State of California

Business, Transportation and Housing Agency

Memorandum

To : MR. RICHARD W. FOX, Chief
Foundation Studies North Section

Date : December 20, 1994

File No. : 01-HUM-255-0.2/1.2
01-296700
Seismic Retrofit
Humboldt Bay Bridge

Br. Nos. : 04-0228, 04-0229, 04-0230

From : DEPARTMENT OF TRANSPORTATION
ENGINEERING SERVICE CENTER
Office of Structural Foundations

Subject : Site Specific ARS Curves

This memo presents the results of site response analysis for Humboldt Bay Bridges and outlines the main assumptions and limitations considered in this analysis.

The Humboldt Bay Bridge lies in an area of complex tectonic interaction among the Gorda, North American and Pacific plates. Geomatrix Consultants has performed a seismic ground motion study of this area for Caltrans. The results can be found in the report "Seismic Ground Motion Study for Humboldt Bay Bridges on Route 255" in which they developed three component rock motions for the controlling fault, "Little Salmon," with a maximum credible earthquake of moment magnitude 7.5. This fault is located 5 km (3 mi) from Humboldt Bay Bridges. The peak bedrock acceleration at this location was estimated about 0.9g. Three rock motions (longitudinal, transverse, and vertical) with a response spectrum matching the magnitude 7.5 target spectrum for these bridges were developed by Geomatrix. For information about the tectonics, seismicity, and geology of the area refer to the above mentioned report by Geomatrix Consultants.

A vicinity map of the Humboldt Bay Bridge is shown on Figure 1. Also shown in the figure are the locations of borings where shear wave velocities were measured. Site response analyses were conducted based on the information from these borings including shear wave. However, our design recommendations are based only on measurements conducted in August 1994 because of the higher reliability of the Suspension P-S Logging System and its information about deep soil layers. For more information about subsurface investigation refer to Ken Cole's report "Shear Wave Velocity Measurements at Humboldt Bay Bridges."

According to the Geomatrix report, the bedrock is estimated to be at a depth ranging from 300 m (1000 ft) to 600 m (2000 ft). Since the deepest site for which "Shake" program results have been compared to earthquake recorded data is about 150 m (500 ft), special sensitivity analysis techniques were applied in the analysis of this deep site. Within the last year, the Electrical Power Research Institute (EPRI) has developed a set of modulus reduction and damping curves for deep sites up to 300 m (1000 ft). A series of sensitivity analysis was conducted in order to determine the range of variation of soil response when a combination of three different site depths (244 m (800 ft), 366 m (1200 ft), and 458 m (1500 ft) with three different modulus reduction and damping curves (Dobry, et.al. 1987, Idriss 1992, EPRI 1993) is used. In terms of depth, this sensitivity analysis showed very little differences in site response due to the high measured shear wave velocities, about 600 m/sec (2000 fps), beyond 214 m (714 ft) depth. The variation of the modulus reduction curve showed also very little impact on the results. However, the soil response proved to be very sensitive to the damping curve used. The EPRI damping curves produced an unusual high acceleration level for structure periods of 1.5 to 2.5 seconds. The EPRI results were not included in the design because they induced soil strains on the order of 10% well above the validation limits of the program "Shake."

In another set of sensitivity analysis, different intensities of the input motion from 10% to 100% were applied to all three sites. The Dobry 1987 damping curves resulted in consistent spectral shape for the output motions. When using EPRI 93 damping curves anomalous amplifications occurred, accompanied by excessively high strains.

The "Shake" results can be found on Figures 2 to 4. Due to the similarity of these curves, only one design ARS curve is recommended for all three bridges. This curve is shown on Figure 5. These acceleration response spectra were computed 1.5 m (5 ft) below ground surface at the approximate location of the pile cap for all bents on land. Caution should be applied when using these results for the bents in the middle of the channel, where the pile cap is at sea level elevation, many feet above ground surface. In this case, we recommend a dynamic soil-pile interaction analysis to determine the response at the pile cap elevation which we can provide, if requested.

If you have any questions or comments, please call Angel Perez-Cobo at 227-7167 or Abbas Abghari at 227-7172.

