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Diablo Canyon Nuclear Power Plant

Turbine Pedestal Evaluation for the 7.5M Hosgri Earthquake

Status Report
August 15, 1978

prepared for

Pacific Gas & Electric Company

by

URS/John A. Blume & Associates, Engineers
130 Jessie Street
San Francisco, California

TURBINE PEDESTAL

This report describes qualification criteria, methods and results of analyses used in reviewing the Diablo Canyon turbine pedestals for response to the postulated 7.5M Hosgri earthquake. A discussion of proposed structural modifications to enhance seismic performance is also provided.

INTRODUCTION

The turbine pedestals for units 1 and 2 are housed in the turbine building. Each pedestal is a massive reinforced concrete space frame which supports the generator, turbines and other related equipment at the top (el. 140'). It essentially consists of six transverse rectangular single bent frames approximately 55 feet high and 55 feet wide, connected by longitudinal beams. The total length is 208 feet.

The pedestal is supported on the common turbine building mat foundation but is otherwise isolated from the turbine building. There is a 1-1/2 inch gap between the pedestal and the building floor diaphragm at el. 140'.

Units 1 and 2 were completed in 1971 and 1972 respectively.

QUALIFICATION CRITERIA

Loading Conditions. The seismic load has been considered applied with dead load and operational load.

In general, strength evaluation has been undertaken according to ACI Standard "Building Code Requirements for Reinforced Concrete (ACI 318-77)" except

with capacity reduction factors, ϕ, of one as actual concrete and steel strengths were used.

METHOD OF ANALYSIS

Linear three-dimensional finite element response spectrum analyses were undertaken using the SAP IV structural analysis computer code. The model consisted of beam elements (cracked section properties) with finite rigid joints to account for the stiff zones at beam-column connections (Figure 1). Equipment mass was applied at appropriate nodes.

The model was subjected to seismic loading, including nominal torsion equivalent to 5% eccentricity of the center of mass, dead load and operational load. Seismic loading in the horizontal direction corresponds to the Newmark/7.5M Hosgri elastic spectrum for 7% damping and $\tau = 0.067$. This was more severe than the equivalent Blume/7.5M Hosgri spectrum ($\tau = 0.08$) after scaling by 0.8 $(1/\sqrt{2\mu - 1})$ to reflect the allowable ductility factor of 1.3 for an inelastic response spectrum. Calculated displacements were scaled up by a factor of 1.3 to account for the above.

Seismic loading in the vertical direction corresponds to 2/3 of the Newmark free-field elastic spectrum for 7% damping which was again more severe than the equivalent Blume spectrum.

The E/W torsion was obtained by applying static forces to the model in the E/W direction which yields a torsional moment corresponding to a 5% eccentricity of the center of mass such that the significant E/W torsional mode obtained from dynamic analysis was approximated. The N/S torsion was obtained by applying static forces in the N/S direction proportional to the tributary

mass so that the forces result in 5% eccentricity of the mass. The N/S and E/W torsion results were added directly to the N/S and E/W seismic results respectively. The resulting N/S and E/W responses and the vertical seismic results were combined on a SRSS basis. This total effect was in turn combined with dead load and operation load. Operation loads requiring consideration during an earthquake are confined to condensor vacuum loads, normal operating torque and possibly short circuit torque (taken as ten times normal torque). The following three load combinations were investigated:

1) seismic and dead load (algebraic)
2) seismic, dead load, vacuum and normal ~~type~~ torque (algebraic)
3) seismic and short circuit torque (SRSS) plus vacuum and dead load.

RESULTS

The SRSS combined effects of the separate response spectrum analyses for moment, shear/torsion and axial load are shown in Tables 1 through 5. The ratios of the bending moment to the yield moment for each direction are given in Table 3. This ratio exceeds one only for the transverse beam of Frame 6. Minor plastic deformation may occur.

For the combined shear/torsion axial load condition, the calculated response exceeds the estimated capacities based on an assumed 6000 psi concrete compressive strength for three piers. These results are summarized in Figure 2. The calculated turbine pedestal displacements at el. 140' are summarized in Table 6. The maximum relative displacement between the pedestal and building diaphragm is estimated at approximately 2-1/2" which exceeds the existing gap of 1-1/2".

DISCUSSION OF RESULTS

The axial tensions generated in the pedestal piers as a result of seismic overturning moment reduce the shear/torsion carrying capacity of the piers to an extent such that structural modifications designed to increase the shear strength of the pedestals are recommended. The most effective procedure is to post-tension the overloaded piers to counteract the seismic-induced tensions. Other modification possibilities examined proved ineffective and furthermore very difficult to implement.

It is planned to post-tension the overloaded piers as shown in Figures 3-6, sufficient to counterbalance the seismic-induced axial tensions. The calculated ratios of applied shear/torsion to capacity, based on a concrete strength of 5000 psi are given in Tables 7-9. Nominal compressive stresses of under 200 psi would result. The gap at el. 140' is also to be increased to 3-1/2" as shown in Figure 7.

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isco, California 94105

Table 1

SHEET NO.
2902-14 JOB Diablo Review BY GEG DATE 4/18/78
P.G.&E. SUBJECT Turbine Pedestal - Seismic Moments CHK'D DW DATE 4/24/78

SEISMIC MOMENTS (K-ft x 10^3)

Beam #	Element #	E/W		5% Ecc E/W		E/W Tot.		N/S		5% Ecc N/S		N/S Tot.		Vertical		S.R.S.S. (Tot.)		
		± M_2	± M_3	± M_2	± M_3	± M_2	± M_3	± M_2	± M_3	± M_2	± M_3	± M_2	± M_3	± M_2	± M_3	± M_2	± M_3	
1	1	2.564	35.046	1.871	9.588	4.435	44.634	77.55	0.226	4.799	2.062	82.349	2.288	3.079	0.644	82.526	44.697	C
3	11	9.867	93.035	6.323	12.606	16.190	105.641	125.430	4.185	7.492	0.208	132.922	4.393	3.135	4.048	133.941	105.810	
5	21	5.250	64.124	2.831	1.553	8.081	65.677	58.762	0.803	3.522	0.443	62.284	1.246	1.955	3.952	62.836	65.802	
7	31	4.455	71.404	2.539	3.443	6.994	74.847	55.100	0.256	3.343	0.543	58.443	0.799	1.750	5.223	59.896	75.033	
9	41	2.686	53.993	1.670	6.227	4.356	60.220	38.954	0.594	2.357	0.652	41.311	1.246	2.012	3.766	41.589	60.351	
11	51	1.679	48.831	0.917	8.624	2.596	57.455	21.964	1.143	1.438	1.191	23.402	2.334	1.243	3.011	23.578	57.581	
13	62	3.244	2.855	2.894	1.575	6.138	4.430	1.195	41.489	2.589	1.544	3.784	43.033	0.748	1.731	7.249	43.295	L
15	70	17.305	3.867	2.899	2.140	20.204	6.007	3.378	36.925	1.798	2.483	5.166	39.408	1.246	1.304	20.891	39.885	
17	78	2.001	1.769	1.355	0.768	3.356	2.537	1.492	14.400	1.047	0.997	2.539	15.397	0.985	0.847	4.322	15.628	
19	86	11.710	1.092	0.355	0.944	12.065	2.036	2.171	18.503	0.859	1.246	3.030	19.749	0.538	0.768	12.451	19.869	
21	94	2.991	0.534	0.687	0.307	3.678	0.841	3.070	9.878	0.788	0.646	3.858	10.524	0.554	0.838	5.359	10.591	
23	102	3.637	25.303	2.156	7.332	5.793	32.635	0.351	0.827	3.230	1.539	3.581	2.366	1.809	0.874	7.047	32.732	T
25	108	3.429	55.964	1.233	6.851	4.662	62.815	0.684	8.528	1.929	0.226	2.613	8.754	0.094	3.923	5.345	63.543	
27	112	3.615	44.783	2.228	0.683	10.843	45.466	3.645	0.721	2.682	0.439	6.327	1.160	1.264	1.289	12.617	45.499	
28	118	2.593	54.100	1.696	3.134	4.289	57.234	3.688	0.176	2.668	0.493	6.356	0.669	0.487	1.364	7.731	57.254	
30	124	3.482	38.166	0.231	4.627	3.713	42.793	3.338	0.396	0.686	0.497	4.524	0.887	0.530	1.843	5.877	42.842	
33	128	10.464	31.830	0.404	5.257	10.868	37.087	2.784	0.459	1.753	0.833	4.537	1.292	1.296	1.796	11.848	37.151	

Table 2

New Montgomery)
nia 94105

SHEET NO.

