1.5 Surface Fault Dislocation

The same method as applied in the Gas research project is used to analyze surface dislocation caused by fault. Gas research project applied "elastic dislocation theory" by Steketee (1958) [22] to earthquake induced ground displacements, propose analysis equations and perform simulations using the magnitude of fault displacement as a parameter. The outline of the method is briefly described as below referring to the gas research project report[2-9].

1.5.1 Elastic Dislocation Theory

The dislocation model of the fault by Steketee[20] is schematically introduced as figure 1.42.

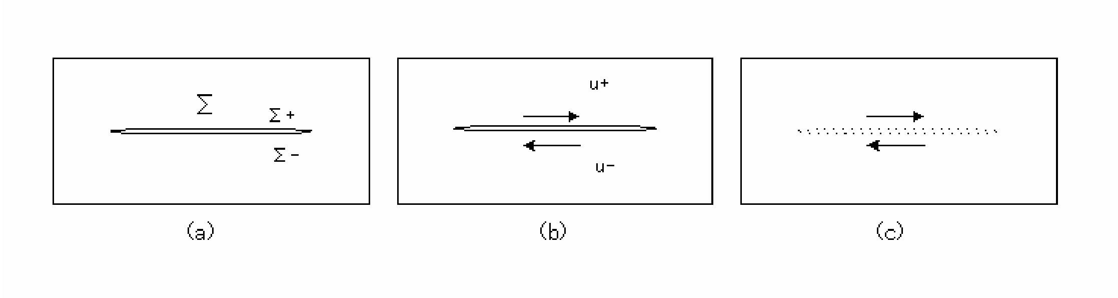


Figure.1.42　Dislocation outline

We call the surface where a discontinuity of the displacements at both sides exists a dislocation.
A dislocation can be explained simply in the following way.

a) A cut made in the elastic body produces two new internal boundaries. We designate them by $\Sigma^{+}$and Σ^{-}.
b) Displacements along the same line and opposite directions are applied on the boundaries, namely displacement u^{+} on Σ^{+} and displacement u^{-} on Σ^{-}
c) The boundaries are bonded together. Then due to the discontinuity of the displacements the boundary line is deformed. This configuration is called dislocation, and the surface Σ is called dislocation (fault) surface.

The equation to calculate fault displacements resulting from the dislocation is thereafter derived assuming small stain and linear elastic theory in the case of rectangular fault model. The derived equation is as follows;

1.5.2 Equations of Motion of an Elastic Body

Although the dislocation theory is simply an extension to the treatment of a continuous body subjected to discontinuities, in order to numerically introduce the earthquake motion, we first rewrite the governing partial differential equations under the assumptions of small strain and linear elastic stress-strain relation.

First, we adopt a 3-D Cartesian coordinate system, and divide the force into components along x_1, x_2 and x_3 directions. Then we denote the external force acting on a unit volume of the body by

$f(f_1, f_2, f_3)$ (along x_1, x_2 and x_3 directions), and the acceleration by $\ddot{u}(\ddot{u}_1, \ddot{u}_2, \ddot{u}_3)$. Here, $\ddot{u}$ is the second derivative in time of the displacement *u*.

The equation of motion of an infinitesimal cube in tensor notation becomes,

$$\rho\ddot{u}_i = \sigma_{ji,j} + f_i \tag{3.20}$$

where,

σ_{ji} : stress tensor,

$\sigma_{ji,j}$: spatial partial derivative of σ_{ji} in respect to x_j ,

$\sigma_{ji,j} = \partial\sigma_{ji,j} / \partial x_j$ $(i, j$ =1, 2, 3)

If the external loads excluded the body will return to its original configuration by elastic work; the stress-strain relation in the process is governed by the Hook's law

$$\sigma_{ij} = c_{ijkl} \cdot e_{kl} \tag{3.21}$$

where,

c_{ijkl} : elastic constants representing the physical properties of the body

If we use the Lame's constants λ and μ, c_{ijkl} can be expressed as,

$$c_{ijkl} = \lambda\delta_{ij}\delta_{kl} + \mu(\delta_{ik}\delta_{jl} + \delta_{il}\delta_{jk}) \tag{3.22}$$

where,

δ_{ij} : Kroneker delta function. If $i = j$, δ_{ij} =1. Otherwise, δ_{ij} =0.

μ : elastic shear modulus

λ : Poisson's ratio,

$$\lambda = \frac{E\nu}{(1+\nu)(1-2\nu)} = \frac{2\mu\nu}{1-2\nu} \tag{3.23}$$

We could obtain the equation of motion of the continuous body by substituting Eq. (3.21) into Eq.(3.20). If we substitute Eq. (3.22) instead we arrive at the following equation,

$$(\lambda + \mu)u_{ji.j} + \mu u_{i,jj} + f_i - \rho\ddot{u}_i = 0 \tag{3.24}$$

The above second order partial differential equation can be rewritten as an integral equation provided an integration mesh of size L is adopted (Betti's theorem). First, we think of two different equilibrium states which are solutions of the governing equations and for which the integration mesh is uniform with size L. Inside the considered domain V the body forces are designated by f^{I} and f^{II} the forces on the boundary surface S having normal vector n under the two states are designated by T^{I} and T^{II}, and the displacements by $u^{\mathrm{I}\,'}$ and $u^{\mathrm{II}\,'}$. When under these assumptions displacements occur at point x inside the domain, the relation between u^{I} and u^{II} is given by the following equation,

$$
\begin{aligned}
&\iiint_V (f^{\mathrm{I}} - \rho\ddot{u}^{\mathrm{I}}) \cdot u^{\mathrm{II}} dV + \iint_S T(u^{\mathrm{I}}, n) \cdot u^{\mathrm{II}} dS \\
&= \iiint_V (f^{\mathrm{II}} - \rho\ddot{u}^{\mathrm{II}}) \cdot u^{\mathrm{I}} dV + \iint_S T(u^{\mathrm{II}}, n) \cdot u^{\mathrm{I}} dS
\end{aligned}
\tag{3.25}
$$

In addition, if we integrate in time, $t_{\mathrm{I}} = t$, $t_{\mathrm{II}} = \tau - t$; t from $-\infty$ to $+\infty$, and consider the static state before τ_0 ($\tau \le \tau_0$, $u^{\mathrm{I}} = u^{\mathrm{II}} = u^{\mathrm{I}\,'} = u^{\mathrm{II}\,'}$) the acceleration terms vanish and the following equation is obtained.

$$
\begin{aligned}
&\int_{-\infty}^{+\infty} dt \iiint_V \left\{ u^{\mathrm{I}}(x,t) \cdot f^{\mathrm{II}}(x, \tau - t) - u^{\mathrm{I}}(x, \tau - t) \cdot f^{\mathrm{II}}(x,t) \right\} dV \\
&= \int_{-\infty}^{+\infty} dt \iiint_S \left\{ u^{\mathrm{II}}(x, \tau - t) \cdot T(u^{\mathrm{I}}(x,t), n) - u^{\mathrm{I}}(x,t) \cdot T(u^{\mathrm{II}}(x, \tau - t), n) \right\} dS
\end{aligned}
\tag{3.26}
$$

When a force is applied along the position vector ξ at its source point (force application point), i.e. when the force is acting at the current time along direction n, the displacement vector along the component direction i of the position vector x can be expressed in terms of the Green's function $G_{in}(x;\xi)$. In this way, the physical properties of the elastic body like density, elastic modulus, and the fault movement boundary conditions can be expressed as functions in space. The Green's function $G_{in}(x;\xi)$ related to Eq. (3.25) has to satisfy the following special differential equation.

By applying Eq. (3.26) to the Betty's theorem written for state II, and substituting in the body force expression $f^{\mathrm{II}}(x)$ in $\delta_{in}\delta(x - \xi)$, and $u^{\mathrm{II}}(x)$ in $G_{kn}(x;\xi)$ we get,

$$
\begin{aligned}
u_n(x,t) &= \iiint_V f_i(\xi, \tau) G_{ni}(x;\xi) dV(\xi) \\
&+ \iint_S \left\{ T_i(u(\xi), n) G_{ni}(x;\xi) - u_i(\xi) c_{ijkl}(\xi) n_j \frac{\partial G_{nk}(x;\xi)}{\partial \xi_l} \right\} dS(\xi)
\end{aligned}
\tag{3.27}
$$

This equation gives the displacement at point x along direction n when a force is applied at the source point ξ along direction i. Further details are referred to the Gas Research Project.

1.5.3 Analysis Result

The analyzed fault dislocations are shown in Figure 1.43 to 1.46. Figures show the greatest cases caused by vertical fault dislocation.

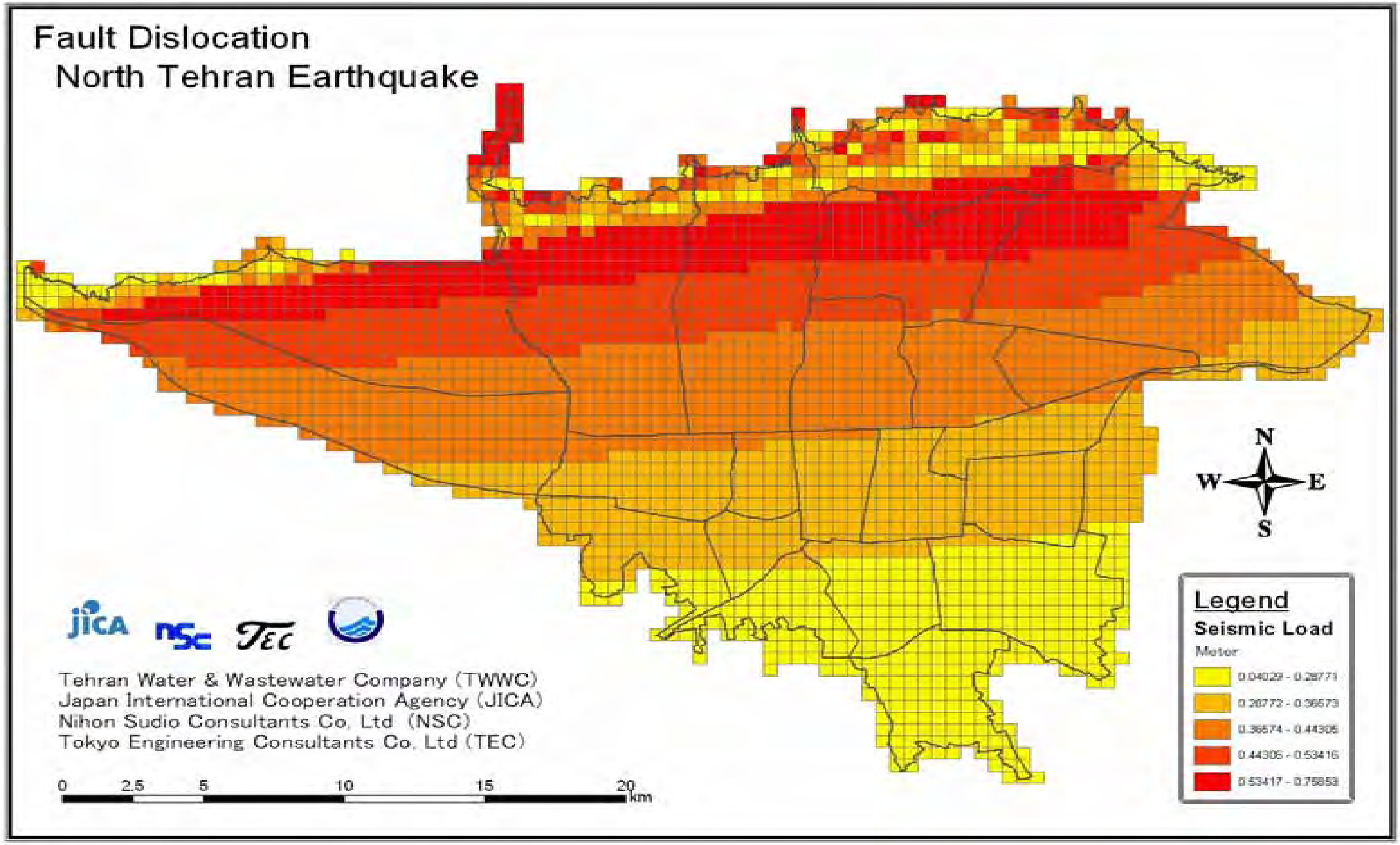


Figure 1.43 Surface Fault Dislocation North Tehran Fault

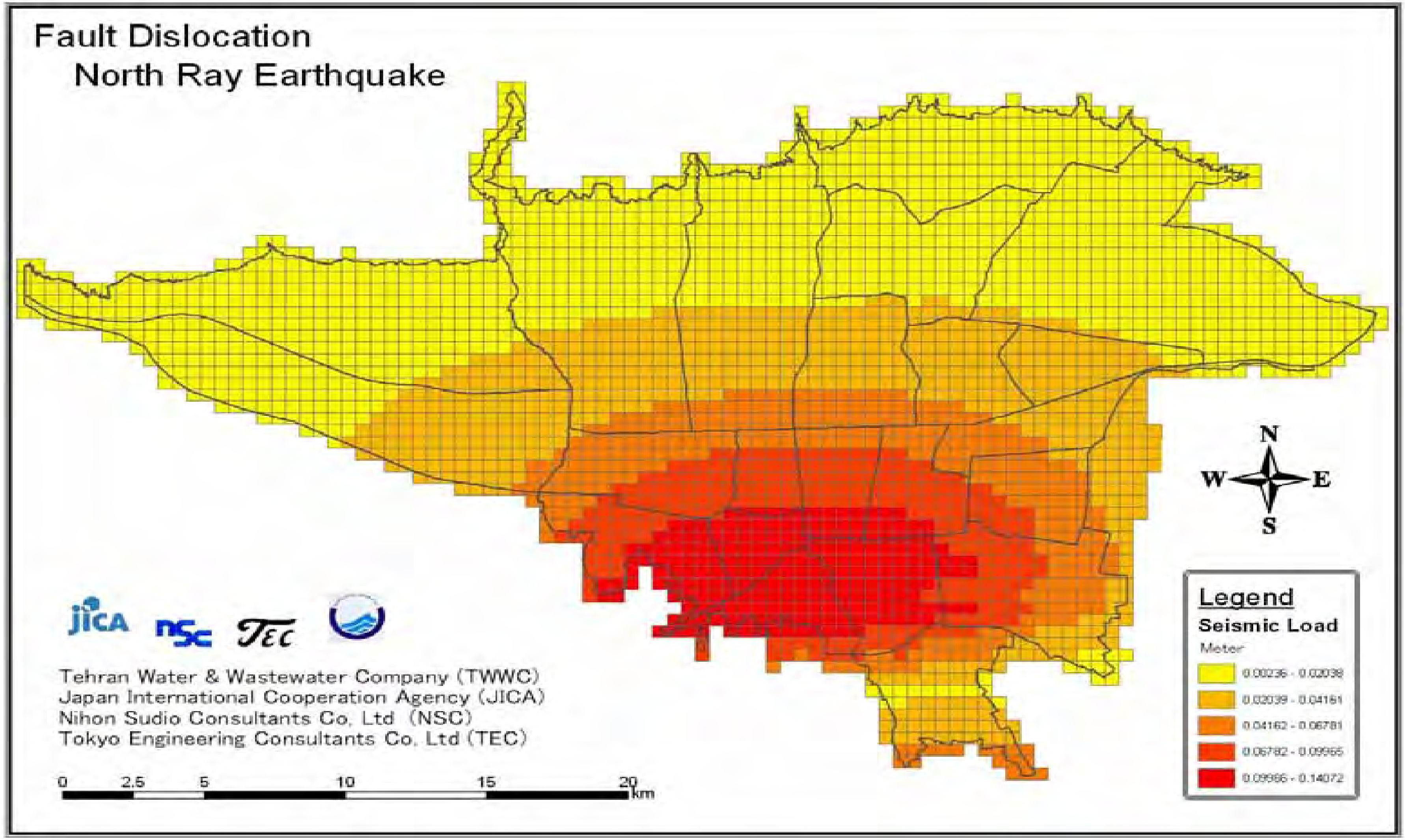


Figure 1.44 Surface Fault Dislocation North Ray Fault

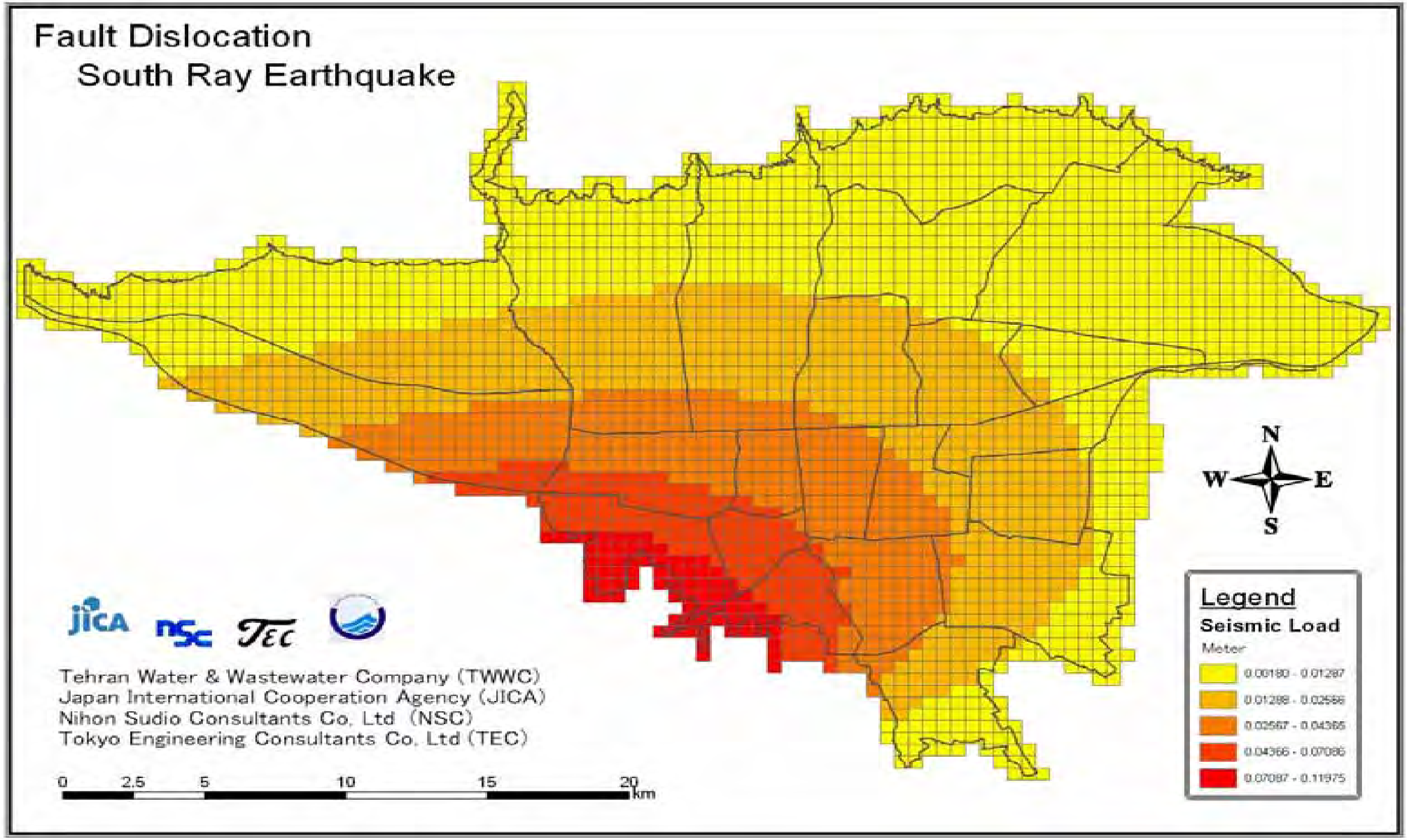


Figure 1.45 Surface Fault Dislocation South Ray Fault

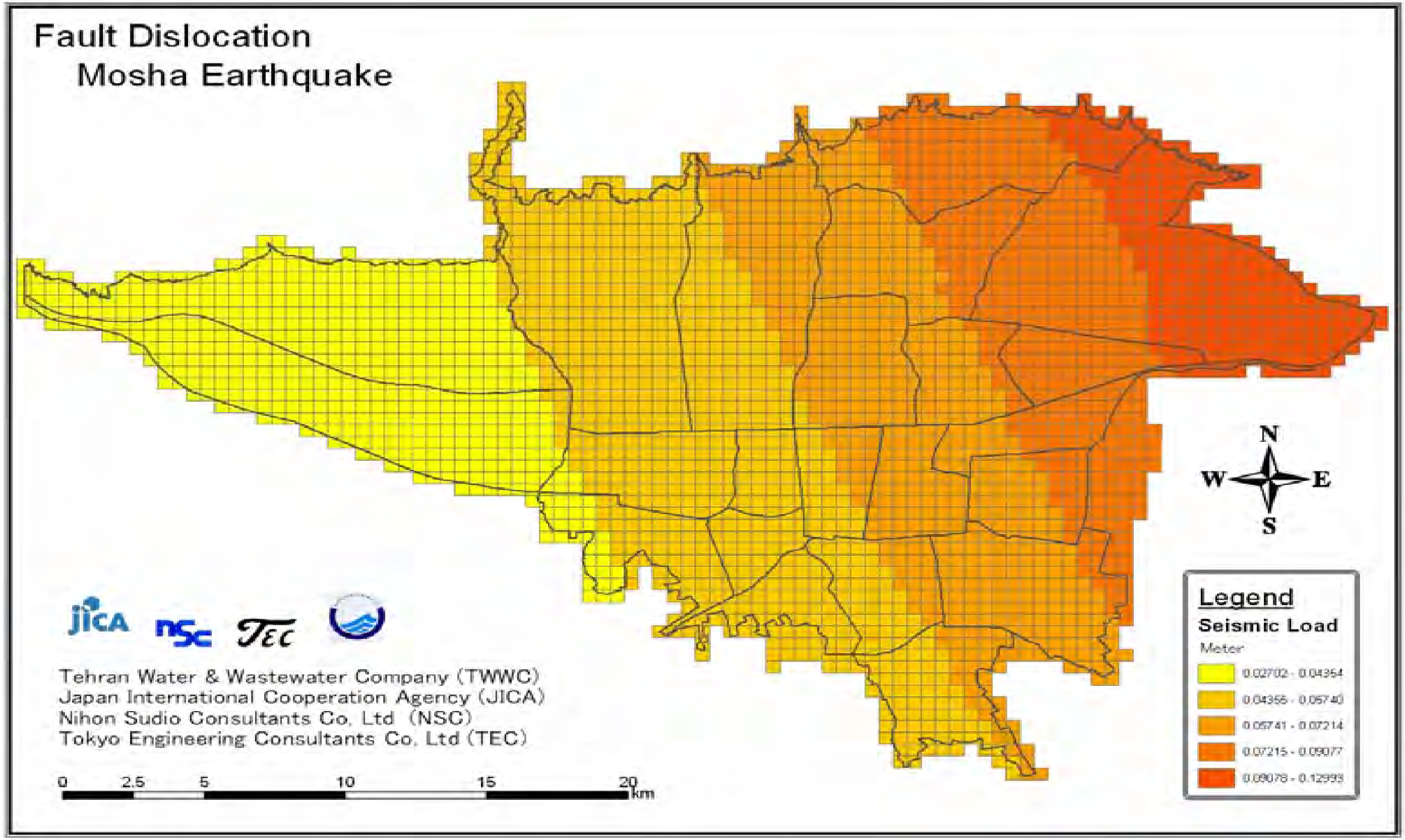


Figure 1.46 Surface Fault Dislocation Mosha Fault

1.6 Liquefaction

As mentioned in 3.3.2 (1) Seismic force, the liquefaction potential is confirmed low by the borehole investigation at the suspected area in the Gas research project[2-10]. Therefore the estimated result is not used for subsequent assessment. However, the estimated lateral spread and settlement due to liquefaction are shown in figure 1.47 and 1.48 only for reference,

Figure 1.47 Lateral spread

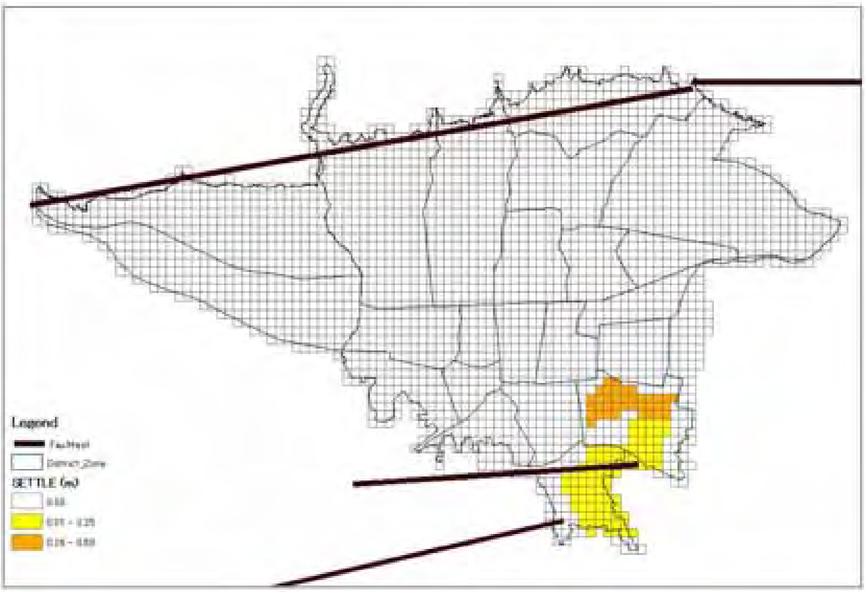


Figure 1.48 Settlement

1.7 Estimation of Building Damage in Tehran city

1.7.1 Purpose of Buildings Damage Estimation

The purpose of damage estimation of buildings in Tehran city is to estimate damage to service pipeline belonging to buildings and to estimate a number of peoples who lost their houses in order to prepare emergency response.

1.7.2 Damage State of Buildings

The extent and severity of damage to buildings are categorized three damage states Major damage, Moderate damage, and Minor damage according to Gas research project. Definition of the damage state similar to that in Gas research project is as follows:

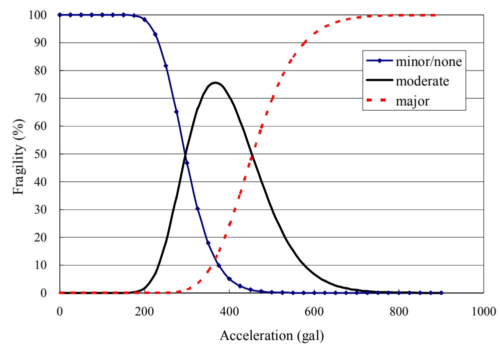
Major damage : A building has server damage or completely collapsed. In this damage state, water service pipe and other instrument cannot run due to damage to building and facility itself.

Moderate damage : A building has moderate damage, under which water is continuously supplied to buildings without leakage. However, repair for supply pipes should be done after earthquakes.

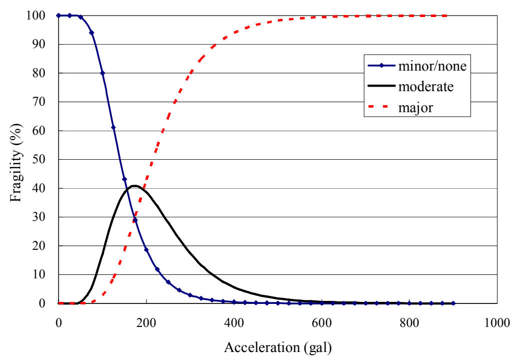
Minor damage : A building has slight damage. No repair for water service pipe is occurred.

1.7.3 Fragility Curves for Buildings

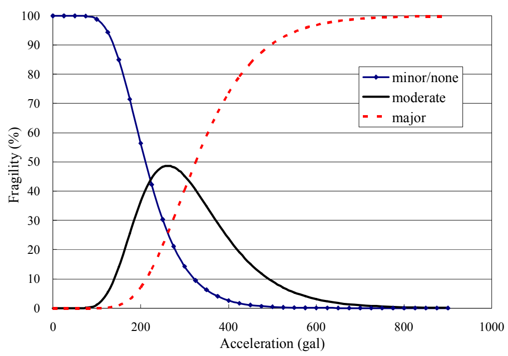
Fragility curves for building damage estimation are same as those of Gas research project shown in figure 1.49. details are referred to the Gas Research Project[2-11].