Angel Perez

ANGEL PEREZ-COBO
Transportation Engineer
Earthquake Engineering Section

A. Abghari

ABBAS ABGHARI, Acting Chief
Associate Materials & Research Engineer
Earthquake Engineering Section

REGISTERED PROFESSIONAL ENGINEER
ABBAS ABGHARI
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Exp. 12/31/94
CIVIL
STATE OF CALIFORNIA

Attachments

AP-C/jlm

cc: ELeivas

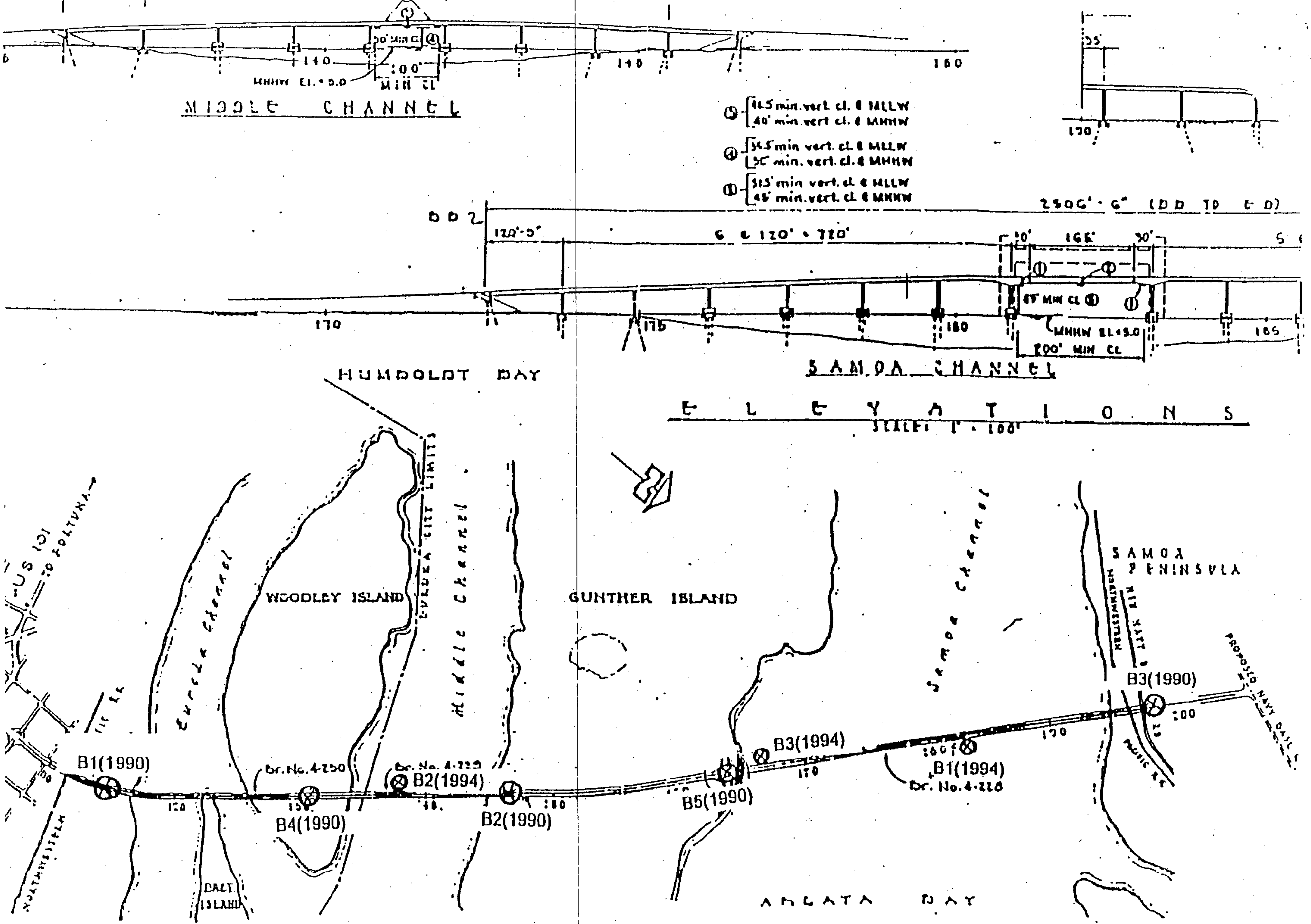

Figure 1. Site Plan of Humboldt Bay Bridges

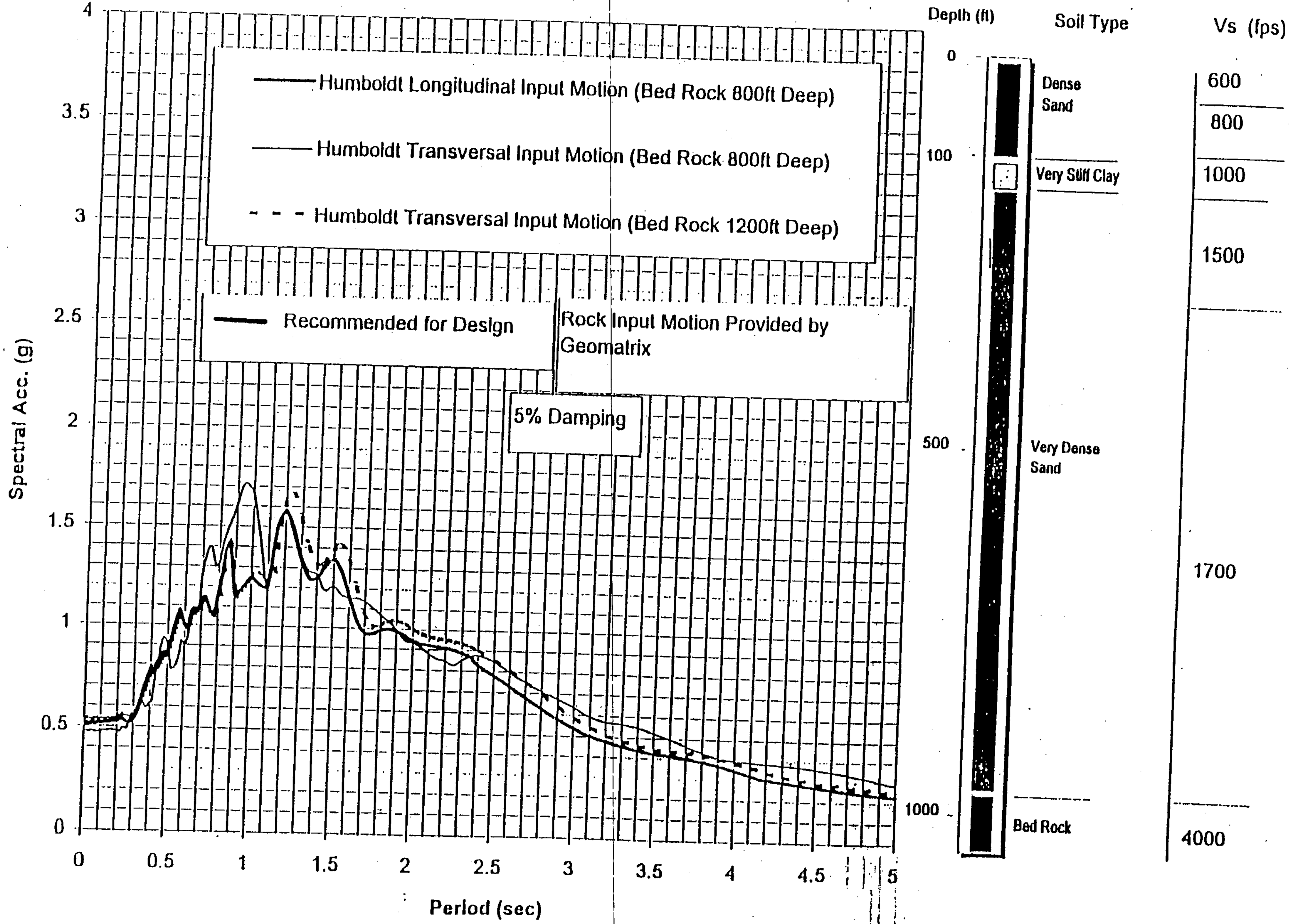

Figure 2. Acceleration Response Spectra for Humboldt Bay Bridge at Samoa Channel

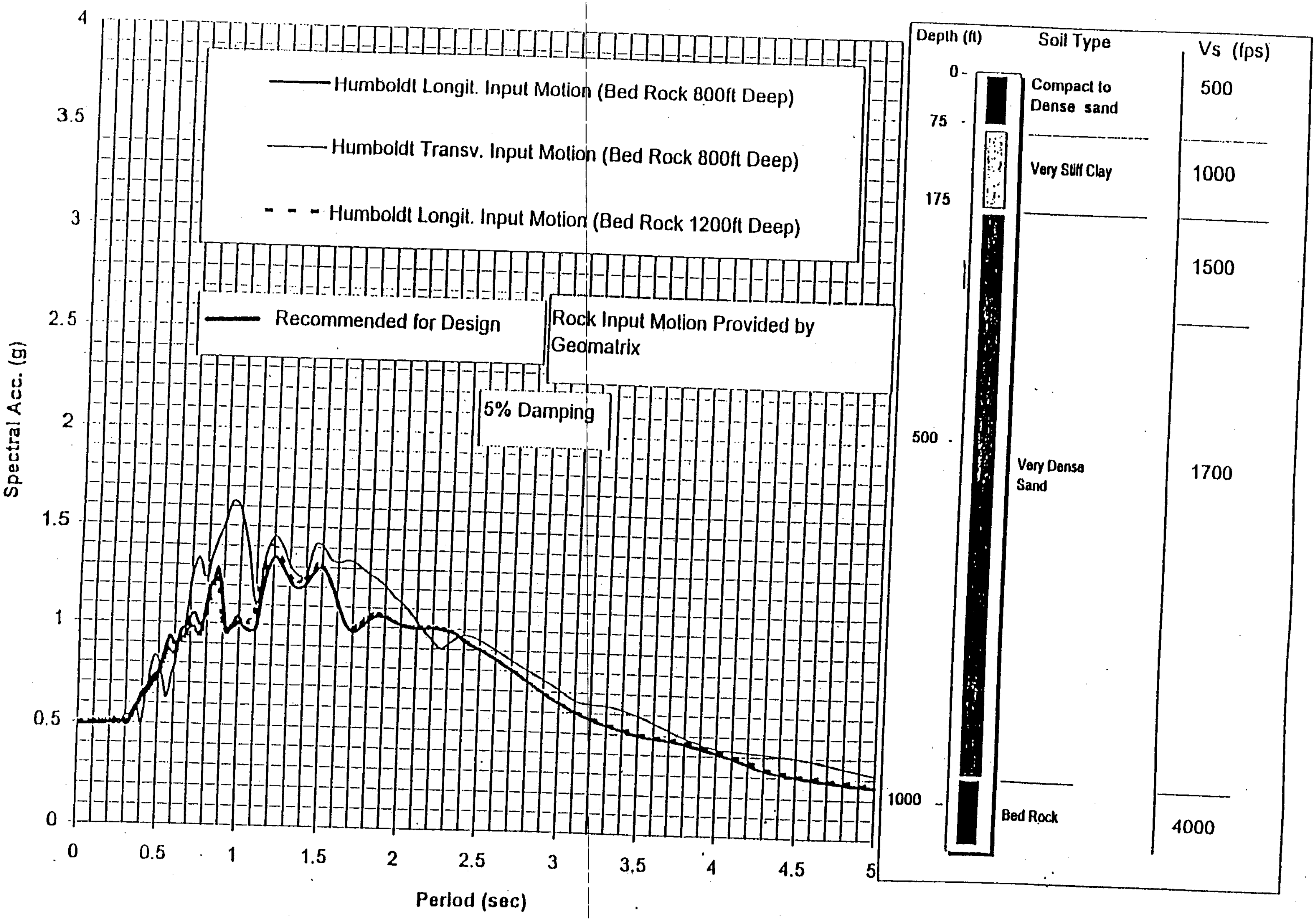

Figure 3. Acceleration Response Spectra For Humboldt Bay Bridge at Middle Channel