JOB Diablo Review — BY GEG DATE 4/20/78

SUBJECT Turbine Pedestal — CHK'D EW DATE 4/25/78

– Moments (K-ft x 10^3)

Dead Load		Vacuum		±Normal Torque		Seismic & Dead Load				Seismic, Dead Load & Operation				S.R.S.S. (Seismic & I.O.D.T.) + Vacuum + D.			
M_2	M_3	M_2	M_3	$\pm M_2$	$\pm M_3$	$-M_2$	$-M_3$	$+M_2$	$+M_3$	$-M_2$	$-M_3$	$+M_2$	$+M_3$	$-M_2$	$-M_3$	$+M_2$	$+M_3$
+1.635	+0.434	−0.056	−0.026	+0.131	−0.045	−80.891	−44.263	84.161	45.131	−81.079	−44.282	84.236	45.202	−80.957	−44.239	84.115	45.1
−1.650	+2.838	−0.235	−0.557	−0.215	−0.017	−135.571	−102.972	132.291	108.649	−135.571	−102.432	132.741	109.222	−135.373	−102.445	132.543	109.
−0.326	+1.436	−0.016	+0.762	0.019	−0.005	−63.162	−64.372	62.510	67.244	−63.197	−63.615	62.513	68.011	−63.178	−63.610	62.494	68.
−0.428	+1.416	−0.072	+0.813	+0.041	−0.004	−58.924	−73.617	58.943	76.449	−59.042	−72.809	58.812	77.266	−59.002	−72.804	58.773	77.
−0.670	+1.387	−0.246	+0.475	+0.064	+0.003	−42.259	−58.764	40.918	61.738	−42.567	−58.492	40.737	62.216	−42.510	−58.489	40.678	62.
−0.426	+1.527	−0.094	+0.208	−0.002	+0.006	−24.004	−56.054	23.152	59.103	−24.100	−55.852	23.060	59.322	−24.098	−55.846	23.058	59.
+0.185	−1.631	±0.004	−0.068	−0.038	−0.635	−7.064	−44.926	7.434	41.004	−7.098	−45.629	7.476	42.231	−7.070	−45.457	7.448	42.
+0.640	−1.892	−0.001	−0.324	+0.017	−0.249	−20.251	−41.777	21.531	37.993	−20.267	−42.350	21.549	37.918	−20.251	−42.174	21.533	37.
−0.179	−1.073	−0.001	−0.181	−0.106	−0.056	−4.501	−16.701	4.143	14.555	−4.608	−16.938	4.248	14.430	−4.630	−16.892	4.270	14.
+0.060	−1.363	−0.001	−0.250	−0.019	−0.210	−12.391	−21.232	12.511	18.506	−12.411	−21.692	12.529	18.466	−12.393	−21.593	12.511	18.
−0.094	−0.633	−0.022	+0.051	−0.004	+0.014	−5.453	−11.224	5.265	9.958	−5.479	−11.187	5.247	10.023	−5.475	−11.174	5.243	10.
+0.280	−1.129	±0.005	−0.110	−0.030	−0.448	−6.767	−33.861	7.327	31.603	−6.792	−34.419	7.362	31.941	−6.768	−34.276	7.338	31.
−0.058	−5.022	0.000	−0.990	−0.015	−1.346	−5.403	−68.565	5.287	58.521	−5.418	−70.901	5.302	58.877	−5.405	−70.745	5.289	58
+0.025	+0.935	0.000	+0.128	−0.004	−0.381	−12.592	−44.564	12.642	46.434	−12.516	−44.817	12.646	46.943	−12.592	−44.575	12.642	46
−0.004	+0.956	0.000	+0.070	±0.014	−0.382	−7.735	−56.298	7.727	58.210	−7.747	−56.610	7.741	59.662	−7.736	−56.355	7.728	58.
±0.001	+1.265	0.000	+0.006	−0.006	−0.302	−5.876	−41.577	5.870	44.107	−5.882	−41.873	5.884	44.415	−5.876	−41.677	5.878	44
−0.010	+1.255	−0.004	−0.113	−0.017	−0.168	−11.853	−35.896	11.838	38.706	−11.879	−36.177	11.851	38.161	−11.863	−36.047	11.835	38.

1 Torque is ant. symmetric loading. Has opposite sign moments on opposite side of structure.

Table 3

New Montgomery
ia 94105

SHEET NO.

JOB Diablo Review — BY GEG DATE 4/24/78

SUBJECT Turbine Pedestal — CHK'D KW DATE 4/24/78

– Moments ($k\text{-}ft \times 10^3$)

	Maximum Total Applied Moment				Yield Moment				Ratio of Yield Moment				
	$-M_2$	$+M_2$	$-M_3$	$+M_3$	$-My_2$	$+My_2$	$-My_3$	$+My_3$	$-M_2/My_2$	$+M_2/My_2$	$-M_3/My_3$	$+M_3/My_3$	
	-81.078	+84.236	-44.292	+45.202	130.016	130.016	62.362	62.362	0.624	0.648	0.710	0.725	
	-135.591	+132.741	-102.972	+109.222	222.799	222.799	148.024	148.024	0.609	0.596	0.696	0.738	
	-63.197	62.513	-64.372	+68.011	110.803	110.803	102.852	102.852	0.570	0.564	0.626	0.661	Columns
	-59.042	+58.843	-73.617	+76.449	110.803	110.803	102.852	102.852	0.533	0.531	0.716	0.743	
	-42.569	+40.919	-58.964	+62.216	83.858	83.858	91.776	91.766	0.509	0.488	0.642	0.678	
	-24.100	+23.152	-56.054	+59.322	57.624	57.624	72.616	72.616	0.418	0.402	0.772	0.817	
	-7.098	+7.476	-45.629	+42.231	48.486	50.497	75.092	59.902	0.146	0.148	0.608	0.705	
	-20.267	+21.549	-42.350	+37.993	57.693	62.744	79.399	43.203	0.351	0.343	0.533	0.879	
	-4.630	+4.270	-16.938	+14.555	57.693	62.744	79.399	43.203	0.080	0.068	0.213	0.337	
	-12.411	+12.529	-21.692	+18.506	57.693	62.744	79.399	43.203	0.215	0.200	0.273	0.428	
	-5.479	+5.265	-11.224	+10.023	81.656	63.066	53.189	24.378	0.067	0.083	0.211	0.411	Longitudinal Beams
	-6.742	+7.362	-34.419	+31.941	80.590	66.478	52.289	59.798	0.084	0.111	0.658	0.534	
	-5.418	+5.302	-70.965	+58.941	28.152	28.152	117.599	82.123	0.192	0.188	0.603	0.718	
	-12.596	+12.646	-44.917	+46.943	50.313	50.313	99.006	90.192	0.250	0.251	0.453	0.520	
	-7.749	+7.741	-56.610	+58.662	50.313	50.313	99.006	90.192	0.154	0.154	0.572	0.650	
	-5.882	+5.884	-41.873	+44.415	18.552	16.660	43.590	50.974	0.318	0.353	0.961	0.871	
	-11.874	+11.851	-36.177	+38.461	21.791*	20.774*	35.413*	30.544*	0.545*	0.570*	1.020*	1.259*	Transverse Beams

*f'_c=6000psi used for yield moment

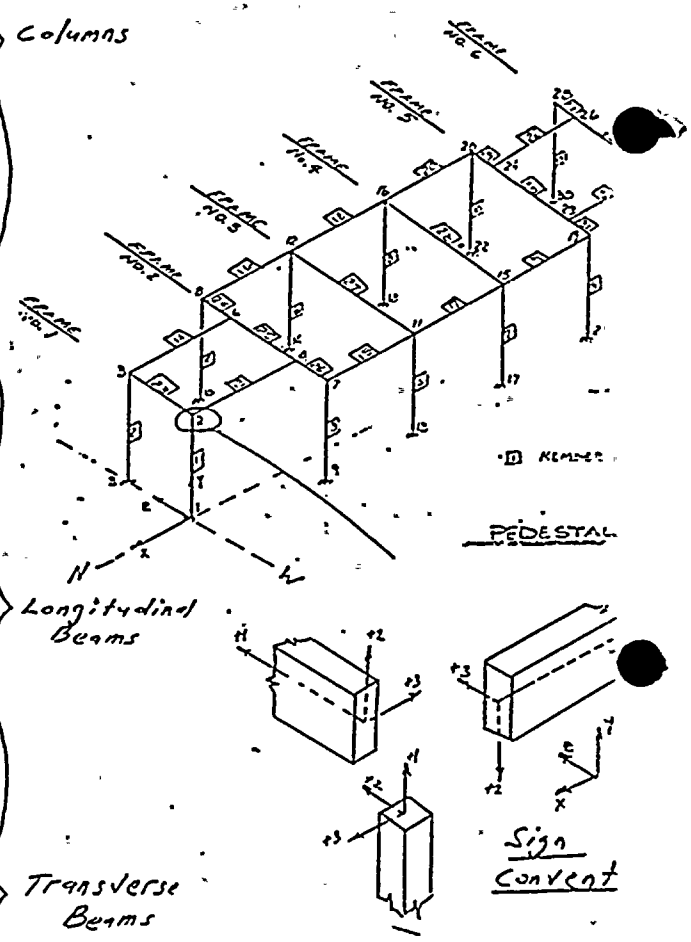


Table 4

UME
eet (at New Montgomery)
California 94105

SHEET NO.

