 <th1< th=""> <th1< th=""> <th1< th=""></th1<></th1<></th1<>		c	ı, (kgi/cm²)			0 430	0.830	1.230	1 730	2030	2,630		3.230	005 5		
Vsi (m/sec) *** Ground Type - Depth of Calculation m *** 3 *** and a state state *** and a state *** and a state *** and a state *** <td></td> <td></td> <td>N value</td> <td></td> <td></td> <td>1</td> <td>25</td> <td>15</td> <td>ī</td> <td>-</td> <td>1</td> <td></td> <td></td> <td>5</td> <td></td> <td></td>			N value			1	25	15	ī	-	1			5		
Ground Type I N Depth of Calculation m Si Si Si Si Si Si Si Si Si Si Si Si Si S		١	/si (m/sec)					<u> </u>			2			······	-ŀ	
Depth of Calculation m SI SI SI SI SI SI SI SI SI SI SI SI SI S		G	round Type											- <u></u>		
and m m <td>Ca</td> <td>Di</td> <td>epth of ulation on</td> <td></td> <td></td> <td>2.15</td> <td>51</td> <td>5.15</td> <td>65</td> <td>0.15</td> <td>1,15</td> <td></td> <td><u>.</u></td> <td></td> <td></td> <td></td>	Ca	Di	epth of ulation on			2.15	51	5.15	65	0.15	1,15		<u>.</u>			
All all all all all all all all all all	_		19 8	_					8							
E B C		Valu	alar A S													
B B		Ē	주 유				~		~		$ \geq$					
Geology Second		<i>w</i>	<u>e</u> 2					~		¥		- e		······		
Depth (m)		Ge	eology	_												<u> </u>
Elevation (m)	(Эер	ահ (որ)	800											mu	8
Scale (m) O D O O	Ele	va	1000 (m)						·		<u> </u>					
53 55 ⁴ ⁴	S	cai	ie (m)	0	-,-		- n		; ;	2	-1-1-1-1-	\$			-, -,	

•

<u>ر</u>							-r					•			
ļ	Fw(z)	_		00					8 8	0.0	2	5		00	
	5	0	_		_								_	0	
	stributi	~													
	بي م	-				<u> </u>								a l	
	Depth (m)		0	· ·	•••		, ,,	10.		5	, , ,	20.			
┢	Judgement	-													
	F						ĺ								
19	Shear stress rai L	[מ												-	
	Stress reduction	- -	+			• • • • •		<u> </u>						-	
	lactor r _d	- -						·							
	R	1												d dake	
1	RL	1-									•			eartho	
19	2	- -	+-											5 e e	
12	Na				_									Cor Jy	
esista	NI														
, dic	c2	7													
ľ		- -												t tact ts bas	2
		┦													i
	cw														}
	Fc (%)	┢	\top												
		╀		<u>ę</u>	5	۶.	79	52	2	19	62				
ĺ		╬		· ·						·					
	Y _G (Will ^e)	-					-	<u> </u>	<u></u>						
ĺ.	ip Dia taun			25.0	25.0	25.0	25.0	25.0	25.00	25.00	25.00				
	U10 (mm)	-													
c Dat	D50 (mm)			0,005	0.005	0.005	0.005	0.005	0.005	0.005	0.005				
Bas	o, '(kgl/cm²)	—		87	0530	20	65	030	115	5	5				
	a ikolismi)	┝		<u>P</u>	 		-	<u>ہ</u>	<u>- 11</u>	<u></u>	<u></u>				
	O _y (kgauit)	-		5	0.83	173	1 63	703	243	3031	3,63(
	N vakie		1	Ξ	30	35	61	2	2	25	27				
	Vsi (m/sec)	-							 9						
	Ground Type														
	Depth of		╂	63											_
Ca	alculation m		<u> </u>	21	7	5	<u>.</u>	<u>ē</u>	121	15,1	18.1				
	alue er leve 50 60			·	·····				<u>}</u>		•			·	
	T N v dwate	-			~	-		b	F						
	CCUL CCUL			.0				0	~						\exists
	Geology														-
1	Depth (m)	8		+##########	للتلليك			шш						uuui	\dashv
C 1.	evaluon (m)	0													\square
	eranon (m)														ĺ
	Scale (m)	0			6	1-1-	-11	ŧ.		1		2		-,,, 10	4

,

Liquefaction Potential Analysis

•

Tehran Seismic Microzoning Boring No S207-8 Khc=0.60

Tehran Seismic Microzoning Boring No 30-1 Khc=0.49

Bits selectors Bits se	ſ					<u> </u>	.	.	<u> </u>		<u>.</u>			•	<u> </u>		
Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction		Fw(z)				<u> </u>	8	8		ŏ		5	8		g		
Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction Construction <td>ļ</td> <td>Ş</td> <td>e</td> <td>┝╌┝╾╸</td> <td></td> <td>ถิ</td> <td></td> <td></td>	ļ	Ş	e	┝╌┝╾╸											ถิ		
0:00000000000000000000000000000000000		stribut	N	┝╌┼──-				. <u> </u>									
Depth (m) 0	ļ	ت ل	-												8		
Opport Col	ŀ				- 	-,-,	- , ,	·							ΡĽ		
State State <th< td=""><td>F</td><td>Depth (m)</td><td></td><td>°</td><td></td><td>ю </td><td></td><td>2</td><td></td><td></td><td>5.</td><td></td><td></td><td></td><td></td><td></td><td></td></th<>	F	Depth (m)		°		ю 		2			5.						
Contrastingeneration Contrastingeneration Stress resolution R RL RL RL <td>ŀ</td> <td>Judgemen</td> <td></td> <td></td> <td>·</td> <td></td>	ŀ	Judgemen			·												
Construction Construction Stars strategy R RL R R R R R R R R R R R R R R R R R R R R R R R R R R R		۳ <u>،</u>			······							_					
Stess reduction factor f, R R<	l	hear stress r. L	aboj	Í													
I.A.M. 1/4 R.	F	ilress reduct	on	_											-		
State M M M 0 25 2 <td>┝</td> <td></td> <td>-</td> <td></td> <td></td> <td>·····</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td><u> </u></td> <td><u> </u></td> <td></td> <td></td> <td></td> <td></td>	┝		-			·····						<u> </u>	<u> </u>				
Back Concretation Concretation Concretation Concretation Concretation Concretation Concretation Concretation Concretation Concretation Concretation Concretation Concretation Concretation Concretation		К	_													quake	
Na Na Outcome Ni 1 1 1 1 1 1 0		RL,		í												earth leguin	
NI Chick restance All Water 0 See Summary 131 All Water	200	Na													-	be be	
M1 C2 C1 C2 C1 C2 C1 C2 C2 <thc2< th=""> C2 C2 C2<!--</td--><td>tance</td><td></td><td>-ŀ</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>_</td><td>L DC</td><td></td></thc2<>	tance		-ŀ												_	L DC	
String Contrast Contrast <thcontrast< th=""> Contrast <t< td=""><td>C fesus</td><td></td><td>_</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>_</td><td></td><td></td><td></td><td>ed case</td><td></td></t<></thcontrast<>	C fesus		_									_				ed case	
c1 c1 c1 cw c1 c1 cw c1 fright c1 cw c1 fright c1 cw c1 fright c1 fright c1 cw c1 fright c2 fright <	30	c2														ased o tequifi	
Cw I	j	cl												<u></u>	-	to hon fai wis bi to be	
tw J. 0[1] Fc (%) 12			-[-		<u> </u>										-		
Fc (%) if j if j if j if j			_ _	╡												0. Ha e O	
Ya (tilm3) 000000000000000000000000000000000000		Fc (%)	Í	Ĩ	162	79.1	79.1	79 1	18/	10	Ĩġ	181	14]	B 2 3	,
Yu (Wm²) 0000 ip 0001 ip ip		Y ₁₂ (ti/m3)							8						┼─		
Ip Ip <thip< th=""> Ip Ip Ip<!--</td--><td>ł</td><td>γ₁₁ (Wm³)</td><td></td><td></td><td></td><td></td><td></td><td></td><td>8</td><td></td><td></td><td></td><td></td><td></td><td>-</td><td></td><td></td></thip<>	ł	γ ₁₁ (Wm³)							8						-		
D10 (nmn) I	[ip	1	25.00	25.00	25.00	25.00	25.00	8	200	2.00	8	8.5		┢	- ·	
D50 (mm) D50 (mm) 0		D10 (mm)	1							<u></u>	<u> </u>	<u> </u>	~	_	╉╌		
a a		D50 (mm)		500	500	202	- S	505	50	5	50	5	5	<u> </u>	╉┈	·····	
Or, (kg/lcm ²) II III IIII IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII		a Ykolikad				<u>م</u>	6						8				
o., (kgt/cm ²) iii iii iii iii iii iii iii iii iii ii	ŀ	o, (kgaune)		62	0.80	8	2	<u></u>	1 60	1.80	2.001	2.201	2,403				
N value Q </td <td>ĺ</td> <td>o, (kgi/cm²)</td> <td>ĺ</td> <td>0.214</td> <td>0.814</td> <td>1.214</td> <td>1614</td> <td>2,014</td> <td>2414</td> <td>2.674</td> <td>214</td> <td>1614</td> <td>1014</td> <td></td> <td></td> <td></td> <td>_</td>	ĺ	o, (kgi/cm²)	ĺ	0.214	0.814	1.214	1614	2,014	2414	2.674	214	1614	1014				_
Vsi (m/sec) gg Ground Type m Depth of Calculation m 5 10 10 10 10 10 10 10 10 10 10 11 10	ſ	N value		20		8		e	0								
Bit (minute) Bit (minute) Ground Type M Depth (m) Bit (minute)	f	Vsi (m/sec)	┢										·^				_
Column Type Depth of Calculation m 5	ł	Cound Tune							368								
Depth (m) 8 Depth (m) 8	Ľ	Denth of															
image: second	Cal	culation m		0.1	4.07	807	B 07	10,07	12 07	14.07	16 07	18 07	20 07				
Set are x + y + y + y + y + y + y + y + y + y +	-	a Parte Sevel Sevel			- 8-	-0											_
Ex B	1	twater 8 to 14															4
Geology Depth (m)	100																_
Depth (m) 8		ieology	_	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		mm		ШШ	IIIIII				HIIII	I Mini	IIII		7
	De	epth (m)	8	uuuuu			miiii	шШ					ШШ			ul	-
			•	<u> </u>												250	
Levation (m)	:Jen	ation (m)						_	_								
Scale (m) O vn C vn N vn N vn N vn N vn N vn N vn N	Sc	ale (m)				•		2	· · · · ·	15	1 1		8	· · · · ·	-,-		1

Tehran Seismic Microzoning Boring No S365-1 Khc=0.41

	2	
	Bas	a" (köl/a
		o _r (kgl/c
		N valu
		Vsi (m/se
		Ground T
	Ca	Depth of sculation
,		SPT N value Groundwater level
		Geology
41	(Depth (m)
, , , ,	Ek	evalion (m

	Fw(z)			8		0 0	000	0.0	00.0	<u>v</u>	8	8	T	2	
										···				0.00	
[bution	~												£	
	Det	_							-·				\neg		
ĺ	ш.								<u> </u>						
ſ	Depth (m)		0	· · · · · ·	·^ -,-	·····	ě	-,,-		· , ,		2		1	
Ē	Judgement									·······				4	
	FL				-						1			1	
	Shear stress ra	tio	-											4	
┢	L Stress reductiv	_				·			<u> </u>		4			1	
	factor r													1	
ł	R													· · · ·	
1	RI	-		··					·						
					<u> </u>		_			• · <u>_</u> ·		_		2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	
	Na Na													e fa	
Destan	N1											1		X: case o	
0 Gelo	c2	T									\uparrow	1-	-	clor for a ased on lequifie	
	ci										╀			ation far Cwis by to be	
	CW													0 (correl latuon of ment : C	
	Fc (%)			1 82			78.1	192	- i'er	1.0	Ī	1	-	Calcu Judge	•
ĺ	Υ _α (Wm3)			-			8				<u> </u>	I			
	ץ _{נו} (tt/m³)	Γ					8				_				
	ip	ſ		25.00	0052	1	8	2,00	80	20	ß		\rightarrow		
	D10 (mm)	Γ							N		-				
sic Data	D50 (mm)			0.005	0.005		0.005	0002	500.0	0.005	0.005		-		
Ba	ar, (kgl/cm²)			0.63	1.115		1415	1 615	1 815	2215	2.365				
	σ, (kgl/cm²)			0.63	1.430		2,010	2,430	3.030	3.630	026.5				
	N value			5	22		p,	28	20	32	ŝ	·	1		
ĺ	Vsi (m/sec)		ĺ				3				T		+		Ì
	Ground Type						:	_				u			-
<u> </u>	Depth of			5	5		0	5	2	2	12				
U¢	n noteitua g g	_			ri		2	5	13.	8	=			·	_[
	value ter lev 0 50	_		7					~		0				
	T N-			o Mr		6		~		\leq					-
	Sources S	_					·								7
	Geology	-					лm				пп				
	Depth (m)										Щ_		-		
											200				
E.K	(m) 20064			*···		,		, , _	,, , ,						
5	cale (m)	0		<u>دە</u>		2		•	\$		8	, - -		52	7