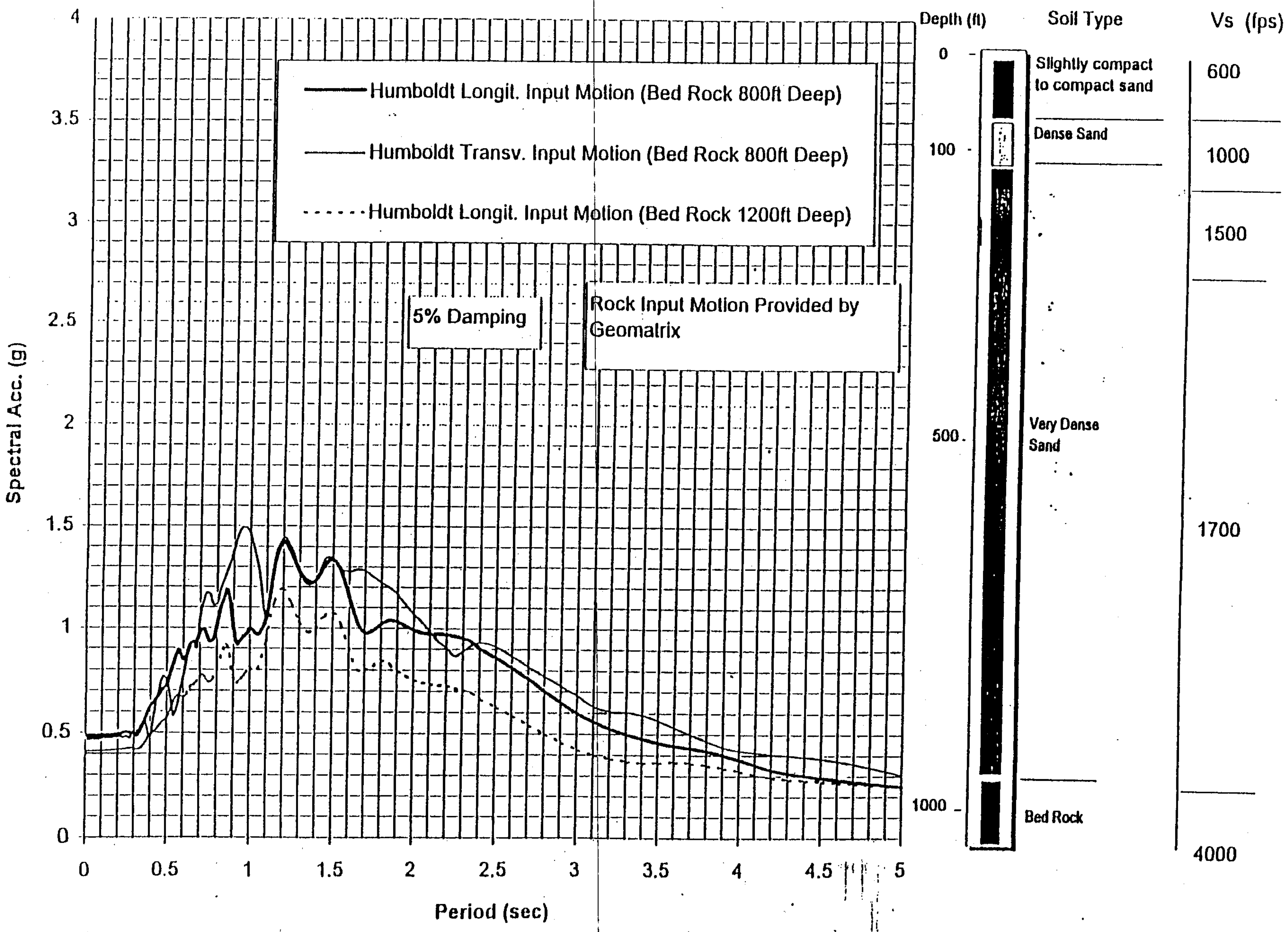

Figure 4. Acceleration Response Spectra for Humboldt Bay Bridge at Gunther Island (Boring B2-Samoa)