2-17 JOB DIABLO REVIEW BY DW DATE 2/23/78

E SUBJECT Turbine Pedestal – Shear/Torsion Loads CHK'D DATE

Seismic Loading ($\times 10^{-3}$)									Dead Load			5% Ecc N/S			5% Ecc E/W			E/W total			N/S total			SRSS	
E/W			N/S			Vert																			
V_2(k)	V_3(k)	T(k-ft)	V_2(k)	V_3(k)	T(k-ft)	V_2(k)	V_3(k)	T(k-ft)	V_2(k)	V_3(k)	T(k-ft)	V_2	V_3	T	V_2	V_3	T	V_2	V_3	T	V_2	V_3	T	V_2	V_3
1.636	.114	.991	.018	2.877	.077	.057	.210	.142	.028	.154	.021	.094	.211	1.563	.434	.087	.645	2.070	.201	1.636	.112	3.11	1.642	2.10	3.28
3.882	.326	6.757	.262	4.670	.896	.303	.196	.468	.174	.071	.272	.011	.270	.820	.520	.238	2.927	4.402	.564	9.684	.273	4.940	1.716	4.60	5.05
2.336	.213	5.839	.047	2.324	.118	.284	.137	.177	.078	.007	.040	.016	.134	.140	.056	.110	2.135	2.392	.323	7.974	.063	2.458	.258	2.49	2.49
2.580	.171	1.522	.020	2.107	.179	.369	.121	.108	.077	.015	.007	.018	.123	.179	.118	.094	1.868	2.698	.265	3.390	.038	2.227	.358	2.80	2.36
2.061	.115	3.586	.041	1.672	.181	.270	.155	.080	.083	.034	.006	.024	.097	.133	.230	.068	1.048	2.291	.183	4.634	.065	1.769	.314	2.39	1.82
1.934	.081	2.043	.083	.979	.129	.225	.106	.056	.100	.024	.008	.047	.062	.265	.340	.039	.573	2.274	.120	2.616	.130	1.041	.394	2.39	1.88
.134	.490	.968	2.026	.068	1.264	.273	.111	.572	.367	.014	.583	.087	.094	.203	.090	.126	.481	.224	.616	1.449	2.113	.162	1.467	2.50	.66
.237	1.296	9.976	2.436	.222	3.176	.161	.076	1.756	.267	.030	.677	.166	.105	.051	.145	.175	1.146	.382	1.471	11.122	2.602	.327	3.227	2.90	1.54
.160	.722	4.998	1.337	.133	1.053	.089	.090	1.729	.214	.009	.093	.091	.089	.108	.072	.142	2.057	.232	.864	7.055	1.430	.222	1.161	1.67	.91
.106	.129	5.748	1.410	.188	.974	.178	.085	1.576	.258	.003	.615	.097	.071	.165	.078	.074	2.407	.186	.203	8.155	1.507	.259	1.139	1.79	.34
.069	.554	3.942	1.433	.359	2.562	.075	.061	.899	.126	.001	.175	.088	.047	.422	.046	.020	2.028	.115	.574	5.970	1.521	.406	2.984	1.65	.71
3.337	.479	3.853	.030	.360	.001	.077	.047	.001	.267	.0	.0	.203	.426	3.248	.967	.284	.091	4.304	.763	3.944	.233	.786	3.248	4.58	1.10
4.831	.296	.745	.010	.156	.000	.089	.021	.000	.143	.0	.0	.020	.167	.309	.591	.106	.195	5.422	.402	.940	.030	.323	.309	5.57	.52
2.717	.134	.148	.028	.514	0	.284	.119	0	.318	.0	.0	.027	.144	.136	.169	.092	.075	3.086	.226	.223	.055	.658	.136	3.42	.71
1.996	.182	.104	.023	.406	0	.389	.056	0	.254	.0	.0	.026	.036	.038	.242	.013	.032	2.238	.195	.136	.049	.442	.038	2.53	.49
1.664	.547	.622	.031	.307	0	.300	.142	0	.218	.0	.0	.044	.092	.412	.275	.021	.338	1.939	.568	.760	.075	.399	.412	2.18	.71

Table 5

IME
et (at New Montgomery)
California 94105

SHEET NO.

2-19 JOB Diablo Review — BY GEG DATE 4/24/78
SE SUBJECT Turbine Pedestal — CHK'D DW DATE 4/25/78

BEAM #	ELEMENT #	Axial Force (K)x10³													Area (in²)	Maximum Tensile Stress (psi)
		Seismic						Dead Load	Operation		Seismic + Dead Load	Seismic + Dead Load + operation	(Seismic stress +10(N.T) + Vacuum) + Dead Load	Maximum Net Tension		
		E/W Translation	E/W 5% Ecc.	N/S Translation	N/S 5% Ecc.	Vertical	S.R.S.S.		Vacuum	Normal Torque						
1	1	3.261	0.877	1.961	0.115	0.569	4.664	-2.036	-0.002	0.094	2.628	2.720	2.720	2.720	199"x 86" =17114 in²	158.9
3	11	5.135	0.537	0.409	0.098	0.901	5.765.	-3.094	-0.234	0.114	2.671	2.551	2.549	2.671	204"x120" =24480 in²	109.1
5	21	2.412	0.110	1.196	0.051	0.730	2.907	-2.589	-0.492	0.056	0.318	-0.119	-0.121	0.319	156"x120" =18,720 in²	17.0
7	31	2.901	0.175	0.096	0.033	1.007	3.239	-2.687	-0.523	0.083	0.552	0.112	0.134	0.552	156"x120" =18,720 in²	29.5
9	41	1.991	0.210	0.051	0.016	0.809	2.346	-1.964	-0.266	0.165	0.382	0.281	0.638	0.638	120"x120" =14,400 in²	44.3
11	51	1.606	0.229	1.472	0.044	0.527	2.438	-1.224	-0.011	0.143	1.214	1.346	1.591	1.591	96"x120" =11,520 in²	138.1

*Note: (-) negative represents compression

Table 6

URS/BLUME
130 Jessie Street (at New Montgomery)
San Francisco, California 94105

SHEET NO.