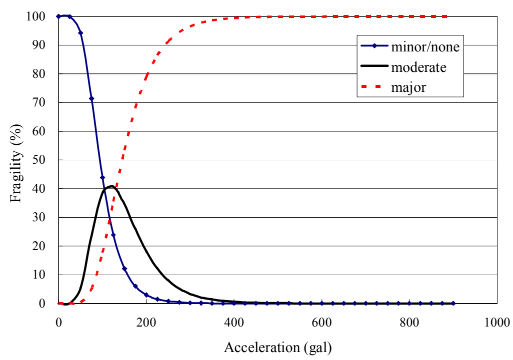
(a) Steel (TYPE1)



(b) RC (TYPE2)



(c) Brick and steel (TYPE3)



(d) Other detached buildings (TYPE4)

Figure 1.49 Fragility curve for buildings

1.7.4 Numerical Results

Estimation of damage to four categories of buildings is implemented based on the above assessment method. Table 1.7 shows the building number in Tehran city as per 1996 census. Figure 1.50 shows building distribution, and the results of damaged estimation for each scenario earthquake are listed in Tables 1.8 and also shown in figure 1.51 as one example of North Tehran Earthquake.

The most significant case is the one in which an earthquake of North Tehran earthquake occurs due to the highly generated acceleration. The case provides 27 % of all buildings in major damage and also same 27 % in moderate damage. In number, 380 thousand buildings would collapse.

Table 1.7 Building Number in Teheran City

Type	STEEL	RC	Brick & Steel	Others	Total
Number	601,120	166,027	605,108	59,545	1,431,800

Table 1.8 Building Damage Estimation Result

	North Tehran Fault	North Ray Fault	South Ray Fault	Mosha Fault
Major	384,796	177,807	166,137	62,341
Moderate	387,244	261,940	217,987	129,748
Total	772,040	439,747	384,124	192,089

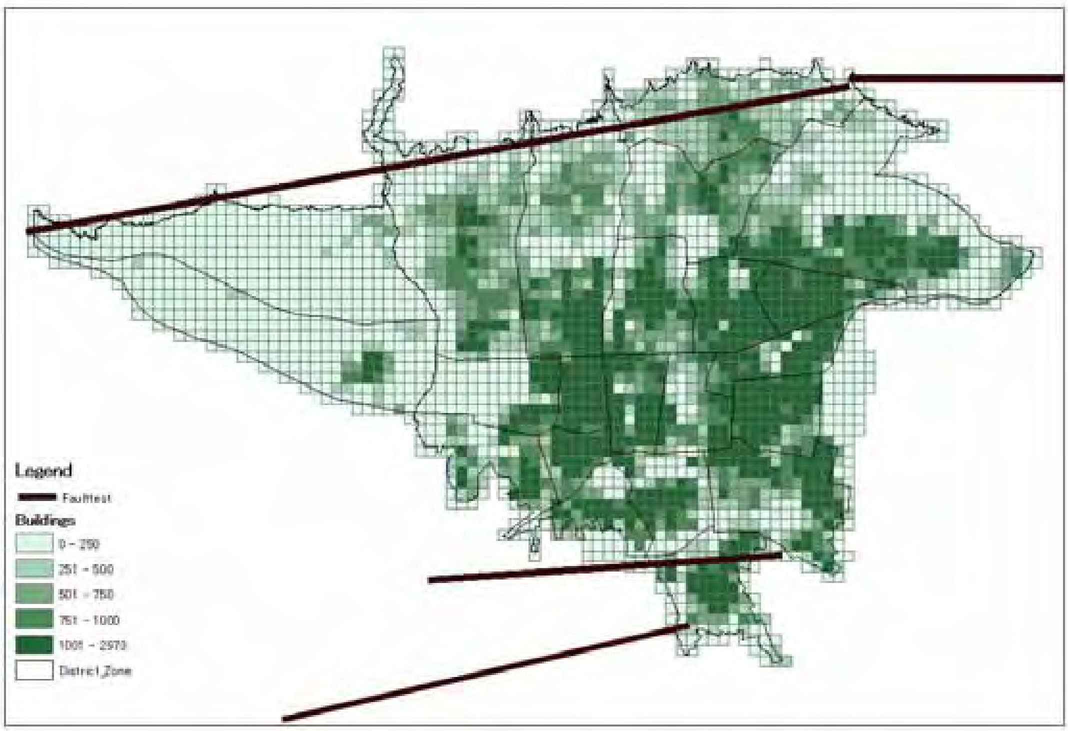


Figure 1.50 Distribution of Buildings in Tehran city

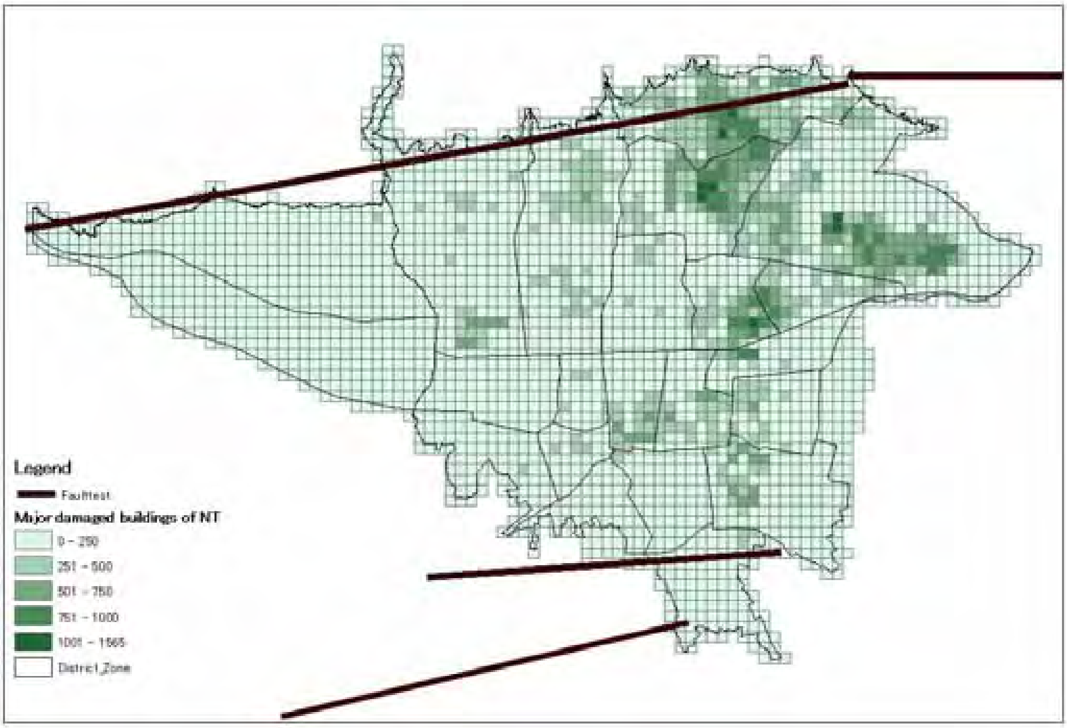


Figure 1.51 Major damaged buildings of North Tehran earthquake

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APPENDIX-2

Pipeline Data

1. Table of Transmission Main
2. Table of distribution trunk main
3. Table of distribution sub main
4. Table of water demand and allocation to reservoir zones
5. Table of present stage condition
6. Table of next stage condition
7. Table of final stage condition

1. Table of Transmission Main

Diameter (mm)	Ductile Iron Pipe	Concrete Pipe	Steel Pipe	Total
150	0.20	0.00	0.00	0.20
250	0.00	0.00	8.07	8.07
300	2.73	0.00	8.92	11.65
350	0.20	0.00	0.00	0.20
400	5.85	0.00	0.05	5.90
450	0.00	0.00	0.86	0.86
500	22.27	0.00	4.23	26.49
600	18.34	0.00	1.19	19.53
700	13.70	3.06	6.61	23.38
800	0.00	0.00	24.19	24.19
900	0.00	9.71	60.18	69.89
1000	0.00	0.00	25.23	25.23
1100	0.00	0.00	24.06	24.06
1200	0.00	5.07	63.10	68.17
1250	0.00	10.35	5.64	15.99
1350	0.00	6.23	0.00	6.23
1400	0.00	0.00	26.81	26.81
1600	0.00	0.15	18.31	18.47
1700	0.00	1.20	0.00	1.20
1850	0.00	21.77	0.00	21.77
2000	0.00	0.00	0.07	0.07
2200	0.00	0.00	0.98	0.98
Total	63.30	57.55	278.50	399.35

2. Table of Distribution Trunk Main

ZONE	Total Length (m)	Asbestos	Cast Iron	Ductile Iron	Steel	Line Number	Segement Number in Line
1	15,622	0	14,209	984	430	5	10
2	34,108	0	22,642	5,673	5,793	10	10
3	11,413	0	10,953	461	0	3	10
4	21,287	0	20,515	240	531	6	10
5	18,856	0	16,675	1,510	671	5	10
6	16,171	0	12,794	1,849	1,529	5	10
7	26,281	2,053	177	22,382	1,668	8	10
8	22,312	0	10,359	5,372	6,582	6	10
10	7,777	0	1,494	5,453	830	2	10
11	4,161	0	0	4,089	73	1	10
12	0	0	0	0	0	0	10
13	19,257	0	2,992	12,840	3,425	6	10
14	1,839	0	0	1,064	775	1	10
15A	6,757	0	0	4,270	2,488	2	10
15 − 16 − 53	81,117	0	2,775	62,250	16,091	23	10
18	3,744	0	0	3,744	0	1	10
19	6,055	0	0	6,055	0	2	10
20	3,162	0	0	3,162	0	1	10
21	9,915	0	0	9,598	317	3	10
22	7,406	0	0	7,313	94	2	10
23	5,864	0	0	5,864	0	2	10
24	17,792	0	0	17,792	0	5	10
26	4,347	0	0	4,347	0	1	10
27	9,164	0	0	8,423	741	3	10
28	427	0	0	427	0	0	10
29	4,302	0	0	3,898	404	1	10
30	0	0	0	0	0	0	10
31	18,385	0	5,871	11,066	1,448	5	10
32	2,317	0	0	2,317	0	1	10
33	0	0	0	0	0	0	10
36	28,159	0	7,691	14,053	6,415	8	10
37	32,790	0	0	31,093	1,697	9	10
38	17,178	0	203	12,719	4,256	5	10
39	0	0	0	0	0	0	10
40	589	0	0	589	0	1	4
41	15,766	0	0	12,864	2,902	5	10
42	3,911	0	0	1,076	2,835	1	10
43	29,790	0	0	25,886	3,904	9	10
45	113	0	0	113	0	1	1
48	3,480	0	0	3,303	177	1	10
51	47,285	1,836	212	37,788	7,449	14	10
54	16,233	0	1,125	13,302	1,805	5	10
55	16,861	0	0	14,417	2,444	5	10
56	14,278	0	0	9,335	4,942	4	10
57	15,761	0	0	11,182	4,578	5	10
58	13,188	0	0	6,169	7,019	4	10
59	8,532	0	0	7,144	1,388	2	10
9 − 61	16,315	0	3,495	7,026	5,794	5	10
62	3,243	0	0	2,290	954	1	10
63	19,276	0	0	10,829	8,447	6	10
64	516	0	0	516	0	1	2
65	12,755	0	0	11,691	1,065	4	10
66	12,157	0	0	9,353	2,804	4	10
67	5,237	0	0	5,237	0	2	10
68	8,354	0	0	8,354	0	2	10
69	3,045	0	0	3,045	0	1	10
70	767	0	0	767	0	0	10
71	2,310	0	0	1,480	829	1	10
72	8,819	0	0	7,059	1,759	3	10
74	2,624	0	0	2,624	0	1	10
75	3,087	0	0	3,087	0	1	10
77	6,322	0	0	5,040	1,282	2	10
80	17,641	0	0	8,526	9,115	5	10
81	22	0	0	0	22	0	10
82	1,442	0	0	639	803	0	10
91	491	0	0	491	0	1	4
Total	768,179	3,890	134,182	501,532	128,576		

3. Table of Distribution Sub Main

ZONE	Total Length (m)	Cast iron Dia<200mm	Cast iron Dia>=200mm & Dia<300mm	Ductile iron Dia<200mm	Ductile iron Dia>=200mm & Dia<300mm	Asbestos	PVC	Polyethylene	Line Number	Segement Number in Line
1	85,867	17,760	6,630	7,271	3,484	0	26	50,695	8	100
2	187,026	25,249	19,518	17,237	2,394	0	0	122,627	17	100
3	186,972	26,955	9,990	6,973	0	0	140	142,914	17	100
4	179,887	33,713	15,785	3,942	1,550	0	406	124,491	16	100
5	207,145	35,664	16,914	14,669	10,423	0	163	129,311	19	100
6	290,105	44,891	22,191	40,129	2,953	0	475	179,465	27	100
7	264,341	3,303	1,376	216,806	13,087	0	44	29,725	24	100
8	89,988	18,299	7,245	15,909	1,240	0	165	47,131	8	100
10	53,854	102	0	47,455	3,532	0	0	2,764	5	100
11	103,086	0	0	90,149	8,662	0	0	4,275	10	95
12	12,329	0	0	5,019	1,997	0	23	5,290	2	55
13	186,600	5,288	1,831	129,791	7,241	0	170	42,279	17	100
14	36,667	179	0	28,327	5,029	0	0	3,132	4	85
15A	65,000	0	0	53,218	9,327	0	69	2,386	6	100
15 − 16 − 53	650,218	15,526	15,463	440,377	59,647	0	2,746	116,459	60	100
18	31,631	0	0	27,510	3,046	0	69	1,007	4	72
19	135,294	0	0	108,651	15,702	48	0	10,893	12	100
20	157,033	0	0	120,775	11,919	0	0	24,339	15	95
21	153,712	0	0	118,604	12,725	0	0	22,383	14	100
22	66,018	0	0	56,114	6,227	0	298	3,378	6	100
23	46,133	0	0	33,306	7,003	0	0	5,823	5	85
24	57,739	0	0	49,996	5,951	0	0	1,792	6	88
26	73,639	0	0	55,581	8,359	0	0	9,700	7	95
27	65,159	0	0	45,184	8,970	0	0	11,005	6	100
28	37,669	0	0	26,826	6,023	0	0	4,821	4	85
29	6,346	0	0	4,718	1,458	0	0	171	1	58
30	19,592	0	0	14,120	3,235	0	0	2,236	2	85
31	194,151	8,994	5,945	90,914	9,217	0	209	78,871	18	98
32	18,316	0	0	13,223	3,018	0	0	2,074	2	85
33	4,517	0	0	2,523	709	0	0	1,286	2	20
36	228,099	8,093	4,228	167,448	16,719	0	993	30,617	21	100
37	64,069	835	0	52,183	9,849	0	0	1,202	6	100
38	98,162	0	0	71,891	12,022	0	364	13,885	9	100
39	19,818	0	0	14,568	2,838	0	0	2,412	3	60
40	32,104	0	0	25,983	3,203	0	0	2,918	3	100
41	65,770	0	0	48,149	5,616	0	0	12,006	6	100
42	36,949	0	0	32,193	4,584	0	0	172	4	85
43	371,742	0	0	279,407	62,640	0	3,805	25,891	34	100
45	13,783	0	0	3,984	4,443	0	0	5,356	2	60
48	16,863	0	0	8,548	3,748	0	0	4,567	2	75
51	242,434	0	0	203,681	28,956	0	329	9,468	22	100
54	116,678	1,093	78	96,145	9,978	0	695	8,689	11	96
55	130,747	948	0	95,818	20,645	0	332	13,005	12	100
56	32,929	0	0	18,410	4,783	0	329	9,406	3	100
57	102,485	0	0	80,626	12,277	0	1,014	8,568	9	100
58	96,544	0	0	44,303	9,328	0	3,507	39,406	9	95
59	50,750	0	0	21,336	3,212	0	8,762	17,440	5	90
9 − 61	82,703	2,160	3,418	56,643	6,671	0	26	13,785	8	95
62	47,432	197	0	39,452	4,322	0	0	3,461	5	86
63	103,307	0	0	89,599	11,546	0	326	1,836	10	94
64	47,795	0	0	41,415	6,321	0	0	60	5	87
65	90,749	2,130	923	65,580	10,418	0	434	11,264	9	93
66	66,510	0	0	20,363	6,953	0	701	38,493	6	100
67	89,879	0	0	69,609	5,793	0	59	14,417	8	100
68	87,744	0	0	42,746	11,350	0	0	33,648	8	100
69	39,008	0	0	33,401	4,250	0	0	1,356	4	90
70	3,332	0	0	3,302	0	0	0	30	1	30
71	80,783	0	0	31,654	11,356	0	664	37,108	8	92
72	55,168	0	0	36,567	4,221	0	0	14,379	5	100
74	25,439	0	0	8,455	7,191	0	0	9,792	3	80
75	32,786	0	0	19,915	8,918	0	0	3,953	3	100
77	1,840	0	0	1,691	0	0	0	149	1	17
80	104,583	0	0	56,378	16,649	0	2,885	28,671	10	95
81	8,664	0	0	3,086	1,516	0	125	3,937	1	79
82	19,070	0	0	12,891	3,926	0	0	2,253	2	86
91	13,177	0	0	8,585	1,769	0	0	2,822	2	60
Total	6,385,927	251,379	131,534	3,791,323	572,141	48	30,357	1,609,145		

4. Table of Water Demand and Allocation to Reservoir Zones

Reservoir Zone	Allocated Volume (m^3/day)
1	34,952
2	111,456
3	80,179
4	95,040
5	58,277
6	108,907
7	76,992
8	125,885
10	24,235
11	49,594
12	20,000
13	93,485
14	27,734
15A	42,216
15 − 16 − 53	306,931
18	11,980
19	138,121
20	61,426
21	43,891
22	10,800
23	98,064
24	14,260
26	30,413
27	23,921
28	7,171
29	4,879
30	5,120
31	105,235
32	14,571
33	3,800
36	82,512
37	47,760
38	33,869

Reservoir Zone	Allocated Volume (m^3/day)
39	24,235
40	16,572
41	16,330
42	30,311
43	237,868
45	7,102
48	38,350
51	106,706
54	74,218
55	22,896
56	67,219
57	70,762
58	59,866
59	6,907
9 − 61	43,896
62	6,826
63	45,274
64	16,500
65	28,631
66	28,631
67	42,216
68	560
69	6,600
70	6,600
71	37,078
72	20,909
74	9,139
75	7,340
77	7,340
80	22,253
81	34,590
82	12,000
91	9,677

Tatal	3,159,076

5. Table of Present Stage Condition

Stage : Present

Line category : Tranmission main

ZONE	Scenario earthquake			
	North Ray	South Ray	North Tehran	Mosha
1		13.8	15.6	0
2		0.0	0.0	0
3		5.8	5.8	0
4		7.4	7.4	0
5		1.3	1.3	0
6		10.8	12.7	0
7		0.0	0.0	0
8		32.3	66.2	0
10		7.2	7.2	0
11		10.6	12.3	0
12		25.8	25.8	0
13		2.2	2.2	0
14		6.9	18.5	0
15A		0.0	0.0	0
15－16－53		10.6	10.6	0
18		7.5	14.7	0
19		0.5	0.7	0
20		19.3	39.4	0
21		0.0	0.0	0
22		1.7	12.5	0
23		9.5	20.8	0
24		2.4	14.1	0
26		21.5	70.6	0
27		26.6	44.9	0
28		26.2	86.2	0
29		27.8	72.9	0
30		55.6	71.4	0
31		34.6	34.6	0
32		5.1	69.4	0
33		26.2	86.2	0
36		0.0	0.0	0
37		4.1	4.1	0
38		5.3	24.7	0
39		7.2	7.2	0
40		0.0	0.0	0
41		13.6	13.6	0
42		36.8	64.4	0
43		13.1	13.1	0
45		0.0	0.0	0
48		6.2	23.2	0
51		28.0	28.0	0
54		5.7	5.7	0
55		19.8	39.8	0
56		2.6	2.6	0
57		0.9	0.9	0
58		1.1	1.1	0
59		1.6	1.6	0
9－61		8.4	10.2	0
62		19.3	19.3	0
63		10.1	10.1	0
64		32.3	32.3	0
65		0.0	0.0	0
66		2.5	2.5	0
67		14.5	14.5	0
68		0.0	0.0	0
69		0.0	0.0	0
70		0.0	0.0	0
71		0.0	0.0	0
72		18.7	39.0	0
74		13.6	13.6	0
75		19.6	19.6	0
77		19.6	19.6	0
80		1.6	1.6	0
81		1.6	1.6	0
82		14.2	48.9	0
91		2.9	37.3	0

Stage : Present

Line category : Distribution trunk main

ZONE	Scenario earthquake			
	North Ray	South Ray	North Tehran	Mosha
1	1.9	0.0	1.9	0.0
2	2.1	0.0	7.5	0.0
3	8.0	8.2	8.2	0.0
4	6.2	6.0	6.5	1.6
5	4.8	4.5	4.5	1.9
6	4.5	4.2	4.5	0.0
7	0.0	0.0	0.0	0.0
8	0.0	0.0	1.4	0.0
10	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0
15A	0.0	0.0	0.0	0.0
15－16－53	6.4	0.0	0.3	0.0
18	0.0	0.0	0.0	0.0
19	0.0	0.0	3.7	0.0
20	0.0	0.0	6.3	0.0
21	0.0	0.0	5.7	0.0
22	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0
24	0.0	0.0	14.5	0.0
26	0.0	0.0	0.0	0.0
27	0.0	0.0	6.2	0.0
28	0.0	0.0	0.0	0.0
29	0.0	0.0	6.8	0.0
30	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0
32	0.0	0.0	6.8	0.0
33	0.0	0.0	0.0	0.0
36	5.1	2.5	19.1	0.0
37	0.0	0.0	1.8	0.0
38	0.0	0.0	3.7	0.0
39	0.0	0.0	0.0	0.0
40	0.0	0.0	12.8	0.0
41	0.0	0.0	22.1	0.0
42	0.0	0.0	0.0	0.0
43	0.0	0.0	3.1	0.0
45	0.0	0.0	42.8	0.0
48	0.0	0.0	0.0	0.0
51	0.0	0.0	0.0	0.0
54	0.0	0.0	0.0	0.0
55	0.0	0.0	0.0	0.0
56	0.0	0.0	0.0	0.0
57	0.0	0.0	0.0	0.0
58	0.0	0.0	0.0	0.0
59	0.0	0.0	0.0	0.0
9－61	0.0	0.0	0.0	0.0
62	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0
64	0.0	0.0	0.0	0.0
65	4.5	1.7	0.0	0.0
66	1.8	0.0	0.0	0.0
67	3.5	0.0	0.0	0.0
68	0.0	0.0	0.0	0.0
69	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0
71	0.0	0.0	0.0	0.0
72	0.0	0.0	5.7	0.0
74	0.0	0.0	0.0	0.0
75	0.0	0.0	7.3	0.0
77	0.0	0.0	3.5	0.0
80	0.0	0.0	0.0	0.0
81	0.0	0.0	0.0	0.0
82	0.0	0.0	0.0	0.0
91	0.0	0.0	12.4	0.0

Table of Present Stage Condition (continued)

Stage : Present				
Line category : Distribution sub main				
ZONE	Scenario earthquake			
	North Ray	South Ray	North Tehran	Mosha
1	0.0	0.0	0.0	0.0
2	0.8	0.5	4.3	0.8
3	0.1	0.0	0.0	0.0
4	0.2	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0
10	0.0	0.0	16.2	0.0
11	0.0	0.0	0.1	0.0
12	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0
14	0.0	0.0	10.8	0.0
15A	0.0	0.0	0.0	0.0
15 − 16 − 53	4.3	0.0	0.2	0.0
18	0.0	0.0	0.0	0.0
19	0.0	0.0	1.4	0.0
20	0.0	0.0	53.1	1.9
21	0.0	0.0	16.4	0.1
22	0.0	0.0	54.4	0.0
23	0.0	0.0	54.3	3.1
24	0.0	0.0	14.7	0.0
26	0.0	0.0	58.1	6.3
27	0.0	0.0	54.1	0.8
28	0.0	0.0	65.5	15.4
29	0.0	0.0	51.5	0.0
30	0.0	0.0	33.1	0.0
31	0.0	0.0	0.0	0.0
32	0.0	0.0	43.9	0.0
33	0.0	0.0	34.6	1.8
36	11.0	7.8	27.0	0.1
37	0.0	0.0	46.0	0.0
38	0.0	0.0	1.9	0.0
39	0.0	0.0	12.5	0.0
40	0.0	0.0	48.7	0.0
41	0.0	0.0	53.2	3.7
42	0.0	0.0	1.4	0.0
43	0.0	0.0	8.0	0.0
45	0.0	0.0	54.4	0.0
48	0.0	0.0	28.3	0.5
51	0.0	0.0	0.1	0.0
54	0.0	0.0	0.0	0.0
55	0.0	0.0	13.6	0.0
56	0.0	0.0	0.0	0.0
57	0.0	0.0	0.0	0.0
58	0.0	0.0	4.0	0.0
59	0.0	0.0	0.2	0.0
9 − 61	0.0	0.0	0.0	0.0
62	0.0	0.0	21.3	0.0
63	0.1	0.0	0.0	0.0
64	0.0	0.0	0.0	0.0
65	6.4	0.1	0.0	0.0
66	4.6	0.0	0.0	0.0
67	3.5	0.0	0.0	0.0
68	0.6	0.0	0.0	0.0
69	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0
71	0.0	0.0	0.1	0.0
72	0.0	0.0	40.1	0.0
74	0.0	0.0	12.6	0.0
75	0.0	0.0	13.2	0.0
77	0.0	0.0	3.9	0.0
80	0.0	0.0	0.1	0.0
81	0.0	0.0	0.0	0.0
82	0.0	0.0	44.8	0.0
91	0.0	0.0	46.5	0.0

Stage : Present				
Line category : Combined				
ZONE	Scenario earthquake			
	North Ray	South Ray	North Tehran	Mosha
1	15.5	13.8	17.2	0.0
2	2.8	0.5	11.5	0.8
3	13.4	13.5	13.5	0.0
4	13.4	13.0	13.4	1.6
5	6.0	5.8	5.8	1.9
6	14.9	14.5	16.6	0.0
7	0.0	0.0	0.0	0.0
8	32.3	32.3	66.6	0.0
10	7.2	7.2	22.3	0.0
11	10.6	10.6	12.4	0.0
12	25.8	25.8	25.8	0.0
13	2.2	2.2	2.2	0.0
14	6.9	6.9	27.3	0.0
15A	0.0	0.0	0.0	0.0
15 − 16 − 53	19.8	10.6	11.0	0.0
18	7.5	7.5	14.7	0.0
19	0.5	0.5	5.8	0.0
20	19.3	19.3	73.4	1.9
21	0.0	0.0	21.2	0.1
22	1.7	1.7	60.1	0.0
23	9.5	9.5	63.9	3.1
24	2.4	2.4	37.3	0.0
26	21.5	21.5	87.7	6.3
27	26.6	26.6	76.3	0.8
28	26.2	26.2	95.2	15.4
29	27.8	27.8	87.8	0.0
30	55.6	55.6	80.9	0.0
31	34.6	34.6	34.6	0.0
32	5.1	5.1	84.0	0.0
33	26.2	26.2	90.9	1.8
36	15.5	10.0	41.0	0.1
37	4.1	4.1	49.1	0.0
38	5.3	5.3	28.8	0.0
39	7.2	7.2	18.8	0.0
40	0.0	0.0	55.3	0.0
41	13.6	13.6	68.5	3.7
42	36.8	36.8	64.9	0.0
43	13.1	13.1	22.5	0.0
45	0.0	0.0	73.9	0.0
48	6.2	6.2	44.9	0.5
51	28.0	28.0	28.0	0.0
54	5.7	5.7	5.7	0.0
55	19.8	19.8	48.0	0.0
56	2.6	2.6	2.6	0.0
57	0.9	0.9	0.9	0.0
58	1.1	1.1	5.0	0.0
59	1.6	1.6	1.7	0.0
9 − 61	8.4	8.4	10.2	0.0
62	19.3	19.3	36.5	0.0
63	10.2	10.1	10.1	0.0
64	32.3	32.3	32.3	0.0
65	10.6	1.8	0.0	0.0
66	8.6	2.5	2.5	0.0
67	20.4	14.5	14.5	0.0
68	0.6	0.0	0.0	0.0
69	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0
71	0.0	0.0	0.1	0.0
72	18.7	18.7	65.5	0.0
74	13.6	13.6	24.5	0.0
75	19.6	19.6	35.3	0.0
77	19.6	19.6	25.4	0.0
80	1.6	1.6	1.6	0.0
81	1.6	1.6	1.6	0.0
82	14.2	14.2	71.8	0.0
91	2.9	2.9	70.6	0.0