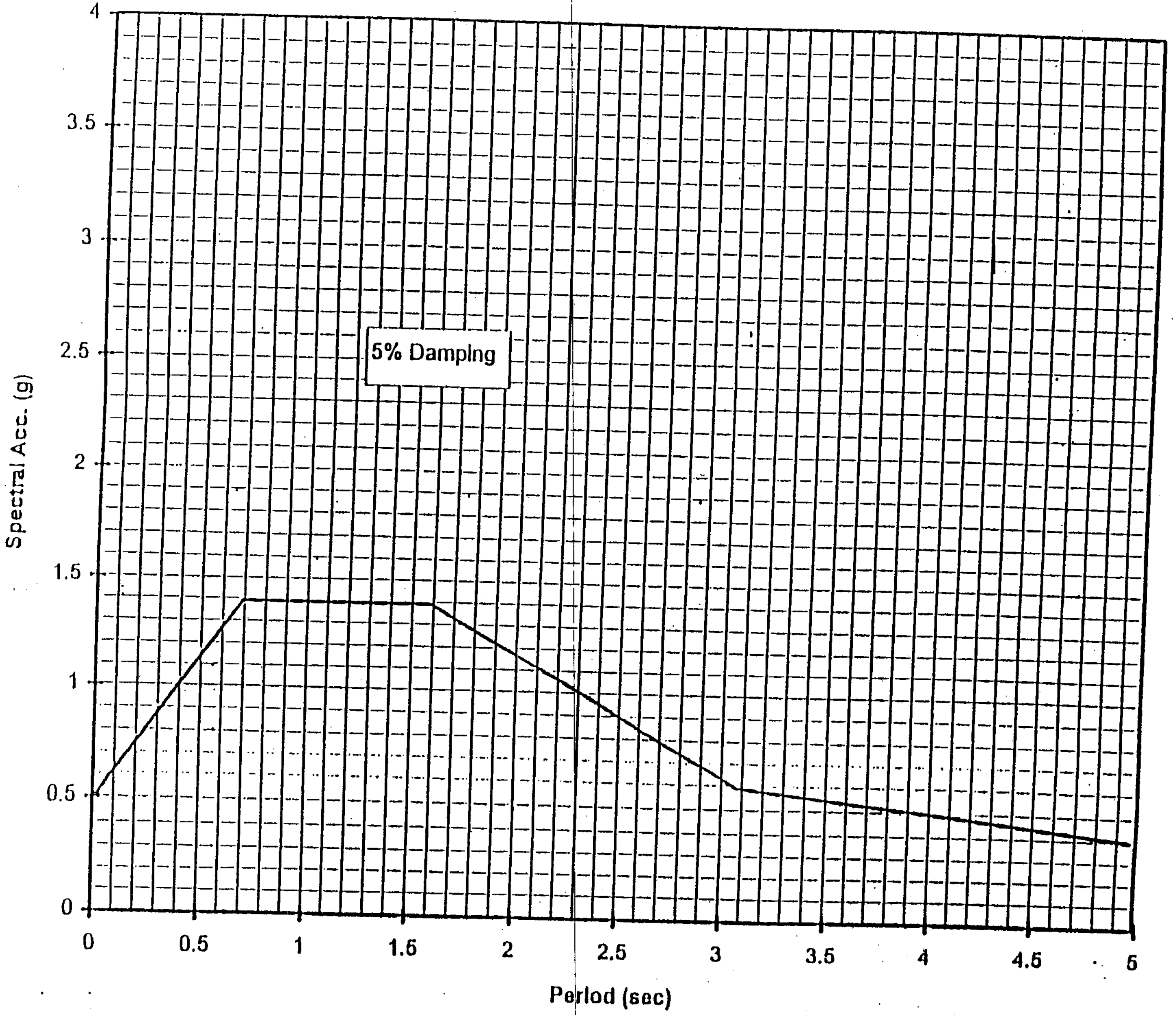

Figure 5. Design Acceleration Response Spectrum for Humboldt Bay Bridges

State of California

Business, Transportation and Housing Agency

Memorandum

To: MR. TOM POST
Office of Structure Design

Attention: Mr. Saad El-Azazy

Date: April 15, 1999

File: 01-HUM-255-0.7
01-296701

Middle Channel Bridge
Bridge No. 04-0229

From: **DEPARTMENT OF TRANSPORTATION**
ENGINEERING SERVICE CENTER
Office of Materials and Foundations - MS 5
Structure Foundations Branch

Subject: Soil parameters for COM624 computer program for the Middle Channel Bridge

This memo presents recommended soils parameters for the COM624 computer program for the Middle Channel Bridge which was requested by you.

A generalized soil profile along the approximate bridge centerline was developed based on nine (9) soil borings drilled in 1967. Recommended soil parameters for various soil layers at each bent location to the anticipated maximum pile tip depth are shown on the attached data tables. In developing the soil parameters, we have utilized the available laboratory test results. These laboratory tests were performed on samples retrieved from the four (4) soil borings drilled in 1994 along the Humbolt Bay Bridges. All elevations in the data tables for groundwater surface are for the purpose of developing the recommended soil parameters only.

The soil parameters presented in the attached data tables are for static loading conditions. Under seismic (cyclic) loading conditions, as recommended in the COM624 program documentation, the "Slope for Soil Modulus", k, for the 'Soil Type 2" layers in the attached data tables should be taken as 40 percent of the static value.