Tehran Seismic Microzoning Boring No S367-1 Khc=0.47

Г			1 1			<u>. </u>	<u> </u>						•		
ŀ	Fw(z)		\square			5		5	8	000	2	3		8	
	5		\square				·] °	
	stribut	N	\square											ו	
	ت س	-			·									8	
ŀ						·		,						Ъ.	
	Depih (m)		0			ю. 		2 '		- 61		, ¢			
┝	Judgement	!	_				_								
L	F.					_									
S	hear stress n L	atico													
5	iress reducts	<u></u>						··							
┝	factor r _d	-					_								
	R														ade R
	RL														earthe lequife
e 730	Na						1		·						Type 1 of to be
esistanc	IN	1										_		-	ea) zase for X:n
Cyclic r	c2	↑	1								<u> </u>			-	lor for ar sed on c equified
	c1	╞	+		<u> </u>										thon fact ov is ba 7. to be ! ≥1.0
	CW	╊	+	··										-	(correts bruon of hent. O
	Fc (%)	1-	+	1.9			2	 						-	cz=1.0 Calcula Judgen F: O
	Y ₀ (tl/m3)		+		<u> </u>	<u>F</u>	F	2	8	78	2				
	γ ₁₁ (Wm ³)	┢	┽─						<u>5</u>					╇	
ţ	 Ip	1		8	8	8	8	8		8	8				
ł	D10 (mm)	╋		<u> </u>		<u>N</u>	37	32		52	72			+	
	D50 (mm)	1-		5	8	8	8		·				—·.	- -	
	~ '/kallam?	┼╴	┢		- 20		00	50	·	000	8.				
╞	o" (räncus.)	┥	_	C.4:	0.71	Ĩ	171	1 515		1 915	2115				
ļ	σ, (kgl/cm²)	Ļ		0 430	0:830	1 430	1 830	2,430		3 230	3.630				
	N value			36	1	27	20	05		\$0	50			ſ	
	Vsi (m/sec)								655					Ì	
0	Ground Type			_	I									†	
l Cak	Depth of culation m			2.15	115	.15	15	15		15	13			┢	
_	<u>a</u> 8									<u> </u>	<u>=</u>				
	e terte			<u> </u>						0	-0				
10	a kan					_									
	, <mark>6</mark> 8				<u>``</u>	_						-			
G	Seology											ΠΠΠ	ΠΠ		
De	epih (m)	000			_								****		8
iev	ation (m)												<u> </u>	•	
Sc	ale (m)	-					_	<u>, </u>		·	, ,		···,,		-

.

-

Tehran Seismic Microzoning Boring No S390-1 Khc=0.39

	r						· <u> </u>					•			
	Fw(z))	+	<u> </u>	8	8	00	0.0	0.0		8		000		
	- UQID	•	ッ├─┤			··							0 K		
	Destrib	0	┢╾╂			<u> </u>									
i	ц "	*-	1									{	00		
	Depth (n	n)				₁ , _ . o		0	<u>, , , ,</u>	·····			Ĩ		
	Judgeme	กไ											-		
ļ	F														
	Shear stress L	ratio											-		
	Stress reduc factor r	bon .					<u> </u>						-		
I	R					·							-	uake. J	
l	RL												-	earthqu lequified	
	Na									<u> </u>			1	r Type 1 hol to be	
ras eta	N1	_											1.	area) I case for Id X:∣	
Ē	c2													actor for based on e lequifie D	
	c1														
	CW		_											1 datuon o ment: Oct 0	
	Fc (%)			1,97	1.62	79.1		79 E	79.1	142	191		1	Catcu Ludge	
	Υ ₀ (tl/m3)							2.00							
	Y ₁₁ (ti/m³)	_ -	+					2.00							_
		_ -		25.00	25.0	25.00		25.00	25,00	25.00	25.00			<u> </u>	_
ē	010 (mm)								_ ·	··					
Hasic Da	- USU (MM)				000			0.005	0,005	00 ²	0.005				
	G (köncu.	י -	┇		101	1.265		1.915	1 945		2,515				
	o, (kgvcm,	'		0.63	1.030	1.530		2.230	2,030	3.630	4.030	_			7
	N value		ļ					•n	a	5	0	Ţ			1
	Vsl (m/sec)	- -	<u> </u>					284							1
1	Depth of	님_	<u> </u>			· •									
Ca	culabon m			315	5 15	7.65		11.15	1465	18.15	20,15				1
	value lertev 0 50 6	—			-8-										1
ļ	N Pr	=			Й!					\angle					-
	200 B	F		G			_								1
	Geology]		ΠΗΠΠ	ΠΙΙΠ		MM		 			mm	_		1
٥	lepth (m)	8							umm <u>mm</u>		u <u>uuu</u>	шШ 8	••••	<u> </u>	
le	valion (m)				·		•		<u> </u>					—· — -	
S	cale (m)	-		·····	vi -		5	-1 11-		 .	 8		<u>ب</u>	·	
			_			_	-	_					**	•	4

٠

Tehran Seismic Microzoning Boring No S390-2 Khc=0.39

:

	<u> </u>		. –	·														
	Fw(z)	_	╞	<u> </u>	8	8		8	0.0	2			8	8			000	
	5	3	<u> </u>	ļ													.0	
	stribut	~	-														Ĩ	
	ڭ ي				_							·					5	
ĺ			 	 , ,,-	- .												1	
	Depth (m)) 	د ر			5				2			20.			
	Judgemer	u	-										-	1				
ļ	<u>۲</u>						_											
	Shear stress i L	rabo															1	
ľ	Stress reduct	ion											┥	┼			-	
ł		-	-				···										_	
	К	_	_					_										oquake led
	RL										ļ							l'ead
	R Na												+-	1				Type I to be
1	N1	-†	╉					+									-	×er ×er
1		- -	_											ļ				or area on car lifed
Ś	c2																	actor i based e lequ 0
	c1					_								1			1	ation f Cwis € to b
l	CW	- -	╧					\vdash		_			┢				1	(correl c
┝		╺╌┟╴	╬		-			_			·		<u> </u>					
ĺ	Fc (%)				<u> </u>	ē	. ē	Ĩ		Ā	78 1	Ŕ	1.02					8031
ľ	Υ _α (Шm3)				_						58							
	ץ _{נו} (ווֹיַה)	_ -	4			<u></u>	<u>-</u> -	<u> </u>			500			_				
	- di	_ _	╺╢╌			22.0	25.0(25.0	_	520	25.00	25.00	25.00					
_	D10 (mm)				·													
c Data	D50 (mm)			0.005	4	0.005	0.005	0.005		8	0.005	0.005	0.005					
Bas	o, (kgi/cm²)		Γ			511	365	515		2	815		2			\neg	_	
	a (kalicar)	┼╴	╈				-	-	. <u></u>		<u>~</u>	4	5			_		
			╉	80	:	<u>1</u>		22		ŝ.	2		3					_
	N value			5	:	" "	2	:	:	=	20	3	ŝ					
	Vsi (m/sec)	Ł	ĺ								5							
	Ground Type		Γ					*							-	-		
<u></u>	Depth of	1-	1-	5		?	5	15	ž		2	8	₽				_	
	<u>ହ</u> ି ଅ ଜଣାହାର ଆ		-	*			80	2			2	2	18					
	value iter ke to so	E			ř			_			•	~	0				_	
	N 14 N	E			م_ل	\leq					7							
	N 8 N						· · · · ·	0	0									
	Geology																	
1	Depth (m)	000					_											8
Ek	wation (m)											•						<u></u>
ç	cale (m)			······································	-			<u> </u>			- <u></u>		·	- ;		-,-	-,	_
3	vere (m)						5				10			2		·	-	55

-

Tehran Seismic Microzoning Boring No S390-3 Khc=0.39

			· · · · · · · · · · · · · · · · · · ·		010	5	<u>.</u>	<u> </u>	<u> </u>			•		
	Fw(z)		┟╾┞──		8		8	8	ŏ		8	8 8		8
	8	6	<u> _ </u>						-					
ĺ	tributiv	N												6
1	F, Ds	-												
							_	_						
	Depth (m))		• •	ю	, ,-	, ,	ę.,		15	- 1, -1	50	, _ .	7
ļ	Judgemen	ł												1
	FL													
ſ	Shear stress (alio							-					1
ł	Stress reduct	100			-			·	_ _					
+	factor r _a	_							_					
1	R													d ake.
	RL												i	earthc
	Ra Na	-			1-		+-				- -	<u> </u>		to be
		÷				·						·····		× - Po
the rose		4									_			or area on cas filed
Č	5 c2	_			1		_							factor f based be lequ .0
l	c1													
İ	CW						1				+		{	(com thuon c Ment
ŀ	Fc (%)	- -			-		┼_				+-			Calcuta budgen ","
	y., (11/m3)	┽			2	2	2	<u></u>	2	79.	79	62		
l	y, (tilm ³)	- -						<u>5</u>						
ļ	10	-1-		8	8	8	8	<u>5</u>	18					
ļ	D10 (mm)	- -			12	2	12	25.	25	25.0	1	25.0		
ĺ	010 (1111)										<u> </u>			
02	D50 (mm)		-	8	8	80	80	a.005	0.005	0.005	0.005	0.005		
B	σ, '(kgi/cm²)			0.730	1.015	1.265	1.415	1.665	1.815	2.065	2,215	2,465		
	a ^r (köl/cw _y)	ļ		052.0	000 1	230	130	55	22	130	ą	000	\neg	
	N value	1		2			-		~	м и				
	Vsl (m/sec)	┦╴	┼───							~~	~		_ -	
	Ground Turne		╉────					267						
	Depth of	-		T								·		
Ca	iculation m	<u> </u> _	<u> </u>	36:	212	7 65	915	11 63	13 15	15 65	17 15	19 65		
	s level s se	E			8					_				
	N va vater o 40	E	<u> </u>		×									
	SPT Send	E			÷.		-0-				<u> </u>	0		
	<u> </u>	[пип	mm			~ ~~~						
		_												
(Depth (m)	8											350	
Ek	evation (m)	$\left[\right]$							<u>.</u>			·		
s	cale (m)	-			 0			· · · · ·	 -	<u>, , , , , , , , , , , , , , , , , , , </u>	.		_, Ĺ,	l
_	1						Ŧ			¥		20		2

•

Tehran Seismic Microzoning Boring No S390-4 Khc=0.39

	٢			-)-	·	8	81				<u> </u>		<u> </u>			•			
	\mathbf{h}			╶┼╴		j 	ă	<u> </u>	8		0.0	8 	_	ŏ	ŏ			00	
		viton	C	┉┝╴													_	0.0	
		Osthb	c	• [<u> </u>									_		
		<u>ند</u>														·	-1		
		Depih (n	n)	<u>_</u>			6	111	_,	5			÷	·	·	8		4	
	╞	Judgeme	nt																
		F.																	
		L	rauo 												T			1	
	s	tress reduc factor r	bon. I		l														
1		R					1					_		-	+			<u>-</u>	
		RL					- -			_								earthqu	Derrinh
	98						╧											ype 1	8
	stance	N1	-	╈			╎				·—							() () () () () () () () () () () () () (
	e e e	c2	-	-			┢		<u></u> .					_			_	for area for area for case	
ľ	5 		-ŀ				-			•					\perp			n factor Is based I be len	0
I	┟		_	_ -														O cvi	é
ŀ	4	CW					<u> </u>											.0 (co ulatruon ement,	Š,
		Fc (%)			101	79.1	Ē	ia		181	1.62	-	192					김영영	<u>.</u>
		Y _e (ti/m3)							500	3						1		<u> </u>	
	-	γ _{ct} (Wm ³)	_ -	4			-		5	}						1	╈		
	╞		- -	╇	25.0	25.0	25.0	25.00		25.00	25,00		25.00	25.00					
ata	┢	Did (mm)	┥	╬		5	5							<u> </u>					
lasc D:	┝			-		000	0.00	88		0.0	8		0.00	0.00		<u>. </u>			
	Ľ	o" (k∂i/cm²)			0.43	0.93	11	1.36	_	1.515	1815		2215	2.385	_				
		1, (kgl/cm²)	_	\downarrow	0.430	0.830	1,230	1.730		2,230	2.630		3.430	3.730					
		N value			27	2	÷	17		20	22		20	:		•	- 		
	v	/si (m/sec)							307					11	7		╈	<u> </u>	-1
	Gr	ound Type													1		+		
C	De	epth of lation m			2.15	4 8	6 15	8 65		11.15	13 15		17 15	8 65			1-		-
		S 80													_				
	N V3	watei 0 40										_	2	-0-					
	SP1	pung R	_		0	~	.		-		~	\leq							
		<u>a</u> 5	\neg	тт	minim	mm			TT1111										
_	66)	clogy	┛	11111											Щ				
	~p		3											_	20.50				
Ek	eval	юп (т)							_						1		_		
S	cak	3 (m)				. ,, 		,		-,-		5			÷'-		, ,	33	
									_							_	_	_	