6. Table of Next Stage Condition

Stage : Next

Line category : Tranmission main

ZONE	Scenario earthquake			
	North Ray	South Ray	North Tehran	Mosha
1	13.8			0
2	0.0			0
3	5.8			0
4	7.4			0
5	1.3			0
6	10.8			0
7	0.0			0
8	32.3			0
10	7.2			0
11	10.6			0
12	25.8			0
13	2.2			0
14	6.9			0
15A	0.0			0
15 − 16 − 53	10.6			0
18	7.5			0
19	0.5			0
20	19.3			0
21	0.0			0
22	1.7			0
23	9.5			0
24	2.4			0
26	21.5			0
27	26.6			0
28	26.2			0
29	27.8			0
30	11.2			0
31	34.2			0
32	5.1			0
33	26.2			0
36	0.0			0
37	4.1			0
38	5.3			0
39	7.2			0
40	0.0			0
41	13.6			0
42	36.8			0
43	13.1			0
45	0.0			0
48	6.2			0
51	28.0			0
54	5.7			0
55	19.8			0
56	2.6			0
57	0.9			0
58	1.1			0
59	1.6			0
9 − 61	8.4			0
62	19.3			0
63	10.1			0
64	32.3			0
65	0.0			0
66	2.5			0
67	14.5			0
68	0.0			0
69	0.0			0
70	0.0			0
71	0.0			0
72	18.7			0
74	13.6			0
75	19.6			0
77	19.6			0
80	1.6			0
81	1.6			0
82	14.2			0
91	2.9			0

Stage : Next

Line category : Distribution trunk main

ZONE	Scenario earthquake			
	North Ray	South Ray	North Tehran	Mosha
1	0.5	0.0	0.5	0.0
2	0.4	0.0	1.5	0.0
3	2.0	2.0	2.0	0.0
4	1.5	1.5	1.6	0.4
5	1.1	1.1	1.1	0.4
6	1.0	0.9	1.0	0.0
7	0.0	0.0	0.0	0.0
8	0.0	0.0	0.2	0.0
10	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0
15A	0.0	0.0	0.0	0.0
15 − 16 − 53	0.5	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0
19	0.0	0.0	0.2	0.0
20	0.0	0.0	0.4	0.0
21	0.0	0.0	0.4	0.0
22	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0
24	0.0	0.0	1.0	0.0
26	0.0	0.0	0.0	0.0
27	0.0	0.0	0.4	0.0
28	0.0	0.0	0.0	0.0
29	0.0	0.0	0.5	0.0
30	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0
32	0.0	0.0	0.5	0.0
33	0.0	0.0	0.0	0.0
36	0.6	0.3	2.4	0.0
37	0.0	0.0	0.1	0.0
38	0.0	0.0	0.3	0.0
39	0.0	0.0	0.0	0.0
40	0.0	0.0	0.9	0.0
41	0.0	0.0	1.5	0.0
42	0.0	0.0	0.0	0.0
43	0.0	0.0	0.2	0.0
45	0.0	0.0	2.9	0.0
48	0.0	0.0	0.0	0.0
51	0.0	0.0	0.0	0.0
54	0.0	0.0	0.0	0.0
55	0.0	0.0	0.0	0.0
56	0.0	0.0	0.0	0.0
57	0.0	0.0	0.0	0.0
58	0.0	0.0	0.0	0.0
59	0.0	0.0	0.0	0.0
9 − 61	0.0	0.0	0.0	0.0
62	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0
64	0.0	0.0	0.0	0.0
65	0.3	0.1	0.0	0.0
66	0.1	0.0	0.0	0.0
67	0.2	0.0	0.0	0.0
68	0.0	0.0	0.0	0.0
69	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0
71	0.0	0.0	0.0	0.0
72	0.0	0.0	0.4	0.0
74	0.0	0.0	0.0	0.0
75	0.0	0.0	0.5	0.0
77	0.0	0.0	0.2	0.0
80	0.0	0.0	0.0	0.0
81	0.0	0.0	0.0	0.0
82	0.0	0.0	0.0	0.0
91	0.0	0.0	0.8	0.0

Table of Next Stage Condition (continued)

Stage : Next

Line category : Distribution sub main

ZONE	Scenario earthquake North Ray	South Ray	North Tehran	Mosha
1	0.0	0.0	0.0	0.0
2	0.6	0.4	3.1	0.5
3	0.1	0.0	0.0	0.0
4	0.2	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0
10	0.0	0.0	15.2	0.0
11	0.0	0.0	0.1	0.0
12	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0
14	0.0	0.0	9.3	0.0
15A	0.0	0.0	0.0	0.0
15 − 16 − 53	3.7	0.0	0.1	0.0
18	0.0	0.0	0.0	0.0
19	0.0	0.0	1.3	0.0
20	0.0	0.0	49.3	1.7
21	0.0	0.0	15.1	0.0
22	0.0	0.0	49.3	0.0
23	0.0	0.0	46.6	2.7
24	0.0	0.0	13.3	0.0
26	0.0	0.0	52.0	5.6
27	0.0	0.0	47.1	0.7
28	0.0	0.0	55.7	13.1
29	0.0	0.0	40.4	0.0
30	0.0	0.0	28.0	0.0
31	0.0	0.0	0.0	0.0
32	0.0	0.0	37.2	0.0
33	0.0	0.0	29.5	1.6
36	9.5	6.7	23.2	0.1
37	0.0	0.0	38.6	0.0
38	0.0	0.0	1.7	0.0
39	0.0	0.0	10.8	0.0
40	0.0	0.0	44.2	0.0
41	0.0	0.0	49.0	3.4
42	0.0	0.0	1.2	0.0
43	0.0	0.0	6.6	0.0
45	0.0	0.0	38.0	0.0
48	0.0	0.0	22.4	0.4
51	0.0	0.0	0.1	0.0
54	0.0	0.0	0.0	0.0
55	0.0	0.0	11.4	0.0
56	0.0	0.0	0.0	0.0
57	0.0	0.0	0.0	0.0
58	0.0	0.0	3.4	0.0
59	0.0	0.0	0.1	0.0
9 − 61	0.0	0.0	0.0	0.0
62	0.0	0.0	19.4	0.0
63	0.1	0.0	0.0	0.0
64	0.0	0.0	0.0	0.0
65	5.4	0.1	0.0	0.0
66	4.1	0.0	0.0	0.0
67	3.3	0.0	0.0	0.0
68	0.6	0.0	0.0	0.0
69	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0
71	0.0	0.0	0.1	0.0
72	0.0	0.0	37.2	0.0
74	0.0	0.0	9.3	0.0
75	0.0	0.0	9.9	0.0
77	0.0	0.0	3.9	0.0
80	0.0	0.0	0.1	0.0
81	0.0	0.0	0.0	0.0
82	0.0	0.0	36.2	0.0
91	0.0	0.0	40.6	0.0

Stage : Next

Line category : Combined

ZONE	Scenario earthquake North Ray	South Ray	North Tehran	Mosha
1	14.2	13.8	14.2	0.0
2	1.0	0.4	4.5	0.5
3	7.7	7.7	7.7	0.0
4	9.0	8.8	8.9	0.4
5	2.4	2.3	2.3	0.4
6	11.7	11.6	11.7	0.0
7	0.0	0.0	0.0	0.0
8	32.3	32.3	32.5	0.0
10	7.2	7.2	21.3	0.0
11	10.6	10.6	10.7	0.0
12	25.8	25.8	25.8	0.0
13	2.2	2.2	2.2	0.0
14	6.9	6.9	15.5	0.0
15A	0.0	0.0	0.0	0.0
15 − 16 − 53	14.2	10.6	10.7	0.0
18	7.5	7.5	7.5	0.0
19	0.5	0.5	2.1	0.0
20	19.3	19.3	59.3	1.7
21	0.0	0.0	15.4	0.0
22	1.7	1.7	50.1	0.0
23	9.5	9.5	51.7	2.7
24	2.4	2.4	16.2	0.0
26	21.5	21.5	62.3	5.6
27	26.6	26.6	61.4	0.7
28	26.2	26.2	67.3	13.1
29	27.8	27.8	57.2	0.0
30	11.2	11.2	36.1	0.0
31	34.2	34.2	34.2	0.0
32	5.1	5.1	40.7	0.0
33	26.2	26.2	48.0	1.6
36	10.1	7.0	25.1	0.1
37	4.1	4.1	41.2	0.0
38	5.3	5.3	7.1	0.0
39	7.2	7.2	17.3	0.0
40	0.0	0.0	44.7	0.0
41	13.6	13.6	56.6	3.4
42	36.8	36.8	37.5	0.0
43	13.1	13.1	19.0	0.0
45	0.0	0.0	39.8	0.0
48	6.2	6.2	27.2	0.4
51	28.0	28.0	28.0	0.0
54	5.7	5.7	5.7	0.0
55	19.8	19.8	28.9	0.0
56	2.6	2.6	2.6	0.0
57	0.9	0.9	0.9	0.0
58	1.1	1.1	4.5	0.0
59	1.6	1.6	1.7	0.0
9 − 61	8.4	8.4	8.4	0.0
62	19.3	19.3	35.0	0.0
63	10.2	10.1	10.1	0.0
64	32.3	32.3	32.3	0.0
65	5.7	0.2	0.0	0.0
66	6.6	2.5	2.5	0.0
67	17.5	14.5	14.5	0.0
68	0.6	0.0	0.0	0.0
69	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0
71	0.0	0.0	0.1	0.0
72	18.7	18.7	49.1	0.0
74	13.6	13.6	21.6	0.0
75	19.6	19.6	27.9	0.0
77	19.6	19.6	22.9	0.0
80	1.6	1.6	1.6	0.0
81	1.6	1.6	1.6	0.0
82	14.2	14.2	45.3	0.0
91	2.9	2.9	42.8	0.0

7. Table of Final Stage Condition

Stage : Final				
Line category : Tranmission main				
ZONE	Scenario earthquake			
	North Ray	South Ray	North Tehran	Mosha
1	1.1			0
2	0.0			0
3	5.8			0
4	7.4			0
5	1.2			0
6	8.5			0
7	0.0			0
8	2.4			0
10	7.2			0
11	10.2			0
12	20.8			0
13	2.2			0
14	4.6			0
15A	0.0			0
15 − 16 − 53	3.0			0
18	1.8			0
19	0.5			0
20	19.3			0
21	0.0			0
22	1.2			0
23	9.5			0
24	2.4			0
26	21.5			0
27	26.6			0
28	26.2			0
29	27.8			0
30	11.2			0
31	2.6			0
32	5.1			0
33	26.2			0
36	0.0			0
37	4.1			0
38	5.3			0
39	7.2			0
40	0.0			0
41	13.6			0
42	36.8			0
43	6.6			0
45	0.0			0
48	6.2			0
51	27.6			0
54	0.5			0
55	19.8			0
56	2.6			0
57	0.9			0
58	1.1			0
59	1.6			0
9 − 61	4.9			0
62	19.3			0
63	10.0			0
64	32.0			0
65	0.0			0
66	2.5			0
67	14.5			0
68	0.0			0
69	0.0			0
70	0.0			0
71	0.0			0
72	18.7			0
74	13.6			0
75	19.6			0
77	19.6			0
80	1.6			0
81	1.6			0
82	14.2			0
91	2.9			0

Stage : Final				
Line category : Distribution trunk main				
ZONE	Scenario earthquake			
	North Ray	South Ray	North Tehran	Mosha
1	0.02	0.00	0.02	0.00
2	0.02	0.00	0.08	0.00
3	0.08	0.08	0.08	0.00
4	0.06	0.06	0.07	0.02
5	0.05	0.05	0.05	0.02
6	0.05	0.04	0.05	0.00
7	0.00	0.00	0.00	0.00
8	0.00	0.00	0.02	0.00
10	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00
15A	0.00	0.00	0.00	0.00
15 − 16 − 53	0.08	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00
19	0.00	0.00	0.05	0.00
20	0.00	0.00	0.08	0.00
21	0.00	0.00	0.08	0.00
22	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00
24	0.00	0.00	0.19	0.00
26	0.00	0.00	0.00	0.00
27	0.00	0.00	0.08	0.00
28	0.00	0.00	0.00	0.00
29	0.00	0.00	0.09	0.00
30	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00
32	0.00	0.00	0.09	0.00
33	0.00	0.00	0.00	0.00
36	0.06	0.03	0.23	0.00
37	0.00	0.00	0.02	0.00
38	0.00	0.00	0.05	0.00
39	0.00	0.00	0.00	0.00
40	0.00	0.00	0.17	0.00
41	0.00	0.00	0.29	0.00
42	0.00	0.00	0.00	0.00
43	0.00	0.00	0.04	0.00
45	0.00	0.00	0.57	0.00
48	0.00	0.00	0.00	0.00
51	0.00	0.00	0.00	0.00
54	0.00	0.00	0.00	0.00
55	0.00	0.00	0.00	0.00
56	0.00	0.00	0.00	0.00
57	0.00	0.00	0.00	0.00
58	0.00	0.00	0.00	0.00
59	0.00	0.00	0.00	0.00
9 − 61	0.00	0.00	0.00	0.00
62	0.00	0.00	0.00	0.00
63	0.00	0.00	0.00	0.00
64	0.00	0.00	0.00	0.00
65	0.06	0.02	0.00	0.00
66	0.02	0.00	0.00	0.00
67	0.05	0.00	0.00	0.00
68	0.00	0.00	0.00	0.00
69	0.00	0.00	0.00	0.00
70	0.00	0.00	0.00	0.00
71	0.00	0.00	0.00	0.00
72	0.00	0.00	0.08	0.00
74	0.00	0.00	0.00	0.00
75	0.00	0.00	0.10	0.00
77	0.00	0.00	0.05	0.00
80	0.00	0.00	0.00	0.00
81	0.00	0.00	0.00	0.00
82	0.00	0.00	0.00	0.00
91	0.00	0.00	0.17	0.00

Table of Final Stage Condition (continued)

Stage : Final				
Line category : Distribution sub main				
ZONE	Scenario earthquake			
	North Ray	South Ray	North Tehran	Mosha
1	0.00	0.00	0.00	0.00
2	0.49	0.34	2.72	0.49
3	0.10	0.00	0.00	0.00
4	0.16	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00
6	0.02	0.00	0.00	0.00
7	0.00	0.00	0.01	0.00
8	0.00	0.00	0.00	0.00
10	0.00	0.00	1.86	0.00
11	0.00	0.00	0.01	0.00
12	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00
14	0.00	0.00	1.57	0.00
15A	0.00	0.00	0.00	0.00
15 – 16 – 53	0.99	0.01	0.04	0.00
18	0.00	0.00	0.00	0.00
19	0.00	0.00	0.20	0.00
20	0.00	0.00	11.22	0.40
21	0.00	0.00	3.32	0.01
22	0.00	0.00	6.21	0.00
23	0.00	0.00	10.02	0.58
24	0.00	0.00	1.41	0.00
26	0.00	0.00	11.02	1.19
27	0.00	0.00	12.13	0.18
28	0.00	0.00	12.19	2.86
29	0.00	0.00	4.73	0.00
30	0.00	0.00	5.74	0.00
31	0.00	0.00	0.00	0.00
32	0.00	0.00	7.57	0.00
33	0.00	0.00	11.48	0.60
36	2.08	1.46	5.08	0.03
37	0.00	0.00	3.85	0.00
38	0.00	0.00	0.37	0.00
39	0.00	0.00	2.25	0.00
40	0.00	0.00	7.38	0.00
41	0.00	0.00	12.62	0.89
42	0.00	0.00	0.10	0.00
43	0.00	0.00	1.05	0.00
45	0.00	0.00	23.36	0.00
48	0.00	0.00	9.04	0.16
51	0.00	0.00	0.01	0.00
54	0.00	0.00	0.00	0.00
55	0.00	0.00	2.16	0.00
56	0.00	0.00	0.00	0.00
57	0.00	0.00	0.00	0.00
58	0.00	0.00	1.76	0.00
59	0.00	0.00	0.06	0.00
9 – 61	0.00	0.00	0.00	0.00
62	0.00	0.00	2.87	0.00
63	0.01	0.00	0.00	0.00
64	0.00	0.00	0.00	0.00
65	1.16	0.02	0.00	0.00
66	2.77	0.00	0.00	0.00
67	0.76	0.00	0.00	0.00
68	0.27	0.00	0.00	0.00
69	0.00	0.00	0.00	0.00
70	0.00	0.00	0.00	0.00
71	0.00	0.00	0.05	0.00
72	0.00	0.00	12.42	0.00
74	0.00	0.00	5.37	0.00
75	0.00	0.00	2.37	0.00
77	0.00	0.00	0.55	0.00
80	0.00	0.00	0.03	0.00
81	0.00	0.00	0.00	0.00
82	0.00	0.00	7.93	0.00
91	0.00	0.00	12.39	0.00

Stage : Final				
Line category : Combined				
ZONE	Scenario earthquake			
	North Ray	South Ray	North Tehran	Mosha
1	1.1	1.1	1.1	0.0
2	0.5	0.3	2.8	0.5
3	5.9	5.9	5.9	0.0
4	7.7	7.5	7.5	0.0
5	1.2	1.2	1.2	0.0
6	8.5	8.5	8.5	0.0
7	0.0	0.0	0.0	0.0
8	2.4	2.4	2.4	0.0
10	7.2	7.2	9.0	0.0
11	10.2	10.2	10.2	0.0
12	20.8	20.8	20.8	0.0
13	2.2	2.2	2.2	0.0
14	4.6	4.6	6.1	0.0
15A	0.0	0.0	0.0	0.0
15 – 16 – 53	4.1	3.0	3.1	0.0
18	1.8	1.8	1.8	0.0
19	0.5	0.5	0.7	0.0
20	19.3	19.3	28.4	0.4
21	0.0	0.0	3.4	0.0
22	1.2	1.2	7.4	0.0
23	9.5	9.5	18.6	0.6
24	2.4	2.4	4.0	0.0
26	21.5	21.5	30.2	1.2
27	26.6	26.6	35.5	0.2
28	26.2	26.2	35.2	2.9
29	27.8	27.8	31.3	0.0
30	11.2	11.2	16.3	0.0
31	2.6	2.6	2.6	0.0
32	5.1	5.1	12.4	0.0
33	26.2	26.2	34.7	0.6
36	2.1	1.5	5.3	0.0
37	4.1	4.1	7.8	0.0
38	5.3	5.3	5.7	0.0
39	7.2	7.2	9.3	0.0
40	0.0	0.0	7.5	0.0
41	13.6	13.6	24.7	0.9
42	36.8	36.8	36.8	0.0
43	6.6	6.6	7.6	0.0
45	0.0	0.0	23.8	0.0
48	6.2	6.2	14.7	0.2
51	27.6	27.6	27.6	0.0
54	0.5	0.5	0.5	0.0
55	19.8	19.8	21.5	0.0
56	2.6	2.6	2.6	0.0
57	0.9	0.9	0.9	0.0
58	1.1	1.1	2.8	0.0
59	1.6	1.6	1.6	0.0
9 – 61	4.9	4.9	4.9	0.0
62	19.3	19.3	21.7	0.0
63	10.0	10.0	10.0	0.0
64	32.0	32.0	32.0	0.0
65	1.2	0.0	0.0	0.0
66	5.2	2.5	2.5	0.0
67	15.2	14.5	14.5	0.0
68	0.3	0.0	0.0	0.0
69	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0
71	0.0	0.0	0.0	0.0
72	18.7	18.7	28.8	0.0
74	13.6	13.6	18.2	0.0
75	19.6	19.6	21.6	0.0
77	19.6	19.6	20.1	0.0
80	1.6	1.6	1.6	0.0
81	1.6	1.6	1.6	0.0
82	14.2	14.2	21.0	0.0
91	2.9	2.9	15.0	0.0

APPENDIX- 3

Modelling of Fault Crossing

and

Underground Beam Structure

1. Model of Fault

2. Details of Underground Beam Structure Model

3. Analysis Examples

1. Model of Fault

Followings are basic fault dislocation model.

- Vertical dislocation caused by reverse or thrust fault
- Horizontal dislocation caused by slip fault
- Tensile displacement caused by reverse fault
- Compressive displacement caused by thrust fault

Actual displacement is a combination of these mechanisms. Pipelines are suffered pure shear deformation by dislocation and fractured with shear mode and/or bending mode as a model of beam. Each region divided by fault line has a same movement inside the regions. Under this condition relative displacement of points which are located in each region is considered. Relative dislocation component is not influenced the location of the selected points. Considering pipeline as beam, outer force or forced displacement can be divided into axial components and lateral ones. Therefore neither of these two elements are not influenced by the position of selected points. *Figure 1* shows example of these conditions. Relative displacement between point A and C is same as of between B and D. Displacement of point A is same as point B, for both point A and B are on the same ground region.

As described above the relative displacement is independent of selection of points. On the other hand strain caused at pipeline differs with selection of points. Selection of two points with long length becomes small compared to that of with short length. Strain caused between points A and D in the figure becomes smaller than that of between points B and C. Therefore to avoid excess concentration of strain, which might be hazardous to pipeline, countermeasures with selected two points shall be set based on these considerations.

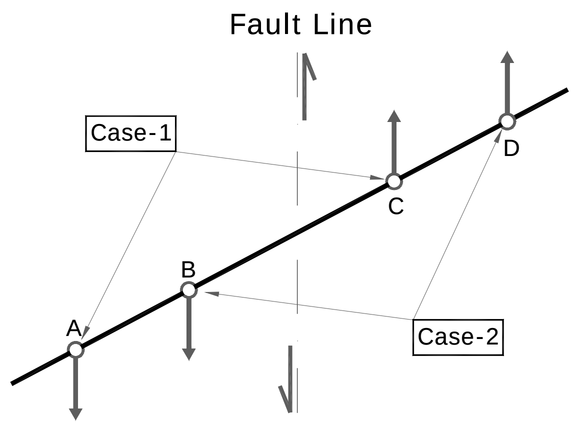


Figure 1 Fault Model

In case of selecting near points across the fault line like B and C like on the figure, both longitudinal and lateral strain become large and pipe joints detach easily. Even detach-resistant joints in case of ductile iron pipe, strain might exceed allowable limit because of concentration of the strain. Reduction of such concentration is necessary even when flexible joints are used, for basic purpose of such flexible is to avoid damage caused by ground settlement which value is small compared to that of fault dislocation effects. Therefore to use flexible joints is not always best way to avoid damage by earthquake, especially fault crossing. When setting flexible joints at places of ground settlement, it is easy to specify the possible points. On the other hand in case of fault crossing, to specify the precise fault location is rather difficult considering the ground covered fault. Therefore allowance of such uncertainty should be in consideration and many of flexible joints might be set at intervals. However this tactic has a fear of having weak structure points.

There are several methods to avoid excessive concentration of strain other than use of expansion joints. Using of casing pipe or reinforced concrete culvert is other alternative. These structures are modeled as beam structure and displacement becomes gradually even near fault line and main pipe inside does not suffer abrupt deformation. However surrounding soil restraints are considered properly to attain the purpose. If surrounding soil conditions are good enough, in other words soil is relatively soft case, welded steel pipeline satisfy the condition without any special measures.

Typical methods of absorbing such relative displacement are shown below. First avoiding method of axial deformation is described. If there is no possibility of joint deform concentration use of pipe with detach-resistant joints are adequate. However this case in only as ideal one and it is difficult to find such case. Therefore additional measure is necessary considering actual conditions. *Figure 2* shows schematic illustration of the case. Certain length of concrete culvert is installed perpendicular to fault line and direction of fault movement is modeled only detaching. Offset of ground is distributed along culvert and every joint displacement becomes small.

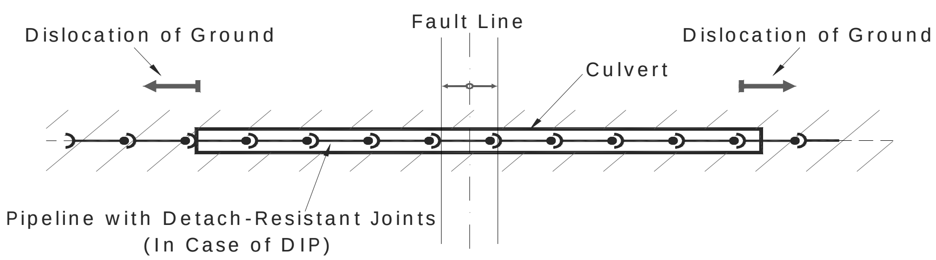


Figure 2 Deformation Absorbing Mechanism

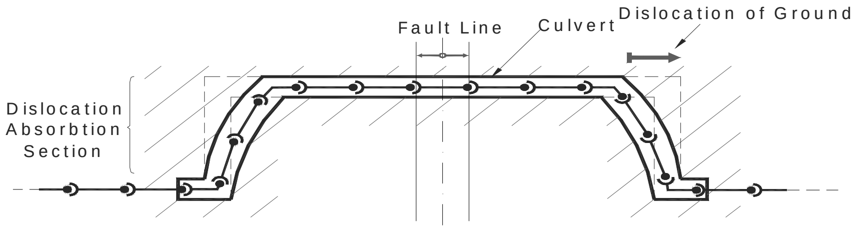


Figure 3 Deformation Absorbing Mechanism

Another method is absorbing dislocation with bending of such box culvert itself. *Figure 4* shows the example. Same dislocation mentioned above occurs and such dislocation can be absorbed by two vertical elements shown in the figure. If weld steel pipes are used as main pipes and enough length of culvert can not be secured this type of measures can be applied.

Second lateral displacement along pipeline is considered. Such culvert or casing pipes are considered as beam structure and this beam is suffered both forced displacement and soil restraint. Soil restraint acts as supporting spring and after large deformation soil acts as pressure load because of soil failure. Schematic illustrations are shown in *Figure 4* and *Figure 5*.

Main pipe inside such culvert is bended gradually and can avoid occurrence of excessive strain conditions.

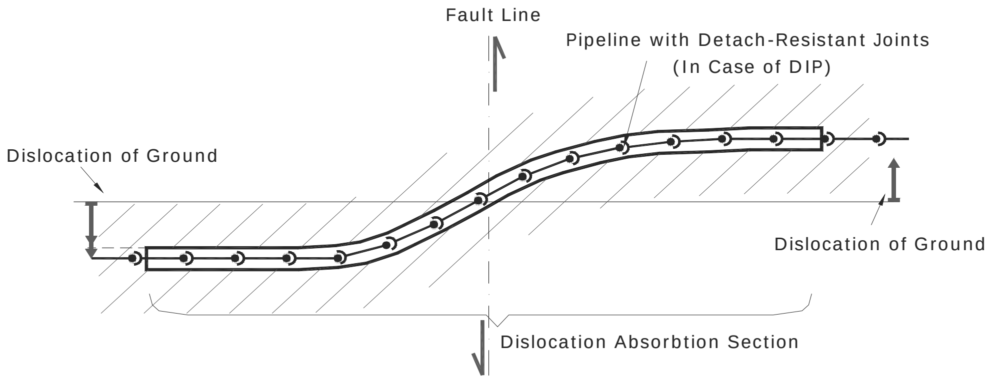


Figure 4 Box Culvert Deformation at Fault

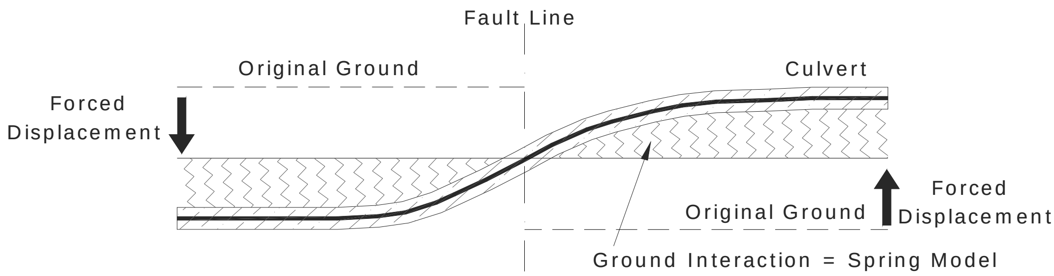


Figure 5 Beam Model

Combined situation is common during fault dislocation. Therefore measures of combined shape can be applied such as type shown in *Figure 3*. Surround soil condition is essential for these models. In case of no surrounding restraint culvert remains straight shape and deformation is concentrated to both ends, small slope deflection or kink occurs at those points. Therefore some measures are necessary to avoid damage caused by such conditions. One of the samples of this condition is above ground bridge structure. There is no surrounding restraint and pipeline kink occurs at bride support. The magnitude of these kinks becomes small as bridge span increase. Therefore long span bridge is one of the best solutions to avoid the influence of fault dislocation, however construction cost becomes huge especially in case of long span structure.

2. Details of Underground Beam Structure Model

Figure 6 shows example of underground beam model. In this figure, δ means half of fault dislocation and w is soil reaction load as a result of forced displacement of beam. Actually beam is supported with surrounding soil modeled as spring like shown in *Figure 5*. However as a result of even little displacement of the beam, spring reactions reach to soil fracture level, which is passive earth pressure. Therefore even applying these soil fracture load on whole length of beam, error is relatively small and is considered as practical. Left end of the beam is considered as fix points. However radius of curvature of beam is considered as infinite and bending moment becomes zero at this point. Length L is derived from these δ, w and flexural rigidity of beam EI. This method is easy to estimate possibility of such measures.