For the "Soil Type 4" layers identified in our report dated March 10, 1999 as being potentially liquefiable but not prone to lateral spreading, the seismic (cyclic) p-y curves should be obtained by multiplying the p-value of the static p-y curves by a factor of 0.3. The near surface soil layers undergoing lateral spreading will not provide any lateral resistance to the piles during earthquakes. Furthermore, additional lateral loads due to lateral spreading should be applied at these locations as recommended in our report dated March 10, 1999.

If you have any questions or comments, please call Mohammed S. Islam at 227-7094 or Abbas Abghari at 227-7172.

A. Abghari

MOHAMMED S. ISLAM
Transportation Engineer

ABBAS ABGHARI, Chief
Geotechnical Earthquake Engineering Section

Attachments

cc: ELeivas - SFB

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SOIL PARAMETERS FOR COM624 PROGRAM

BRIDGE NAME: Middle Channel Bridge BRIDGE NO. 04-229	EA: 01-296701	BENT NO. M-2	APPROX. FOOTING BOTTOM ELEVATION (FT): -8.0	APPROX. EXISTING GROUND SURFACE ELEVATION (FT): -4.0	APPROX. GROUNDWATER SURFACE ELEVATION (FT): 0.0

LAYER NO.	SOIL TYPE[1]	ELEVATION (ft)	DEPTH (ft) (From O.G. Surface)	LAYER THICKNESS (ft)	SOIL UNIT WT.[2] (pcf)	UNDRAINED SHEAR STRENGTH, c (psf)	FRICTION ANGLE, ϕ (degree)	50 PERCENT STRAIN, ε_{50}	SLOPE FOR SOIL MODULUS, k (lb/in^3)
1	1	-4 to -10	0 to 6	6	58	500	-	0.02	-
2	4	-10 to -28	6 to 24	18	60	-	32	-	60
3	4	-28 to -55	24 to 51	27	70	-	36	-	125
4	4	-55 to -70	52 to 66	15	77	-	40	-	150
5									
6									
7									
8									
9									
10									

[1] SOIL TYPE:
1 SOFT CLAY
2 STIFF CLAY BELOW WATER TABLE
3 STIFF CLAY ABOVE WATER TABLE
4 SAND BELOW WATER TABLE
5 SAND ABOVE WATER TABLE

[2] Submerged (effective) or moist (total) for soils below or above water table, respectively.