_____ŧ

٠

•

Tehran Seismic Microzoning Boring No S390-5 Khc=0.39

	Fw(z)		<u> </u>	8	8	8	<u>10</u> 0		3	8		— r	_
ł					-		<u>~</u>			o 			
	ndhon	3						······			·	8). 1
	Destri	~		_									
	н <u>г</u>	-					•	••				<u>:</u>	
	Depth (m)			\$	••••	-	, i	-, <u> </u> ,	·	\$			
	Judgement				1		0						
	Ft						0.531						
1	Shear stress ra L	lio				1	225	_					
Ī	Siress reduction	ж			╉		2					[
╞		-			╉	4							
1	<u>н</u>	_			_		×						nquake led
	RL					1000							l" earlt Hequin
	Na				T	010							Type
a a a a a a a a a a a a a a a a a a a	N1	1			┢	1		•				{	X:nc
l S S S S	<u> </u>	╉	·	·····	╀								for and lon ca
ð		_ -			\downarrow								based based be lequ
	c1				1	1084							
	cw				Γ	8					·		(come tituon o Ment: (X1:0
-	Fc (%)	- -					<u> </u>						
	Y. (I/m3)	- -	* 8	2	2		<u>^</u>	3	<u></u>		1'a2		<u> </u>
i	Y., (t/m ³)	┢	8		_	10 2.1				070		·	
	lp	┤─		8	8	- - -	8	8	8		8		
	D10 (mm)	┦─	<u> </u>	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	2	⊢		<u></u>	52				
g	D50 (mm)	-	5	ŝ	20	8	5	8	5				- .
Basic				5 0(5 0.0	5 2.1	•		8		č		······································
ł	o, (vgvan)	_	<u>8</u>	1.11	121	5	<u> </u>	1.72	1.92				
	σ _e (kgl/cm²)		0.830	52	5	5091	2	2,439	668.2		3.839		
	N value	1		=	-	1	2	16	20				-
ſ	Vsi (m/sec)	í	6		1	픫						<u> </u>	
ļ	Ground Type		<u>~</u>			=	<u> </u>				——————————————————————————————————————		
<u> </u>	Depth of	-		5	5	8:	 }	5	2				
La	<u>ຮ</u> 8			•	-			12	7		19.1		
	A SC SC SC SC SC SC SC SC SC SC SC SC SC					_			~				
	N R R												
	G P			_• Timn	0 11. •	<u>्</u> यः		пла					
 	anth (ch	_			<u>I</u>	1							
	epui (m)	00			2	9 9						23.52]
Ele	vation (m)												
Sc	:ale (m)	0	نا الالار	·	•–-	-	- <u></u>	- 	<u>.</u>		8 8	┍━┲╍┻┱╍	

1

.

٠

Tehran Seismic Microzoning Boring No S390-6 Khc=0.41

	<u> </u>			2		91	<u> </u>			<u>-</u>	<u> </u>					
	Fw(z)		┢╌┨	ŏ		8	<u> </u>	2		ĕ	8 8		8		000	
	ş	e	\vdash												e E	
ĺ	stribut	N													Ĭ	
	ц. С	-	-												a	
			_	_, ,_			—,,,		 _;-		· · · · · · · · · · · · · · · · · · ·				ä	
	Depth (m)) 	-					2			15.	•••	2			
ł	Judgemen		$\left \cdot \right $				· · · ·									
ļ	<u>۲</u>															
	Shear stress r L	atio														
Ī	Stress reducti factor r	on				1								·	-	
ľ	R		╞	•		╡									-	ate
	RL	┤				+				+					-	earthqu
	Na		- -												+	Type 1* to be a
et and		- -	+		·	+	·				<u> </u>		•			a) Selor X:no
in ra	c2	-	┼			╋	<u> </u>									r for are ed on ca quified
	c1	┥	+													on facto « is bas to be le b≥1.0
ļ	CW	┦	╋			-										
_			╇			 				<u> </u>				_		
	Fc (%)			1.62		1.62	191		79.1	Ē	161	L et	791			유요국다 -
	Υ ₀ (U/m3)	4-	_								2.00					
	Υ ₁₁ (ll/m ³)		╞			·		_			700					
	qi 		_	22:0	25.0	25.00	25.00		25.00	25.00	25.00	25.00	25.00			
	D10 (mm)															
sic Data	D50 (mm)			0.005	0.005	0.005	0.005		0,005	0.005	0.005	0.005	0.005			
88	σ, '(kgi/cm²)			0.430	0.930	1.215	1.465		1 865	2,015	2,215	2415	2.615			<u> </u>
	σ, (kgl/cm²)			0.430	056.0	1,230	1.730		2,530	2.830	3.230	3.630	050.4			
	N value			1	:	51	24		23	3	8	23	2	 ,		
	Vsi (m/sec)										2					
	Ground Type]_			-											
C:	Depth of			15	33	£.			65	5	5	1	15			
~~	<u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u></u>					<u>~</u>			2	=			8			
	value Iterke 10 50					<u>~</u>		_							-	
						¥	_0									
_,	20 0 20 0			0		-0							<u>~o</u>			
	Geology															<u> </u>
۵	Depih (m)	800											uuuu	بسس	411	8
Eie	valion (m)						·									×
S	cale (m)	-	··			•···• •	<u>, , </u>	-,		-						<u> </u>

Tehran Seismic Microzoning Boring No S390-7 Khc=0.41

-						_												
	Fw(z)				2010	80	8.	80.0	9 C C	8	8	8.0	8	000	T	8		
	ő	c	,	ļ										-		<u>.</u> 0		
	stribut	0	·						·									
	L D	-	·													3.34		
ŀ	Death (m					·	·		•	 .			·· · · · · · · · · · · · · · · · · · ·	- 		<u>"</u>		
ŀ	Judgemen	nt I	+			- _			=		—r-		<u>-</u>	50				
ſ	 F_	-	Π	·								·		·		-		
s	hear stress r	ratio						1-	3									
ŀ	L.																	
Ľ	lactor ra	-00						0.885								1		
	R							0.157						·			uake d	
	RL							0.167									earthg lequitie	
06130	Na							6 093	1		1-					1	Type 1 of to be	
resistan	N1		1					1	1		+					.·	rea) case for X T	
S B B C	c2	ľ			-			1233	1		+						ised on lequified	
	c1							1081	1					·			duuris Cewis by Cible ≥1,0	
	CW					1		8			+			<u> </u>	-			
	Fc (%)		1	79.1	79 [1 gr		7	191	1.91	5	ā			-	Ī		,
	γ ₁₂ (tl/m3)				2.00	d		510	<u> </u>		1.~			8				
	γ _n (Шm ³)		Τ		200	-		2.10	1					8			<u> </u>	
	lp			25.00	25.00	25.00	22.00		85	25.00	25.00	\$2.00		- <u>-</u> -	-†		<u> </u>	
	D10 (mm)	_ _									1			<u> </u>	\neg			
	050 (mm)			0.005	0.005	0.005	0.005	2.100	0 005	0.005	0.005	0.005		aroos				
¹ -	σ, '(kgl/cm²)			0.330	0.730	1 030	1,115	1.515	1 693	1.893	2.043	2243		2.593				
	o, (kgi/cm²)			OEFO	0.730	1.030	1 430	1.815	2.158	2.558	2,858	3.258						
L	N value			=	2	2	-	Ê	•	•	22			• <u> </u>		••••	<u> </u>	-
┝	Vsi (m/sec)	<u> </u>			262			150	<u> </u>				•••	222				-
0	fround Type	_			-										+			┥
l alc	Depth of suiation m			1 65	3 65	515	7.15	0.6	10 65	12.65	14.15	6,15			- -		<u> </u>	-
	S Sevel					8					_							-
2	dwater 8		-			-14				·						_		
5	R Cours			-0	-0	-0					6							-
G	eology				IIIII	mn		•			mm	TUUT				TTT		
De	թնի (m)	8	mm	uuuu	πmi		uuiti s	 8	шЩ							Ĩ		-
lev.	ation (m)						-1	10								25.0		
Sci	ale (m)			· · · ·	-, _	r	┯┷┯	<u></u>	-,,									
		_				•		2			12		, e			. 5		1

Tehran Seismic Microzoning Boring No E37-16 Khc=0.46

ſ	<u> </u>	_		···			······				_,	
	Fw(z)	_	_	0	ŏ				<u>}</u>			
	5						·				0.0	
	stibut	~										
	ڭ س	-	- <u> </u>									
4	<u></u>	-			-,,,	. , . , . , .	•	•	•			
	Depth (m)	_	° 		ю ————————————————————————————————————	2			ŝ	· ·		
ł	Juogement	┥					0	C	20		-	
ŀ	۲ <u>،</u>		_					0.56	0 Se			
ľ	L	1001					0.392	0.401	8			
1	Stress reductio	n					8	5	8		1	
h	R						<u> </u>	6	5	- <u></u>	-1	<u>n</u>
1					· <u> </u>	····		0.2	62		4	rthqual lified
	RL						0.267	0.227	0.224			r 1°eau be lequ
	Na						5.628	1,305	876		1	of to I
tistan.	NI	1	1					392	= g		()))	A io
병		+-						<u> </u>	Ξ		for an	d on cr lutified
٥ ا	· · · · · · · · · · · · · · · · · · ·	- -	-		••		0.23	0.23	0.22			s base be leg
1	c1						1.084	1 084	1 062		elation	50°
	СЖ	Γ					8	80	8		<u>5</u>	Nent. X-1.0
	Ec.(%)	┢							큭		2-10 2-10	
		┽╌		<u><u></u></u>	<u>*</u>			<u> </u>	₹		-	
		┢			0 20			5	_			
	T(1 (will)	┼╴		8	<u>8</u>			1 5				
	010 (mm)	╀─		25	25	35						
8	D60 (mm)	┢	·	2								
SC D	DJO (meny	-		0.0	8	000	2,10	2 to	210			
ä	cr, '(kgi/cm²)			0.830	0E2.1	2,030	2.647	3,180	3.305			
	a _r (kgl/cm²)	Γ		1830	230	830		B	2		·	
	N value	┢		<u> </u>		~ *	~~~~			<u> </u>		
		┢	[N	N	<u>-</u>		<u>. </u>	~	ł-		-
	Vst (m/sec)				267		251	237				
	Ground Type	<u> </u>		-								
C	Depinion m			4.15	6 15	10.15	14.15	19 00	20 12			
	tevel so so						0			l	-	
	N val Iwater Do 40	_										
	SpT Sround 0 20 1			<u></u>	-0				0			
-	Geology								:1		_	
1	Depth (m)	8		uUII		<u>۱۱۱۱۱۱۱۱۲۰</u> 8						
		-						·	8			
ы —	evason (m)											}
5	icale (m)	0		5	· · – T	· •	1 <u>1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 </u>	2			22	

•

•

Tehran Seismic Microzoning Boring No E37-17 Khc=0.49

	Fw(z)					3 8		8 8		8	5	Т	
										<u> </u>			
	ibution	0										┨┋	
ĺ	F_Dist	-						·				15	
										-	•	18	
-	Depth (m)	_							1 <u>12</u>	· · · ·	2	- 1	
ł	Judgement	_									0		
	r _L		_ _					<u> </u>		······································	0,00		
Ľ	L						_				0.546		
	Stress reduction factor r	n									100		
	R										1208 		d take
	RL						· · · · · · · · · · · · · · · · · · ·				1208		earling lequife
QE 4	Na										5458	-	Type 1 not to be
recretan	N1											-	area) I crase fou d X:⊥
Cvolic	c2										0.233		ctor for a lased on a lequifie
	c1										1.084	-	lation fa f cw is b O: to be ≥ 1.0
	cw										1 000	-	0 (com faturon c ment : -
	Fc (%)				112	79.1	79.1	78.1	16		2		Calculation
	Y ₀ (il/m3)			2.10				2.00			5.10		
ĺ	Y _{II} (ti/m³)			2.10				200			210	┢	
	lp	_				25.00	25.00	25.00	25.00				
	D10 (mm)	4_	ļ										
isic Data	D50 (mm)	- _			2.100	0.005	0.005	0.005	D.005		2100		
83	o _e '(kgi/cm²)	_	<u> </u>		0.872	1 165	1.565	1.765	2,165		2.522		
	σ, (kgl/cm²)	_			0.872	1.280	2.080	2480	3.280		3.966		
	N value				18	2	2	25	14		*	1	
ĺ	Vsi (m/sec)			210				262		5			
	Ground Type					- <u>-</u>						+-	
Ca	Depth of Iculation m	ĺ	ĺ		415	6 15	015	2.15	615		50 8	+-	
	evel evel	F	<u> </u>		8				······			<u></u>	
	N vat vater						·						
	SPT SPT SPT				 					·			
	័ភ្ម៍ ទ			_	\geq	-0						_,	
	Geology	_		<u>.</u>						TIIIII.		_	
()epih (m)	000			83					19.00			
Ek	vation (m)												
S	cale (m)					· · ·	÷		÷	<u>}</u> ;	,,	•	8