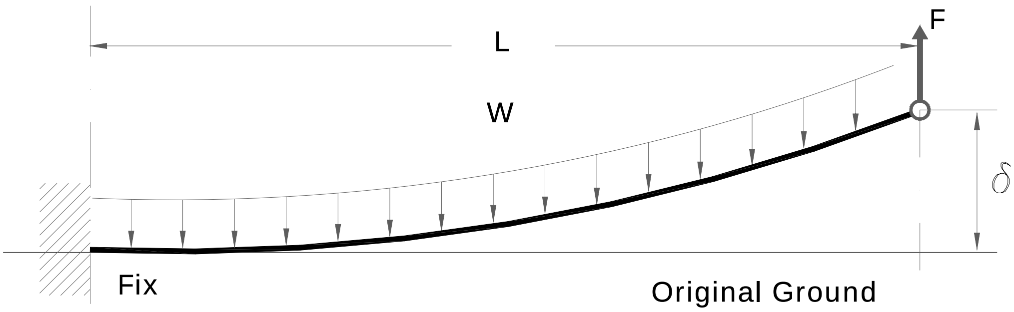


Figure 6 Simple Method

3. Analysis Examples

(1) Example of analysis result using simple method

Design conditions are as follows.

Outer diameter of pipe=100cm thickness of pipe=1.5cm

Material of pipe is steel and young's modulus E=2,100,000 kgf/cm^2

Half of fault dislocation δ =20cm

Passive load along beam width w=125 kgf/cm

Passive load is assumed based on soil condition c=0 and ϕ =35° and earth cover of 200cm

Therefore moment inertia of pipe I=562,000 cm^4

Length L is derived from following formula.

$$L = \sqrt[4]{\frac{24EI\,\delta}{w}}$$

L=1,459 cm= 14.59 m

And maximum axial stress=2,950 kgf/cm^2 at location 7.3 m from fault line.

(2) Finite Beam Method

To investigate more details, finite beam method can be applied. Effect of surrounding soil condition can be included by modeling the effect as spring and effect of soil fracture can be also included.

Same model results using finite beam method are shown to compare with simplified method. Spring constant K is derived from soil data. In this case surrounding ground is assumed to be replaced to sand and spring constant K is about 150kgf/cm^2.

Result from finite beam method.

L= 11m

Maximum axial stress=2,873 kgf/cm^2 at location 7.0 m from fault line.

Shape of beam after forced displacement is shown in *Figure 7*.

From these results simplified analytical method is enough satisfactory to estimate the condition.

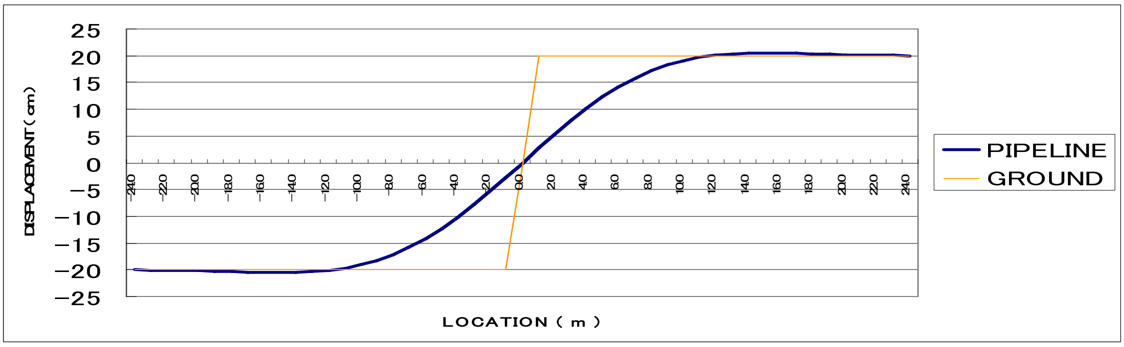


Figure 7 Shape of beam after deformation

(Result of Finite Beam Analysis)

(3) Concrete Box Culvert

Examples similar to steel casing described before are shown next. Assuming height and width of concrete culvert is approximately 100 cm and thickness is 20 cm. Ratio of steel reinforcing bar is 5 %.

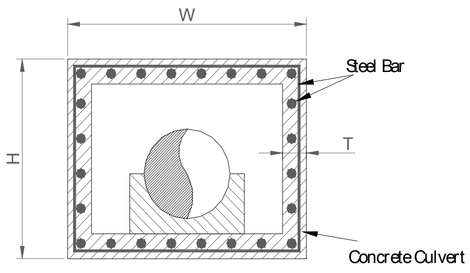


Figure 8 Box Culvert Model

Soil conditions are as follows.

Kp=1,500 kgf/cm for Stiff soil
Passive load along beam width w=300 kgf/cm for Stiff soil

Kp=150 kgf/cm for Loose Sand
Passive load along beam width w=125 kgf/cm for Loose Sand

Figure 8 shows resultant bending moment. Bending moment is reduced in case of loose sand is used as backfill materials. *Figure 9* shows bending moment distribution to compare the difference of surrounding conditions.

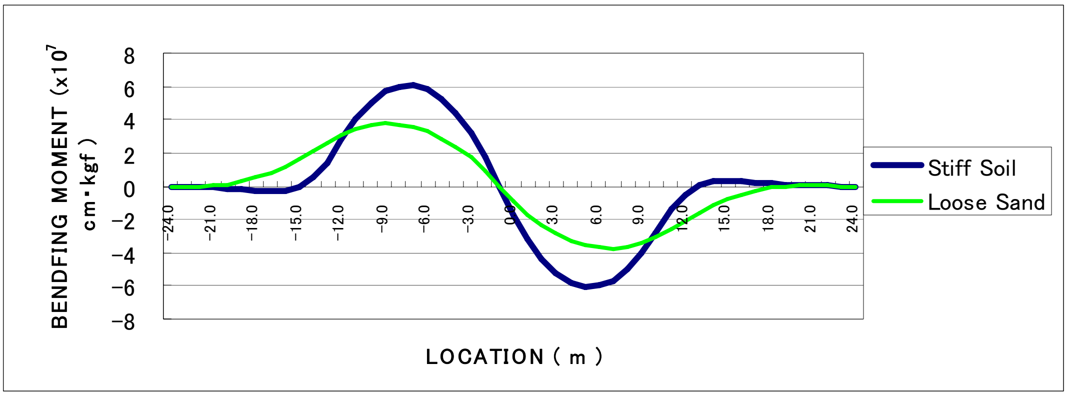


Figure 9 Bending Moment Distribution

APPENDIX 4

DTSC: Diagnosis Table for Seismic Capacity

DTSC represents a degree of seismic resistance, and also has a function of a record of site survey.

These DTSC, which compile here, are record of present situations of facility up to the point of Aug 2005, when some facilities were plan or not start, we marked accordingly on these DTSC, see the note of table.

Moreover, we made a DTSC tentatively for Pump House based on Reservoir because the number of pump house is so many, but we did not apply to general building. So the description on DTSC of such Generator House was on the basis of structural analysis. Generally in Japan, these buildings are evaluated by area of RC wall, this method is mentioned for reference on attached document named Diagnostic Manual. On the other hand, Iranian brick wall must have spring effect on structural fram, so if Japanese wall area evaluation method would be modified somehow, it could be applied.

In the future Iranian earthquake research of damage might be made progress, these examples of DTSC would help Iranian Engineer to add new evaluation items or modify the fragility point, also wall area evaluation method for building might be useful on the basis of making some reductions of wall area for brick wall.

Followings are shown in the Appendix

1. **DTSC for Reservoir (A-4.2 ～4.10)**
2. **DTSC for Pumping Station (A-4.11～4.15)**
3. **DTSC for WTP tank (A-4.16～4.17)**

1. Diagnosis sheet (Reservior) 1/9

Name of Facility			Reservoir No. 1	Reservoir No. 2	Reservoir No. 3	Reservoir No. 4	Reservoir No. 5	Reservoir No. 6	Reservoir No. 7	Reservoir No. 8	Reservoir No. 9	Reservoir No. 10	Reservoir No. 11	Reservoir No. 12	Reservoir No. 13	Reservoir No. 14
Risk Factor	Cope	Fragility Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point
Ground	Ground	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Type-2	1.0														
	Type-3	1.8														
Liquefaction	not occur	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	possible	2.0														
	occur	3.0														
Land features	Cutting ground	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	sloping ground	1.2														
	Top of mountain	1.3														
	landfill	1.5														
Elevation	On the ground	1.2														
	Semi-buried	1.1										1.1				1.1
	Underground	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0	
Material	RC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Brick	3.0														
Wall area of X-axis and Y-axis ／tank area	0.05＜	1.0														
	0.05＞	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Water depth	5m≧	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0				1.0		1.0
	5m＜	1.3									1.3	1.3	1.3		1.3	
Structural formation	Wall	1.0														
	Column & Beam	1.2														
	Flat slub	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Soil cover	0.4m≧	1.0														
	0.4m＜	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Construction year	from 1995 onward	1.0														
		1.2														
	before 1994	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Flexible pipe	existing	1.0														
	nothing	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ex. j	good condition	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	bad condition	2.0														
Degraded degree	small	1.0	1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	middle rank	1.5														
	intense	2.0						2.0								
Seismic intensity scale	5	1.0	3.8	3.8	3.8	3.8	3.8	7.6	3.8	3.8	4.9	5.4	4.9	3.8	4.9	4.2
	6	2.2	8.3	8.3	8.3	8.3	8.3	16.6	8.3	8.3	10.8	11.9	10.8	8.3	10.8	9.1
	7	3.6	13.6	13.6	13.6	13.6	13.6	27.2	13.6	13.6	17.7	19.5	17.7	13.6	17.7	15.0
Aseismicity	high-level	10＞	5 , 6	5 , 6	5 , 6	5 , 6	5 , 6	5	5 , 6	5 , 6	5	5	5	5 , 6	5	5 , 6
	middle-level	10～17	7	7	7	7	7	6	7	7	6	6	6	7	6	7
	low-level	17＜						7			7	7	7		7	
Senario Surface Acceleration (gal)	North Teheran Fault		228	258	226	271	293	306	285	267	245	316	441	318	231	331
	Mosha Fault		94	133	104	113	120	125	149	119	98	119	187	136	125	107
	South Ray Fault		87	124	127	147	154	157	107	125	87	73	121	104	127	77
	North Ray Fault		81	134	134	116	126	142	152	110	77	92	131	69	145	88
Code 2800			350	350	350	350	350	350	350	350	350	350	350	350	350	350
													on the Fault			on the Fault

note

(magenta)	Facility for Plan	(cyan)	Aseismicity is high-level
(light green)	Facility performed suvey	(yellow)	Aseismicity is middle-level
(green)	Data assumed	(red)	Aseismicity is low-level

1. Diagnosis sheet (Reservior) 2/9

Name of Facility			Reservoir No.15	Reservoir No.16	Reservoir No.17	Reservoir No.18	Reservoir No.19	Reservoir No.20	Reservoir No.21	Reservoir No.22	Reservoir No.23	Reservoir No.24	Reservoir No.25	Reservoir No.26	Reservoir No.27	Reservoir No.28
Risk Factor	Cope	Fragility Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point
Ground	Ground	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Type-2	1.0														
	Type-3	1.8														
Liquefaction	not occur	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	possible	2.0														
	occur	3.0														
Land features	Cutting ground	1.0	1.0	1.0		1.0	1.0		1.0	1.0	1.0	1.0				
	sloping ground	1.2						1.2					1.2	1.2	1.2	1.2
	Top of mountain	1.3														
	landfill	1.5														
Elevation	On the ground	1.2														
	Semi-buried	1.1		1.1		1.1		1.1		1.1	1.1	1.1	1.1	1.1		1.1
	Underground	1.0	1.0				1.0		1.0						1.0	
Material	RC	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Brick	3.0														
Wall area of X-axis and Y-axis	0.05<	1.0														
/tank area	0.05>	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Water depth	5m≧	1.0				1.0	1.0		1.0	1.0						
	5m<	1.3	1.3	1.3				1.3			1.3	1.3	1.3	1.3	1.3	1.3
Structural formation	Wall	1.0														
	Column & Beam	1.2														
	Flat slub	1.4	1.4	1.4		1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Soil cover	0.4m≧	1.0														
	0.4m<	1.2	1.2	1.2		1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Construction year	from 1995 onward	1.0														
		1.2														
	before 1994	1.5	1.5	1.5		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Flexible pipe	existing	1.0														
	nothing	2.0	2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ex.j	good condition	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	bad condition	2.0														
Degraded degree	small	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	middle rank	1.5														
	intense	2.0														
Seismic intensity scale	5	1.0	4.9	5.4		4.2	3.8	6.5	3.8	4.2	5.4	5.4	6.5	6.5	5.9	6.5
	6	2.2	10.8	11.9		9.1	8.3	14.3	8.3	9.1	11.9	11.9	14.3	14.3	13.0	14.3
	7	3.6	17.7	19.5		15.0	13.6	23.4	13.6	15.0	19.5	19.5	23.4	23.4	21.2	23.4
Aseismicity	high-level	10>	5	5		5, 6	5, 6	5	5, 6	5, 6	5	5	5	5	5	5
	middle-level	10～17	6	6		7	7	6	7	7	6	6	6	6	6	6
	low-level	17<	7	7				7			7	7	7	7	7	7
Senario Surface Acceleration (gal)	North Teheran Fault		175	223	621	241	558	511	659	408	691	449	671	511	583	483
	Mosha Fault		111	115	187	96	235	177	198	111	216	126	222	177	187	156
	South Ray Fault		158	212	112	73	100	67	108	65	117	58	110	67	72	65
	North Ray Fault		174	208	99	73	101	63	91	85	88	67	88	63	61	58
Code 2800			350	350	350	350	350	350	350	350	350	350	350	350	350	350
note			t		Booster P						modify based on structural analysis			on the Fault		

1. Diagnosis sheet (Reservior) 3/9

Name of Facility			Reservoir No. 29	Reservoir No. 30	Reservoir No. 31	Reservoir No. 32	Reservoir No. 33	Reservoir No. 34	Reservoir No. 35	Reservoir No. 36	Reservoir No. 37	Reservoir No. 38	Reservoir No. 39	Reservoir No. 40	Reservoir No. 41	Reservoir No. 42
Risk Factor	Cope	Fragility Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point
Ground	Ground	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Type-2	1.0														
	Type-3	1.8														
Liquefaction	not occur	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	possible	2.0														
	occur	3.0														
Land features	Cutting ground	1.0			1.0			1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0
	sloping ground	1.2	1.2	1.2		1.2						1.2				
	Top of mountain	1.3					1.3									
	landfill	1.5														
Elevation	On the ground	1.2														
	Semi-buried	1.1		1.1		1.1	1.1			1.1		1.1				
	Underground	1.0	1.0		1.0			1.0	1.0		1.0		1.0	1.0	1.0	1.0
Material	RC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Brick	3.0														
Wall area of X-axis and Y-axis ／tank area	0.05＜	1.0														
	0.05＞	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Water depth	5m≧	1.0		1.0	1.0	1.0	1.0	1.0		1.0						
	5m＜	1.3	1.3								1.3	1.3	1.3	1.3	1.3	1.3
Structural formation	Wall	1.0														
	Column & Beam	1.2														
	Flat slub	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Soil cover	0.4m≧	1.0														
	0.4m＜	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Construction year	from 1995 onward	1.0							1.0				1.0			1.0
		1.2														
	before 1994	1.5	1.5	1.5	1.5	1.5	1.5	1.5		1.5	1.5	1.5		1.5	1.5	
Flexible pipe	existing	1.0														
	nothing	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ex. j	good condition	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	bad condition	2.0														
Degraded degree	small	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	middle rank	1.5														
	intense	2.0														
Seismic intensity scale	5	1.0	5.9	5.0	3.8	5.0	5.4	3.8	0.0	4.2	4.9	6.5	3.3	4.9	4.9	3.3
	6	2.2	13.0	11.0	8.3	11.0	11.9	8.3	0.0	9.1	10.8	14.3	7.2	10.8	10.8	7.2
	7	3.6	21.2	18.0	13.6	18.0	19.5	13.6	0.0	15.0	17.7	23.4	11.8	17.7	17.7	11.8
Aseismicity	high-level	10＞	5	5	5 , 6	5	5	5 , 6	5 , 6 , 7	5 , 6	5	5	5 , 6	5	5	5 , 6
	middle-level	10～17	6	6	7	6	6	7		7	6	6	7	6	6	7
	low-level	17＜	7	7		7	7				7	7		7	7	
Senario Surface Acceleration (gal)	North Teheran Fault		583	435	250	386	462		181	112	258	324	441	617	653	554
	Mosha Fault		187	134	150	126	148		91	103	85	102	129	203	207	213
	South Ray Fault		72	59	175	53	65		158	259	67	63	59	124	115	62
	North Ray Fault		61	64	155	63	58		250	296	68	63	93	93	91	72
Code 2800			350	350	350	350	350	350	350	350	350	350	350	350	350	350
note																

1. Diagnosis sheet (Reservior)　4/9

Name of Facility			Reservoir No.43	Reservoir No.44	Reservoir No.45	Reservoir No.46	Reservoir No.47	Reservoir No.48	Reservoir No.49	Reservoir No.50	Reservoir No.51	Reservoir No.52	Reservoir No.53	Reservoir No.54	Reservoir No.55	Reservoir No.56
Risk Factor	Cope	Fragility Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point
Ground	Ground	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Type-2	1.0														
	Type-3	1.8														
Liquefaction	not occur	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	possible	2.0														
	occur	3.0														
Land features	Cutting ground	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	sloping ground	1.2														
	Top of mountain	1.3														
	landfill	1.5														
Elevation	On the ground	1.2														
	Semi-buried	1.1	1.1										1.1	1.1		
	Underground	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0
Material	RC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Brick	3.0														
Wall area of X-axis and Y-axis	0.05＜	1.0														
／tank area	0.05＞	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Water depth	5m≧	1.0		1.0								1.0				
	5m＜	1.3	1.3		1.3	1.3	1.3	1.3	1.3	1.3	1.3		1.3	1.3	1.3	1.3
Structural formation	Wall	1.0														
	Column & Beam	1.2														
	Flat slub	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Soil cover	0.4m≧	1.0														
	0.4m＜	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Construction year	from 1995 onward	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0				1.0	1.0	1.0
		1.2														
	before 1994	1.5									1.5	1.5	1.5			
Flexible pipe	existing	1.0														
	nothing	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ex.j	good condition	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	bad condition	2.0														
Degraded degree	small	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	middle rank	1.5														
	intense	2.0														
Seismic intensity scale	5	1.0	3.6	2.5	3.3	3.3	3.3	3.3	3.3	3.3	4.9	3.8	5.4	3.6	3.3	3.3
	6	2.2	7.9	5.5	7.2	7.2	7.2	7.2	7.2	7.2	10.8	8.3	11.9	7.9	7.2	7.2
	7	3.6	13.0	9.1	11.8	11.8	11.8	11.8	11.8	11.8	17.7	13.6	19.5	13.0	11.8	11.8
Aseismicity	high-level	10＞	5，6	5，6，7	5，6	5，6	5，6	5，6	5，6	5，6	5	5，6	5	5，6	5，6	5，6
	middle-level	10～17	7		7	7	7	7	7	7	6	7	6	7	7	7
	low-level	17＜									7		7			
Senario Surface Acceleration (gal)	North Teheran Fault		336			604					174	218	218	262	270	
	Mosha Fault		131			203					104	117	113	125	177	
	South Ray Fault		101			100					103	207	205	104	100	
	North Ray Fault		82			100					155	229	205	112	106	
Code 2800			350	350	350	350	350	350	350	350	350	350	350	350	350	350
note																

1. Diagnosis sheet (Reservior) 5/9

Name of Facility			Reservoir No.57	Reservoir No.58	Reservoir No.59	Reservoir No.60	Reservoir No.61	Reservoir No.62	Reservoir No.63	Reservoir No.64	Reservoir No.65	Reservoir No.66	Reservoir No.67	Reservoir No.68	Reservoir No.69	Reservoir No.70
Risk Factor	Cope	Fragility Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point
Ground	Ground	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5
	Type-2	1.0												1.0		
	Type-3	1.8														
Liquefaction	not occur	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	possible	2.0														
	occur	3.0														
Land features	Cutting ground	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0
	sloping ground	1.2														
	Top of mountain	1.3							1.3							
	landfill	1.5														
Elevation	On the ground	1.2														
	Semi-buried	1.1					1.1		1.1	1.1						
	Underground	1.0	1.0	1.0	1.0	1.0		1.0			1.0	1.0	1.0	1.0	1.0	1.0
Material	RC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Brick	3.0														
Wall area of X-axis and Y-axis ／tank area	0.05＜	1.0														
	0.05＞	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Water depth	5m≧	1.0								1.0	1.0	1.0				
	5m＜	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3				1.3	1.3	1.3	1.3
Structural formation	Wall	1.0														
	Column & Beam	1.2														
	Flat slub	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Soil cover	0.4m≧	1.0														
	0.4m＜	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Construction year	from 1995 onward	1.0			1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0
		1.2														
	before 1994	1.5	1.5	1.5					1.5							
Flexible pipe	existing	1.0														
	nothing	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ex.j	good condition	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	bad condition	2.0														
Degraded degree	small	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0
	middle rank	1.5														
	intense	2.0										2.0				
Seismic intensity scale	5	1.0	4.9	4.9	3.3	3.3	3.6	3.3	7.0	2.8	2.5	5.0	3.3	6.6	3.3	3.3
	6	2.2	10.8	10.8	7.2	7.2	7.9	7.2	15.5	6.1	5.5	11.1	7.2	14.4	7.2	7.2
	7	3.6	17.7	17.7	11.8	11.8	13.0	11.8	25.3	10.0	9.1	18.1	11.8	23.6	11.8	11.8
Aseismicity	high-level	10＞	5	5	5 , 6	5 , 6	5 , 6	5 , 6	5	5 , 6	5 , 6 , 7	5	5 , 6	5	5 , 6	5 , 6
	middle-level	10～17	6	6	7	7	7	7	6	7		6	7	6	7	7
	low-level	17＜	7	7					7			7		7		
Senario Surface Acceleration (gal)	North Teheran Fault		288	255	287		255	435	109	210	128	140	151	240	184	172
	Mosha Fault		98	78	96		100	200	85	120	85	81	164	152	96	93
	South Ray Fault		104	61	110		85	105	147	206	276	233	303	201	156	151
	North Ray Fault		129	75	137		76	131	172	284	292	256	224	291	219	244
Code 2800			350	350	350	350	350	350	350	350	350	350	350	350	350	350
note											operation from 2001 deterioration		operation from 2000		

1. Diagnosis sheet (Reservior)　6/9

Name of Facility			Reservoir No. 71	Reservoir No. 72	Reservoir No. 73	Reservoir No. 74	Reservoir No. 75	Reservoir No. 76	Reservoir No. 77	Reservoir No. 78	Reservoir No. 79	Reservoir No. 80	Reservoir No. 81	Reservoir No. 82	Reservoir No. 83	Reservoir No. 84
Risk Factor	Cope	Fragility Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point
Ground	Ground	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Type-2	1.0														
	Type-3	1.8														
Liquefaction	not occur	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	possible	2.0														
	occur	3.0														
Land features	Cutting ground	1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	sloping ground	1.2					1.2									
	Top of mountain	1.3														
	landfill	1.5														
Elevation	On the ground	1.2														
	Semi-buried	1.1		1.1			1.1					1.1				
	Underground	1.0	1.0		1.0	1.0		1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0
Material	RC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Brick	3.0														
Wall area of X-axis and Y-axis ／tank area	0.05＜	1.0														
	0.05＞	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Water depth	5m≧	1.0			1.0			1.0	1.0				1.0	1.0		
	5m＜	1.3	1.3	1.3		1.3	1.3			1.3	1.3	1.3			1.3	1.3
Structural formation	Wall	1.0														
	Column & Beam	1.2														
	Flat slub	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Soil cover	0.4m≧	1.0														
	0.4m＜	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Construction year	from 1995 onward	1.0				1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
		1.2														
	before 1994	1.5	1.5	1.5	1.5											
Flexible pipe	existing	1.0														
	nothing	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ex. j	good condition	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	bad condition	2.0														
Degraded degree	small	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	middle rank	1.5														
	intense	2.0														
Seismic intensity scale	5	1.0	4.9	5.4	3.8	3.3	4.3	2.5	2.5	3.3	3.3	3.6	2.5	2.5	3.3	3.3
	6	2.2	10.8	11.9	8.3	7.2	9.5	5.5	5.5	7.2	7.2	7.9	5.5	5.5	7.2	7.2
	7	3.6	17.7	19.5	13.6	11.8	15.6	9.1	9.1	11.8	11.8	13.0	9.1	9.1	11.8	11.8
Aseismicity	high-level	10＞	5	5	5, 6	5, 6	5, 6	5, 6, 7	5, 6, 7	5, 6	5, 6	5, 6	5, 6, 7	5, 6, 7	5, 6	5, 6
	middle-level	10～17	6	6	7	7	7			7	7	7			7	7
	low-level	17＜	7	7												
Senario Surface Acceleration (gal)	North Teheran Fault		248	399	181	513	522		505			262	272	299		
	Mosha Fault		164	120	91	166	169		170			75	74	108		
	South Ray Fault		82	108	158	60	61		56			59	49	61		
	North Ray Fault		83	96	259	65	62		60			78	69	61		
Code 2800			350	350	350	350	350	350	350	350	350	350	350	350	350	350
note			WTP No.3 on the Fault				on the Fault		on the Fault					on the Fault		

1. Diagnosis sheet (Reservior) 7/9

Name of Facility			Reservoir No.85	Reservoir No.86	Reservoir No.87	Reservoir No.88	Reservoir No.89	Reservoir No.90	Reservoir No.91	Reservoir No.92	Reservoir No.93	Reservoir No.94	Reservoir No.95	Reservoir No.96	Reservoir No.97	Reservoir No.98
Risk Factor	Cope	Fragility Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point
Ground	Ground	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Type-2	1.0					1.0									
	Type-3	1.8														
Liquefaction	not occur	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	possible	2.0														
	occur	3.0														
Land features	Cutting ground	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	sloping ground	1.2														
	Top of mountain	1.3														
	landfill	1.5														
Elevation	On the ground	1.2														
	Semi-buried	1.1							1.1				1.1			
	Underground	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0		1.0	1.0	1.0
Material	RC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Brick	3.0														
Wall area of X-axis and Y-axis ／tank area	0.05＜	1.0														
	0.05＞	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Water depth	5m≧	1.0							1.0					1.0		1.0
	5m＜	1.3	1.3	1.3	1.3	1.3	1.3	1.3		1.3	1.3	1.3	1.3		1.3	
Structural formation	Wall	1.0														
	Column & Beam	1.2														
	Flat slub	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Soil cover	0.4m≧	1.0														
	0.4m＜	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Construction year	from 1995 onward	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0				1.0
		1.2														
	before 1994	1.5							1.5				1.5	1.5	1.5	
Flexible pipe	existing	1.0														
	nothing	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ex.j	good condition	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	bad condition	2.0														
Degraded degree	small	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	middle rank	1.5														
	intense	2.0														
Seismic intensity scale	5	1.0	3.3	3.3	3.3	3.3	6.6	3.3	4.2	3.3	3.3	3.3	5.4	3.8	4.9	2.5
	6	2.2	7.2	7.2	7.2	7.2	14.4	7.2	9.1	7.2	7.2	7.2	11.9	8.3	10.8	5.5
	7	3.6	11.8	11.8	11.8	11.8	23.6	11.8	15.0	11.8	11.8	11.8	19.5	13.6	17.7	9.1
Aseismicity	high-level	10＞	5，6	5，6	5，6	5，6	5	5，6	5，6	5，6	5，6	5，6	5	5，6	5	5，6，7
	middle-level	10～17	7	7	7	7	6	7	7	7	7	7	6	7	6	
	low-level	17＜					7						7		7	
Senario Surface Acceleration (gal)	North Teheran Fault						115		386	241	281	248	248	253	248	
	Mosha Fault						82		126	104	92	164	164	168	164	
	South Ray Fault						378		53	134	94	82	82	131	82	
	North Ray Fault						371		63	121	127	83	83	130	83	
Code 2800			350	350	350	350	350	350	350	350	350	350	350	350	350	350
note							operation from 2004						on the Fault		on the Fault	