SOIL PARAMETERS FOR COM624 PROGRAM

BRIDGE NAME: Middle Channel Bridge	EA:	BENT NO.	APPROX. FOOTING BOTTOM ELEVATION (FT):	APPROX. EXISTING GROUND SURFACE ELEVATION (FT):	APPROX. GROUNDWATER SURFACE ELEVATION (FT):
BRIDGE NO. 04-229	01-296701	M-3	+3.0	-10	0.0

LAYER NO.	SOIL TYPE[1]	ELEVATION (ft)	DEPTH (ft) (From O.G. Surface)	LAYER THICKNESS (ft)	SOIL UNIT WT.[2] (pcf)	UNDRAINED SHEAR STRENGTH , c (psf)	FRICTION ANGLE, ϕ (degree)	50 PERCENT STRAIN, ε_{50}	SLOPE FOR SOIL MODULUS, k (lb/in^3)
1	1	-10 to -17	0 to 7	7	58	500	-	0.02	-
2	4	-17 to -38	7 to 28	21	70	-	37	-	125
3	2	-38 to -45	28 to 35	7	63	2000	-	0.007	650
4	4	-45 to -65	35 to 55	20	73	-	37	-	150
5									
6									
7									
8									
9									
10									

[1] SOIL TYPE:

1	SOFT CLAY	4	SAND BELOW WATER TABLE
2	STIFF CLAY BELOW WATER TABLE	5	SAND ABOVE WATER TABLE
3	STIFF CLAY ABOVE WATER TABLE		

[2] Submerged (effective) or moist (total) for soils below or above water table, respectively.

SOIL PARAMETERS FOR COM624 PROGRAM

BRIDGE NAME: Middle Channel Bridge BRIDGE NO. 04-229	EA:	BENT NO.	APPROX. FOOTING BOTTOM ELEVATION (FT):	APPROX. EXISTING GROUND SURFACE ELEVATION (FT):	APPROX. GROUNDWATER SURFACE ELEVATION (FT):
	01-296701	M-4	+3.0	-18.0	0.0

LAYER NO.	SOIL TYPE[1]	ELEVATION (ft)	DEPTH (ft) (From O.G. Surface)	LAYER THICKNESS (ft)	SOIL UNIT WT.[2] (pcf)	UNDRAINED SHEAR STRENGTH, c (psf)	FRICTION ANGLE, ϕ (degree)	50 PERCENT STRAIN, ε_{50}	SLOPE FOR SOIL MODULUS, k (lb/in^3)
1	1	-18 to -24	0 to 6	6	55	500	-	0.02	-
2	4	-24 to -44	6 to 26	20	70	-	36	-	125
3	2	-44 to -50	26 to 32	6	63	2000	-	0.007	650
4	4	-50 to -60	32 to 42	10	73	-	37	-	150
5									
6									
7									
8									
9									
10									

[1] SOIL TYPE:

1 SOFT CLAY
2 STIFF CLAY BELOW WATER TABLE
3 STIFF CLAY ABOVE WATER TABLE
4 SAND BELOW WATER TABLE
5 SAND ABOVE WATER TABLE

[2] Submerged (effective) or moist (total) for soils below or above water table, respectively.

SOIL PARAMETERS FOR COM624 PROGRAM

BRIDGE NAME: Middle Channel Bridge BRIDGE NO. 04-229	EA:	BENT NO.	APPROX. FOOTING BOTTOM ELEVATION (FT):	APPROX. EXISTING GROUND SURFACE ELEVATION (FT):	APPROX. GROUNDWATER SURFACE ELEVATION (FT):
	01-296701	M-5	+3.0	-22.0	0.0

LAYER NO.	SOIL TYPE[1]	ELEVATION (ft)	DEPTH (ft) (From O.G. Surface)	LAYER THICKNESS (ft)	SOIL UNIT WT.[2] (pcf)	UNDRAINED SHEAR STRENGTH , c (psf)	FRICTION ANGLE, ϕ (degree)	50 PERCENT STRAIN, ε_{50}	SLOPE FOR SOIL MODULUS, k (lb/in^3)
1	1	-22 to -25	0 to 3	3	55	250	-	0.02	-
2	4	-25 to -45	3 to 23	20	73	-	38	-	150
3	2	-45 to -50	23 to 28	5	63	2000	-	0.007	650
4	4	-50 to -60	28 to 38	10	77	-	40	-	150
5									
6									
7									
8									
9									
10									

[1] SOIL TYPE:

1	SOFT CLAY	4	SAND BELOW WATER TABLE
2	STIFF CLAY BELOW WATER TABLE	5	SAND ABOVE WATER TABLE
3	STIFF CLAY ABOVE WATER TABLE		

[2] Submerged (effective) or moist (total) for soils below or above water table, respectively.