۲

Tehran Seismic Microzoning Boring No E37-18 Khc=0.45

1		-	I 		<u> </u>		.		_	•		
	Fw(z)				Ö.	8		800			8	
ĺ	c	~									0. 0.	1
	ibuto								·		8	
	Data Data					-					72.	
ļ	ц."	-				•					Ē	
ŀ	Death (m)	_			, -,-	·					ã	
┟	Judoement	_				=				30		
ł	E	-					<u> </u>			_		
		_				0.65						
ľ	ihear stress ra L	100	í			546						
F	Stress reduction	x										
Ļ	lactor re	_				90						
	R					1358					Τ	ake.
	RI RI	┥	+						-		-	uthq. Irified
l						6.9						
2	Na	ļ	Í			3.007						ot to 1
stano	NT.	╧				<u> </u>	-				-{	×: Σetα
C fest		_ _				23.1						
1 2 0	c2					123						tion to be and lequit
ĺ	ci	- -									-	8 8 8 8 8 8 8 9 8 9 9 9 9
		┥				<u> </u>						Generation
	CW	İ				8						
	Fc (%)	1				-	<u> </u>				-	
	()	- -		<u> </u>	3	2	Ř	78.1	- r			
	Υ ₂ (U/m3)	4_		<u>×</u>		2.10		5.00				
	Y _{ci} (từm³)			B.		2.10		2.00			Τ	
	lp			25.00	25.00		25.00	22.00			┢	
i	D10 (mm)										1	
lata	050 (mm)			<u></u>	ŝ	8	8				┢	
asic				3	0	<u>ہ</u>	0.0					
<u>م</u>	σ, '(kgl/cm²)			1.015	1.265	1.426	1 615	1.035				
	σ, (kgl/cm²)			8	R	ş	9	8			┢	
		┢	· · · · · · · · · · · · · · · · · · ·			2	7	2				
	N value			18	5	5	2	32			Ι.	ſ
	Vsl (m/sec)	Γ		-		9		<u>z</u>	<u> </u>		<u> </u>	
ł	Ground Type	1-	N	<u> </u>		Ň		ы Ж	<u> </u>			
	Depth of											
Ca	iculation m			6,15	8 65	101	11.9	14,12				Í
	s tere	_	8			·				• • • • • • • • • • • • • • • • • • • •		
	N vat water 1 40											
	s dund s a	_				-0	-					
	<u>ءِ ق</u>	_	111111111111111111111111111111111111111		111111							
	Geology											
0	epth (m)	0,00			8	81	_	6.75				
Ele	vation (m)	_							· <u> </u>			
		_					 ,		_			
Ş	cale (m)	٩	10	,		2		2		8	-1-	

Tehran Seismic Microzoning Boring No E37-19 Khc≕0.52

	Fw(z)			000	000	0.00		000
						·····		0
	nbuto 2							
	Dist							00
	ш.			L				
	Depth (m)	0	¢, ()		2		8	-
	Judgemenl							
	FL							
Sh	ear stress rabo L							
SI	ress reduction							
-	factor r _a		. <u> </u>		·			ke.
	R							uthqua
	RL							be leg
Laio	Na							c Typ
istance	N1					······		area) case (
yclic res	 c2							ector for
ľ						<u></u>		then ta to be to be
	c1							
	CW							dgeme
	Fc (%)			79.6	162	28.1		ਬਹੁਤਾ
	γ ₀ (ti/m3)				5.00			
.	Υ _ո (ሠጠ ³)				2.00			
	lρ			25.00	25.00	52.00		
	D10 (mm)							
c Data	D50 (mm)			0.005	0.005	0.005		
Bask	σ _v '(kgt/cm²)			1,115	316.1	t,at5		
	a _v (kgl/cm²)			062.1	009.1	2830		
	N value			18	15	=		
	Vsi (m/sec)			11				-
	Ground Type							
Γ	Depth of			6.15	5 5	4.15		
\mathbb{H}	eculation III Teg 8			<u> </u>	L			
	value aler le' 40 50	_						
	PT N N DQ R	_	hr					
	2 0 0 1 0 0						1	
	Geology	_					ļ	
	Depth (m)						<u></u>	
	Elevation (m)		<u> </u>	-,			<u> </u>	· · · · · · · · · · · · · · · · · · ·
	Scale (m)	6	o 10		• •	12	50	3

٠

Tehran Seismic Microzoning Boring No E37-20 Khc=0.47

•		Fw(z)		000	80	00.0	00.0	80		000	
		5 0			<u>.</u>						
		Stributy 2	L								
		- " م	_							- 0	
	_	Depth (m)	┝	 			<u>, , ,</u>			1	
	_	Judgement	┝				•	-			-
		FL	1						•••••••••••••••••••••••••••••••••••••••		
	Sh	ear stress ratio	┢								
	S	ress reduction	-								
	_	R	1						<u> </u>		ad ake.
		RL									1' earth e lequifi
	8 1310	Na									or Type : nol to b
	resistanc	N1			-						rarea) An case f
	Cyclics	c2									factor fo based o be lequif
		cl									Trelation of cw is 0. to 0
		CW									0.1.0 (80 Sement 0.0 O<1.0
		Fc (%)		79.1	79 f	781	79 1	162			붭 영 경 관
		γ ₀ (W/m3)				8					
		γ ₁₁ (i//m ³)				8					
		lρ		S S S	25.0	25.0	25.0	220			
		D10 (mm)	_								·
	sc Dat	D50 (mm)	_	80	00 00	000	0,00	00.0			
	89	α, (kgi/cm²)		0 430	0.015	1.115	1315	1715			
		ar, (kgl/cm²)		0.430	1,230	1 830	2,030	2,830			
		N value		•	•	••	12	a -			
		Vsi (m/sec)				215					
		Ground Type	_	I							
	Ca	Depth of alculation m		2.15	8 15	8 15	10 15	14.15			
		rlevel So 60	-	<u></u>		-					
		T N va dwate 30 40									
		S Ground		0		-0					
ľ		Geology							III		
ŗļ		Depth (m)	0.00						5221		
	E	levation (m)									
Ξĺ	1	Scale (m)	0	, , , , , ,	., , , , , , , , , , , , , , , , , , ,		2	5	50		

o=0, 000 F_L Distribution ę N PL=00 -20-**1**5ò 5 é Depth (m) Judgement $\mathbf{F}_{\mathbf{L}}$ Shear stress ratio Stress reduction factor re cz=1.0 (correlation factor for area) calculation of cw based on case for "Type 1" earthquake. Judgement: O: to be lequified X: not to be lequified F_i : O<1.0 \oplus z=1.0 R RL Cyclic resistance raio Na N1 c2 **c**1 СW Fc (%) 182 181 Ξġ 791 79.1 2,00 2,00 Ya (Wm3) γ₁₁ (ll/m³) 25 00 25.00 25.00 25.00 25.00 tρ D10 (mm) 0.005 0.005 0.005 0.005 0.005 D50 (mm) Basic Dat 1.515 0,915 1.315 1915 0.430 σ, *(kgi/cm²) 0.430 1,230 2,030 2,430 3.230 $\sigma_{\rm v}$ (kgl/cm²) 66 20 2 \$ 3 N value Vsi (m/sec) 31 Ground Type -Depth of Calculation m 12.15 10.15 16.15 2.15 6.15 SPT N value Groundwater level 05 25 49 25 29 8 D Annual and a sector of the sec Geology 17.75 Depth (m) 텱 Elevation (m) Scale (m) 10. 15. 20-25-÷ 0

0.00

Fw(z)

80

0.0 0.00 0.0

Liquefaction Potential Analysis

Tehran Seismic Microzoning Boring No E37-21 Khc=0.48

•

Tehran Seismic Microzoning Boring No E37-22 Khc=0.49

٠

Г		1	8	8	8		138	8			•	
┝		┢									0,00	
	dition C	┝──									8	
	Distrit A			·							79	
	нт _о ет	┢					•				PL=2	
	Depth (m)	5		сц С		ģ				33	+	-
	Judgement						0					
	FL						0.291					
Sh	ear stress rabo	-					1536					
SI	ress reduction											
┝	factor r _e				<u></u>		6 6					, ke
	R						0.15 0.15					uified
	RL						0,156					e 1 es be leq
ê	Na						2963					a Typ
stance	N1	┢					383					d X f
Se res							 g					or for a sed on equine
δ	62	_					6					on tact visba: to be i
	c1						1 084					
	CW						1.00					Demento Demento Cf.
┢	Fc (%)		2	=			5	5				
	Y (ti/m3)	-	~		8		- -	8	-1	·		
	<u>ر (تاریم)</u> ۲۰۰ (۲۰۱				500		5.0	<u></u>	-†			
	lp		8:00	52.00	25.00		<u> </u>	25.00	I			···-
	D10 (mm)											
Data	D50 (mm)		2003	2005	0,005		2100	0.005				_
Basic	o.'(kq(/cm²)	-		20	15		828	 50				
		┝		<u> </u>	-		-	8				
	0, (kgi/cm*)		6	0	9'I		4	2				<u> </u>
ŀ	N value		12	12	2			20				•
	Vsi (m/sec)				252		8	271				
	Ground Type	Γ										
	Depth of acutation m		2.15	4 15	8,15		2.15	14.15				
F	<u>.</u>	╘			8							······
	Tvalu ater k	E			-17							
	A MA R	E										
	νê ÷	-										
Γ	Geology						:··:					
┢╴	Depth (m)	8				8	8		87			
	levalue (m)	⊢	<u>, </u>						-			· .
┝		L			_ 	. <u>.</u> .	<u> </u>	····,,	-			
	යක්ෂ (M)	ı °	,			÷.		-		64		~

- [Endst		8	8	8	8		·•	T T	·
-		FW(4)		<u> </u>	Ó	0	0			ö	
		5 6	_							ß	
		2 tribut	_								
		۲ Dis								00.	
										E.	
		Depth (m)	c	, , , , ,	44		2	: ::::::::::::::::::::::::::::::::::::	30	`	
		Judgement									
		FL									
ľ	Sh	ear stress ratio					······································				
ŀ	SI	L rest reduction	_				<u> </u>				
	50	factor r _d									
ſ		R									d d
			—		· · -						quifie
		КL						· . · · · · · · · · · · · · · · · · · ·			2 8 4 8 4
	80	Na									L T
	stance	N1	—								X ase to
	ic res		_							_	r for au af on c putified
	ð	c2									factor be let e
		c1									
			-				····				
			_								
		Fc (%)		T.B.1	182	791	161			Ì	8034
		Y ₁₂ (il/m3)			·····		8				
		γ _{it} (ti/m³)					8				
		lp		83	20.3	8	8				
		D10 (mm)	_				N			-1	· · · · · · · · · · · · · · · · · · ·
	ata	D50 (mm)	-	S	5	5	5		v	-	
	ascD			3	00	5	6			4	
	ä	oʻʻ(kgl/cm²)		0.430	0.830	151	1.92				
		o, (kgl/cm²)		1430	1830	,630	430				
		Nusha	_				<u>~</u>		·	-	
					ă 	=					
		Vsi (m/sec)					586				
		Ground Type			H			•			
ſ	0	Depth of		13	12	5	2,15				
ł		រាម ខេត្ត									
1		vatue tter le					· · · · · · · · · · · · · · · · · · ·				
		N TY N	_			N					
		6 5 10 2 10 2									
		Geology									
。		Depth (m)	000						80.4		
ō D	F	levation (m)									
5	_		\square			·····	<u> </u>			•	
2[Scale (m)	0	1	6		#	2	30		8

ł

Liquefaction Potential Analysis

Tehran Seismic Microzoning Boring No E37-23 VHD-0 E6

•

.

Tehran Seismic Microzoning Boring No E37-16 Khc=0.60

	Fw(z)			000	000	0.0	0.00	000	000	
	5 0	L							8	
	duda S									
	5	L								
	u. +	ſ		t .					۲. ۲	
	Depth (m)	4	ы 		2	; ; ; ; ;	2	20-		_
-	Judgement									
Γ	FL									
Sh	ear stress ratio	-								
s	ress reduction	┢								
-	factor r _d						<u> </u>			ake.
	R									arthqui
	RL	Ļ		<u> </u>						pe 1'e to be le
CE 130	Na									x: nol:
esistan	N1									or area) on case
280	c2									factor fe based be lequi
	cl									of cw is . to]
	cw	-	······							0 (corr latruon Ment
$\left - \right $				-	=	2				Cator Judge F.:
	v., (ti/m3)			1	8	<u>~</u>				
	ردستای <u>در</u>				8					
	1 ₁₁ (a.m.)	╞─		5.00	8	2,00	8	200	·	<u> </u>
	D10 (mm)			2	<u> </u>	<u>N</u>		N		
2	050 (mm)			S	5	5	8			
asic Da				8	2 0.0	8				<u></u>
ő	o _* '(kgl/cm²)			1.61	174	2.01	240			
	o _y (kgl/cm²)			1.630	1.890	2,430	ž	3,730		
	N value			13		2	ŝ	2		
	Vsı (m/sec)				280					
	Ground Type		1							
	Depth of alculation m			B.15	9 45	12.15	16 07	18 65		
┢━	2 G			8						
	vatu ater k 40 50	_					\sim			
	N La R			<u>ф</u>				5		
	8 Gov 8 Gov	<u> </u>		<u> </u>	0:	-0				
	Geology									
Γ	Depth (m)	8						21.00		
	ilevation (m)	_								
-	Scale (m)				9					

:

Γ	Fw(z)	7	8	0.00	00.0	000		8	
┢								- 0	
	otton C							<u> </u>	
	Distri] <u>;</u>	
	~~~~							= ۲	
F	Depih (m)	0		5		*	8	<u> </u>	•
	Judgement							_	
	FL								
s	hear stress ratio								
	Stress reduction								
$\mathbf{F}$									بو
	к	_						_	arthqu
	RL								o be let
2	Na								or Tys : not to
tance	NI		·····						
10		-							or for s sed on equifie
ľ	52	_				·	<u> </u>	{	on tacl visba: bobel ≥1.0
	c1				·				
	cw								
		-	 	=	5	5			1 2 2 4 1 2 2 4 1 2 2 1
	x (t/m3)		7	<u>~</u> 8	<u> </u>	~			
	7. (it/m ³ )		·	<u>6</u>					
			00	2 20	500	200	1		
	D10 (mm)		N						
	D50 (mm)		500	500	505	005			
	- 10 all - 7		C	 0					
ľ					2				·
l	σ _v (kgl/cm²)		0.830	1,630	5 430				
	N value		24	10	37	0 S			•
	Vsi (m/sec)			=					-
	Ground Type						<u> </u>		
ł	Depth of		15 1	13	513	22	<u> </u>		
-	Calculation m		**		¥	=		l	
	value Ner lev 40 50								
	N Tq: Nundwiz		e	4	<u> </u>				
	<u>ເມຣິ່ຣ</u>	_		<u></u>					
┝	Geology						<u> </u>		
şļ	Depth (m)	8	~						
	Scale (m)	-	a a a a a a a a a a a a a a a a a a a	;	2	5	2	• •	

ı

Liquefaction Potential Analysis

ı,

Tehran Seismic Microzoning Boring No E37-24

Tehran Seismic Microzoning Boring No E37-25 Khc--0.60

1		Fw(z)		8	0.0	00.0		8	8	
									0 10	
		nibution 2 3	_							
		- ¹ Det	_							
						·····	·	<del> </del>	1	
		Depth (m)	Ľ	» 		¥	÷	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		
		F.	┢─							
	Sh	ear stress ratio	_							
		L	_							
	51	factor r ₄								
		R								hquake
		RL	-							1° eart e lequi
		Na				· · · · · · · · · · · · · · · · · · ·	•••••••		{	Type of to b
	ance ra									se for X:n
	c resist	1M								for are d on cr juified
	Cyd≓	c2								) factor is base be leq
		c1								
		cw								0 (cor latiuon Oct 0
		Ec (%)	_			·····				Calcu Judge Fr:
		FC (#)		<u> </u>	g	<u>8</u>		<u>م</u>		
·		τ _α (μ/m ³ )				5				
				0; 0;	83	2		l		
		D10 (mm)		N	<u> </u>					
	Data	D50 (mm)		ŝ	500	500		1005		
	Base [	a 'ikalizm?)		 		<u>0</u>				
					0	<u></u>				
		a, (kgl/cm²)		0.43	0.BJ	503		6 0		
		N value		NA	8	<b>2</b>		ŝ		
		Vsi (m/sec)				580				
		Ground Type			-					
		Depth of alculation m		2.15	4 15	t0.15		18 15		
		8 69 8 65				<u>0</u>				
		N valu Water 1 0 40 5				D				
		Spund Ground								
	_	Geology					ΠΠΠΠΠ			
0		Depth (m)	0.00					80 D2	_	
9. Ç	E	Elevation (m)								
с ЧЧ		Scale (m)	-	<u> </u>	 N	<u> </u>		 8		52

Tehran Seismic Microzoning Boring No E37-26 Khc=0.60

•

Γ	Fw(z)	T	000	0.0	8	000	80	8	<u> </u>
	2 libuto								
	Date	$\downarrow$							
		$\square$			- <u></u>		·		•
	Depth (m)	ہ 	<u></u>	ыл 	<u> </u>	2	x		
-	Judgement								
	<b>۲</b> ۱						<u></u>		
	L								
St	ress reduction factor r								
П	R								atuake bi
	PI	-							earthy lequific
		_							to be
NCE FRIC	Na								X: not
esistar	N1								or artea on cas
Cyclic I	c2								i factor fo is based i be lequi c1.0
	c1								melation of cw i
	CW	-							1.0 (col culaturon germent Oct.(
	Fc (%)		181	79.1	191	78.1	79.1	<del></del> _	유입철 ^{다.}
	γ _e (tl/m3)				2.00				
	γ ₁₁ (tt/m³)				5.00	<u></u>			·
	1p		25.00	22.00	25.00	25.00	25.0		
	D10 (mm)								
c Data	D50 (mm)		0.005	6.005	0.005	0002	0.00		
Bas	a, '(kgi/cm²)		0.430	0071	1815	2215	2.815		
	σ, (kgl/cm²)		0.430	1,230	2.030	2.830			
	N vatue		28	30		<b></b>	<b>2</b>		 
	Vsì (m/sec)				284				
	Ground Type			-					
	Depth of Calculation m		2.15	6 15	10 15	14 15	18 15		
	e ee e ee	<b> </b> _			3				
	N valu water 1 0 40 5			V	*	~			
	TqS Tound	F	0				>		
-	⊙ ≌ Geology	-						<del></del>	-
$\vdash$	Depth (m)	2					<u>muuuuu</u> S		
	Elevation (m)	Ē							
-	Scale (m)	┝	<u> ,,.</u> ,			<u> </u>		_, , , _	
L_		_L				-			

Tehran Seismic Microzoning Boring No E37-27 Khc=0.60

							-			-
	Fw(2)	]	8.	0000	0.00	0.00	8		8	
	5 0	_				·			ġ	
	yindiri ≥									
	ۍ بي م	_		,,,					- ii	
_		_	<u> </u>	, <del>- ,</del>	·		<del></del>	<u> </u>	녝	
	Depth (m)	<u> </u> _'			¥	¥		<del>م</del>	_	
_	F	-							$\neg$	•
Sh	ear stress ratio							- <u>,</u>	-	
SI	ress reduction factor r									
	Ř									thquake. Itfied
	RL				<u>.</u>					pe 1" ear o be lequ
nce raio	Na	_							_	e for "Tyn X: not te
resista	N1									r area on cas fied
Cycle	c2			··· <b>···</b> ·····	·					factor fo s based be lequi
	cl			·····						netaton nof cwr b to to to
	CW							_		tculativo dgement Oct.
	Fc (%)	_	79 1	16/	<b>2</b>	78.1	62			8032
	Y ₁₂ (tl/m3)	_			50				_	
	Υ ₁₁ (11/m³)	_		Ô		o			_	
	lp		25.0	720	25.0	25.0	25.0		_	
_	D10 (mm)									
sic Data	D50 (mm)			0.00	1000 1000	000 0	0.00		$\square$	
Ba	σ, '(kgl/cm²)		0.430	1,230	1,915	2.365	2,715			
	cy (kgl/cm²)		0.430	062.1	2030	2.830	3,630			
	N value		2 E	=	*	:	16			
	Vsi (m/sec)				288					
	Ground Type			н					_	
C	Depth of alculation m		2.15	6.15	10.15	14.65	1815			
	atue r level so so	_				•••				
	f N vi dwate 30 40									
	S COUL				·····					
	Geology	_								
	Depth (m)	80						21.50	_	
E	levation (m)									
_	Scale (m)	-	<u> </u>	ю , , , , , ,	1 1 1	<u>ب</u>		8		S

0.00 000 80 8 Fw(z) 000 8 F_L Orstribution ო N PL=00 ģ . 5 **1**0. Depth (m) ò n Judgement FL Shear stress ratio Stress reduction factor r_d cc=10 (correlation factor for anea) Calculation of twi is based on case for Type 1' earthquake. Judgement: O' to be kequified X: not to be lequified  $F_1$ : O<1,0 ⊕ ≥1.0 R RL Cyclic resistance raio Na N1 c2 c1 CW Fc (%) 791 701 Ē 79.1 192 200 Y_e (ti/m3) γ₁₁ (tí/m³) 20 25.00 25.00 25.00 25.00 25.00 lρ 010 (mm) 0.005 0.005 0.005 0.005 0.005 1050 (mm) Base Data 2.515 1.230 1.915 2.115 2.015 σ, *(kgl/cm²) 2430 3.230 4.030 1,230 2,030 a, (kgl/cm²) 20 20 28 Ξ 8 N value Vsi (m/sec) 296 Ground Type -Depth of Calculation m 12.15 10.15 18 15 20 15 615 SPT N value Groundwater level 02 03 09 02 02 01 8 团 Geology . 23.00 Depth (m) 80 Elevation (m) ė 15. 20 Scale (m) 5. 25 ó

Liquefaction Potential Analysis

Tehran Seismic Microzoning Boring No E37-28 Khc=0.60
# Tehran Seismic Microzoning Boring No E37-29 Khc=0.60

		Fw(z)		000	0.00	0.0	000	00	000	
		ubon 3							٦°	
		Distrit 2	_			· · · · ·				
		- ^س					·			
	-	Death (m)				,_,_, <u>,</u> _,			<del>-</del> -+**	•
	_	Judgement		·=						
		F	_							
	Ch	"L								
	314	L								
	St	ress reduction							Ì	
			—							ake.
		к 								uffaqu Iuffed
		RL								19 19 19 19 19
	Si Si	 Na								e te
	ance I									
	resist	N1								or are lifted
	0,de O,de	c2								based based
		 c1								
				-			,	<u></u>		(correl ucon ol ant. (
		CW								o la louistico de marie
		Fc (%)		1.6	5	- -	19.1	181		88후교
		v. (tilm3)	_	~			8			
•							<u> </u>			
		I() (10111 7		8	8	8	5	00;		
		Ψ 010 (mm)		32	<u></u>					
				5			<u></u>	<u> </u>		
	c Dat	D50 (mm)		00.0	88	80				
:	Bas	a, '(kgl/cm²)		0.430	1330	216.1	2.315	2.715		
'		a (kni/cm²)		R	65		22	220		
				ð	2	X	2	ਲ		
		N value		16	a	*	=	:	 	-
		Vsi (m/sec)	1				541			
		Ground Type			···					
	1	Depth of		15	<u></u>	5	5	\$		
	C	alculation m		4	¢;	<u> </u>	41	8		
		atue at leve 50 6								
		N vs thvate				- M				
		SPUN SPU	_	0				0		·····
	_	Geology	-							
_		Deoth (m)								8
2.6	┝╍╸		0.0							
Ĩ	8	ilevation (m)								
Ż		Scale (m)	6	· · · · · · · · ·	n	5	1 1 1	20		50 10 10

٠

.

	Fw(z)		00 0	0.00	0.00	80	 8	
	F _L Distribution 1 2 3						 =00, 0=0,(	
	Denth (m)				· <del>-</del> ·····		 嶂	:
	Judgement	-				-		-
	FL							
Sh	ear stress rabo							
St	ress reduction factor r _d						 	_
	R							nquake. Ređ
	RL.						 	-1" earl oe lequi
e raio	Na							or Type : not to 1
resistanc	NI						 	or area) on case f ified X
Q Q Q Q	c2							factor f s based be lequ 1.0
	c1							of cwit
	CW							0.1.0 (cor sulation Dement :
	Fc (%)		1.62	1.62	1 62	79.1		
	Y ₀ (tt/m3)					2.00		
	ץ _{נו} (ឃ/៣³)					2.00		
	lρ		25.00	25.00	25.00	25.00		
	D10 (mm)		·····					
x Data	D50 (mm)		0.005	0.005	0.005	0.005		
Bas	a" (köl/cm²)		0.430	1,230	2,015	2.415		
	σ, (kgí/cm²)	:	0 430	1,230	2.030	2.830		
	N value		12	10	•	Ξ		
	Vsi (m/sec)					222		
	Ground Type			-				
C	Depth of alculation m		2.15	6.15	1015	14.15		
	tevel So So				8		 	·····
	N val Water 0 40						 	
	SPT Spund Spund		0				 	
	Geology Geology							
_	Depth (m)	000					 لللسب	22.28
E	ilevation (m)					-		
	Scale (m)		· · · · · · · · · · · · · · · · · · ·			<u> </u>	1 1	

Tehran Seismic Microzoning Boring No E37-30

1

-

Tehran Seismic Microzoning Boring No F49-1

5	
ŭ	_
Ž	200
5	Ĩ
٥	2

Γ	Fw(z)	$\Box$	0.00	0.00	80		000
	dindin ⊳ ottodin	L					
	1 Dest						
	_	L	<b> </b>	<del></del>	-,		
	Depth (m)	Ľ			<u>م</u>	5 22 2	
-	Judgement	┢┉			—		-
	F	L			<u> </u>		-
I SI	near stress rabo L						
s	tress reduction factor r						-
F	R						quake.
	RL	┢			-		e lequit
20	Na	╞╌					or Type
sistance	N1	╞					area) area) ed X;
Cyclic re	c2	┢					actor for based o e lequiñ 0
	c1	┢		<u> </u>			elaton f of cwis of: to ty ≥1.
		┢					(corr atruon C<1.0
┝		-	-	-	-	,	cz=1.0 Calcul Judge F ₁ : (
		$\vdash$	Ŕ	<u>*</u>	2		
	Υ ₂ (10/11-5)	-		,			
	10 In		8	90'3	8	8	
	010 (mm)		Ň		3		
ata	D50 (mm)		50	502	005		
Base D	σ '(kqi/cm²)		000	550 D	930 Q		
	a (kat/cm²)	-	080	550 G.	930 Q.		-
			<i>0</i>	3	۲ ۵		
	IN VAILUE	<u> </u> _	-	-			1-
	Vsi (mvsec)	<u> </u>					
-	Ground Type	_		~	-		
4	alculation m		¥0	2.71	16		
	slue r level So 60	╞				······································	
	T N vz rdwałe 30 40	_				<u></u> ₩	
	R Ground		<b>。</b> —		0		
	Geology						
	Depth (m)	800	 				35.00
; ; [	Elevation (m)						
Ē	Scale (m)	6	)			² ² ² ² ²	

-

•

Tehran Seismic Microzoning Boring No E49-4 Khc=0.60

												_		_
Γ	Fw(z)	$\Box$	80	80	0.0	80		2.95	00.0	000	80	8		
	5 0											e		
	lributo 2											;		
	F, Dist													
					··			•	<u> </u>			<u>i</u>		
	Depth (m)	-	, T		دي 				¥	+	5 			
$\vdash$	Judgement							<u>9</u>	h					
-														
	L							u.52						
S	ress reduction factor r							0.835						
	R							18		_			luake. d	
													eartho	
		_						<u>8</u>	<u></u>				ype 1 to be	
1 2 2 2 2	Na							716					e for 1 X: not	
resistar	N1							7.221					or area) on cas fied	
Cyclic	c2							662.0					actor fo based be lequi	
	c1							084						
								8					(corre teuon o cent · (	
	CW												Z=1.0 Valouta Conta	
	Fc (%)		791	3	79.1	2		2	, in the second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second	79.f	1			
	Y ₂ (II/m3)		2.00	2.10		2.00		2.10			0 50			
	ץ _{וו} (נו/m²)		50	510				2.10	8	8	8			
	lp		25.0		25.0	250				25.1	25.	-		
	D10 (mm)		5			LO LO	<u> </u>	0			<u>ي</u>			
sc Dat	D50 (mm)		000	2.10	000	60		510	80	8	8			
ä	o, '(kgi/cm²)		0130	163.0	0.845	1.245		2,125	2,405	2.775	3.015			
	σ, (kgl/cm²)		1 [30	1437	1845	345		2225	2770	3.510	0667			
	N value							13	<u>n</u>		:			-
	Vei (mlear)	-	-					-			0		<u></u>	
	Ground Turns		30	22		<u> </u>		<u> </u>	[		38	·		
$\vdash$	Depth of		10					8		33	75		·	
	alculation m		90	ភ	Ŧ			=	13	2	<u>4</u>			
	ratue er leve o so st							ĕ ₽						_
	PT N mdwat		5	~	~	>		₽ <u></u>			$\leq$			
	5 C C S								<u></u>					
	Geology												ШШЦ	
	Depth (m)	80	5	3.0			10.00	12.50					25.00	
	Elevation (m)													
	Scale (m)	6	<del>ا – ا</del>	••••			, , è	2	‡ 		20-	, ,		

•

,

Tehran Seismic Microzoning Boring No E49-8 Khc=0.60

_			1.0		<u>~</u>		• • <u>•</u> —•	·
L	Fw(z)	L	<u>х</u>	ĕ	ě – – – – – – – – – – – – – – – – – – –	ŏ	_   g	
	c m	L				•		
	2 libuto							
	Distr 1						_ ;	
ļ	Ц.,							
	Depth (m)	1	0	s 5		8		:
	Judgement			···-·				
Į	FL							
SI	hear stress ratio				······	· • · • • • • • •		
s	tress reduction factor r _e							
	R							hquake.
	RL							e 1° cart be lequr
2021 22	Na							for "Typ. C: not to
resistan	NI							X area) on case
Cyclic	c2							factor fe s based be lequi f 0
	cl							nelation O.Covit
	CW							10 (30 Catabuod gement Oct.(
	Fc (%)		78-1	79.1	78.1	1.87		B2월단
	ץ _פ (ווֹ/ח3)			500				
	ץ _{נו} (נו/m²)			2.00				
	lp		25.00	25.00	25.00	25.00		
	D10 (mm)			-	-			
c Data	D50 (mm)		0.005	2005	0.005	0.005		
Base	σ, '(kgi/cm²)		0.130	1 630	2415	2.815		
	σ, (kgi/cm²)		0.130	1.630	2.830	0535		
	N value		17	40 	<del></del>	24	1	
i	Vsi (m/sec)			262				
	Ground Type		<b>н</b>	,				
с	Depth of alculation m		0.65	B.15	14.15	18.15		
	evel B 25		<b>-</b>	0.0				
	a ser	_						
	- tas		- G	······································		O		· · · · · · · · · · · · · · · · · · ·
	<u><u> </u></u>	_					·	
	Geology	_						
	Depih (m)	0.00				20,50		
E	levabon (m)			·····		_ <b></b>	···	
	Scale (m)	0		•• £	5	8	-	8

ī

Appendix III: Ambient Vibration Measurement

-

•

.

# The Study on the Seismic Microzoning of the Greater Teheran Area in the Islamic Republic of Iran

**Ambient Vibration Measurements on Buildings** 

# **Final Report**

Prepared for: Pacific Consultants International JICA Study Team for the Study on the Seismic Micro-zoning