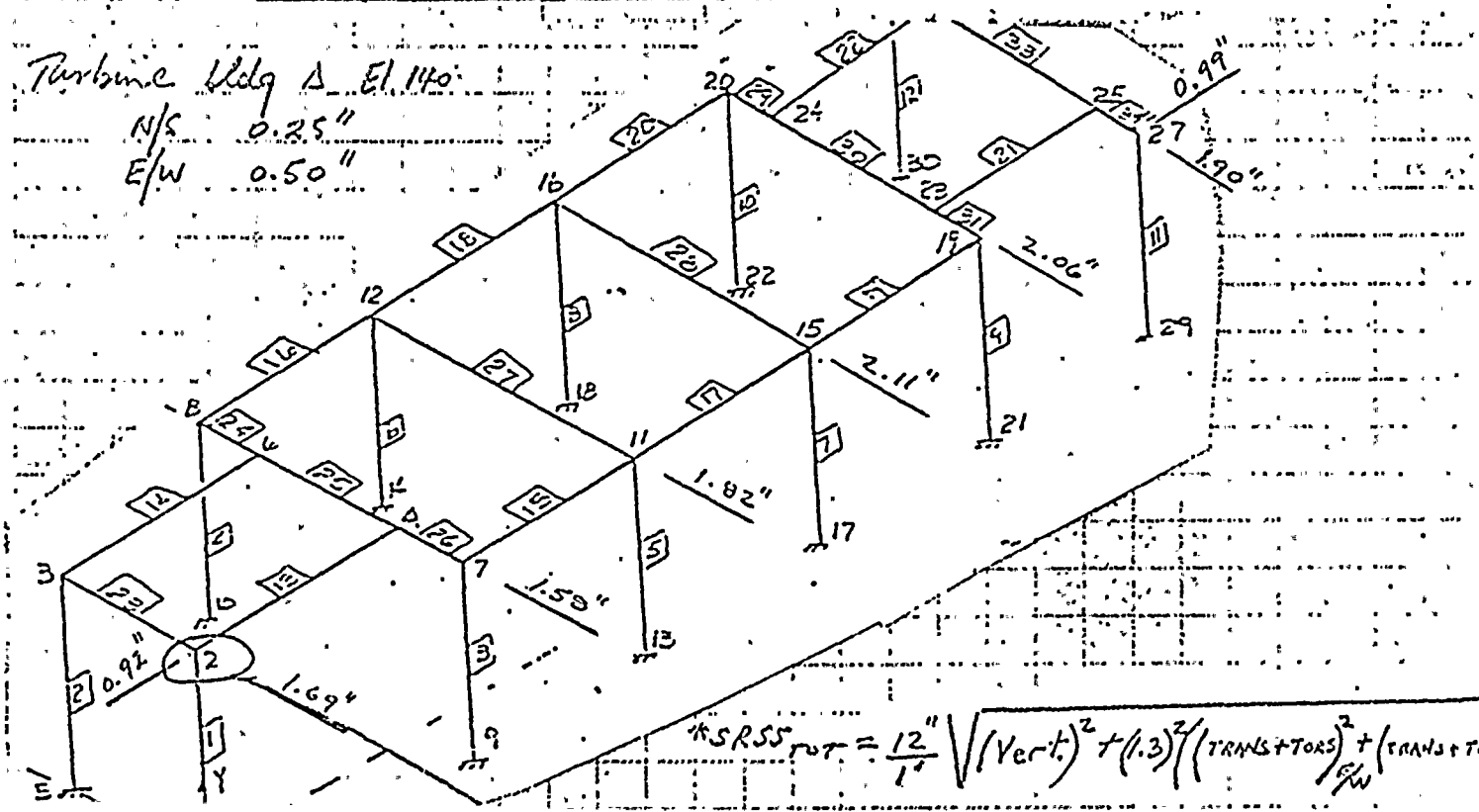
JOB NO. 0902-19 JOB Diablo Review BY GEG DATE 4/14/1
CLIENT P.G.&E. SUBJECT Turbine Pedestal - Displacements CHK'D DW DATE 4/20/1

TURBINE PEDESTAL DISPLACEMENTS

- From inspection operation loads & Dead load are not significant for displacements.

	Node #	2.000	7.000	11.000	15.000	19.000	27.000
N/S DIRECTION	Vert. (ft)	9.875-04	8.039-04	8.259-04	8.482-04	8.687-04	8.672-04
	E/W TRANS (ft)	1.538-03	5.286-03	5.068-03	4.708-03	4.425-03	4.456-03
	E/W TORS (ft)	9.535-04	2.806-03	2.772-03	2.734-03	2.699-03	2.589-03
	N/S TRANS (ft)	5.649-02	5.658-02	5.781-02	5.869-02	5.916-02	5.931-02
	N/S TORS (ft)	2.755-03	3.517-03	3.625-03	3.709-03	3.759-03	3.898-03
	*SRSS TOT (in)	9.243-01	9.375-01	9.585-01	9.734-01	9.815-01	9.861-01
E/W DIRECTION	Vert. (ft)	1.422-05	1.747-04	2.169-04	2.795-04	1.568-04	4.541-05
	E/W TRANS (ft)	8.464-02	8.929-02	1.138-01	1.288-01	1.181-01	1.034-01
	E/W TORS (ft)	2.379-02	1.289-02	2.694-03	6.628-03	1.399-02	1.808-02
	N/S TRANS (ft)	8.367-06	2.439-04	6.386-05	6.893-05	8.830-05	1.148-04
	N/S TORS (ft)	5.006-03	8.685-05	7.993-04	1.049-03	1.468-03	2.511-03
	*SRSS TOT (in)	1.693+00	1.582+00	1.818+00	2.112+00	2.061+00	1.896+00

Turbine Bldg Δ El 140'
N/S 0.25"
E/W 0.50"



$$*SRSS_{TOT} = \frac{12"}{1'}\sqrt{(Vert.)^2 + (1.3)^2\left[(TRANS+TORS)_{E/W}^2 + (TRANS+TOR\ldots\right.}$$

Table 7

URS/BLUME
120 Jessie Street (at New Montgomery)
San Francisco, California 94105

SHEET NO.

JOB NO. 0902-19 JOB Diablo Review BY GEG DATE 3/9/2

CLIENT PG&E SUBJECT Turbine Pedestal-Shear/Torsion Interaction CHK'D DATE

**Note

***	Element #				
		1.00	***	1.00	***
0	$A_{s\,2-3}$ (in²)	176.00	0	176.00	0
1	M_{3-3} (K-ft x 10²)	45.00	1	45.00	1
2	V_{2-2} (K x 10³)	2.10	2	2.10	2
3	b_{3-3} (in)	199.00	3	199.00	3
4	d_{3-3} (in)	77.00	4	77.00	4
5	A_s (in²)	168.00	5	168.00	5
6	M_{2-2} (K-ft x 10³)	84.00	6	84.00	6
7	V_{3-3} (K x 10³)	3.40	7	3.40	7
8	b_{2-2} (in)	86.00	8	86.00	8
9	d_{2-2} (in)	187.50	9	187.50	9
A	f'_c (psi)	5000.00	A	5000.00	A
B	f_y (psi)	51400.00	B	51400.00	B
C	Y (in)	199.00	C	199.00	C
D	X (in)	86.00	D	86.00	D
E	S (in)	15.00	E	15.00	E
I		0.00	I	0.00	I
***	E (in)	5.25	***	5.25	***
***	A_{TIES} (in²)	0.44	***	0.44	***
***	$A_{STIRRUPS\,(2-2)}$ (in²)	5.72	***	5.28	***
***	$A_{STIRRUPS\,(3-3)}$ (in²)	1.76	***	1.76	***
T	$T_{APPLIED}$ (K-ft x 10³)	2.32	T	2.32	T
Z	$T_{CONCRETE}$ (K-ft x 10³)	6.94	Z	6.94	Z
Y	T_{STEEL} (K-ft x 10³)	2.65	Y	2.65	Y
X	$T_{TOTAL} = T_u$ (K-ft x 10³)	9.59	X	9.59	X
***	$\frac{T_{APPLIED}}{T_u}$	0.06	***	0.06	***
T	$V_{APPLIED\,(2-2)}$ (K x 10³)	2.10	T	2.10	T
Z	V_u' (2-2) (K x 10³)	3.76	Z	3.58	Z
Y	$(V_{APPLIED}/V_u')^2$	0.32	Y	0.34	Y
X	$\left(\frac{T_{APPLIED}}{T_u'}\right)^2 + \left(\frac{V_{APPLIED}}{V_u'}\right)^2$	0.38	X	0.40	X
T	$V_{APPLIED\,(3-3)}$ (K x 10³)	3.40	T	3.40	T
Z	V_u' (3-3) (K x 10³)	3.47	Z	3.47	Z
Y	$(V_{APPLIED}/V_u')^2$	0.96	Y	0.96	Y
X	$\left(\frac{T_{APPLIED}}{T_u'}\right)^2 + \left(\frac{V_{APPLIED}}{V_u'}\right)^2$	1.02	X	1.02	X

for (3) 2-2 stirrups
(1) 3-3 stirrups removed.

for (4) 2-2 stirrups
(1) 3-3 stirrups removed

* no net tension (post-tensioned)

Table 8

URS/BLUME
130 Jessie Street (at New Montgomery)
San Francisco, California 94105

SHEET NO.

JOB NO. 0902-19 JOB Diablo Review BY GEG DATE 3/9/7?