1. Diagnosis sheet (Reservior)　8/9

Name of Facility			Reservoir No. 99	Reservoir No. 100	Reservoir No. 101	Reservoir No. 102	Reservoir No. 103	Reservoir No. 104	Reservoir No. 105	Reservoir No. 106	Reservoir No. 107	Reservoir No. 108	Reservoir No. 109	Reservoir No. 110	Reservoir No. 111	Reservoir No. 112
Risk Factor	Cope	Fragility Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point
Ground	Ground	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Type-2	1.0														
	Type-3	1.8														
Liquefaction	not occur	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	possible	2.0														
	occur	3.0														
Land features	Cutting ground	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	sloping ground	1.2														
	Top of mountain	1.3														
	landfill	1.5														
Elevation	On the ground	1.2														
	Semi-buried	1.1														
	Underground	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Material	RC	1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Brick	3.0														
Wall area of X-axis and Y-axis	0.05<	1.0														
／tank area	0.05>	1.5	1.5	1.5	1.5	1.5	1.5			1.5	1.5	1.5	1.5	1.5	1.5	1.5
Water depth	5m≧	1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0	1.0	1.0	1.0
	5m<	1.3														
Structural formation	Wall	1.0														
	Column & Beam	1.2														
	Flat slub	1.4	1.4	1.4	1.4	1.4	1.4			1.4	1.4	1.4	1.4	1.4	1.4	1.4
Soil cover	0.4m≧	1.0														
	0.4m<	1.2	1.2	1.2	1.2	1.2	1.2			1.2	1.2	1.2	1.2	1.2	1.2	1.2
Construction year	from 1995 onward	1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0	1.0	1.0	1.0
		1.2														
	before 1994	1.5														
Flexible pipe	existing	1.0														
	nothing	2.0	2.0	2.0	2.0	2.0	2.0			2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ex. j	good condition	1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0	1.0	1.0	1.0
	bad condition	2.0														
Degraded degree	small	1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0	1.0	1.0	1.0
	middle rank	1.5														
	intense	2.0														
Seismic intensity scale	5	1.0	2.5	2.5	2.5	2.5	2.5			2.5	2.5	2.5	2.5	2.5	2.5	2.5
	6	2.2	5.5	5.5	5.5	5.5	5.5			5.5	5.5	5.5	5.5	5.5	5.5	5.5
	7	3.6	9.1	9.1	9.1	9.1	9.1			9.1	9.1	9.1	9.1	9.1	9.1	9.1
Aseismicity	high-level	10>	5, 6, 7	5, 6, 7	5, 6, 7	5, 6, 7	5, 6, 7			5, 6, 7	5, 6, 7	5, 6, 7	5, 6, 7	5, 6, 7	5, 6, 7	5, 6, 7
	middle-level	10～17														
	low-level	17<														
Senario Surface Acceleration (gal)	North Teheran Fault							275	330							
	Mosha Fault							121	144							
	South Ray Fault							119	103							
	North Ray Fault							105	86							
Code 2800			350	350	350	350	350	350	350	350	350	350	350	350	350	350
note																

1. Diagnosis sheet (Reservior) 9/9

Name of Facility			Reservoir No. 113	Reservoir No. 114				
Risk Factor	Cope	Fragility Point	Point	Point				
Ground	Ground	0.5	0.5	0.5				
	Type-2	1.0						
	Type-3	1.8						
Liquefaction	not occur	1.0	1.0	1.0				
	possible	2.0						
	occur	3.0						
Land features	Cutting ground	1.0	1.0	1.0				
	sloping ground	1.2						
	Top of mountain	1.3						
	landfill	1.5						
Elevation	On the ground	1.2						
	Semi-buried	1.1						
	Underground	1.0	1.0	1.0				
Material	RC	1.0	1.0	1.0				
	Brick	3.0						
Wall area of X-axis and Y-axis ／tank area	0.05＜	1.0						
	0.05＞	1.5	1.5	1.5				
Water depth	5m≧	1.0	1.0	1.0				
	5m＜	1.3						
Structural formation	Wall	1.0						
	Column & Beam	1.2						
	Flat slub	1.4	1.4	1.4				
Soil cover	0.4m≧	1.0						
	0.4m＜	1.2	1.2	1.2				
Construction year	from 1995 onward	1.0	1.0	1.0				
		1.2						
	before 1994	1.5						
Flexible pipe	existing	1.0						
	nothing	2.0	2.0	2.0				
Ex. j	good condition	1.0	1.0	1.0				
	bad condition	2.0						
Degraded degree	small	1.0	1.0	1.0				
	middle rank	1.5						
	intense	2.0						
Seismic intensity scale	5	1.0	2.5	2.5				
	6	2.2	5.5	5.5				
	7	3.6	9.1	9.1				
Aseismicity	high-level	10＞	5, 6, 7	5, 6, 7				
	middle-level	10～17						
	low-level	17＜						
Senario Surface Acceleration (gal)	North Teheran Fault							
	Mosha Fault							
	South Ray Fault							
	North Ray Fault							
Code 2800			350	350				
note								

2. Diagnosis sheet (Pumping Station) 1/5

Type of Structure			Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab
Name of Facility			Reservoir No. 1	Reservoir No. 2	Reservoir No. 8	Reservoir No. 12	Reservoir No. 13	Reservoir No. 14	Reservoir No. 15	Reservoir No. 16	Reservoir No. 17	Reservoir No. 18	Reservoir No. 19	Reservoir No. 20	Reservoir No. 21
Risk Factor	Cope	Fragility Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point
Ground	Type-1	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Type-2	1.0													
	Type-3	1.8													
Liquefaction	not occur	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	possible	2.0													
	occur	3.0													
Land features	Cutting ground	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0
	sloping ground	1.2												1.1	
	Top of mountain	1.3													
	landfill	1.5													
Elevation	On the ground	1.2	1.2	1.2		1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	Semisubterranean	1.1													
	Underground	1.0													
Material	RC	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Brick	3.0													
Wall area of X-axis and Y-axis	0.05＜	1.0													
	0.05＞	1.5													
／tank area	0.02＞	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Water depth	5m≧	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	5m＜	1.3													
Structural formation	Wall	1.0													
	Column & Beam	1.2	1.2	1.2		1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	Flat slub	1.4													
Soil cover	0.4m≧	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	0.4m＜	1.2													
Construction year	from 1995 onward	1.0													
		1.2													
	before 1994	1.5	1.5	1.5		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Flexible pipe	existing	1.0													
	nothing	2.0	2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ex. j	good condition	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	bad condition	2.0													
Degraded degree	small	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	middle rank	1.5													
	intense	2.0													
Seismic intensity scale	5	1.0	6.5	6.5		6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	7.1	6.5
	6	2.2	14.3	14.3		14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	15.7	14.3
	7	3.6	23.3	23.3		23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3	25.7	23.3
Aseismicity	high-level	10＞	5	5	5 , 6 , 7	5	5	5	5	5	5	5	5	5	5
	middle-level	10～17	6	6		6	6	6	6	6	6	6	6	6	6
	low-level	17＜	7	7		7	7	7	7	7	7	7	7	7	7
Senario Surface Acceleration (gal)	North Teheran Fault		228	258	267	318	231	331	175	223	621	241	558	511	659
	Mosha Fault		94	133	119	136	125	107	111	115	187	96	235	177	198
	South Ray Fault		87	124	125	104	127	77	158	212	112	73	100	67	108
	North Ray Fault		81	134	110	69	145	88	174	208	99	73	101	63	91
Code 2800			350	350	350	350	350	350	350	350	350	350	350	350	350
note					No Pump			on the Fault							

note:

- Planning
- Facility performed suvey
- Data assumed
- Aseismicity is high-level
- Aseismicity is middle-level
- Aseismicity is low-level

2. Diagnosis sheet (Pumping Station)　　2/5

Type of Structure			Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab
Name of Facility			Reservoir No. 22	Reservoir No. 24	Reservoir No. 25	Reservoir No. 26	Reservoir No. 27	Reservoir No. 28	Reservoir No. 32	Reservoir No. 34	Reservoir No. 36	Reservoir No. 37	Reservoir No. 38	Reservoir No. 40	Reservoir No. 43
Risk Factor	Cope	Fragility Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point
Ground	Type-1	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5
	Type-2	1.0													
	Type-3	1.8													
Liquefaction	not occur	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0
	possible	2.0													
	occur	3.0													
Land features	Cutting ground	1.0	1.0	1.0						1.0	1.0	1.0		1.0	1.0
	sloping ground	1.2			1.1	1.1	1.1	1.1					1.1		
	Top of mountain	1.3													
	landfill	1.5													
Elevation	On the ground	1.2	1.2	1.2	1.2	1.2	1.2	1.2		1.2	1.2	1.2	1.2	1.2	1.2
	Semisubterranean	1.1													
	Underground	1.0													
Material	RC	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0
	Brick	3.0													
Wall area of X-axis and Y-axis	0.05＜	1.0													
	0.05＞	1.5													
／tank area	0.02＞	3.0	3.0	3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Water depth	5m≧	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0
	5m＜	1.3													
Structural formation	Wall	1.0													
	Column & Beam	1.2	1.2	1.2	1.2	1.2	1.2	1.2		1.2	1.2	1.2	1.2	1.2	1.2
	Flat slub	1.4													
Soil cover	0.4m≧	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	0.4m＜	1.2													
Construction year	from 1995 onward	1.0													1.0
		1.2													
	before 1994	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	
Flexible pipe	existing	1.0													
	nothing	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ex. j	good condition	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	bad condition	2.0													
Degraded degree	small	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	middle rank	1.5													
	intense	2.0													
Seismic intensity scale	5	1.0	6.5	6.5	7.1	7.1	7.1	7.1	0.0	6.5	6.5	6.5	7.1	6.5	4.3
	6	2.2	14.3	14.3	15.7	15.7	15.7	15.7	0.0	14.3	14.3	14.3	15.7	14.3	9.5
	7	3.6	23.3	23.3	25.7	25.7	25.7	25.7	0.0	23.3	23.3	23.3	25.7	23.3	15.6
Aseismicity	high-level	10＞	5	5	5	5	5	5	5, 6, 7	5	5	5	5	5	5, 6
	middle-level	10～17	6	6	6	6	6	6		6	6	6	6	6	7
	low-level	17＜	7	7	7	7	7	7		7	7	7	7	7	
Senario Surface Acceleration (gal)	North Teheran Fault		408	449	671	511	583	483	386		112	258	324	617	336
	Mosha Fault		111	126	222	177	187	156	126		103	85	102	203	131
	South Ray Fault		65	58	110	67	72	65	53		259	67	63	124	101
	North Ray Fault		85	67	88	63	61	58	63		296	68	63	93	82
Code 2800			350	350	350	350	350	350	350	350	350	350	350	350	350
note						on the Fault			No Pump H			No Pump H.			No Pump H.

2. Diagnosis sheet (Pumping Station) 3/5

Type of Structure			Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab
Name of Facility			Reservoir No.52	Reservoir No.56	Reservoir No.57	Reservoir No.58	Reservoir No.59	Reservoir No.65	Reservoir No.66	Reservoir No.68	Reservoir No.69	Reservoir No.71	Reservoir No.72	Reservoir No.73	Reservoir No.74
Risk Factor	Cope	Fragility Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point
Ground	Type-1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5			0.5	0.5	0.5	0.5
	Type-2	1.0													
	Type-3	1.8													
Liquefaction	not occur	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0
	possible	2.0													
	occur	3.0													
Land features	Cutting ground	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0
	sloping ground	1.2													
	Top of mountain	1.3													
	landfill	1.5													
Elevation	On the ground	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2			1.2	1.2	1.2	1.2
	Semisubterranean	1.1													
	Underground	1.0													
Material	RC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0
	Brick	3.0													
Wall area of X-axis and Y-axis	0.05＜	1.0													
	0.05＞	1.5													
／tank area	0.02＞	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0			3.0	3.0	3.0	3.0
Water depth	5m≧	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0
	5m＜	1.3													
Structural formation	Wall	1.0													
	Column & Beam	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2			1.2	1.2	1.2	1.2
	Flat slub	1.4													
Soil cover	0.4m≧	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0
	0.4m＜	1.2													
Construction year	from 1995 onward	1.0					1.0	1.0	1.0						1.0
		1.2													
	before 1994	1.5	1.5	1.5	1.5	1.5						1.5	1.5	1.5	
Flexible pipe	existing	1.0													
	nothing	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0			2.0	2.0	2.0	2.0
Ex.j	good condition	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0
	bad condition	2.0													
Degraded degree	small	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0
	middle rank	1.5													
	intense	2.0													
Seismic intensity scale	5	1.0	6.5	6.5	6.5	6.5	4.3	4.3	4.3		0.0	6.5	6.5	6.5	4.3
	6	2.2	14.3	14.3	14.3	14.3	9.5	9.5	9.5		0.0	14.3	14.3	14.3	9.5
	7	3.6	23.3	23.3	23.3	23.3	15.6	15.6	15.6		0.0	23.3	23.3	23.3	15.6
Aseismicity	high-level	10＞	5	5	5	5	5, 6	5, 6	5, 6	5, 6, 7	5, 6, 7	5	5	5	5, 6
	middle-level	10～17	6	6	6	6	7	7	7			6	6	6	7
	low-level	17＜	7	7	7	7						7	7	7	
Senario Surface Acceleration	North Teheran Fault		218		288	255	287	128	140	240	184	248	399	181	513
(gal)	Mosha Fault		117		98	78	96	85	81	152	96	164	120	91	166
	South Ray Fault		207		104	61	110	276	233	201	156	82	108	158	60
	North Ray Fault		229		129	75	137	292	256	291	219	83	96	259	65
Code 2800			350	350	350	350	350	350	350	350	350	350	350	350	350
note							No Pump House under construction			No Pump H.	No Pump	No Pump on the fault	No Pump H.		

2. Diagnosis sheet (Pumping Station)　4/5

Type of Structure			Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab
Name of Facility			Reservoir No. 75	Reservoir No. 80	Reservoir No. 81	Reservoir No. 82	Reservoir No. 90	Reservoir No. 92	Reservoir No. 93	Reservoir No. 94	Reservoir No. 95	Reservoir No. 96	Reservoir No. 97	Reservoir No. 99	Reservoir No. 100
Risk Factor	Cope	Fragility Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point
Ground	Type-1	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5
	Type-2	1.0													
	Type-3	1.8													
Liquefaction	not occur	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0
	possible	2.0													
	occur	3.0													
Land features	Cutting ground	1.0		1.0	1.0		1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0
	sloping ground	1.2	1.1												
	Top of mountain	1.3													
	landfill	1.5													
Elevation	On the ground	1.2	1.2	1.2	1.2		1.2	1.2	1.2	1.2		1.2		1.2	1.2
	Semisubterranean	1.1													
	Underground	1.0													
Material	RC	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0		1.0		1.0	1.0
	Brick	3.0													
Wall area of X-axis and Y-axis	0.05＜	1.0													
	0.05＞	1.5													
／tank area	0.02＞	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0		3.0		3.0	3.0
Water depth	5m≧	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0		1.0		1.0	1.0
	5m＜	1.3													
Structural formation	Wall	1.0													
	Column & Beam	1.2	1.2	1.2	1.2		1.2	1.2	1.2	1.2		1.2		1.2	1.2
	Flat slub	1.4													
Soil cover	0.4m≧	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0		1.0		1.0	1.0
	0.4m＜	1.2													
Construction year	from 1995 onward	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0				1.0	1.0
		1.2													
	before 1994	1.5										1.5			
Flexible pipe	existing	1.0													
	nothing	2.0	2.0	2.0	2.0		2.0	2.0	2.0	2.0		2.0		2.0	2.0
Ex. j	good condition	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0		1.0		1.0	1.0
	bad condition	2.0													
Degraded degree	small	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0		1.0		1.0	1.0
	middle rank	1.5													
	intense	2.0													
Seismic intensity scale	5	1.0	4.8	4.3	4.3		4.3	4.3	4.3	4.3	0.0	6.5	0.0	4.3	4.3
	6	2.2	10.5	9.5	9.5		9.5	9.5	9.5	9.5	0.0	14.3	0.0	9.5	9.5
	7	3.6	17.1	15.6	15.6		15.6	15.6	15.6	15.6	0.0	23.3	0.0	15.6	15.6
Aseismicity	high-level	10＞	5	5, 6	5, 6	5, 6, 7	5, 6	5, 6	5, 6	5, 6	5, 6, 7	5	5, 6, 7	5, 6	5, 6
	middle-level	10～17	6	7	7		7	7	7	7		6		7	7
	low-level	17＜	7									7			
Senario Surface Acceleration (gal)	North Teheran Fault		522	262	272	299		241	281	248	248	253	248		
	Mosha Fault		169	75	74	108		104	92	164	164	168	164		
	South Ray Fault		61	59	49	61		134	94	82	82	131	82		
	North Ray Fault		62	78	69	61		121	127	83	83	130	83		
Code 2800			350	350	350	350	350	350	350	350	350	350	350	350	350
note			on the Fault operation from 2003			on the Fault No Pump					No Pump on the fault	New Steel	No Pump H. under construction on the fault		

2. Diagnosis sheet (Pumping Station) 5/5

Type of Structure			Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab	Structure with Slab			
Name of Facility			Reservoir No.101	Reservoir No.102	Reservoir No.104	Reservoir No.105	Reservoir No.114			
Risk Factor	Cope	Fragility Point	Point	Point	Point	Point	Point			
Ground	Type-1	0.5	0.5	0.5	0.5	0.5	0.5			
	Type-2	1.0								
	Type-3	1.8								
Liquefaction	not occur	1.0	1.0	1.0	1.0	1.0	1.0			
	possible	2.0								
	occur	3.0								
Land features	Cutting ground	1.0	1.0	1.0	1.0	1.0	1.0			
	sloping ground	1.2								
	Top of mountain	1.3								
	landfill	1.5								
Elevation	On the ground	1.2	1.2	1.2	1.2	1.2	1.2			
	Semisubterranean	1.1								
	Underground	1.0								
Material	RC	1.0	1.0	1.0	1.0	1.0	1.0			
	Brick	3.0								
Wall area of X-axis and Y-axis	0.05＜	1.0								
	0.05＞	1.5								
／tank area	0.02＞	3.0	3.0	3.0	3.0	3.0	3.0			
Water depth	5m≧	1.0	1.0	1.0	1.0	1.0	1.0			
	5m＜	1.3								
Structural formation	Wall	1.0								
	Column & Beam	1.2	1.2	1.2	1.2	1.2	1.2			
	Flat slub	1.4								
Soil cover	0.4m≧	1.0	1.0	1.0	1.0	1.0	1.0			
	0.4m＜	1.2								
Construction year	from 1995 onward	1.0	1.0	1.0			1.0			
		1.2								
	before 1994	1.5			1.5	1.5				
Flexible pipe	existing	1.0								
	nothing	2.0	2.0	2.0	2.0	2.0	2.0			
Ex.j	good condition	1.0	1.0	1.0	1.0	1.0	1.0			
	bad condition	2.0								
Degraded degree	small	1.0	1.0	1.0	1.0	1.0	1.0			
	middle rank	1.5								
	intense	2.0								
Seismic intensity scale	5	1.0	4.3	4.3	6.5	6.5	4.3			
	6	2.2	9.5	9.5	14.3	14.3	9.5			
	7	3.6	15.6	15.6	23.3	23.3	15.6			
Aseismicity	high-level	10＞	5 , 6	5 , 6	5	5	5 , 6			
	middle-level	10～17	7	7	6	6	7			
	low-level	17＜			7	7				
Senario Surface Acceleration (gal)	North Teheran Fault				275	330				
	Mosha Fault				121	144				
	South Ray Fault				119	103				
	North Ray Fault				105	86				
Code 2800			350	350	350	350	350			
note										

3. Diagnosis sheet (WTP tank) 1/2

Type of Structure															
Name of Facility			WTP No.1 Clarifier	WTP No.1 Filter	WTP No.2 Pulsator	WTP No.2 Filter	WTP No.3 Pulsator	WTP No.3 Filter	WTP No.4 Pulsator	WTP No.4 Filter	WTP No.5 Pulsator	WTP No.5 Filter		WTP No.1 Generator House	WTP No.2 Generator House
Risk Factor	Cope	Fragility Point	Point	Point	Point	Point	Point	Point	Point	Point	Point	Point			
Ground	Type-1	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6			
	Type-2	1.0													
	Type-3	2.0													
Liquefaction	not occur	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6			
	possible	1.0													
	occur	2.0													
Land features	Cutting ground	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0					
	sloping ground	1.2									1.2	1.2			
	Top of mountain	1.3													
	landfill	1.5													
Elevation	On the ground	1.2													
	Semisubterranean	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1			
	Underground	1.0													
Material	RC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			
	Brick	3.0													
Wall area of X-axis and Y-axis	0.2<	1.0	1.0		1.0		1.0		1.0		1.0				
	0.2～0.12	1.2		1.2		1.2		1.2		1.2		1.2			
／tank area	0.12>	1.5													
Water depth	5m≧	1.0	1.0	1.0		1.0		1.0		1.0		1.0			
	5m<	3.0			3.0		3.0		3.0		3.0				
~~Structural formation~~	~~Wall~~	~~1.0~~	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			
	~~Column & Beam~~	~~1.2~~													
	~~Flat slub~~	~~1.4~~													
~~Soil cover~~	~~0.4m≧~~	~~1.0~~	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			
	~~0.4m<~~	~~1.2~~													
Construction year	from 1995 onward	1.0									1.0	1.0			
		1.5													
	before 1994	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8					
Flexible pipe	existing	1.0													
	nothing	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8			
Ex.j	good condition	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0	1.0			
	bad condition	2.0								2.0					
Degraded degree	small	1.0				1.0	1.0	1.0	1.0		1.0	1.0			
	middle rank	1.5	1.5	1.5	1.5					1.5					
	intense	2.0													
Seismic intensity scale	5	1.0	1.9	2.3	5.8	1.5	3.8	1.5	3.8	4.6	2.6	1.0			
	6	2.2	4.2	5.1	12.7	3.4	8.5	3.4	8.5	10.2	5.6	2.3			
	7	3.6	6.9	8.3	20.8	5.5	13.9	5.5	13.9	16.6	9.2	3.7			
Aseismicity	high-level	10>	5, 6, 7	5, 6, 7	5	5, 6, 7	5, 6	5, 6, 7	5, 6	5	5, 6, 7	5, 6, 7			
	middle-level	10～30			6		7		7	6, 7					
	low-level	30<			7										
Senario Surface Acceleration (gal)	North Teheran Fault		242	242	283	283	224	224	260	260	618	618		242	283
	Mosha Fault		104	104	92	92	167	167	167	167	208	208		104	92
	South Ray Fault		134	134	97	97	77	77	81	81	96	96		134	97
	North Ray Fault		121	121	129	129	78	78	78	78	97	97		121	129
Code 2800			350	350	350	350	350	350	350	350	350	350		350	350
note									on the Fault	on the Fault	on the Fault			by Structural analysis	

Pulsator of No.3&4 is observed the crack, therefore degraded degree is middle rank, but wall is thick, and aseismicity is

(magenta)	Planning	(cyan)	Aseismicity is high-level
(light green)	Facility performed suvey	(yellow)	Aseismicity is middle-level
(green)	Data assumed	(red)	Aseismicity is low-level

3. Diagnosis sheet (WTP tank)　2/2

Type of Structure								
Name of Facility			WTP No.4 Chemical House	WTP No.5 Chlorine House	WTP No.5 Chemical House	Chemical Factry		
Risk Factor	Cope	Fragility Point						
Ground	Type-1	0.6						
	Type-2	1.0						
	Type-3	2.0						
Liquefaction	not occur	0.6						
	possible	1.0						
	occur	2.0						
Land features	Cutting ground	1.0						
	sloping ground	1.2						
	Top of mountain	1.3						
	landfill	1.5						
Elevation	On the ground	1.2						
	Semisubterranean	1.1						
	Underground	1.0						
Material	RC	1.0						
	Brick	3.0						
Wall area of X-axis and Y-axis ／tank area	0.2＜	1.0						
	0.2～0.12	1.2						
	0.12＞	1.5						
Water depth	5m≧	1.0						
	5m＜	3.0						
~~Structural formation~~	~~Wall~~	~~1.0~~						
	~~Column & Beam~~	~~1.2~~						
	~~Flat slub~~	~~1.4~~						
~~Soil cover~~	~~0.4m≧~~	~~1.0~~						
	~~0.4m＜~~	~~1.2~~						
Construction year	from 1995 onward	1.0						
		1.5						
	before 1994	1.8						
Flexible pipe	existing	1.0						
	nothing	1.8						
Ex.j	good condition	1.0						
	bad condition	2.0						
Degraded degree	small	1.0						
	middle rank	1.5						
	intense	2.0						
Seismic intensity scale	5	1.0						
	6	2.2						
	7	3.6						
Aseismicity	high-level	10＞						
	middle-level	10～30						
	low-level	30＜						
Senario Surface Acceleration (gal)	North Teheran Fault		260	618	618			
	Mosha Fault		167	208	208			
	South Ray Fault		81	96	96			
	North Ray Fault		78	97	97			
Code 2800			350	350	350			
note			s	on the Fault	on the Fault			
			high, so degraded degree is changed to small.					

APPENDIX 5

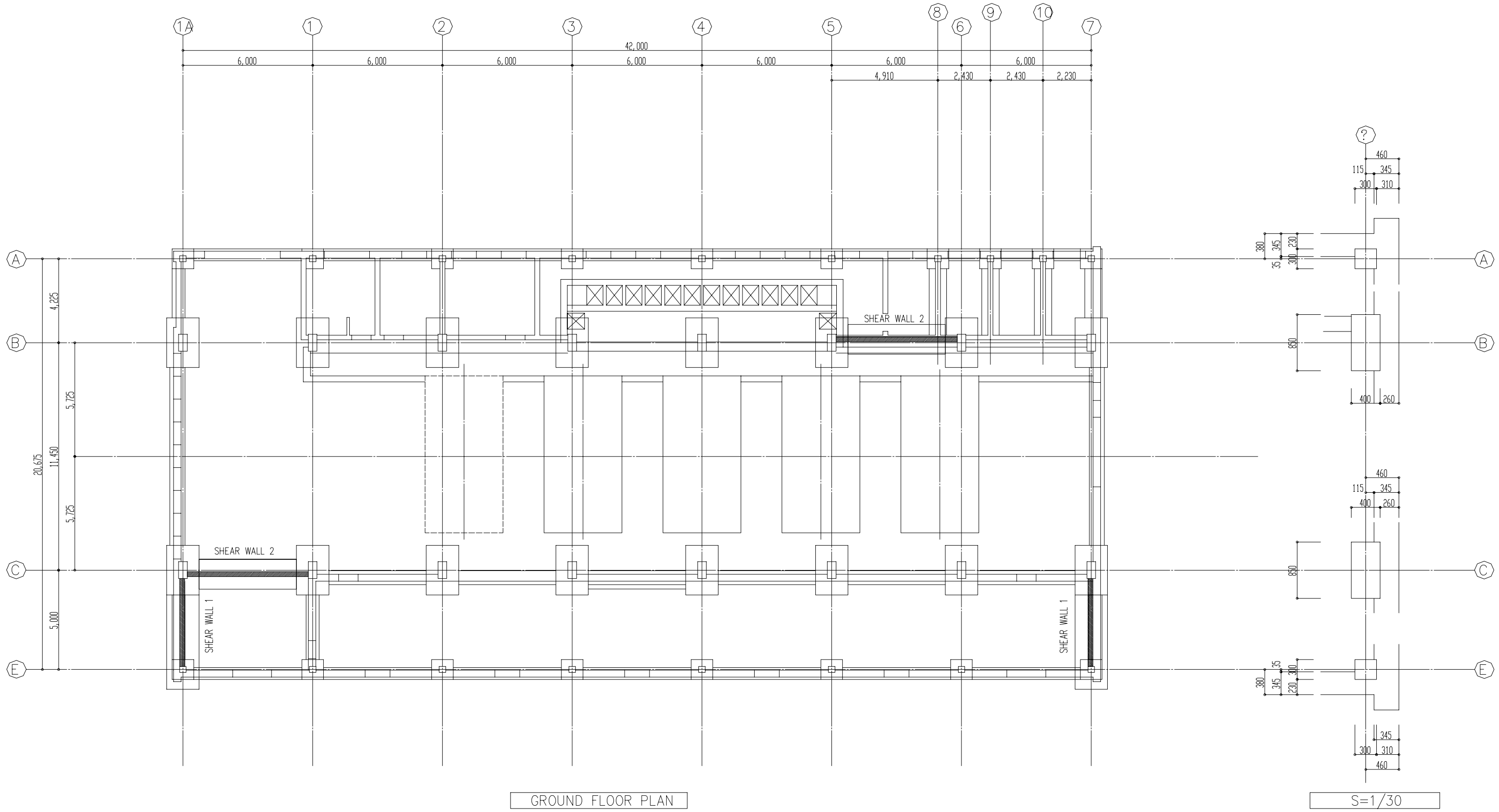
Drawings

We proposed reinforcement for structural member or refurbishment for facility and submit example of outline design in terms of drawing based on structural analysis on bellow facilities.