Principal office: Centre for Earthquake & Environmental Studies of Tehran (CEST) 63 Padidar St. Africa Blvd Tehran 15189, Iran

> Magnetics Co. Principal office: Philips Building, 878 Enghelab Ave. 11318 Tehran Islamic Republic of Iran

#### Teheran, Iran July/August 2000

# TABLE OF CONTENT

- 1. Introduction
- 2. Project outline, place and time
- 3. Methods and equipment used
  - 3.1 Equipment description
    - 3.1.1 Sensors
    - 3.1.2 Sensor installation
    - 3.1.3 Data logger
    - 3.1.4 Power, cabling, grounding, and shielding
    - 3.1.5 Processing computer
  - 3.2 Equipment preparation and verification
    - 3.2.1 Sensor calibration data and calculation of loaded generator constant and external damping resistors
    - 3.2.2 Verification of signal to noise ratio of measurements
    - 3.2.3 Verification of instrument transfer function correction accuracy
  - 3.3 Field measurement procedure
    - 3.3.1 Physical procedure
    - 3.3.2 Sensor excitation considerations
    - 3.3.3 Duration of the measurement
    - 3.3.4 Field data verification
    - 3.3.5 Information about measuring conditions
    - 3.3.6 Data backup
  - 3.4 Data processing
    - 3.4.1 Measurements order
    - 3.4.2 Raw data editing
    - 3.4.3 Processing of edited data
- 4. Results
  - 4.1 Locations of the measured buildings and file coding
  - 4.2 Results
    - 4.2.1 Raw and edited waveform data
    - 4.2.2 Instrument corrected power density spectra and their ratio
    - 4.2.3 Determination of peak values of power density spectra measure on top of the
    - buildings and spectral ratios
    - 4.2.4 Data CD description
- 5 Appendixes
  - 5.1 Field measuring condition forms
  - 5.2 Raw, edited and zoomed waveforms and data editing details
  - 5.3 Spectral data and ratios
  - 5.4 MatLab data processing details
    - 5.4.1 General procedure
    - 5.4.2 PSD.m function
    - 5.4.3 Custom made .m functions
  - 5.5 Sensor technical specifications
  - 5.6 Sensor calibration sheets

5.7 Data logger technical specifications

# ERRATA!

Upon completion of this report we were informed that Site R4 is not "Reinforced Concrete Construction" type, but is "Steel Construction" type. So every where in the DATA-CD, R4 should be replaced by S8 and considered as a steel construction building read as S8.

•

# 1. Introduction

Based on a contract entered into on 24 June 2000 the JICA Study Team for the Study on the Seismic Micro-zoning in the Greater Tehran Area on the one party and with its principal office at c/o Centre for Earthquake & Environmental Studies of Tehran (CEST), and Magnetics Co. on the other party with its principal office Philips Building, 878 Enghelab Ave., 11317 Tehran, Islamic Republic of Iran, Magnetics Co. performed ambient vibration measurements of typical buildings in Tehran and their analysis. The measurements and data processing were performed according to 'Technical Specification for Ambient Vibration Measurements' document issued by JICA Study Team and based on discussions with JICA team before starting field work and analysis.

According to 'Technical Specification for Ambient Vibration Measurements' document, Magnetics Co. has to provide to JICA Team a 'Final Report' covering the information about fieldwork, measurements performed, results, and raw and processed time-waveforms of measurements. This document represents the final report.

# 2. Project outline, place and time

Ambient vibration measurements on typical building in Tehran are a part of broader microzoning project, which will contribute to better earthquake risk mitigation in broader Tehran region. Ambient vibration measurements on the buildings include following phases:

- determination of measuring buildings,
- determination of measuring sites within the buildings from civil engineering and measurement condition consideration,
- measurements of ground motion on the ground floor and top of twenty-four buildings,
- calculation of ground motion power density spectra, spectral ratios, particle motion of the top of the buildings, and
- interpretation of the results in terms of earthquake resistance civil engineering aspect and expected seismic input.

The first phase – determination of measuring buildings – was performed by CEST and JICA Study Team. During the fieldwork precise locations of measuring instruments within the building were determined. The lower sensor was set at ground level (as much as the actual building design allowed) without respect how many underground stories the buildings have. In general, to upper sensors were put on the last fully build store of the buildings. Details are given in site description.

The measurements and calculation of ground velocity power density spectra (PDS) and spectral ratios was performed by Magnetics Co. Dominant peaks in PDSs as well as in spectral ratios were determined, however based purely on the calculated results and without any association with civil engineering, or any other criteria.

JICA team will perform interpretation of PDSs and spectral ratios.

The measurements were performed between July 15, 2000 and July 27, 2000. Table 2.1 shows a list of all buildings measured and the date and time of the measurements (local time).

No	Site	Type of the	No. of floors	Me	asurement
	code	building		Date	Time
1	R5	reinf. concr.	7	15/07/2000	15:40 - 18:10
2	S5	steel constr.	12	16/07/2000	09:35 - 12:45
3	R2	reinf. concr	17	16/07/2000	03:30 - 18:45
4	CEST	steel constr	7	17/07/2000	9:45 - 12:30
5	R8	reinf. concr	5	17/07/2000	15:00 - 18:30
6	R6	reinf. concr	6	18/07/2000	9:45 - 12:30
7	S3	steel constr	16	18/07/2000	14:30 - 18:15
8	S6	steel constr	11	19/07/2000	10:15 - 13:30
9	S14	steel constr	3	19/07/2000	15:15 - 18:30
10	S13	steel constr	4	20/07/2000	10:00 - 13:00
11	S11	steel constr	5	20/07/2000	14:45 -18:10
12	S7	steel constr	8	21/07/2000	9:30 - 13:15
13	R11	reinf. concr	4	21/07/2000	15:00 - 18:15
14	R1	reinf. concr	21	22/07/2000	11:15 - 14:15
15	S4	steel constr	13	22/07/2000	16:30 - 19:45
16	S8	steel constr	9	23/07/2000	10:15 -13:20
17	R12	reinf. concr	3	23/07/2000	15:00 - 18:00
18	R13	reinf. concr	13	24/07/2000	10:30 - 13:50
19	S1	steel constr	24	24/07/2000	18:00 - 21:45
20	R3	reinf. concr	13	25/07/2000	10:30 - 14:00
21	S2	steel constr	16	25/07/2000	15:15 - 19:00
22	R14	reinf. concr	10	26/07/2000	11:15 - 14:20
23	M1	masonry	2	26/07/2000	18:00 - 20:45
24	M2	masonry	3	27/07/2000	10:30 - 13:10
25	M3	masonry	2	27/07/2000	14:30 - 17:00
26	M4	masonry	6	27/07/2000	17:30 - 19:50

Table 2.1. Date and time of measurements

Site codes reflect design information of the buildings. S means steel construction, R means reinforced concrete construction, and M means masonry building.

All information about parameters relevant for interpretation of seismic signals is collected in Field forms, Appendix 5.1. Building properties as well as photo documentation, wind conditions, weather conditions, sensor installation details (if applicable), and information about activity of main building's noise sources (elevators, air-condition, etc.) during the measurements is given in these forms along with data acquisition parameters and general building information. For

building identification purposes two pictures of it and a small map is also provided in these forms.

## 3. Methods and equipment used

#### 3.1 Equipment description

## 3.1.1 Sensors

Kinemetrics SS-1 seismometers were used in these measurements. SS-1 is a typical short period (SP) seismometer. Its output is proportional to ground velocity. Its nominal resonance frequency is 1 Hz. Its frequency operating range is from about 0.1 Hz to over 50 Hz. Relative damping is adjusted by an external damping resistor, usually for nominal relative damping 0.7. Frequency response amplitude is asymptotically flat above resonant frequency and decays below it with -40 dB/dec slope. As it is a passive sensor it doesn't require external power. This fact and its mechanical robustness make it very suitable for fieldwork. Also it has no DC offset voltage problem since it is a passive device.

Usage of SP seismometer in ambient vibration studies facilitates fieldwork and lowers its cost.

Technical details can be found in Appendix 5.5 and on http://www.kinemetrics.com.

#### **3.1.2 Sensor installation**

On all sites we measured on the floor of existing buildings. Hard floor like concrete, ceramics, or solid brick was used.

## 3.1.3 Data logger

We used Kinemetrics SSR-1 S/N 104 seismic data recorder for data acquisition. The data logger has three input channels with common sampling (negligible time skew among channels) and triggering. Its nominal resolution and dynamic range corresponds to 16 bit A/D conversion. At the front end it has a preamplifier with software selectable gain among 1, 10, 100, and 1000. Frequency response is flat from DC to antialiasing filter corner frequency (-3 dB point).

We used 62.5 Hz sampling rate and a 15 Hz antialiasing filter in all channels. The reason for 62.5 Hz sampling is mitigation of 50 Hz interference. Although 50 Hz interference (through the ground and via EMI) can not be directly seen in measurements, which upper frequency range is 10 Hz, cross-modulation distortion which generates spectral components equal to the difference between sampling frequency and 50 Hz may appear in spectra. This difference equals to 12.5 Hz in our case, which is also outside our frequency range of interest, and can therefore not interfere with the measurements.

More details about data logger can be found in Appendix 5.7. and on http://www.kinemetrics.com.

# 3.1.4 Power, cabling, grounding, and shielding

Measuring equipment was powered by main 220 V power.

Three heavy shielded 5m long cables connected the sensors with the data logger. One of them was extendable up to 65m. 'Floating' grounding scheme was used. That means that the shielding of sensor cables was connected to equipment boxes on both sides - to data logger case and to sensor cases. To prevent ground loops, sensors were isolated from electric ground by dry floor. No external instrumental grounding was used.

We used standard, 10 m long, shielded RS232 cable to connect the data logger with the laptop computer for data retrieving.

#### 3.1.5 Processing computer

During field measurements we used either IBM ThinkPad 380D or Zeos Notebook 386+ laptop computer for adjusting data acquisition parameters, data retrieving, verification, and for in-field data back up on 3.5" floppy diskettes.

## 3.2 Equipment preparation and verification

Complete instrumental set up was tested on July 15, 2000 at Magnetics Co. offices for potential technical imperfections and accuracy of amplitude frequency response function of all three channels. The frequency response function accuracy test was also performed on July 29, 2000 after fieldwork was finished at the same place. No changes in measuring equipment were observed, which assures accurate results.

Self noise test of the same equipment was performed in November 1999.

# 3.2.1 Sensor calibration data and calculation of loaded generator constant and external damping resistors

Kinemetrics SS-1 SP seismometers SS-1 S/N 2004, SS-1 S/N 2006, and SS-1 S/N 2511 with following characteristics were used in the measurements.

## (1) SS-1 S/N 2004 Vertical component

Natural frequency (vertical) f ₀ :	0.936 [Hz]
Coil resistance R _e :	5644 [ ]
0.7 relative damping resistor R _{07d} :	4957 [ ]
Relative damping :	0.707 [-]
Open generator constant G ₀ :	336 [Vs/m]
Loaded generator constant calculation:	

$$G_{L-V} = \frac{G_0 \cdot R_{07d}}{R_{07d} + R_c} = \frac{336 \cdot 4957}{4957 + 5644} = 157 \quad [Vs/m]$$

External damping resistor calculation.

Internal input resistance of SSR-1 data logger  $R_{in-SSR} = 100$  [k] must be taken into account in external damping resistor  $R_{d-ext}$  calculation.

 $R_{in-SSR} = 100.000$  []

$$R_{d-ext} = \frac{R_{m-SSR} \cdot R_{07d}}{R_{m-SSR} - R_{07d}} = \frac{1e5 \cdot 4957}{1e5 - 4957} = 5215 \ [ohm]$$

#### (2) SS-1 S/N 2006 N - S component

Natural frequency (horizontal) f ₀ :	0.986 [Hz]
Coil resistance R _c :	5799 [ ]

0.7 relative damping resistor R _{07d} :	4670 [ ]
Relative damping :	0.707 [-]
Open generator constant G ₀ :	338 [Vs/m]
Loaded generator constant calculation:	

$$G_{L-NS} = \frac{G_0 \cdot R_{07d}}{R_{07d} + R_c} = \frac{338 \cdot 4670}{4670 + 5799} = 151 \quad [Vs / m]$$
  
External damping resistor calculation:

Internal input resistance of SSR-1 data logger  $R_{in-SSR} = 100$  [k] must be taken into account in external damping resistor  $R_{d-ext}$  calculation.