CLIENT PG&E SUBJECT Turbine Pedestal-Shear/Torsion Interaction CHK'D DATE

*Note

Code	Element #	for (3) 2-2 stirrups, (1) 3-3 stirrups removed	Code	for (4) 2-2 stirrups, (1) 3-3 stirrups removed	Code
***	Element #	11.00	***	11.00	***
0	As_{3-3} (in²)	300.00	0	300.00	0
1	M_{3-3} (k-ft x 10³)	109.00	1	109.00	1
2	V_{2-2} (k x 10³)	4.70	2	4.70	2
3	b_{3-3} (in)	204.00	3	204.00	3
4	d_{3-3} (in)	108.50	4	108.50	4
5	As (in²)	180.00	5	180.00	5
6	M_{2-2} (k-ft x 10³)	136.00	6	136.00	6
7	V_{3-3} (k x 10³)	5.00	7	5.00	7
8	b_{2-2} (in)	120.00	8	120.00	8
9	d_{2-2} (in)	192.50	9	192.50	9
A	f'c (psi)	5000.00	A	5000.00	A
B	fy (psi)	51400.00	B	51400.00	B
C	Y (in)	204.00	C	204.00	C
D	X (in)	120.00	D	120.00	D
E	S (in)	15.00	E	15.00	E
I		0.00	I	0.00	I
***	E (in)	5.25	***	5.25	***
***	A_{TIES} (in²)	0.44	***	0.44	***
***	$A_{STIRRUPS}$ (2-2) (in²)	7.04	***	6.60	***
***	$A_{STIRRUPS}$ (3-3) (in²)	3.52	***	3.52	***
T	$T_{APPLIED}$ (k-ft x 10³)	10.20	T	10.20	T
Z	$T_{CONCRETE}$ (k-ft x 10³)	13.85	Z	13.85	Z
Y	T_{STEEL} (k-ft x 10³)	3.31	Y	3.31	Y
X	$T_{TOTAL} = T_u'$ (k-ft x 10³)	17.16	X	17.16	X
***	$T_{APPLIED} / T_u'$	0.35	***	0.35	***
T	$V_{APPLIED}$ (2-2) (k x 10³)	4.70	T	4.70	T
Z	V_u' (2-2) (k x 10³)	5.88	Z	5.72	Z
Y	$(V_{APPLIED}/V_u')^2$	0.64	Y	0.58	Y
X	$\left(\frac{T_{APPLIED}}{T_u'}\right)^2 + \left(\frac{V_{APPLIED}}{V_u'}\right)^2$	0.99	X	1.03	X
T	$V_{APPLIED}$ (3-3) (k x 10³)	5.00	T	5.00	T
Z	V_u' (3-3) (k x 10³)	5.69	Z	5.69	Z
Y	$(V_{APPLIED}/V_u')^2$	0.77	Y	0.77	Y
X	$\left(\frac{T_{APPLIED}}{T_u'}\right)^2 + \left(\frac{V_{APPLIED}}{V_u'}\right)^2$	1.13	X	1.13	X

for (3) 2-2 stirrups (1) 3-3 stirrups removed.

for (4) 2-2 stirrups (1) 3-3 stirrups removed.

* no net tension (post-tensioned)

URS/BLUME

130 Jessie Street (at New Montgomery)
San Francisco, California 94105

Table 9

SHEET NO.

JOB NO. 0902-19 JOB Diablo Review BY GEG DATE 3/9/7

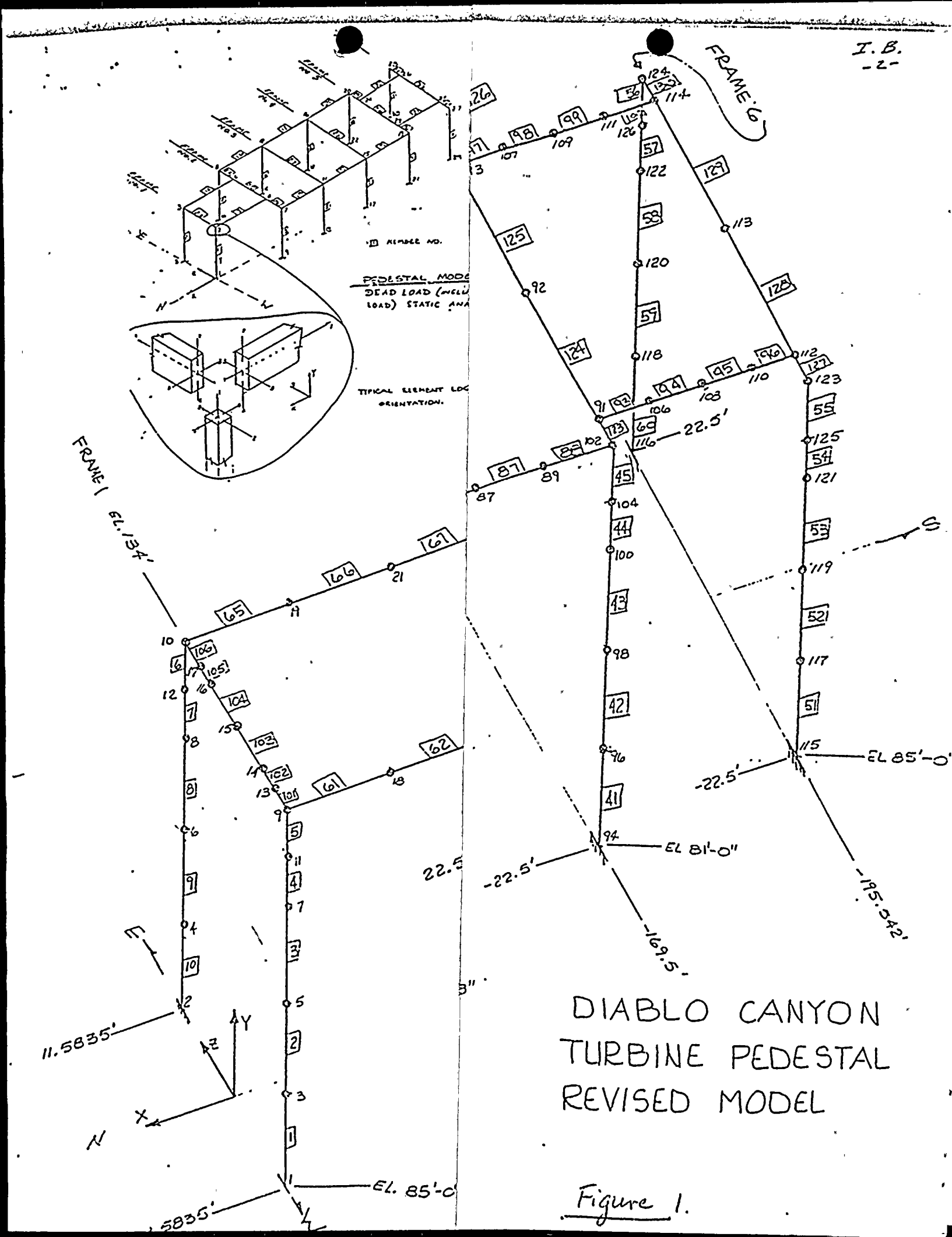
CLIENT PG&E SUBJECT Turbine Pedestal-Shear/Torsion Interaction CK'D DATE

*Note

***	Element #		
		51.00	***
0	As_{3-3} (in^2)	132.00	0
1	M_{3-3} ($K-ft \times 10^2$)	60.00	1
2	P_{2-2} ($K \times 10^2$)	2.40	2
3	b_{3-3} (in)	96.00	3.
4	d_{3-3} (in)	108.50	4
5	A_s (in^2)	128.00	5
6	M_{2-2} ($K-ft \times 10^3$)	24.00	6
7	V_{3-3} ($K \times 10^2$)	1.10	7
8	b_{2-2} (in)	120.00	8
9	d_{2-2} (in)	87.00	9
A	f_c' (psi)	5000.00	A
B	f_y (psi)	51400.00	B
C	Y (in)	120.00	C
D	X (in)	96.00	D
E	S (in)	15.00	E
I		0.00	I
***	E (in)	5.25	***
***	A_{TIES} (in^2)	0.44	***
***	$A_{STIRRUPS(2-2)}$ (in^2)	2.64	***
***	$A_{STIRRUPS(3-3)}$ (in^2)	3.52	***
T	$T_{APPLIED}$ ($K-ft \times 10^3$)	2.70	T
Z	$T_{CONCRETE}$ ($K-ft \times 10^3$)	5.21	Z
Y	T_{STEEL} ($K-ft \times 10^3$)	1.27	Y
X	$T_{TOTAL} = T_u'$ ($K-ft \times 10^3$)	6.45	X
***	$T_{APPLIED} / T_u'$	0.17	***
T	$V_{APPLIED\ (2-2)}$ ($K \times 10^3$)	2.40	T
Z	V_u' (2-2) ($K \times 10^3$)	2.56	Z
Y	$(V_{APPLIED} / V_u')^2$	0.92	Y
X	$\left(\frac{T_{APPLIED}}{T_u'}\right)^2 + \left(\frac{V_{APPLIED}}{V_u'}\right)^2$	1.09	X
T	$V_{APPLIED\ (3-3)}$ ($K \times 10^3$)	1.10	T
Z	V_u' (3-3) ($K \times 10^3$)	2.56	Z
Y	$(V_{APPLIED} / V_u')^2$	0.18	Y
X	$\left(\frac{T_{APPLIED}}{T_u'}\right)^2 + \left(\frac{V_{APPLIED}}{V_u'}\right)^2$	0.36	X

for (1) 2-2 stirrups
(2) 3-3 stirrups
removed.