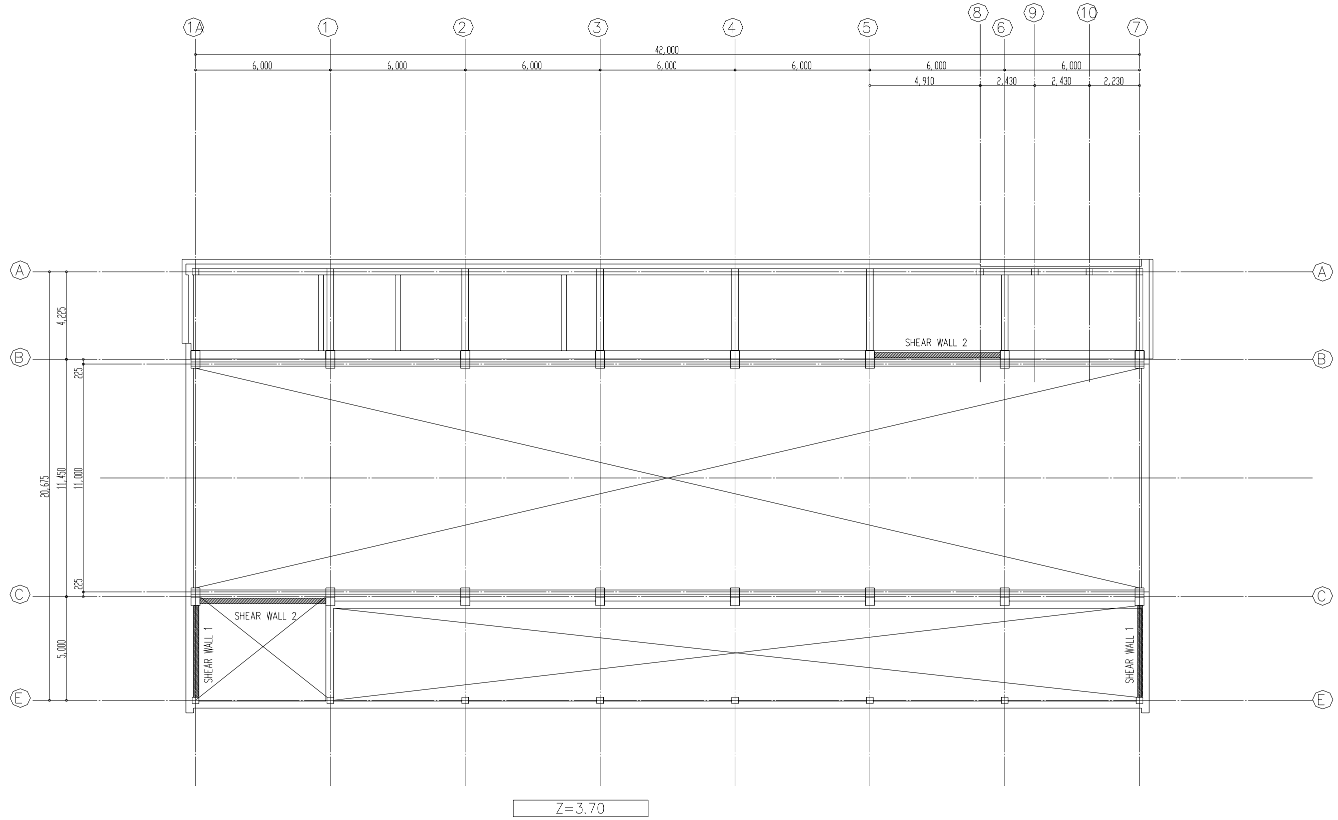
- Generator House on WTP No.1: Fig.5.1 to 5.8
- Pulsator on WTP No.2: Fig.5.9 to 5.11
- Pump House on Reservoir No.2: Fig.5.12 to 5.16
- Reservoir No.6: Fig.5.17 to 5.20

On the other hand, though structural analysis is not carried out, some proposals are represented on drawing on bellow facilities/standard, in addition bar arrangement was made up based on experience or Japanese practice due to covering the difficulties of setting design conditions.

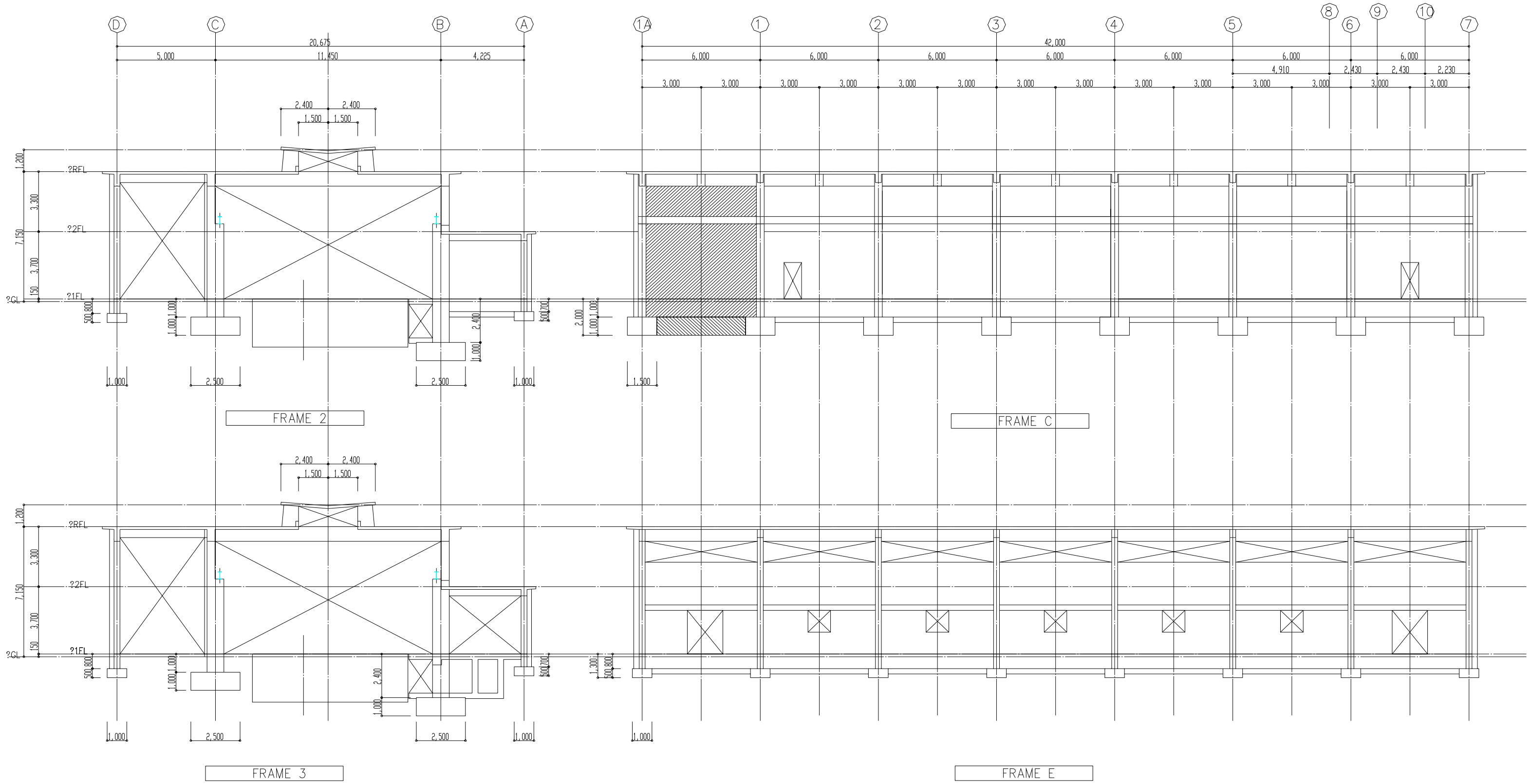
- Bilagan Intake shelter: Fig.5.21
- Breezway: Fig.5.22
- Reinforcement on Brick Wall: Fig.5.23
- Earthquake Resistant Wall (Shear Wall): Fig.5.24 to 5.25
- Reinforcement of Tile and Marble Sheet: Fig.5.26
- Reinforcement of Steel Building: Fig.5.27



JICA	The Study on Water Supply System Resistant to Earthquakes in Tehran Municipality in the Islamic Republic of Iran	Fig. 5.1
	Generator House (Plan 1)	



JICA	The Study on Water Supply System Resistant to Earthquakes in Tehran Municipality in the Islamic Republic of Iran
Generator House (Plan 2)	Fig. 5.2



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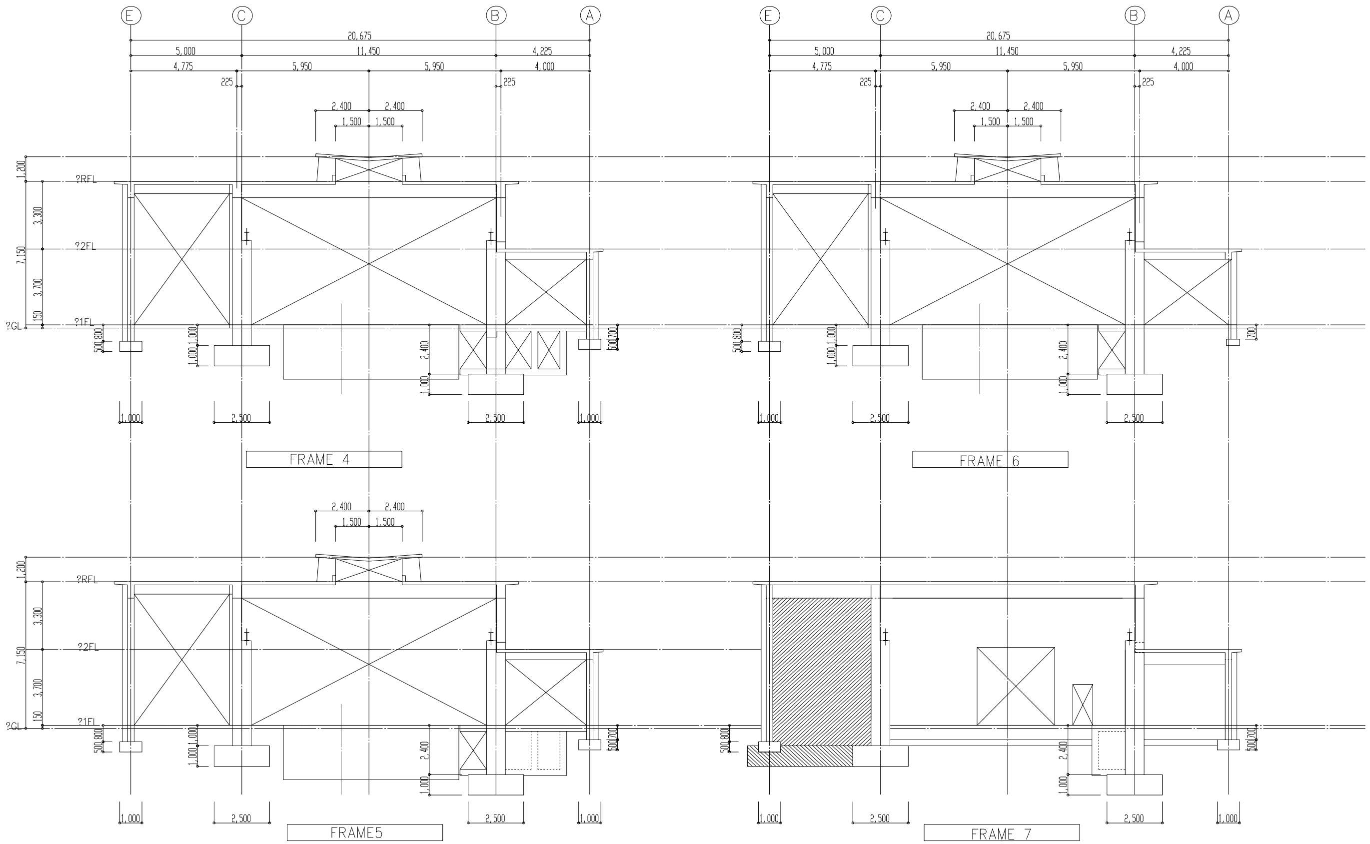
Generator House (Section 1)

Fig. 5.3



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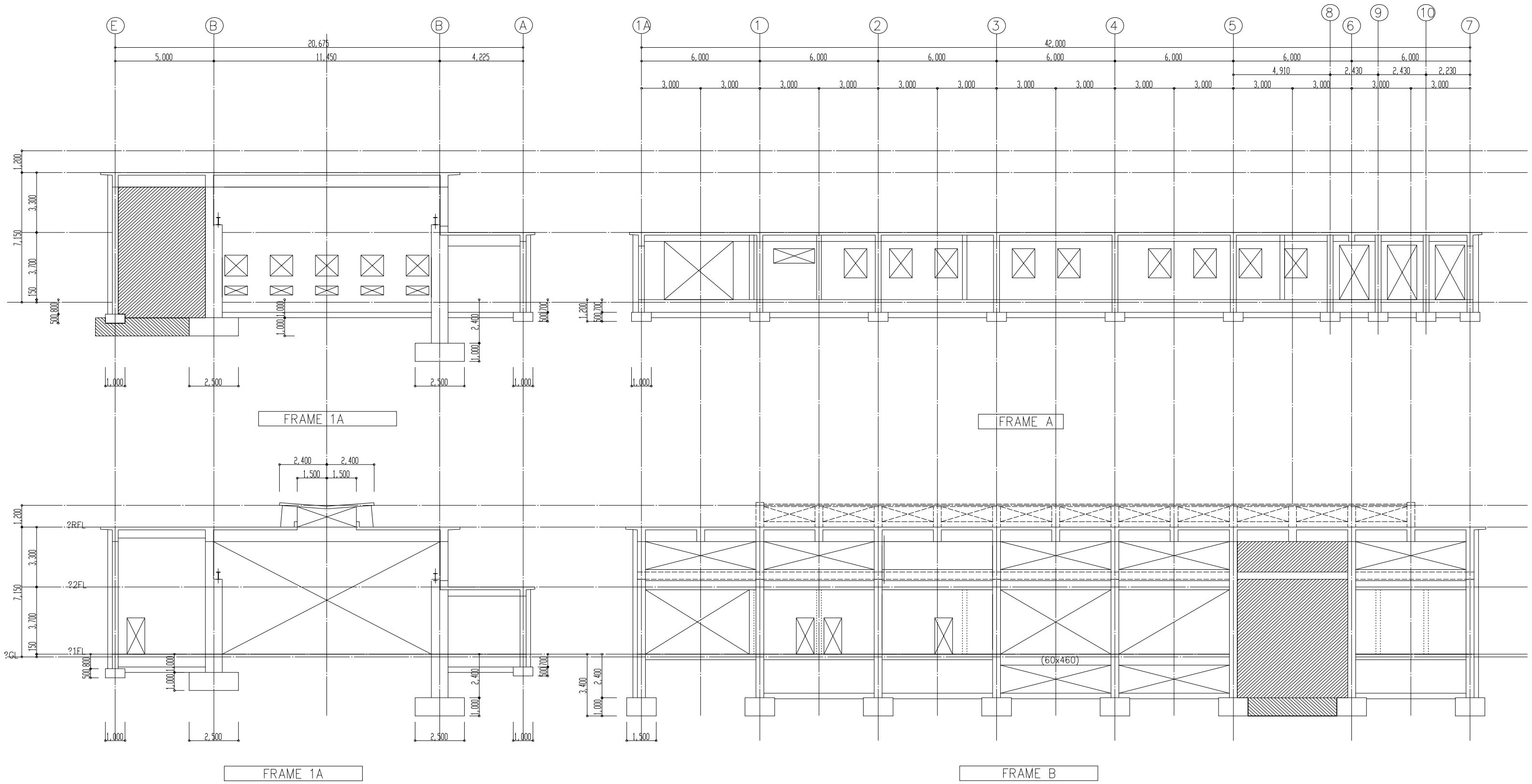
Generator House (Section 2)

Fig. 5.4



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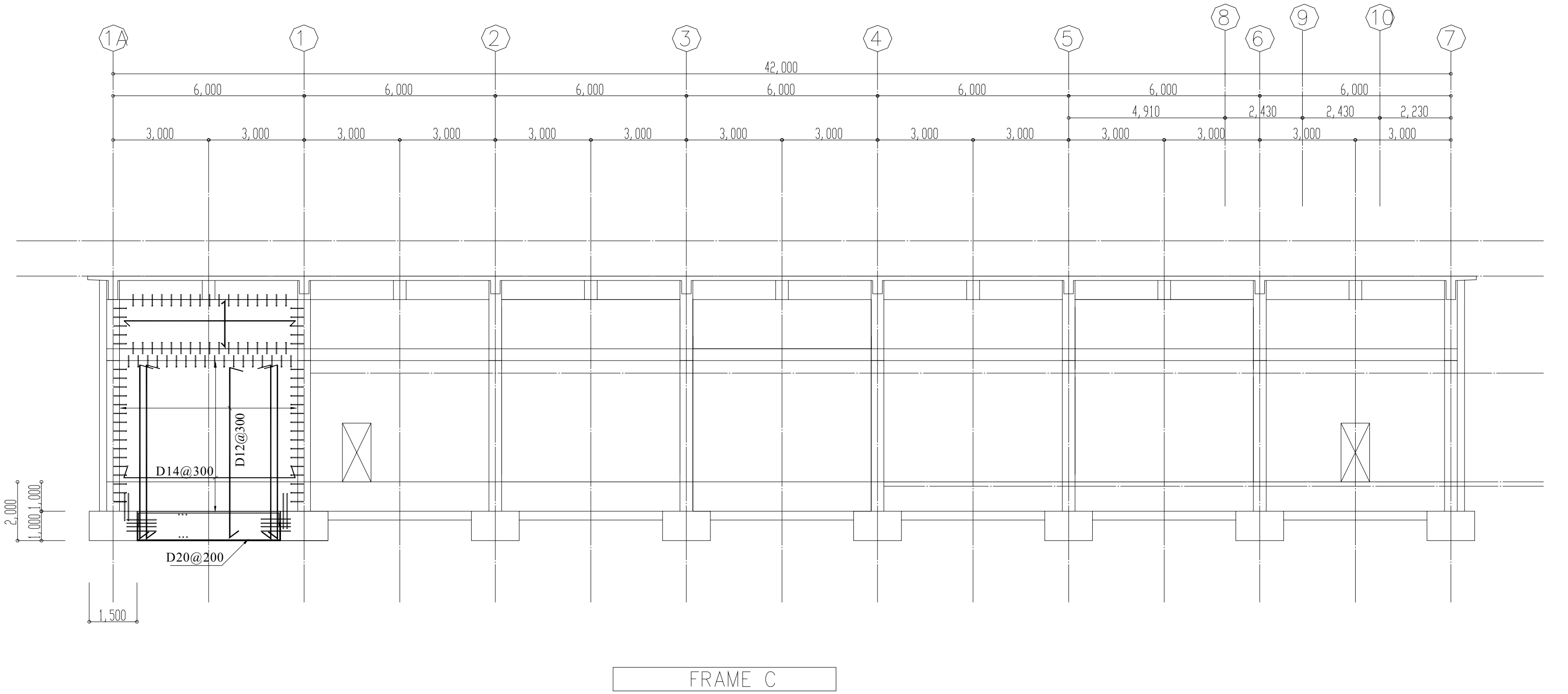
Generator House (Section 3)

Fig. 5.5



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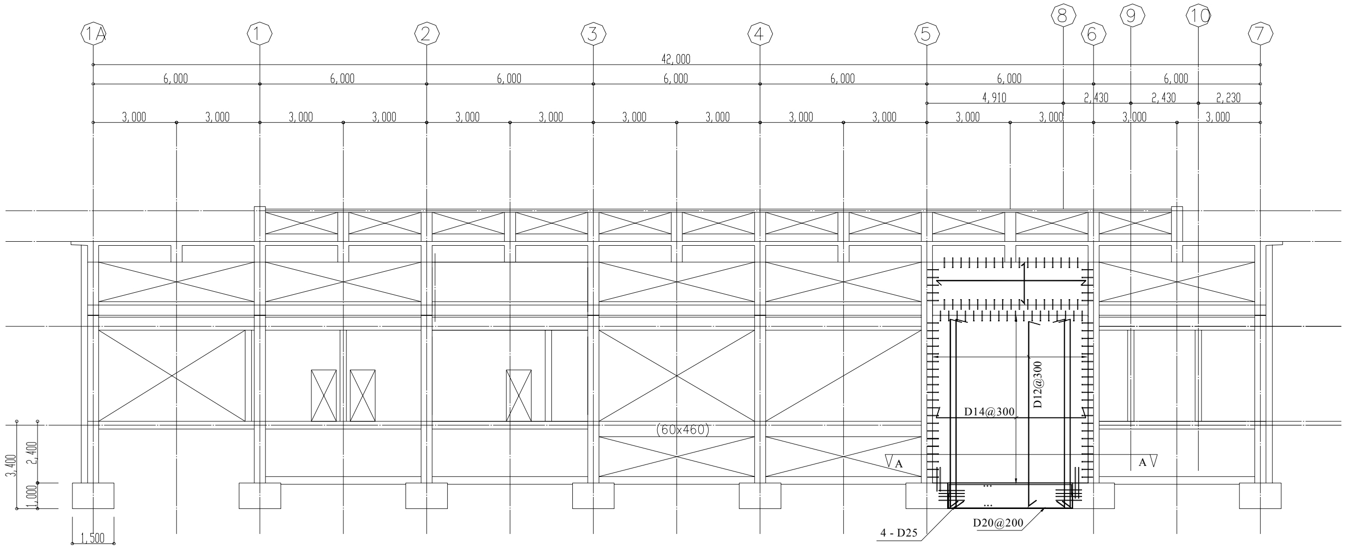
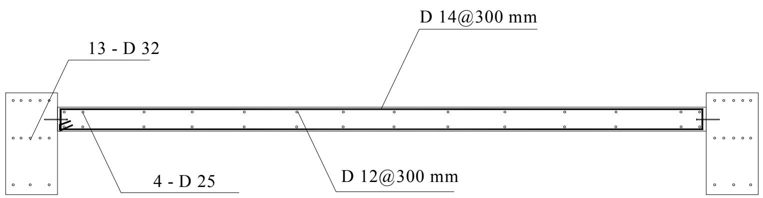
Generator House (Bar Arrangement 1)

Fig. 5.6



FRAME B



SECTION A–A

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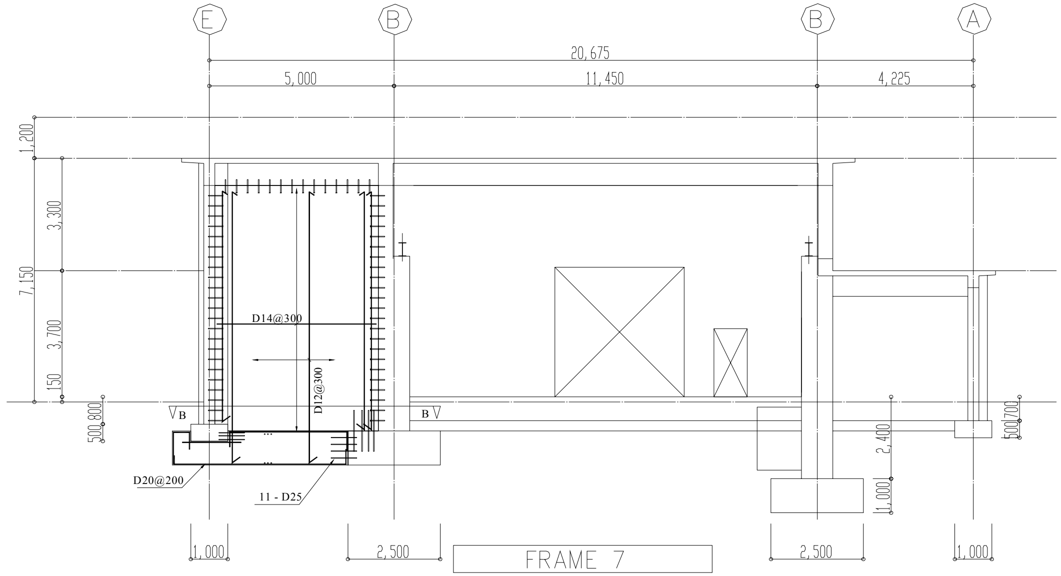
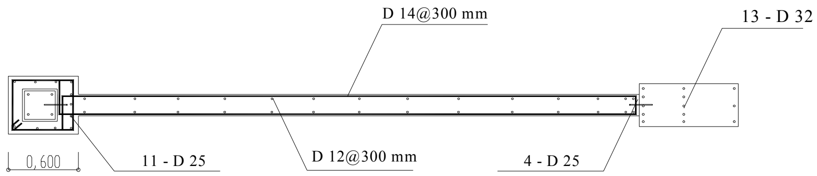
Generator House (Bar Arrangement 2)

Fig. 5.7



FRAME 7



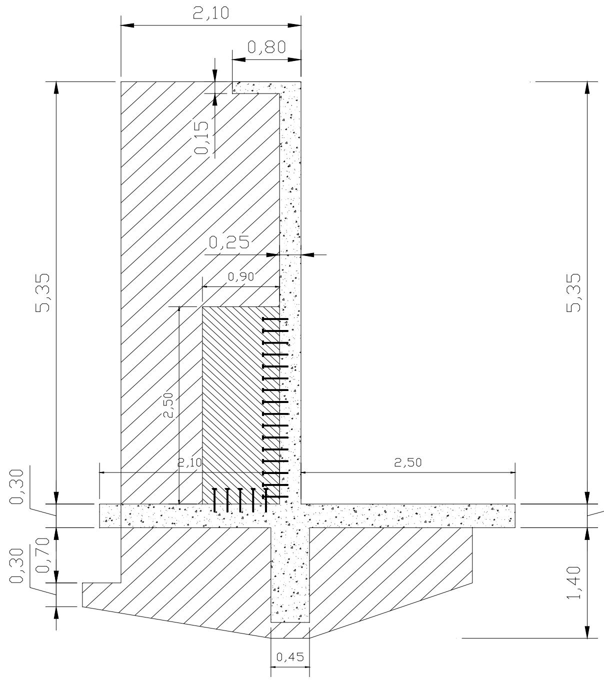
SECTION B-B

JICA

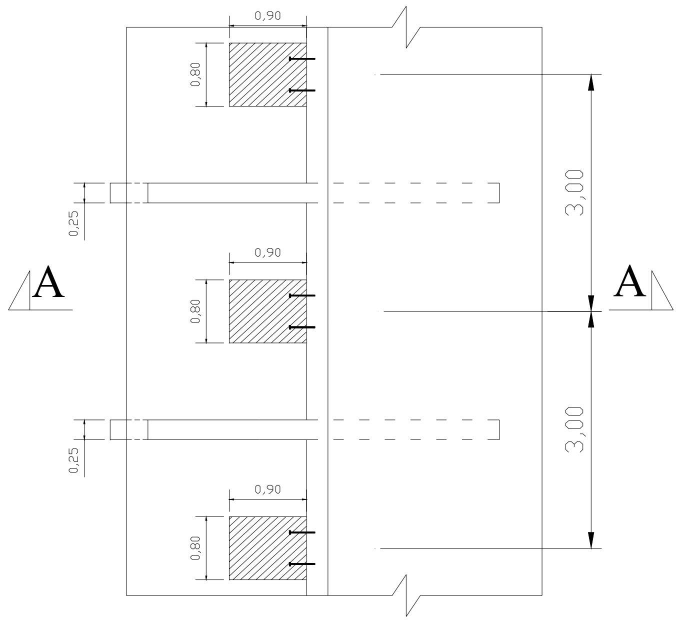
The Study on Water Supply System Resistant to Earthquakes in Tehran Municipality in the Islamic Republic of Iran

Generator House (Bar Arrangement 3)

Fig. 5.8



SEC A-A



PLAN

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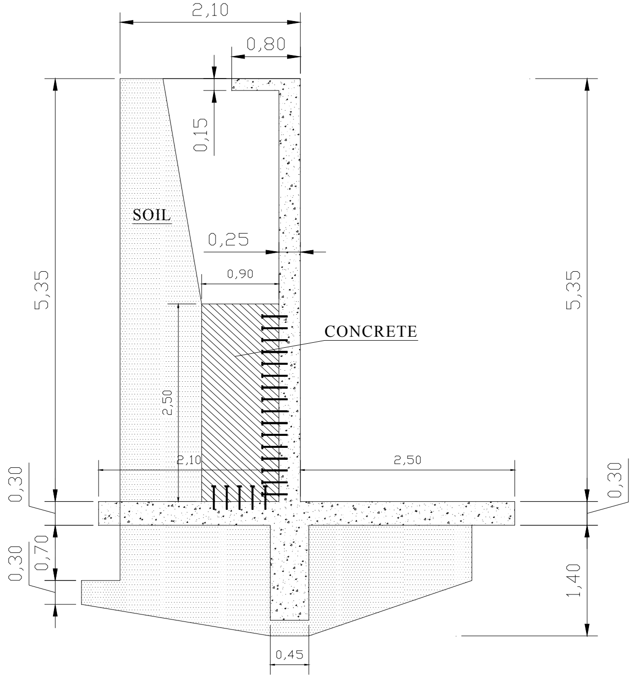
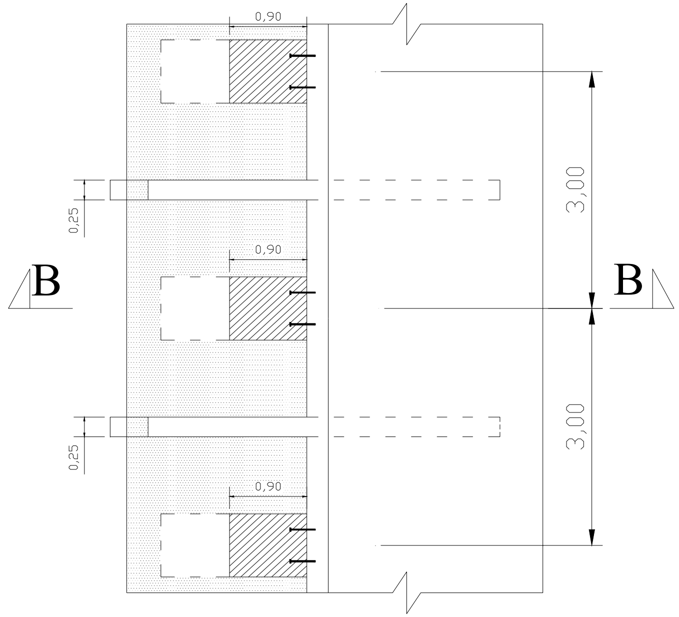
Pulsator Wall (Section , Plan)