 $R_{in-SSR} = 100.000$  []

$$R_{d-ext} = \frac{R_{in-SSR} \cdot R_{07d}}{R_{in-SSR} - R_{07d}} = \frac{1e5 \cdot 4670}{1e5 - 4670} = 4898 \ [ohm]$$

#### (3) SS-1 S/N 2511 E - W component

Natural frequency (horizontal) f ₀ :	0.955 [Hz]
Coil resistance R _c :	5918 []
0.7 relative damping resistor R _{07d} :	5235 [ ]
Relative damping :	0.707 [-]
Open generator constant G _o :	352 [Vs/m]
Loaded generator constant calculation:	

$$G_{L-EW} = \frac{G_0 \cdot R_{07d}}{R_{07d} + R_c} = \frac{352 \cdot 5235}{5235 + 5918} = 165 \quad [Vs / m]$$
  
External damping resistor calculation:

Internal input resistance of SSR-1 data logger  $R_{in-SSR} = 100$  [k] must be taken into account in external damping resistor  $R_{d-ext}$  calculation.

 $R_{m-SSR} = 100.000$  []:

$$R_{d-ext} = \frac{R_{in-SSR} \cdot R_{07d}}{R_{in-SSR} - R_{07d}} = \frac{1e5 \cdot 5235}{1e5 - 5235} = 5524 \text{ [ohm]}$$
  
Actual external damping resistors used were:

S/N2004 = 5220 [] S/N2006 = 4920 [] S/N2511 = 5490 []

#### 3.2.2 Verification of signal to noise ratio of measurements

We checked system self noise of the equipment used in this measurements in November 1999. The complete equipment set-up was installed as for a regular measurement except that all three sensors were oriented in vertical position and that their mass weight compensation springs were released. In this way they were 'clamped' by the weight of their moving mass. A 15 min record of system noise was recorded and processes exactly as mictrotremor measurements. This test is the most rigorous possible since it includes all types of instrument noise in the system – sensor self noise, data logger's quantization noise, data logger analogue noise, and all EMI induced noise. Actually this test is over-conservative at high and low frequency end of frequency band of interest. This is due to the fact that at high frequencies clamping doesn't completely prevent moving mass motion and the resultant noise may be higher than true system self-noise. Also at low frequency end clamping can not prevent minute motion of sensor mass due to temperature changes and material properties. Also here the result of this test are too pessimistic.

Note also that system noise depends on measuring site conditions. Temperature changes, EMI interference, and warm-up time of equipment change from site to site. All these factor influence system noise particularly at low frequency end.

The test measurement was performed in a seismically quiet, bed rock site outaside the town.

The resultant PDSs of the noise of all three channels are given on Fig. 3.1. System self noise is expressed as ground velocity power density in  $[m^2/s^2/Hz]$ . It is sensor transfer function 'corrected' (spectral division method). Therefore it can be directly compared to the ambient vibration PDSs in Appendix 5.3.



Figure 3.1 PDSs of measuring system self noise – vertical, N-S, and E-W channel

System noise is much lower than the signals measured during ambient vibration measurements in the whole frequency range of interest. High dynamic range of measurements is to some extent deteriorated at low frequency end of measurements. The S/N ratio decreases because of decreasing sensitivity of SP seismometers. However, this didn't impair the measurements.

#### 3.2.3 Verification of instrument transfer function correction accuracy

Short period (SP) seismometers have asymptotically flat response to ground velocity above their resonant frequency (roughly 1 Hz for SS-1 sensors). Below resonant frequency their sensitivity falls wit a -40dB/decade slope. One of requirements of this study was flat data from 0.1 to 10 Hz. Therefore we have to correct sensor response. Spectral division method was used. Measured PDSs were divided by square (due to power signal) of sensor transfer function.

Parameters resonant frequency  $f_0$ , open loop generator constant Go, and relative damping of sensors are given in sensor calibration sheets. The accuracy of these factory determined parameters generally suffice for observation of spectra of seismic signals. However, when ratio of spectra is desired the accuracy of data in calibration sheets may become insufficient, particularly if the calibration of sensors was performed long time ago. Also inaccuracies of actually soldered damping resistors and internal input resistance of data logger and cables may result in slightly inaccurate loaded generator constant  $G_L$  and relative damping calculation. Therefore we fine tuned  $f_0$ ,  $G_L$ , and of all sensor in such a way that a given input to all three sensors resulted in identical spectra.

All three sensors were installed as for a regular measurement, except they were all oriented horizontally and carefully aligned in the same direction (see Figure 3.2).





This assures an equivalent input to all three sensors. A 20 min record of seismic noise was acquired and instrument corrected spectra calculated and plotted on the same graph. By slight changes in  $f_0$ ,  $G_L$ , and we optimised the agreement of all three spectra. By observing frequency band around 10 Hz we optimised  $G_L$  (other two parameters  $f_0$  and do not influence the response in this range). Next, observing frequency band from 0.1 to 0.4 Hz we optimised  $f_0$  (parameter does not influence the response in this range). Finally observing frequency band from 0.8 Hz to 1.2 Hz

(that is where relative damping influences the response) we optimised (other two parameters  $f_0$  and  $G_L$  are already optimised).

The measurements were performed at Magnetics Co. in Tehran downtown, in a second floor of a seven-story building, during the day. This check was made before we started and after we finished ambient vibration measurements. No significant differences were observed. This assures that there were no changes in recording parameters during the work. Data of both tests are given on data CD attached to this report.

The final agreement of spectra of all three channels is shown on Figure 3.3. (full frequency range). Details are shown on Figure 3.4 for high frequency end, on Figure 3.5 for frequencies around sensor resonant frequency, and on Figure 3.6 for low frequency end.



Figure 3.3 Coincidence of PDSs of the same ground motion input to all three measuring channels (full frequency range)



Figure 3.4 Coincidence of PDSs of the same input to all three measuring channels (detail at high frequency end from 8 Hz to 9 Hz used for G_L adjustment)

Small stochastic differences between channels observed mainly at extreme low frequencies are due to system noise and can not be nullified by sensor parameter adjustments.



Figure 3.5 Coincidence of PDSs of the same input to all three measuring channels (frequency range from 0.8 Hz to 1.2 Hz used to adjust )





Final sensor parameter values used in data processing are given in Table 3.2.

Sensor	Loaded generator constant G _L [Vs/m]	Resonant frequency [Hz]	Relative damping [-]
SS-1 S/N 2004	157.0	1.045	0.64
SS-1 S/N 2006	154.2	1.02	0.70
SS-1 S/N 2511	158.7	0.965	0.75

Table 3.2 Sensors' parameters used in data processing

#### 3.3 Field measurement procedure

#### 3.3.1 Physical procedure

All buildings were measured during the day. Undesired local seismic sources, which could influence only one measuring site (top or bottom), were searched for. The micro locations of measurements were agreed with CEST personnel. If at all possible elevators and air-condition generators were switched off during the measurements. Notes about general conditions were made

Seismometers were put on the ground, unlocked, connected to well marked cables, oriented (estimated accuracy of orientation is +/-3 deg from desired direction), and their moving mass position was centred.

Cables were uncoiled from the bobbin and connected to data logger. Data logger was switched on immediately after arrival to the site to allow about 15 minutes warm-up time at each site during which the electronics thermally stabilised.

Data logger was connected to Zeos Notebook 386+ or IBM ThinkPad computer via RS232 cable. The distance between sensors and the person who operated the

computer during the measurements was about 5 to 10 m. Moving of people around was mitigated as far as possible.

First a brief test of incoming signals and SSR-1's main and lithium battery voltage was performed using DG9 command (DVM function). Next a short test record was made, data was retrieved and checked for unexpected man-made noise sources, peak-peak amplitude values, potential clipping, and other technical problems. Preamplifier gain was set for maximal resolution of data acquisition. Then the measurement was started manually by setting 'votes to trigger' parameter (#57) of SSR-1 to 0.

During the measurement accompanying persons prevented people to approach the measuring site.

After termination of the measurement, data were retrieved to the laptop and inspected. An immediate backup of raw data was made on diskettes.

During the measurements we experienced no technical problems with equipment.

#### **3.3.2 Sensor excitation considerations**

Ambient vibration measurements should be performed in as much as possible constant conditions without excessive disturbances of man-made seismic noise on a single measuring site. High amplitude seismic noise bursts and spikes on top only or ground floor level only, even if outside the frequency band of interest, may via spectral leakage and/or aliasing, contaminate measurements.

Man-made, natural seismic noise and wind are the main sources of building excitation. If they excite both measuring sites, top and ground floor, they are a desired signal. If only one site is excited, like walking next to ground floor sensor this may unfavourably influence spectra ratio results.

Since weather and wind conditions influence the building excitation, we gather information about these two measuring conditions as well.

The main problem in buildings are elevators and air-condition equipment (with engines on top of the buildings) and walking of inhabitants too close to the seismometers. To stop local human activities was particularly difficult on the buildings still under construction (from economic reasons).

An effective measure is to switch off elevators and air-condition equipment and to prevent walking too close to the sensors by a portable fence.

Measurements were taken during the day. Details can be from Appendix 5.1.

#### 3.3.3 Duration of the measurement

Generally all measurement lasted 30 minutes. Only in some cases where dominant frequency was evident from time domain, we shortened the measurements. However, all measurements are longer than 15 minutes.

#### 3.3.4 Field data verification

In field data inspection included verification of peak-peak values of the signal in scope of potential record clipping and in scope of dynamic range of data acquisition. The gain of the preamplifier in the data logger was adjusted optimally for the best data resolution. Practice showed that we could use maximal preamplifier gain 1000 on some sites only and mostly on ground floor level. Most channels were recorded with the gain 100.

Data were also zoomed-in in time domain to inspect signals in terms of other potential irregularities, technical problems, or unexpected man-made seismic noise sources. No spectra were calculated in the field.

#### 3.3.5 Information about measuring conditions

For competent raw data editing and interpretation of spectra we gathered information about general conditions at the site and the conditions during the measurements. This included a description of weather condition, wind condition, and known man-made sources of seismic noise. Details for each site can be found in Field forms in Appendix 5.1.

#### 3.3.6 Data backup

In the field, raw data was immediately copied to diskettes. A second backup copy of raw data was made after returning from the field and kept on a different place.

#### 3.4 Data processing

#### 3.4.1 Measurements order

Ideally a single three-component measurement of ambient vibration on top and at the ground floor level would suffice to obtain all desired information. For such measurement a six-channel data logger is required. Unfortunately only a three-channel recorder was available. Therefore we made three measurements on each building.