*no net tension (post-tensioned)



DIABLO CANYON TURBINE PEDESTAL REVISED MODEL

Figure 1.

Figure 2

URS/BLUME
130 Jessie Street (at New Montgomery)
San Francisco, California 94105

SHEET NO.

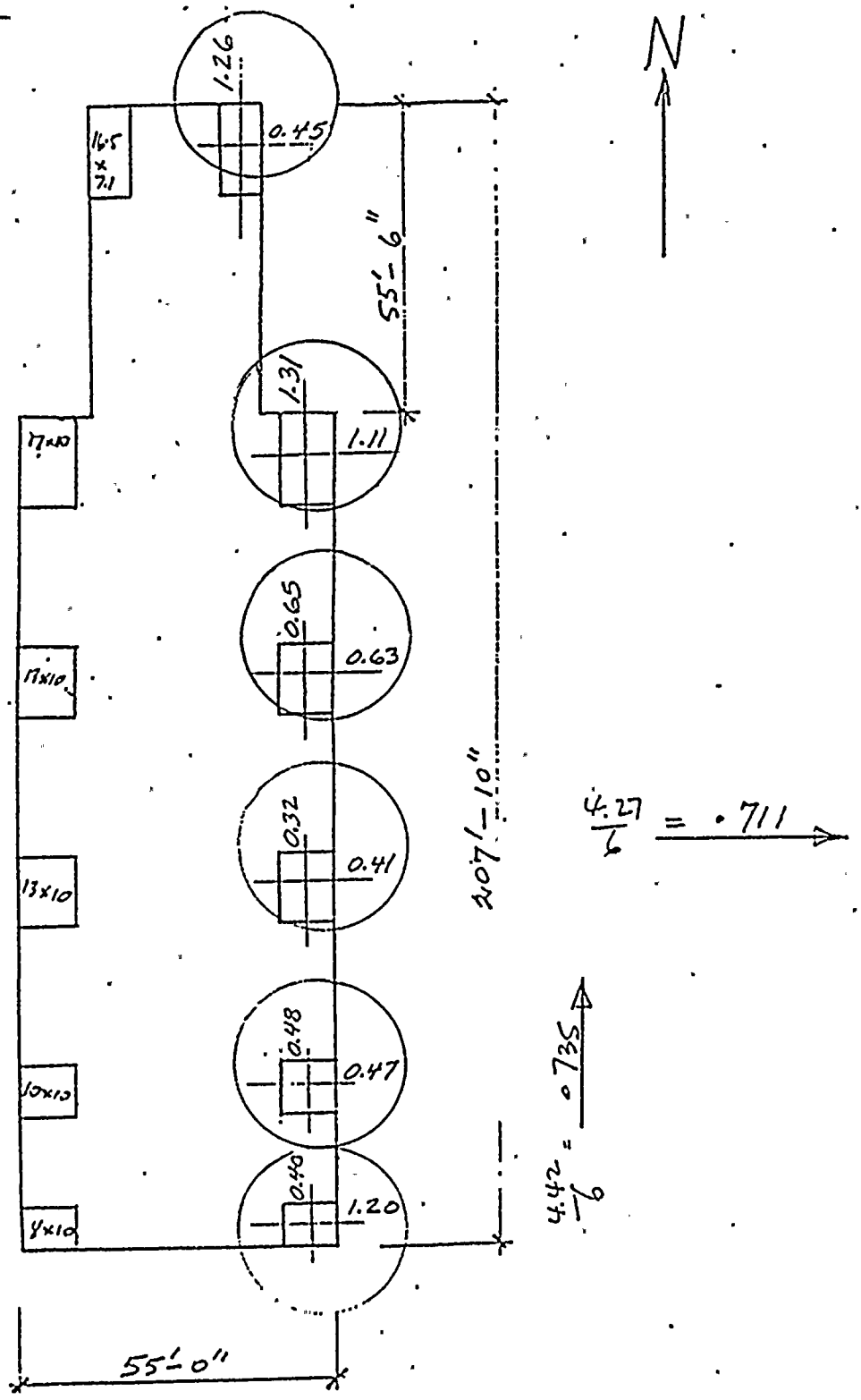
JOB NO. 0902-19 JOB DIABLO REVIEW BY DWL DATE 3/25/

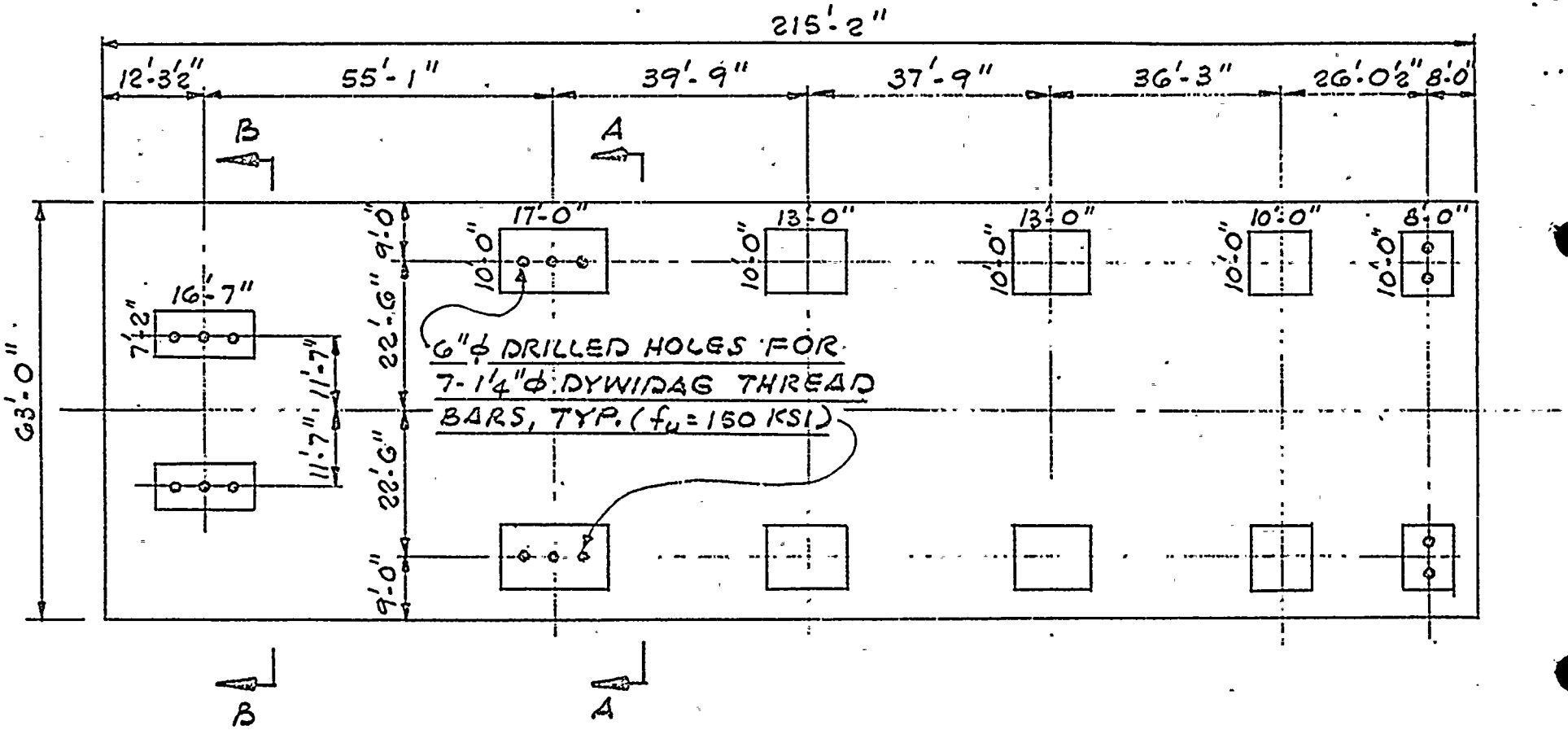
CLIENT PG&E SUBJECT Turbine Pedestal CHK'D DATE

RATIOS OF INTERACTION FOR SHEAR & TORSION (INCLUDING THE EFFECT OF NET TENSION & f'_c=6000psi)

$$\left(\frac{V_{APPLIED}}{V_{CAPACITY}}\right)^2 + \left(\frac{T_{APPLIED}}{T_{CAPACITY}}\right)^2 = RATIO \leq 1$$

*Note: Ratios given are for seismic & dead load case (using f'_c=6000psi & considering the effect of net tension). Two other cases were also investigated: 1) seismic & dead load & operation loads and 2) S.R.S.S. of seismic & 10% normal operating torque plus dead load & vacuum load, these two cases were not found to be appreciably different from the seismic & dead load case.