Fig. 5.9

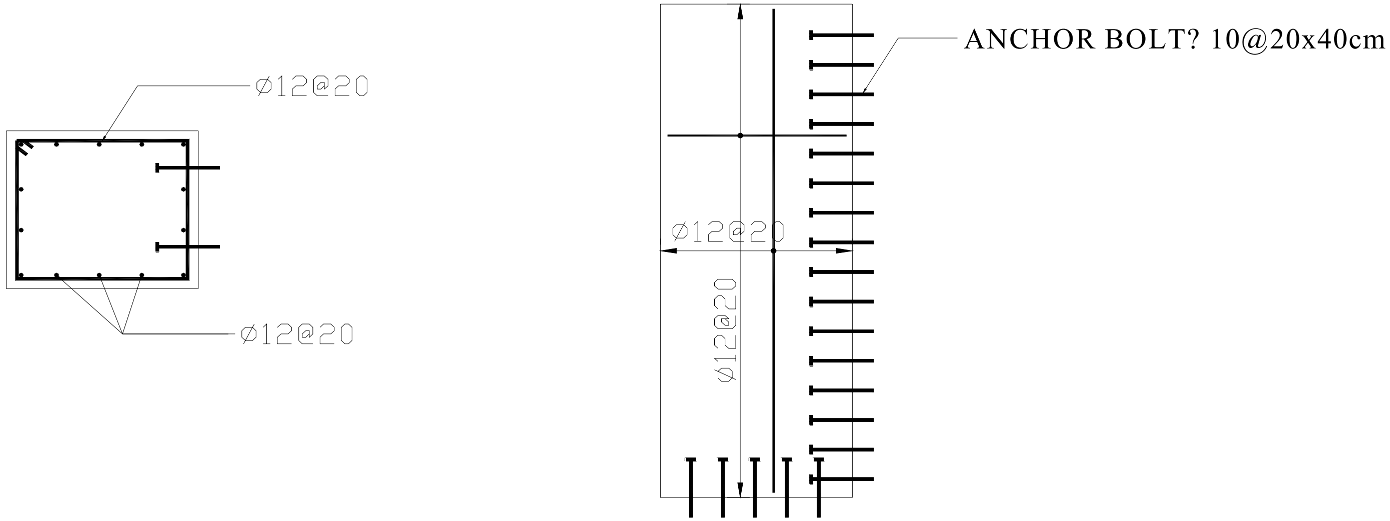


SECTION B-B
EXCAVATION



PLAN
EXCAVATION

JICA	The Study on Water Supply System Resistant to Earthquakes in Tehran Municipality in the Islamic Republic of Iran	Fig.
	Pulsator Wall (Excavation)	**5.10**



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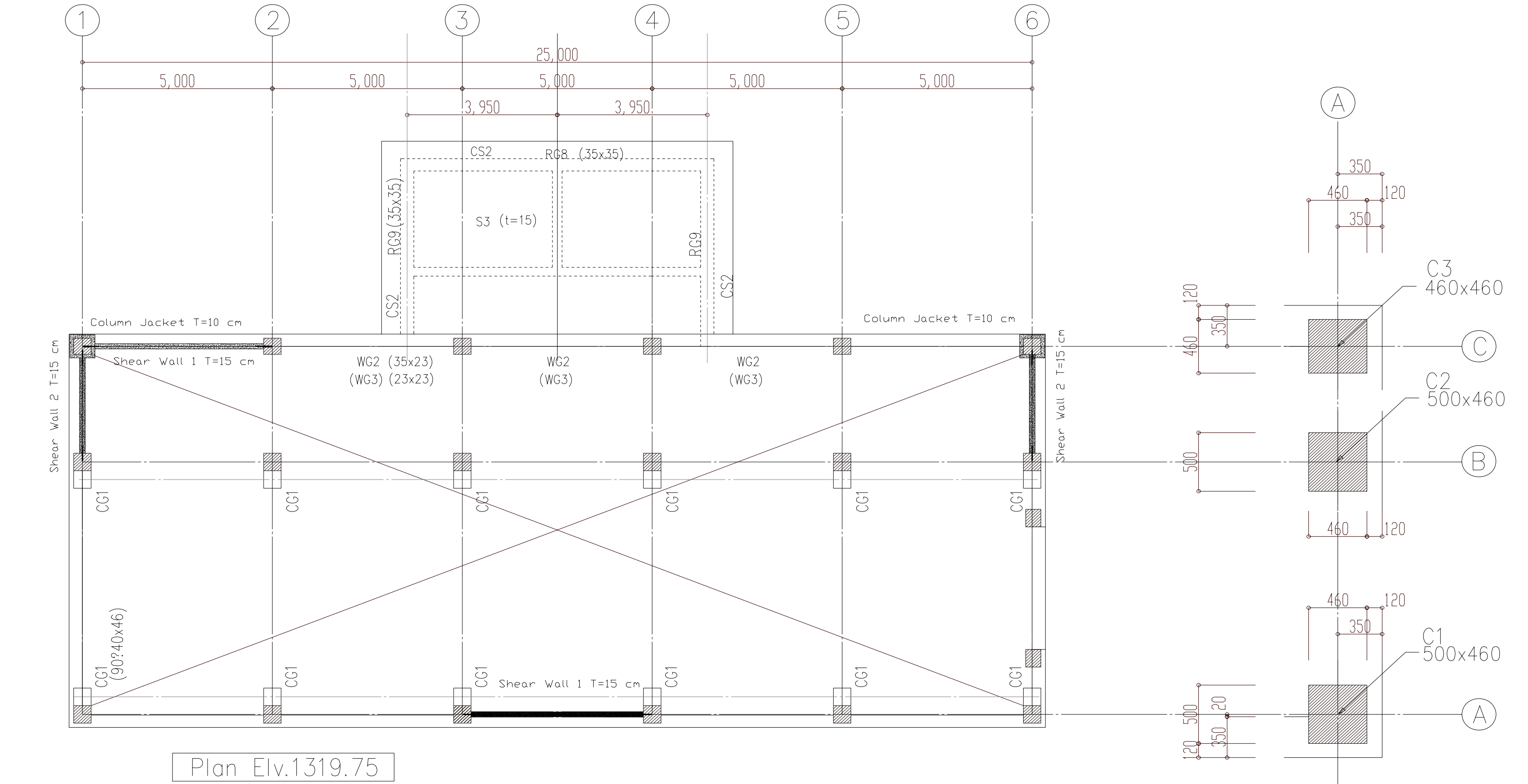
Pulsator Wall (Bar Arrangement)

Fig. 5.11



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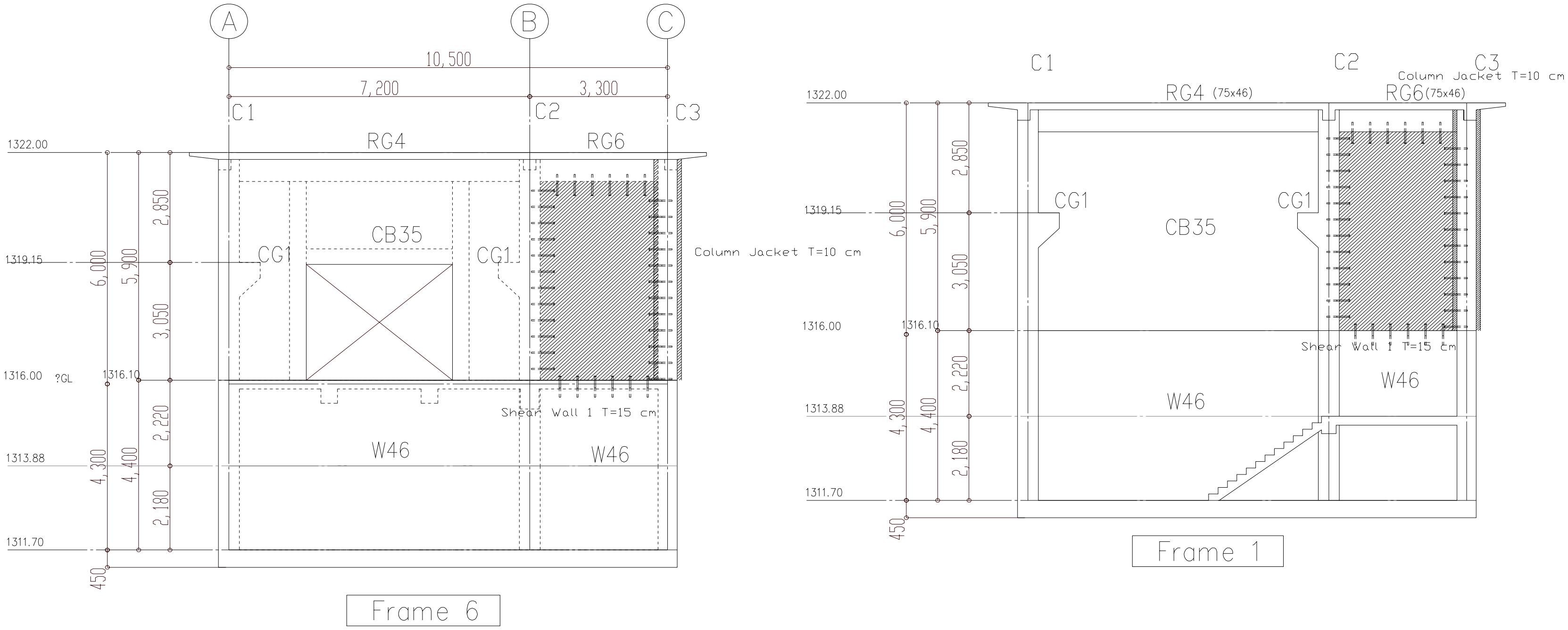
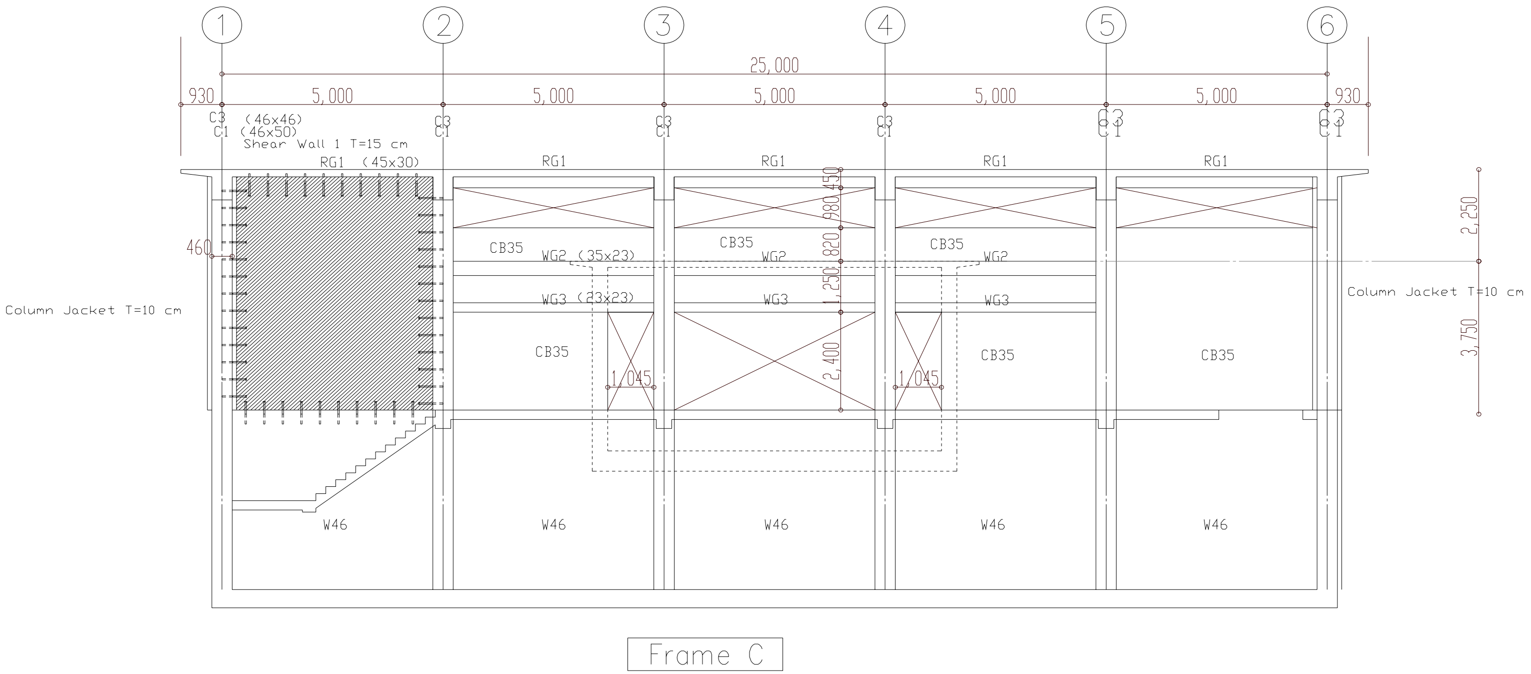
Pump House (Plan)

Fig. 5.12



JICA	The Study on Water Supply System Resistant to Earthquakes in Tehran Municipality in the Islamic Republic of Iran	Fig. 5.13
	Pump House (Section 1)	



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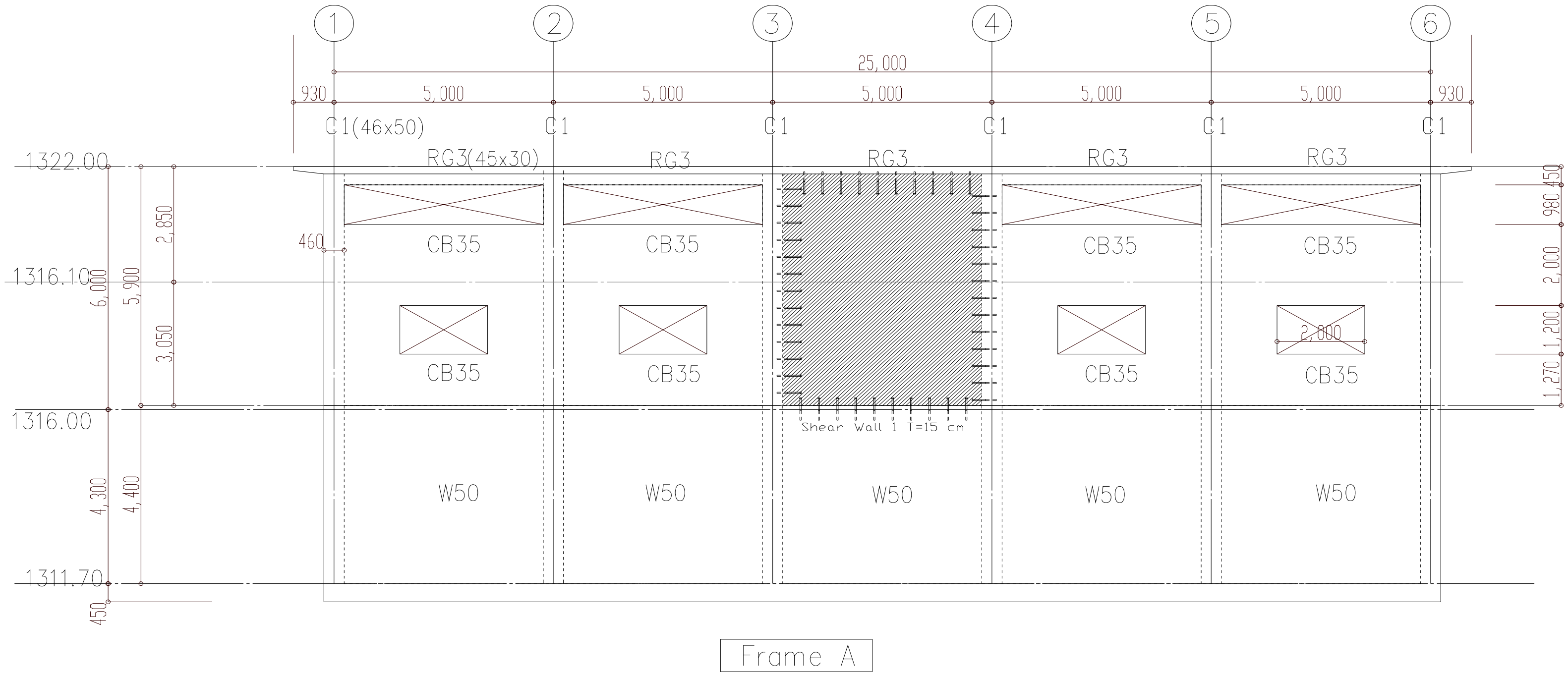
Pump House (Section 2)

Fig. 5.14



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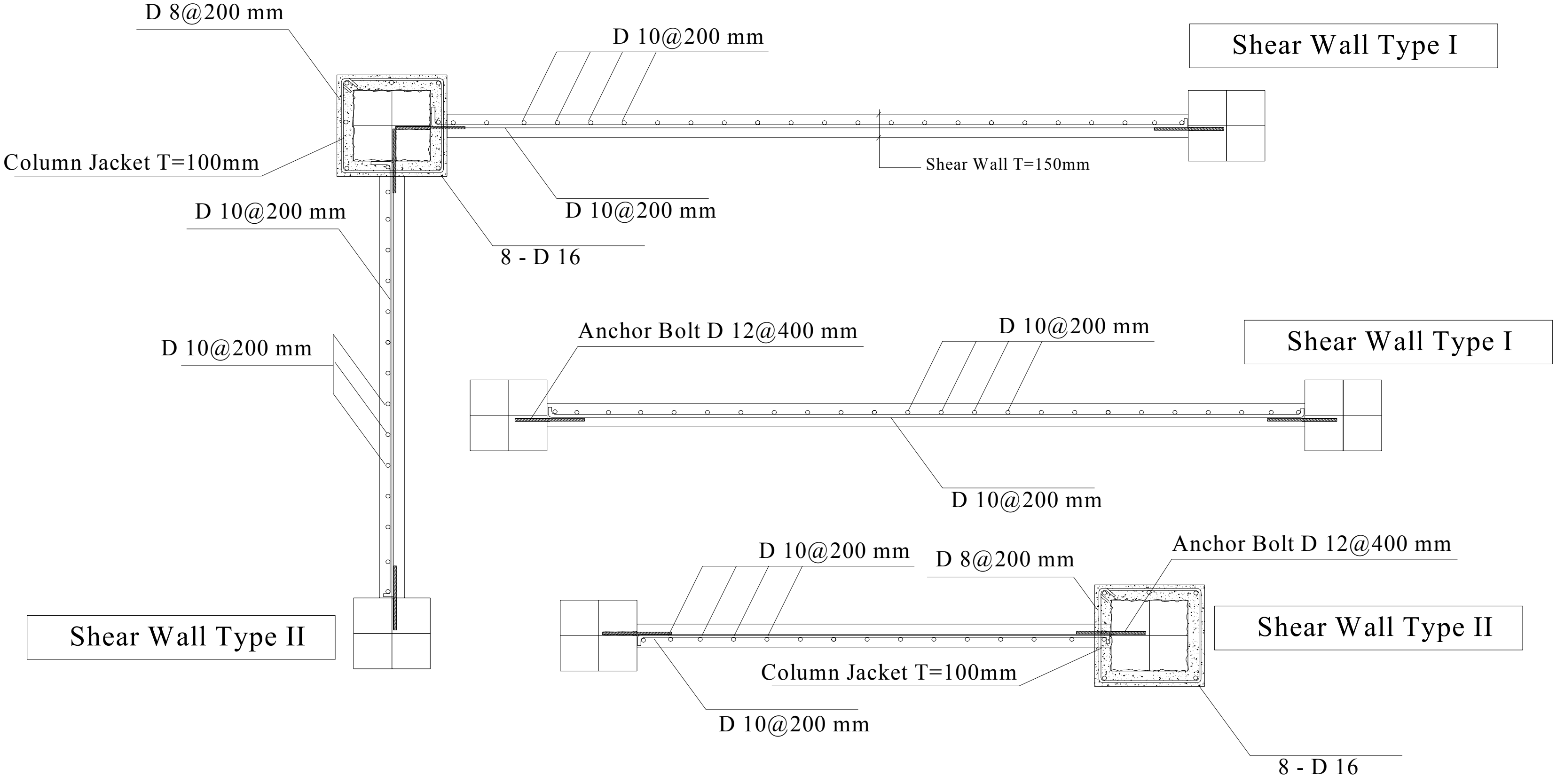
Pump House (Section 3)

Fig. 5.15



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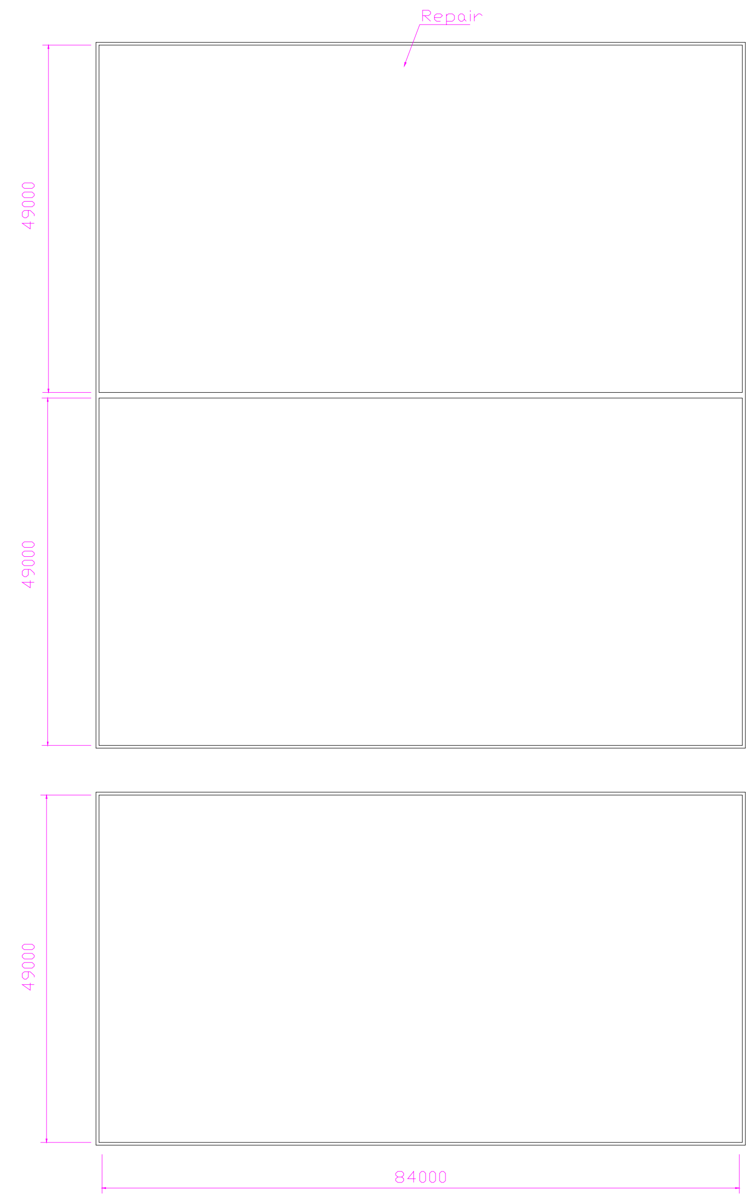
Pump House (Bar Arrangement)

Fig. 5.16



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REFURBISHMENT OF RESERVOIR NO.6

Fig. 5.17

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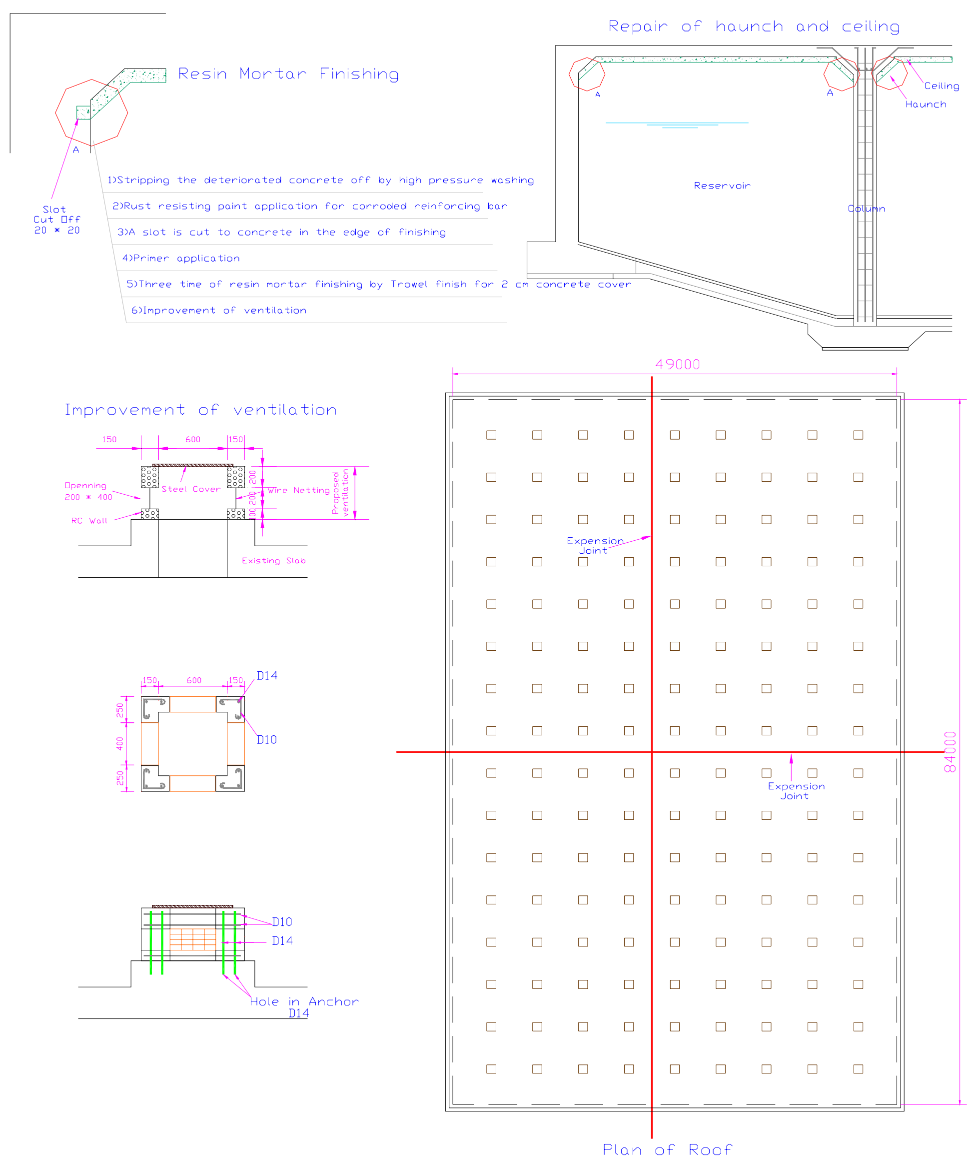

	The Study on Water Supply System Resistant to Earthquakes in Tehran Municipality in the Islamic Republic of Iran	**Fig. 5.18**
	REFURBISHMENT OF RESERVOIR NO.6	

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The Study on Water Supply System Resistant to Earthquakes
in Tehran Municipality in the Islamic Republic of Iran