The first measurement was a two-channel measurement. Top (channel 2) and ground floor level (channel 1) vertical motion was measured. The second measurement was a three-channel measurement. Channel 1 was ground floor longitudinal motion, channel 2 was top longitudinal motion, and channel 3 was top transversal motion. The third measurement was also a three-channel measurement. The channel 1 was ground floor transversal motion, the channel 2 was top longitudinal motion and channel 3 was top transversal motion (the same as in the second measurement).

From the first measurement we get vertical top and ground floor spectra and top/ground floor motion ratio. From the second measurement, channel 1 and channel 2, we get longitudinal spectra and ratio. Channel 3 was not used in data processing. From the third measurement, channel 1 and channel 3, we get transversal spectra and ratio. From channel 2 and channel 3 we get top particle motion.

Seismometers were always oriented in such a way that positive voltage denotes ground motion up during vertical measurements and toward northern half space for the channel 2 and eastern half space for the channel 3.

#### 3.4.2 Raw data editing

In the first step binary SSR-1's files were re-formatted to ASCII format. Kinemetrics CNVA.EXE program performed this conversion. Raw ASCII data was inspected for excessive seismic noise amplitudes, spikes, and noise bursts. All channels of a single measurement were displayed simultaneously and inspected for excessive noise interference. On many records, too noisy portions of the signal were cut out in all channels and remaining data concatenated. No special attention was paid to discontinuities of the signal at concatenation points.

MatLab was used for editing data. Raw and edited waveforms are graphically given in Appendix 5.2 for visual inspection. Details about editing for each site can also be found in Appendix 5.2. in the form of MatLab concatenation commands.

A MatLab command line like:

er5m2ch1 =[ r5m2ch1(1:1000); r5m2ch1 (1100:69000); r5m2ch1 (70000:98461)];

means: edited data file of the site r5/measurement #2/channel 1=longinal direction contains raw data from sample 1 to 1000, from sample 1100 to 69000, and from sample 70000 to the end of the record. Samples from 1001 to 1099 and from 69001 to 69999 are wasted.

#### 3.4.3 Processing of edited data

#### (1) Power density spectra (PDS) calculation

Power density spectra were generally calculated from edited data files. Only a few cases, there wan no need to edit data and the spectra are calculated from raw data. MatLabs psd.m function was used. Its details can be found in Appendix 5.4. With JICA staff we agreed for the following processing parameters:

- 1024 point data windows, resulting in 512 point spectra,
- duration of measurements from 15 to 30 minutes,
- Hanning weighting window applied,
- 25% data points window overlap,
- no confidence level of spectra calculated, and
- linear detrending of data windows is applied.

#### (2) Instrument correction of power density spectra

Calculated PDSs were instrument corrected by spectral division method. We divided calculated PDSs by square value (we deal with signal power!) of individual sensor transfer function to obtain flat response in frequency range from 0.1 Hz to 10 Hz. Details can be found in Appendix 5.4.

Spectra were not corrected for antialiasing filter transfer function in frequency range above ~10 Hz. The six pole analogue antialiasing filters cause certain amplitude distortion in this frequency range. Nominally the amplitude response of these filters is -3 dB down at 15 Hz. Phase distortion is unimportant.

#### (3) Spectral ratio calculation

We calculated three spectral ratios

- vertical top to vertical ground floor (measurement #1),
- horizontal longitudinal top to horizontal longitudinal ground floor (measurement #2),
- and horizontal transversal top to horizontal transversal ground floor (measurement #3).

Custom made MatLab .m function was used for calculations. Details are given in Appendix 5.4.

(4) Particle motion calculation

Particle motion on top of the building was determined from channels 2 and 3 and measurements #3. Both horizontal components were measured on top of buildings during these measurements. Motion velocity is displayed. Only 5000 samples of data are displayed, since this gives a better picture of particle motion. These data were taken mostly from the beginning portion of raw or in some cases of edited data. Particle motion graphs are shown in Appendix 5.3.

# 4. Results

# 4.1 Locations of the measured buildings and file coding

Buildings location are given on maps in the Field forms in Appendix 5.1. Site codes reflect buildings design. R means reinforced concrete buildings, S means steel constructions, and M means masonry buildings. Two pictures of each building are also shown for identification and a brief overview of the design of the buildings.

# 4.2 Results

Results are given in graphic forms for each measured building. Raw data waveforms, edited data waveforms, and zoomed (10 s duration) section of data are given in Appendix 5.2. Top and ground floor spectra along with their ratio are given in pairs for each measuring direction separately. Particle motion on the top of the building is displayed in the last graph. Spectra and ratios are shown in Appendix 5.3.

# 4.2.1 Raw and edited waveform data

Graphs of recorded raw signal and edited signal are published in Appendix 5.2. Both types of graphs have samples on abscissa. This facilitates editing of data, since it is easier to determine, which samples should be cut out due to an excessive man made seismic noise.

In addition, a third graph is given with zoomed signal in time domain. Ten seconds of signals are shown. This allows visual estimate of dominant period from time domain. Abscissa shows time in seconds. Note that these are uncorrected velocity signals. Low frequencies below 1 Hz are under valued in amplitude due to sensor transfer function.

Raw (.ssr, .001, .002, and .003 extension) and edited data ASCII files (.dat extension) are stored on data CD under '/data/"site-code" subdirectory for each site separately. Data of each channel is separated (except in data logger's own files with .ssr extension). Raw data file names start with 'r', 's', or 'm' reflecting type of the building. Number of the site follows. Following 'm' and the number denote measurement number (1 = vertical, 2 = horizontal/ longitudinal, 3 =

horizontal/transversal + particle motion). Channel number is also given (ch1, ch2, ch3). Edited data file names use the same coding, but start with an 'e' (edited data). A file name 'er11m3ch3.dat' therefore means: edited transversal motion from channel 3 (top of the building) at the reinforced concrete building number 11.

These subdirectories also contain original three-channel files in SSR-1's internal binary format. Their extension is '.ssr'. These files can be converted to ASCII format using program CNVA.EXE (usage: CNVA "file name" <return>).

#### 4.2.2 Instrument corrected power density spectra and their ratio

Ground velocity power density spectra (PDS) graphs for all sites are given in Appendix 5.3. On the left graph top and ground floor spectra a given, on the right side their ratio is given. Loglog scale of the graphs is used. Abscissa runs from 0.1 to 10 Hz as required in the 'Technical Specification for Ambient Vibration Measurements'. Ordinate runs from 1e-14 to 1e-6  $[m^2/s^2/Hz]$ . The scale was adjusted for each individual building. Ratio graphs have ordinate from 0.1 to 10.000. Also here the scale was adjusted to individual results.

PDSs and ratio in ASCII format are stored in '/data/"site-code"' subdirectory for each site separately. File names start with 's' for spectra and with 'r' for ratio. Site code follows. Next two characters denote which kind of spectra is contained. The first character denotes measuring direction (v = vertical, l = longitudinal, t =transversal). The second character denotes top or ground floor (g = ground floor, t =top). Therefore, a file name 'ss3tt.dat' means: PDS of a steel construction number 3 in transversal direction measured on top of the building..

Spectral ratio graphs show top/ground floor ratio. These files start with 'r'. Site code follows. The last character denotes measuring direction. A file name 'rm1t.dat' therefore means a top/ground-floor ratio of PDSs at masonry building number 1, measured in transversal direction.

Spectral ratios in ASCII format are also stored in '/data/"site-code" subdirectory for each site separately.

Particle motion graphs show velocity. 5000 data samples (about 80 sec) are shown. This approach results in a better insight into the motion of the top of the building than if the whole data set is plotted where mainly 'outliers' (extreme motion) becomes visible. These 5000 samples were generally taken from raw data and from the beginning of the records. Only in some cases (if the beginning showed too large disturbances) the data were taken from edited data set.

4.2.3 Determination of peak values of power density spectra measure on top of the buildings and spectral ratios

Dominant frequencies in power spectral density on top of the buildings as well as in spectral ratios were determined from graphs in Appendix 5.3.and tabulated in Table 4.1.

Site	Frequency of PDS max peak			Frequency of max Ratio peak		
	Vertical	Longitudinal	Transverse	Vertical	Longitudinal	Transverse
	[Hz]	[Hz]	[Hz]	[Hz]	[Hz]	[Hz]
CEST	1.85	2.95	1.90	1.85	2.95	1.90
R1	0.93	1.0	0.93	1.05	1.0	1.3
R2	2.30	0.67	0.67	0.75	0.79	0,85
R3	7.0	1.2	1.2	8.0	1.6	1.2
S8	2.0	1.55	2.0	2.0	1.7	2.0
R5	1.45	2.1	1.45	2.5	2.15	2.6
R6	2.1	2.5	2.15	2.1	2.6	3.25
R8	?	3.5	3.05	3.3	3.9	3.2
R11	3.4	3.4	3.5	3.4	3.5	3.6
R12	4.7	3.6	4.7	4.7	3.7	5.0
R13	1.2	1.7	1.2	1.7	1.8	1.2
R14	1.95	1.6	1.6	2.0	2.0	2.0
S1	0.53	0.71	0.53	0.53	0.68	0.60
S2	5.2	0.82	0.80	7.8	1.2	0.87
S3	0.68	0.63	0.70	0.73	0.91	0.73
S4	1.05	0.87	1.0	1.05	0.90	0.85
S5	5.0	0.98	0.92	1.95	1.3	092
S6	5.8	086	0.90	7.8	i.8	1.0
S7	1.8	1.8	1.85	1.95	2.0	2.0
S11	2.5	3.2	2.5	?	2.6	2.6
S13	4.1	4.0	2.9	5.0	3.0	3.0
S14	2.7	4.3	2.7	2.7	3.3	3.3
M1	8.0	4.3	4.3	8,6	4.3	4.3
M2	4.6	5.4	4.6	4.6	5.3	4.7
M3	7.3?	10?	7.2	10?	10?	7.6
M4	8.9	2.35	3.05	9.3	2.8	3.05

# Table 4.1. Dominant frequencies and periods in PDSs measured on top of the buildings and spectral ratios.

These peaks were heuristically determined and are solely based on corresponding graphs. No association of these peaks with civil engineering details of the building has been performed. In many cases horizontal dominant frequency reflects in vertical motion as the biggest spectral peak. It was read as 'dominant' peak, although it is not associated with true vertical resonance. Without respect to such and similar cases we always read the highest peak value and did not consider smaller peaks, which may be actually of greater importance. Detailed study of all peaks and their association with civil engineering facts of the building is considered as a part of interpretation of results, which is not the subject of this report.

Note also that building name codes (site number) are not monotonous. Some buildings, which were planned to be measured from the beginning, proved to be inaccessible for the measurement during the project. Therefore some site numbers are missing.

#### 4.2.4 Data CD description

A CD is attached to this report containing:

- raw and edited signal records in original SSR-1 and ASCII format,

- calculated PDSs and spectral ratios in ASCII format,
- data files pertaining to transfer function similarity tests before and after the measurements, and
- an ASCII file (faxis.dat) containing frequency axis of spectra and ratio data files; this file should be combined (using any text processor or MS Excel) with data files for plotting purposes; first line value 'NaN' of spectra and ratio files ('not a number' in MatLab syntax) corresponds to zero frequency and should be discharged for loglog plotting,
- Kinemetrics CNVA.EXE file format conversion program (binary .ssr file format to ASCII format) and custom made MatLab '.m' functions described in chapter 5.4.3.

Raw signal files, edited signal files, PDSs, and spectral ratios are grouped together for each site in '/data/"site-code"/' subdirectories. All programs are in '/programs/' subdirectory.

# 5. Appendixes

.



#### 5.1.1 Field measuring form - Site R1



#### 5.1.2 Field measuring form - Site R2



Page 24

#### 5.1.3 Field measuring form - Site R3



#### 5.1.4 Field measuring form - Site S8



#### 5.1.5 Field measuring form - Site R5



#### 5.1.6 Field measuring form - R6



Page 28

#### 5.1.7 Field measuring form - Site R8



Page 29