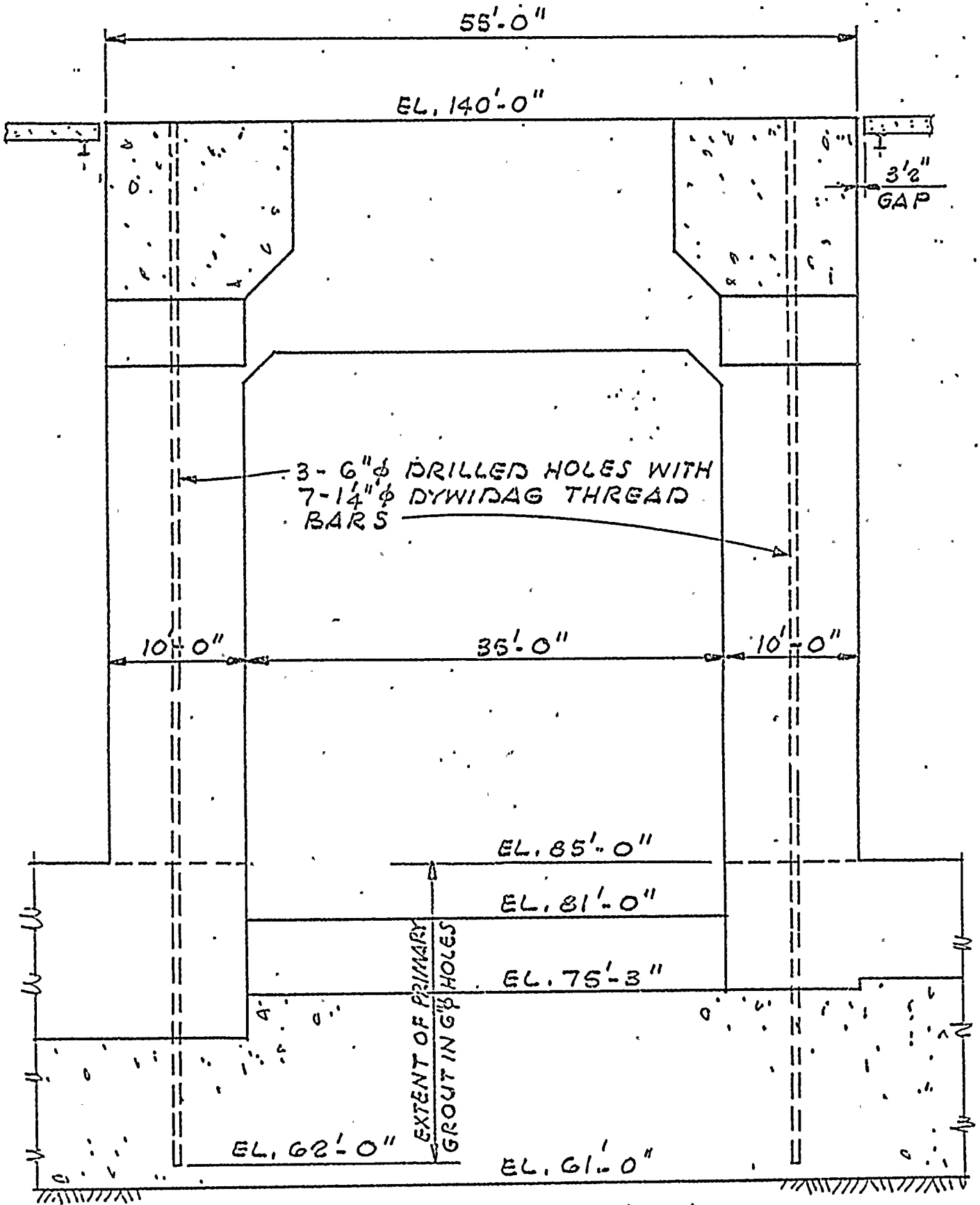


PLAN

N

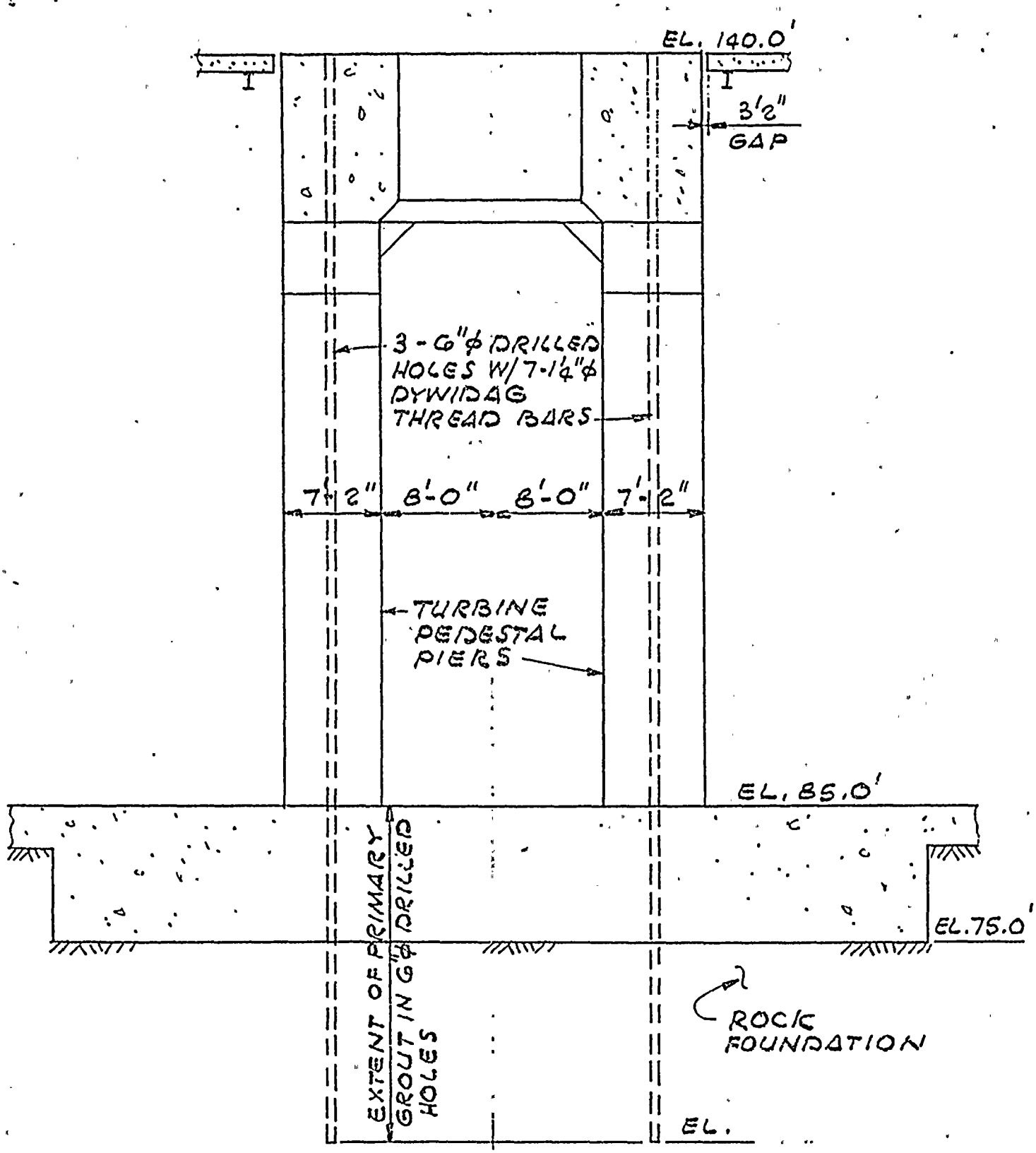
DIABLO CANYON
TURBINE PEDESTAL EL. 85.0'