REINFORCEMENT OF RESERVOIR NO.6

Fig. 5.19

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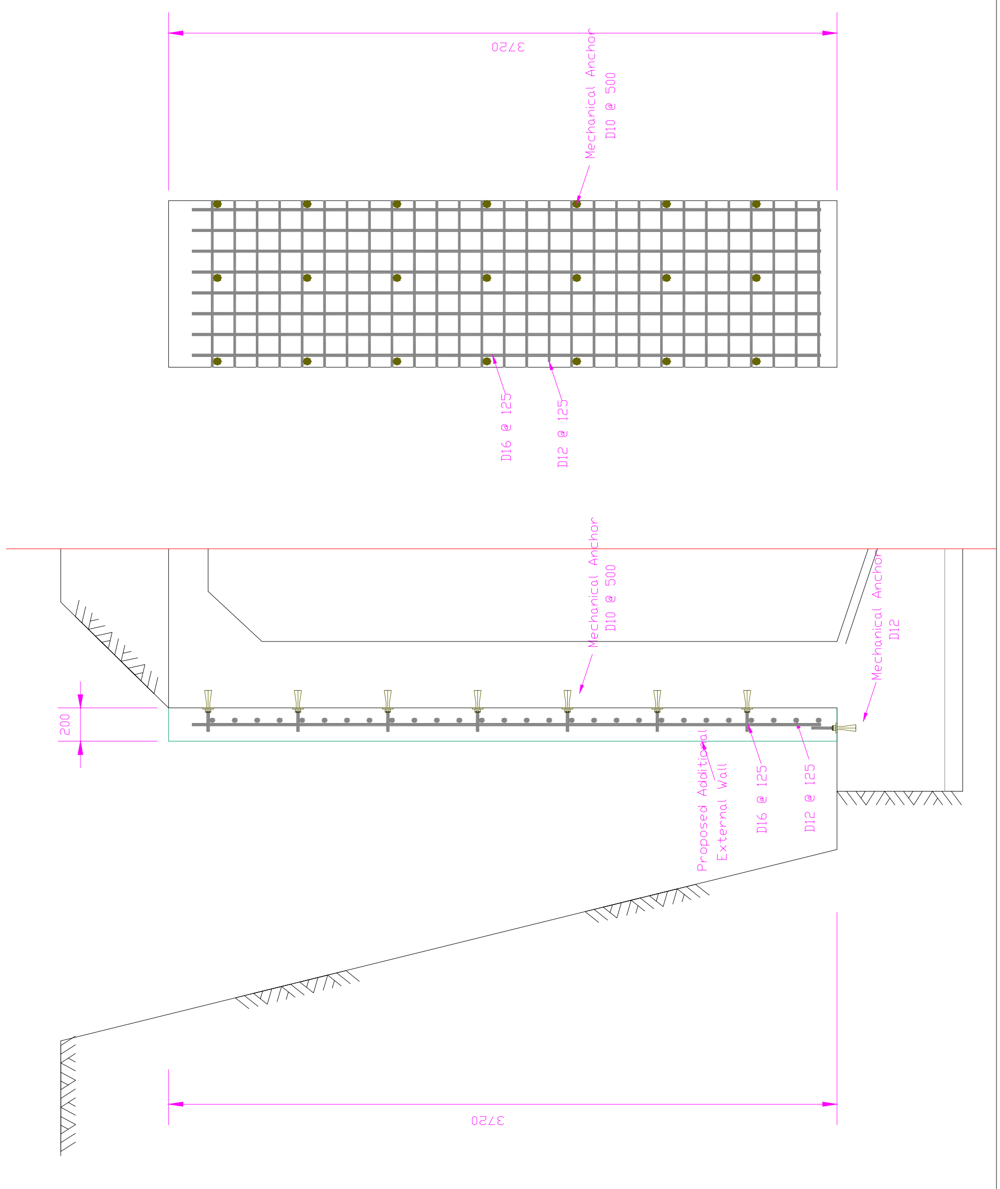

The Study on Water Supply System Resistant to Earthquakes in Tehran Municipality in the Islamic Republic of Iran

REINFORCEMENT OF RESERVOIR NO.6

Fig. 5.20

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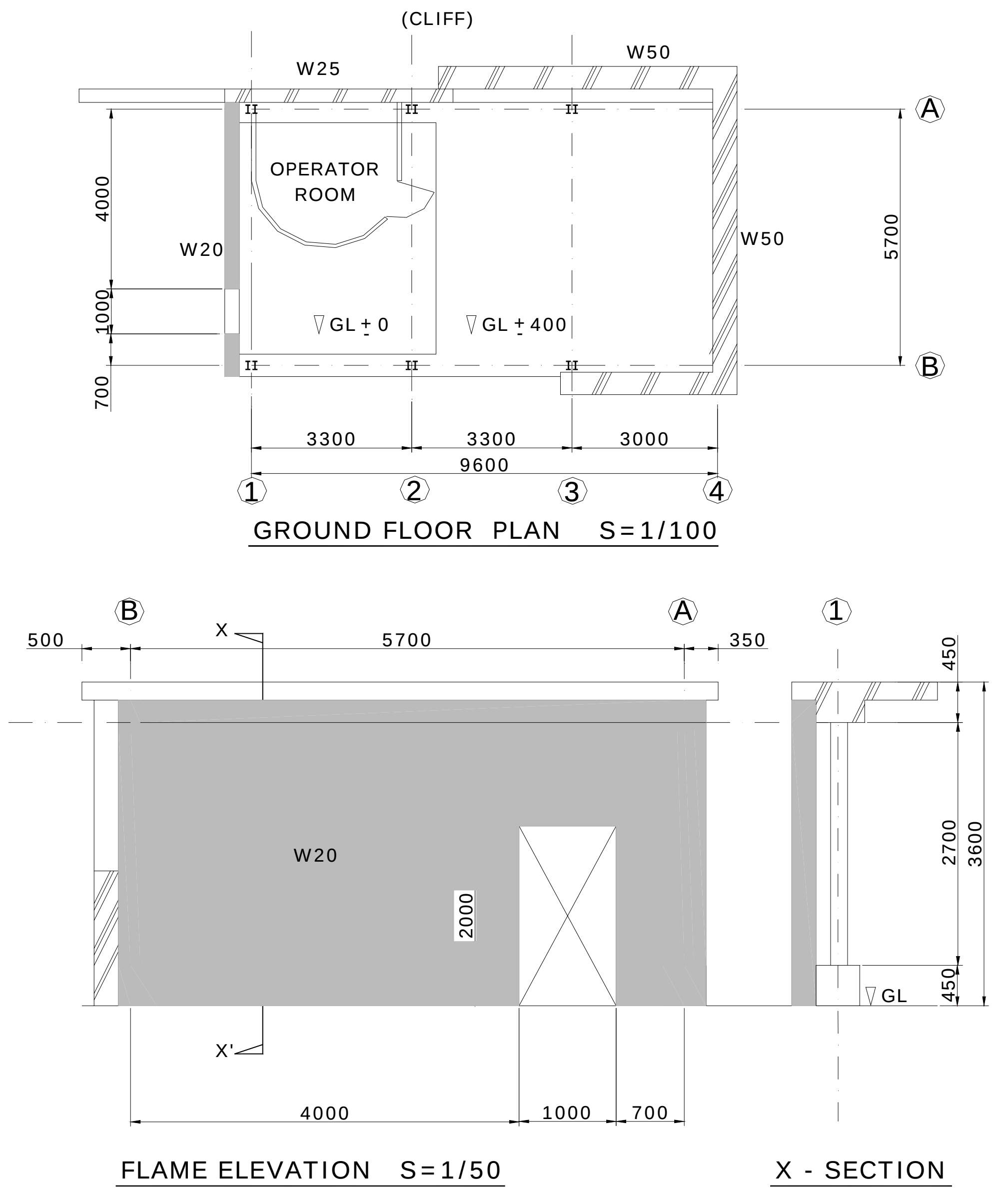
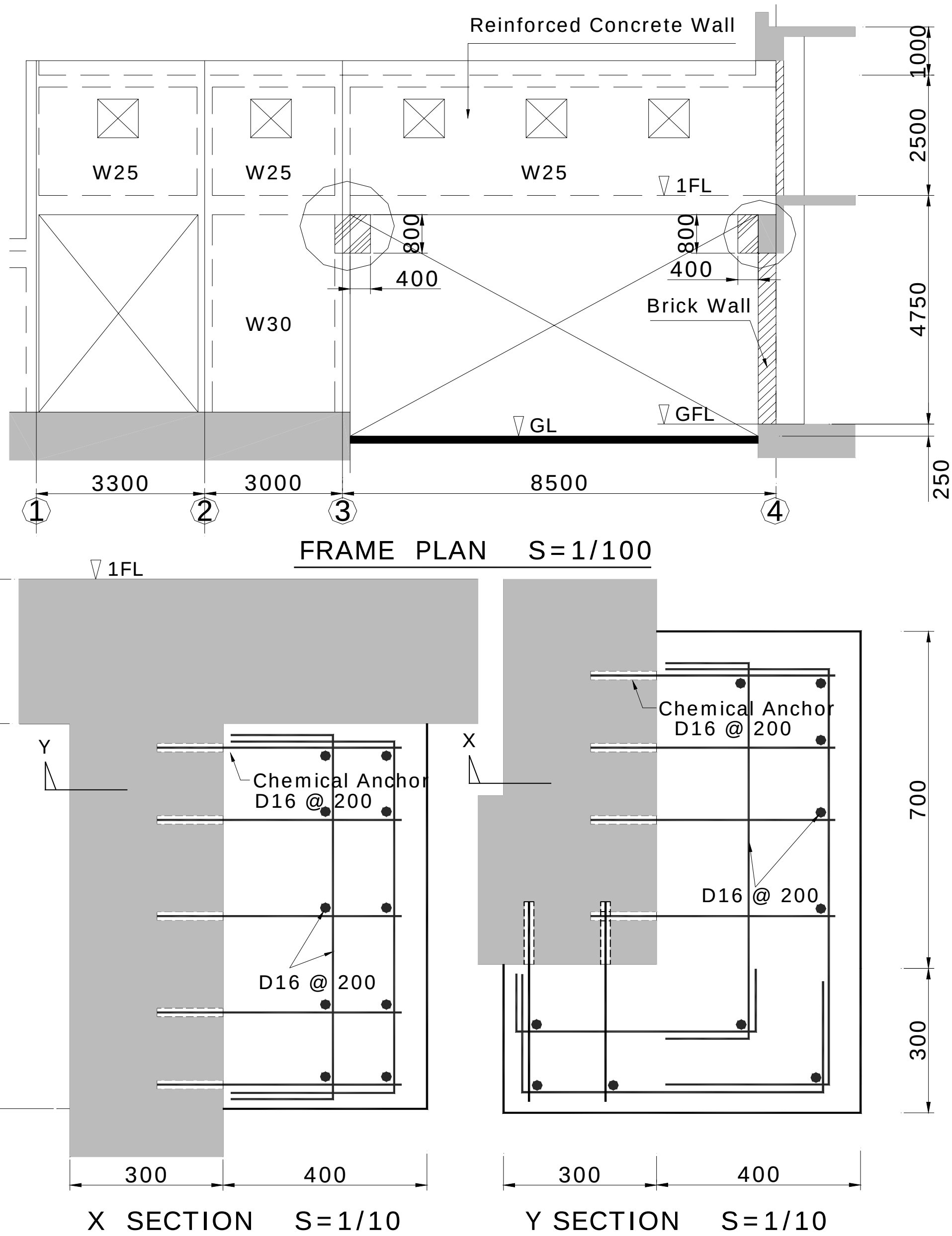


	The Study on Water Supply System Resistant to Earthquakes in Tehran Municipality in the Islamic Republic of Iran	**Fig. 5.21**
Reinforcment Of Blaghan Intake Shelter		

-



	The Study on Water Supply System Resistant to Earthquakes in Tehran Municipality in the Islamic Republic of Iran	Fig. 5.22
Reinforcment Of The Breezway Of Chemical Building At WTP NO.4		

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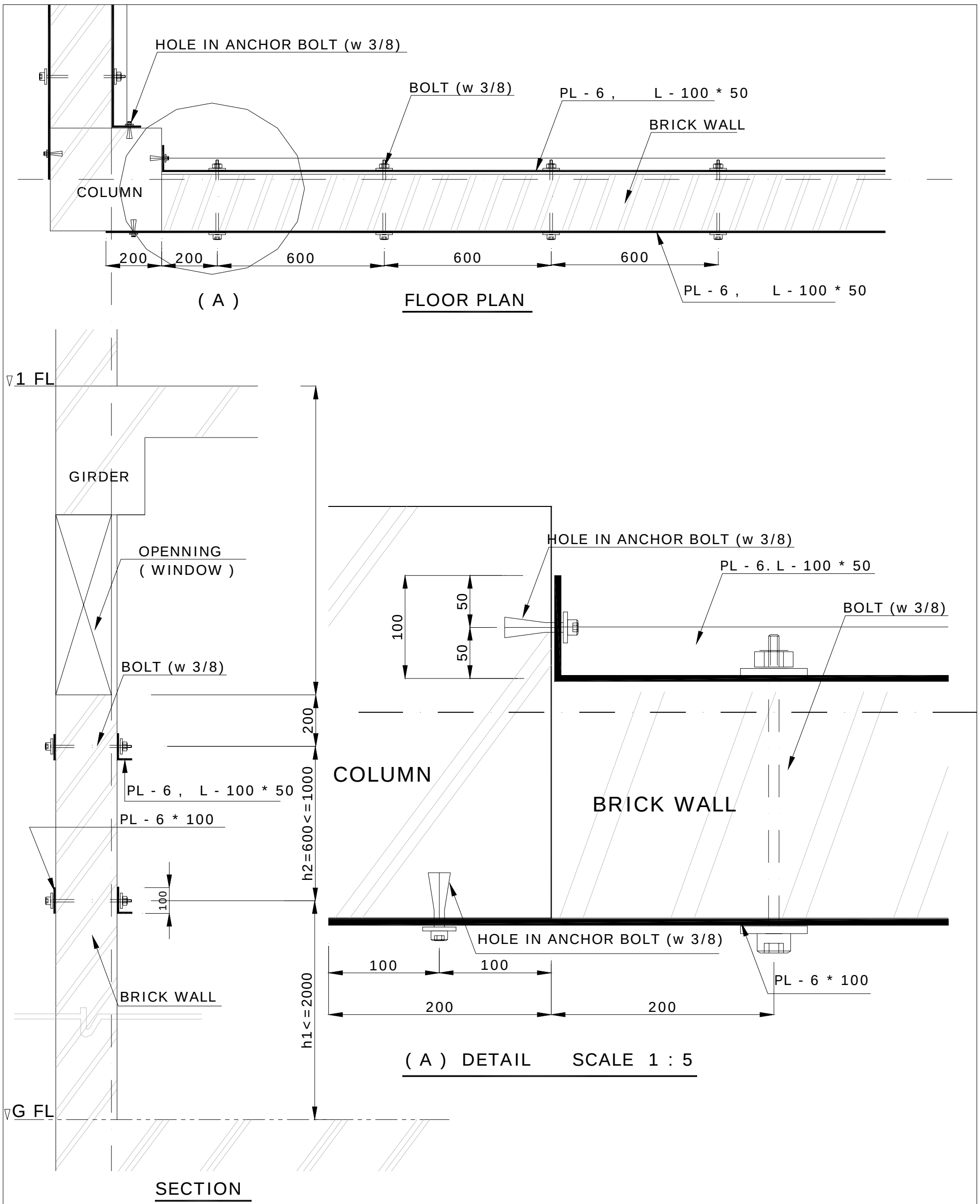

The Study on Water Supply System Resistant to Earthquakes
in Tehran Municipality in the Islamic Republic of Iran

Fig. 5.23

The Reinforcment Of Brick Wall **Scale=1:20**

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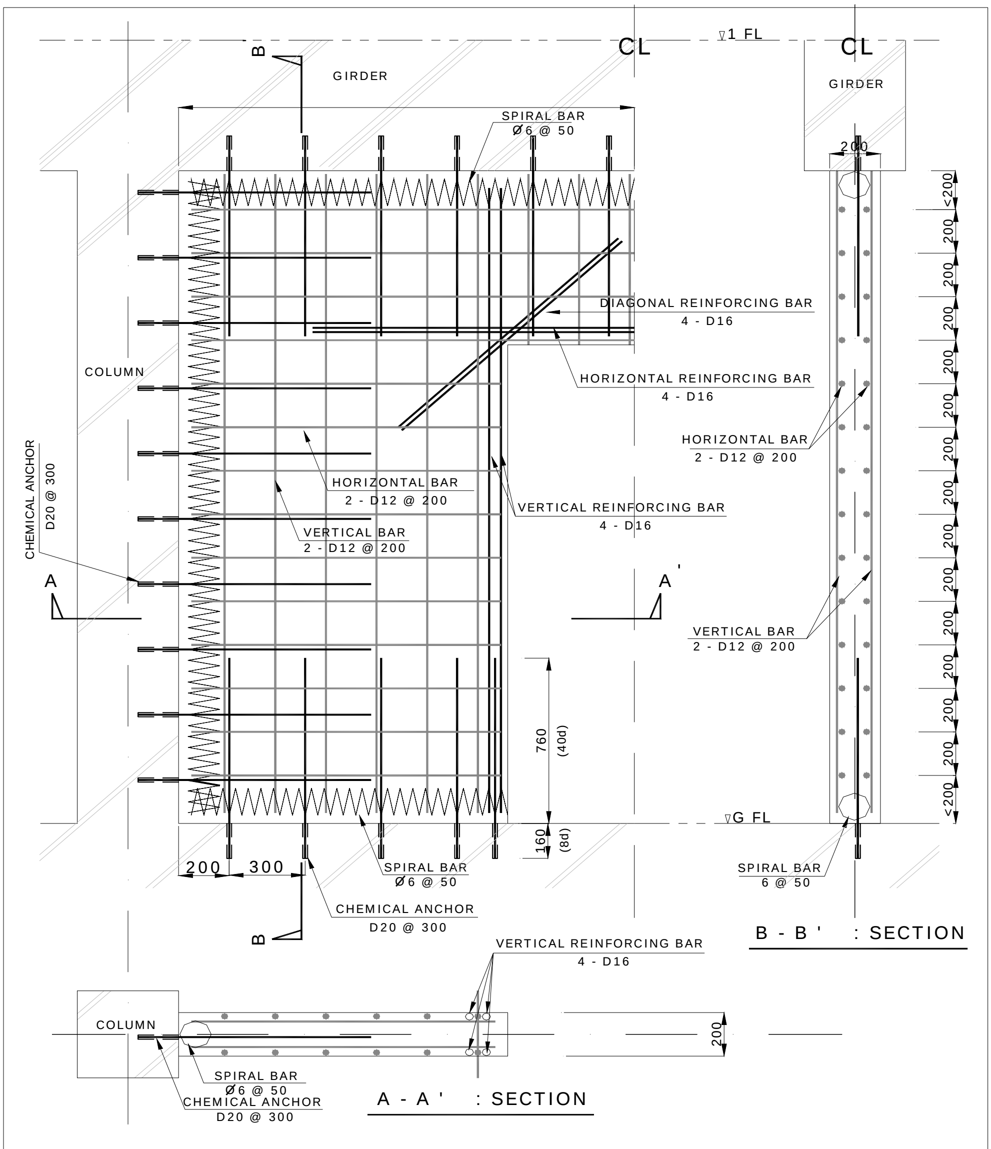

The Study on Water Supply System Resistant to Earthquakes in Tehran Municipality in the Islamic Republic of Iran

The Earthquake Resistant Wall (W20) Scale 1:20

Fig. 5.24

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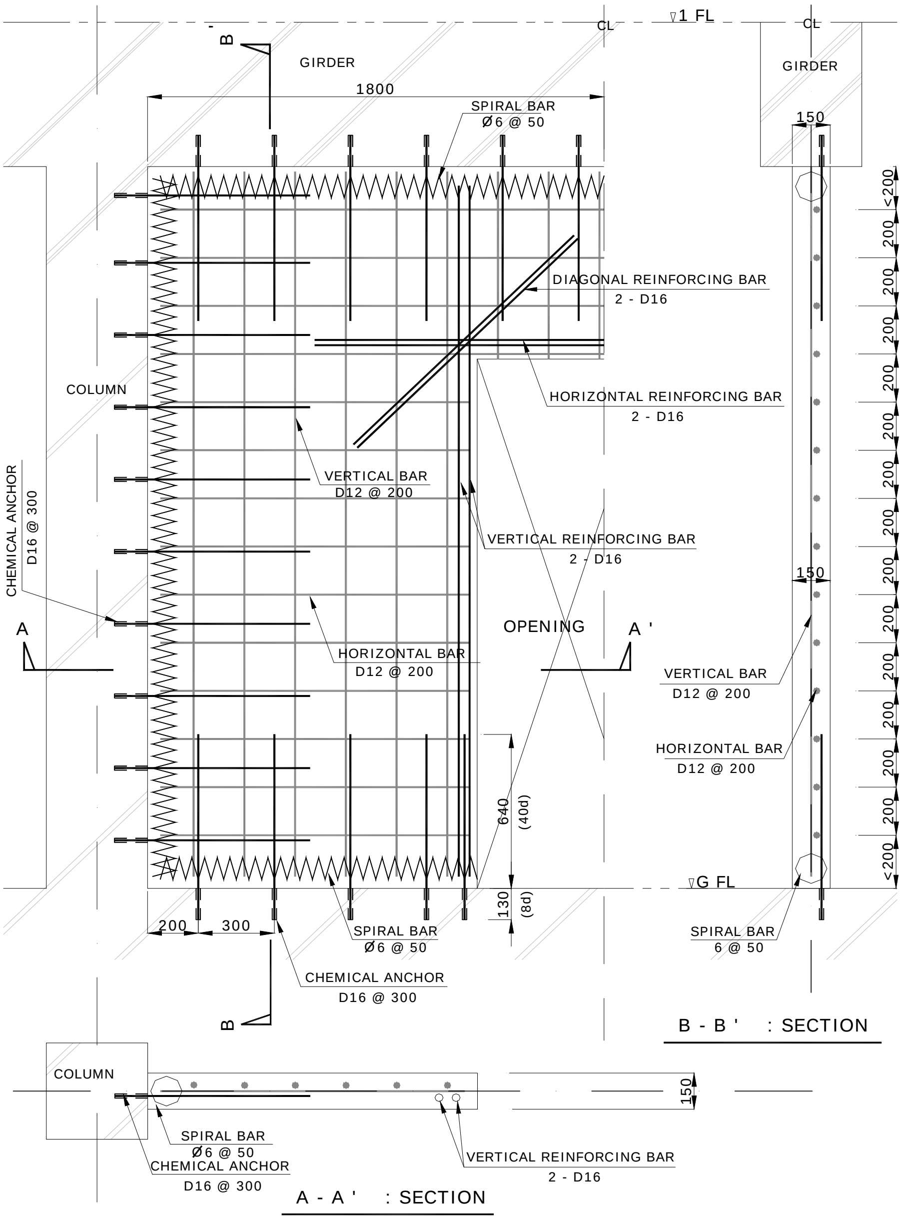

The Study on Water Supply System Resistant to Earthquakes in Tehran Municipality in the Islamic Republic of Iran

The Earthquake Resistant Wall (W15) Scale=1:20

Fig. 5.25

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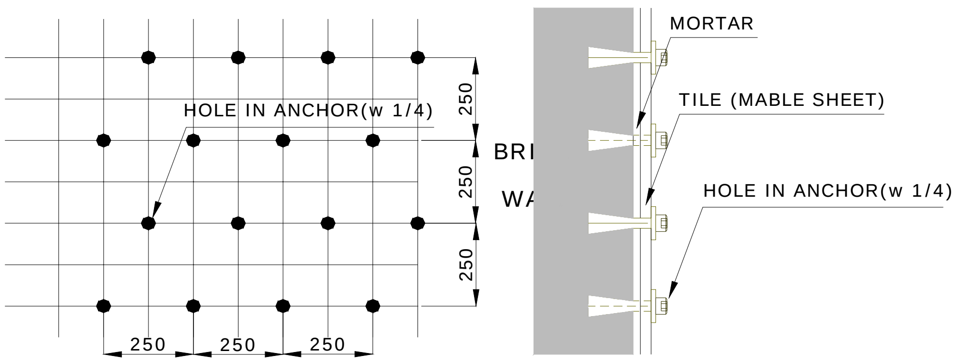
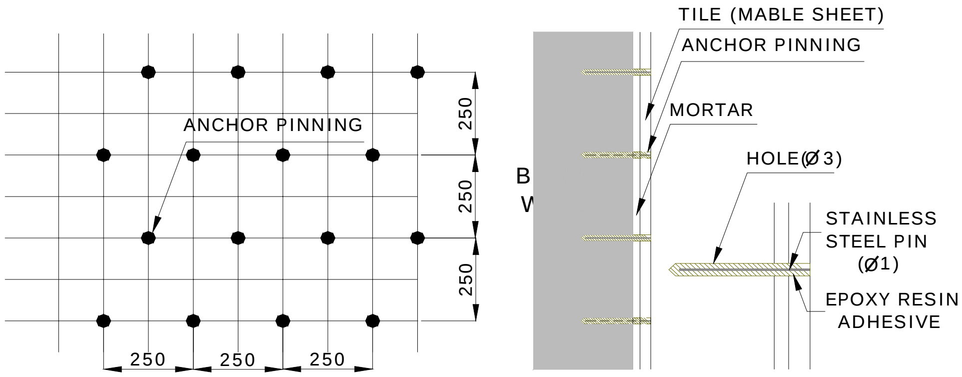
1) HOLE IN ANCHOR METHOD (16 pts / m2)



2) ANCHOR PINNING METHOD (16 pts/ m2)



	The Study on Water Supply System Resistant to Earthquakes in Tehran Municipality in the Islamic Republic of Iran	**Fig. 5.26**
Reinforcment Of Tile & Marble Sheet On The Wall		

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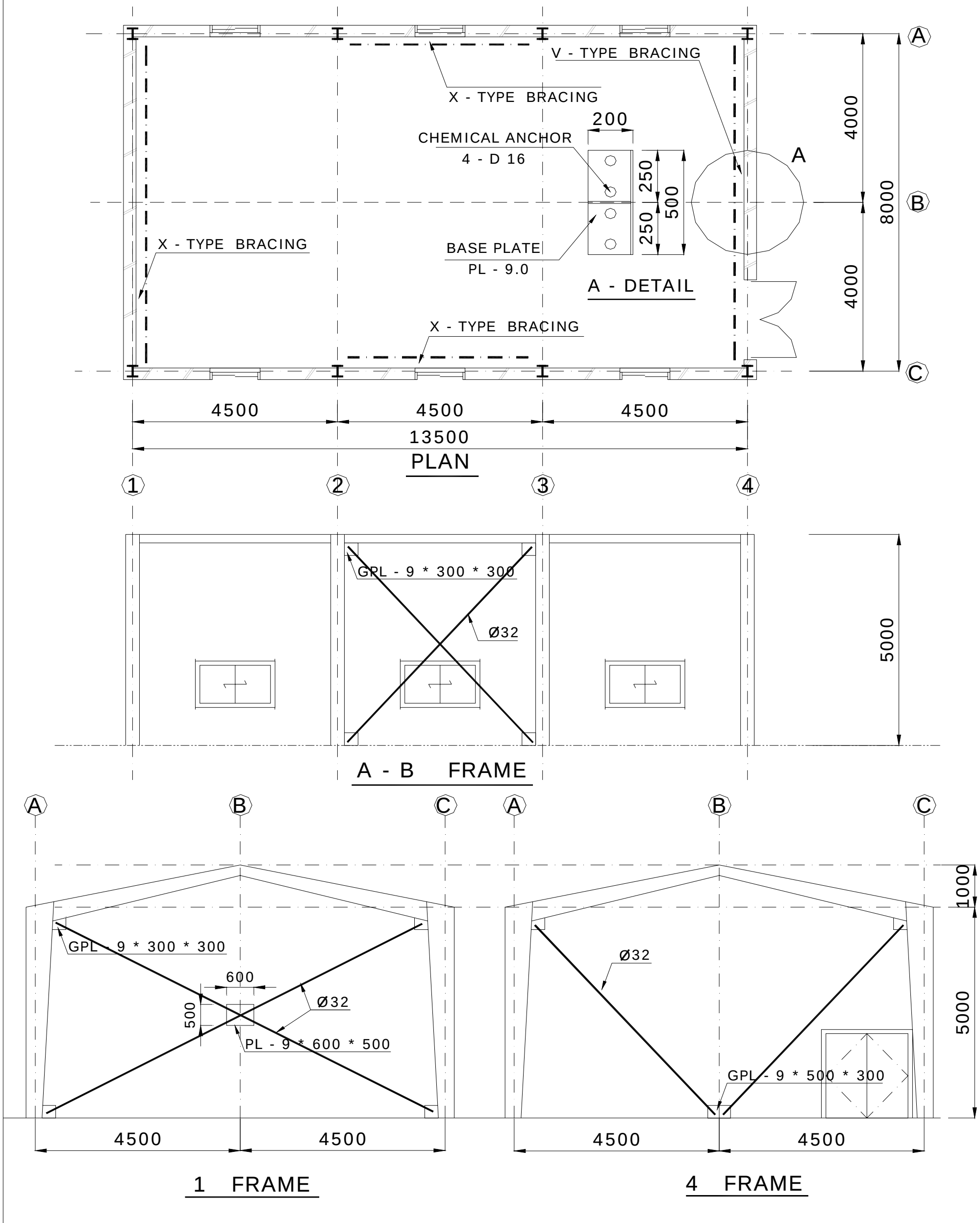

	The Study on Water Supply System Resistant to Earthquakes in Tehran Municipality in the Islamic Republic of Iran	Fig. 5.27
The Reinforcment Of Steel Building Scale=1:100		

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