Figure 3



SECTION A-A

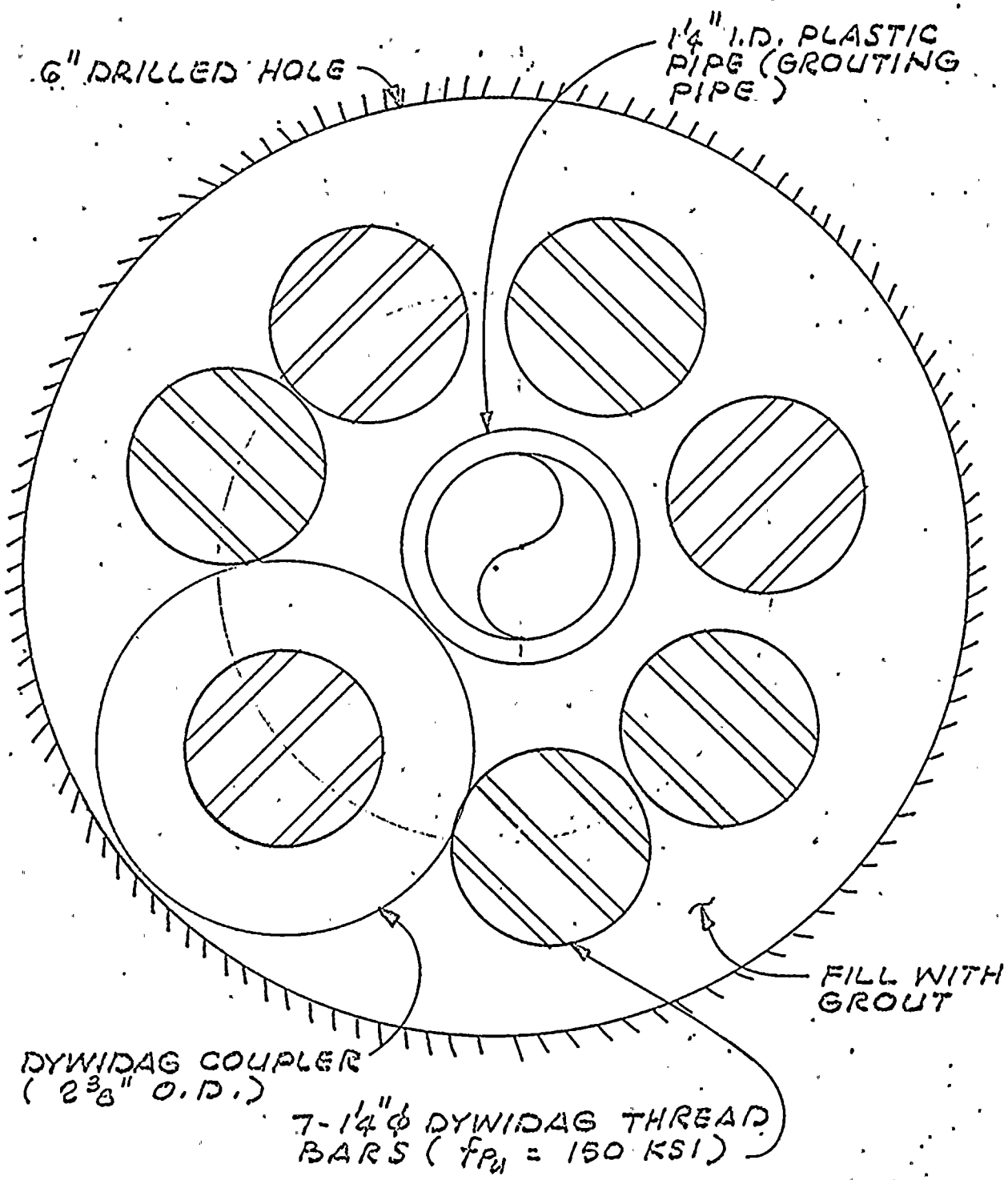
DIABLO CANYON



SECTION B-B

DIABLO CANYON
TURBINE PEDESTAL

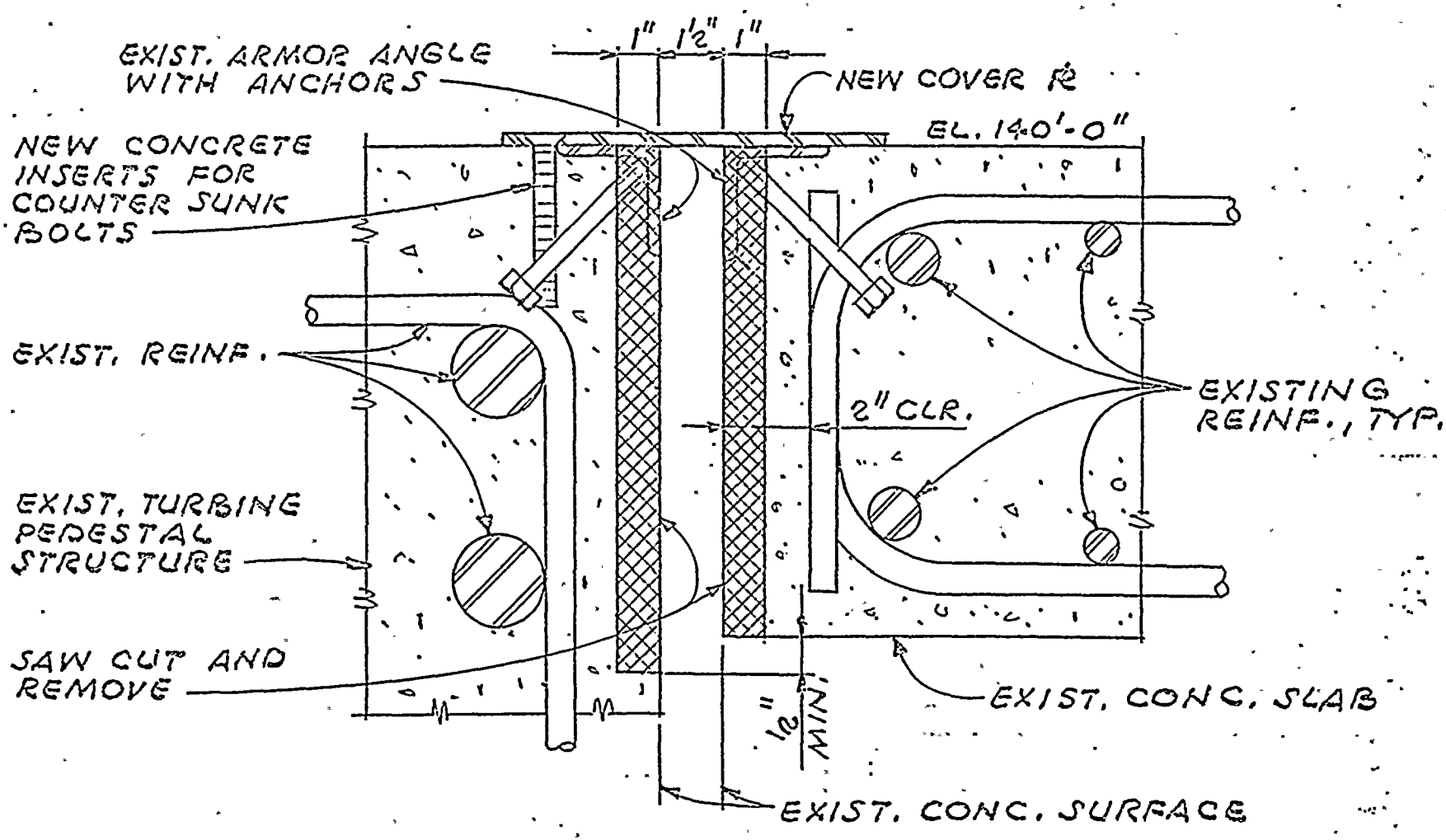
Figure 5



DETAIL OF DRILLED HOLE
WITH PRESTRESSING BARS

DIABLO CANYON
TURBINE PEDESTAL

Figure 6



DETAIL OF ENLARGED GAP BETWEEN TURBINE PEDESTAL AND CONCRETE SLAB AT EL. 140.0'

DIABLO CANYON
TURBINE PEDESTAL

Figure 7.