SOIL PARAMETERS FOR COM624 PROGRAM

BRIDGE NAME: Middle Channel Bridge BRIDGE NO. 04-229	EA:	BENT NO.	APPROX. FOOTING BOTTOM ELEVATION (FT):	APPROX. EXISTING GROUND SURFACE ELEVATION (FT):	APPROX. GROUNDWATER SURFACE ELEVATION (FT):
	01-296701	M-6	+3.0	-21.0	0.0

LAYER NO.	SOIL TYPE[1]	ELEVATION (ft)	DEPTH (ft) (From O.G. Surface)	LAYER THICKNESS (ft)	SOIL UNIT WT.[2] (pcf)	UNDRAINED SHEAR STRENGTH , c (psf)	FRICTION ANGLE, ϕ (degree)	50 PERCENT STRAIN, ε_{50}	SLOPE FOR SOIL MODULUS, k (lb/in^3)
1	1	-12 to -24	0 to 3	3	55	250	-	0.02	-
2	2	-24 to -35	3 to 14	11	70	-	36	-	125
3	3	-35 to -60	14 to 39	25	73	-	37	-	150
4									
5									
6									
7									
8									
9									
10									

[1] SOIL TYPE:

1	SOFT CLAY
2	STIFF CLAY BELOW WATER TABLE
3	STIFF CLAY ABOVE WATER TABLE
4	SAND BELOW WATER TABLE
5	SAND ABOVE WATER TABLE

[2] Submerged (effective) or moist (total) for soils below or above water table, respectively.

SOIL PARAMETERS FOR COM624 PROGRAM

BRIDGE NAME: Middle Channel Bridge BRIDGE NO. 04-229	EA: 01-296701	BENT NO. M-7	APPROX. FOOTING BOTTOM ELEVATION (FT): +3.0	APPROX. EXISTING GROUND SURFACE ELEVATION (FT): -18.0	APPROX. GROUNDWATER SURFACE ELEVATION (FT): 0.0

LAYER NO.	SOIL TYPE[1]	ELEVATION (ft)	DEPTH (ft) (From O.G. Surface)	LAYER THICKNESS (ft)	SOIL UNIT WT.[2] (pcf)	UNDRAINED SHEAR STRENGTH , c (psf)	FRICTION ANGLE, ϕ (degree)	50 PERCENT STRAIN, ε_{50}	SLOPE FOR SOIL MODULUS, k (lb/in^3)
1	1	-18 to -23	0 to 5	5	55	250	-	0.02	-
2	4	-23 to -32	5 to 14	9	70	-	36	-	125
3	4	-32 to -50	14 to 32	18	73	-	37	-	150
4	4	-50 to -60	32 to 42	10	65	-	32	-	85
5	4	-60 to -70	42 to 52	10	73	-	37	-	150
6									
7									
8									
9									
10									

[1] SOIL TYPE:
1 SOFT CLAY
2 STIFF CLAY BELOW WATER TABLE
3 STIFF CLAY ABOVE WATER TABLE
4 SAND BELOW WATER TABLE
5 SAND ABOVE WATER TABLE

[2] Submerged (effective) or moist (total) for soils below or above water table, respectively.

SOIL PARAMETERS FOR COM624 PROGRAM

BRIDGE NAME: Middle Channel Bridge	EA:	BENT NO.	APPROX. FOOTING BOTTOM ELEVATION (FT):	APPROX. EXISTING GROUND SURFACE ELEVATION (FT):	APPROX. GROUNDWATER SURFACE ELEVATION (FT):
BRIDGE NO. 04-229	01-296701	M-8	-11.0	-6.0	0.0

LAYER NO.	SOIL TYPE[1]	ELEVATION (ft)	DEPTH (ft) (From O.G. Surface)	LAYER THICKNESS (ft)	SOIL UNIT WT.[2] (pcf)	UNDRAINED SHEAR STRENGTH , c (psf)	FRICTION ANGLE, ϕ (degree)	50 PERCENT STRAIN, ε_{50}	SLOPE FOR SOIL MODULUS, k (lb/in^3)
1	1	-6 to -9	0 to 3	3	55	250	-	0.02	-
2	2	-9 to -14	3 to 8	5	60	1500	-	0.007	500
3	1	-14 to -18	8 to 12	4	58	720	-	0.02	-
4	4	-18 to -22	12 to 16	4	58	-	30	-	65
5	1	-22 to -30	16 to 24	8	60	1000	-	0.01	-
6	4	-30 to -38	24 to 32	8	70	-	36	-	125
7	4	-38 and -48	32 to 42	10	73	-	37	-	150
8									
9									
10									

[1] SOIL TYPE:

1	SOFT CLAY
2	STIFF CLAY BELOW WATER TABLE
3	STIFF CLAY ABOVE WATER TABLE
4	SAND BELOW WATER TABLE
5	SAND ABOVE WATER TABLE

[2] Submerged (effective) or moist (total) for soils below or above water table, respectively.

SOIL PARAMETERS FOR COM624 PROGRAM

BRIDGE NAME: Middle Channel Bridge BRIDGE NO. 04-229	EA:	BENT NO.	APPROX. FOOTING BOTTOM ELEVATION (FT):	APPROX. EXISTING GROUND SURFACE ELEVATION (FT):	APPROX. GROUNDWATER SURFACE ELEVATION (FT):
	01-296701	M-9	-6.0	0.0	0.0

LAYER NO.	SOIL TYPE[1]	ELEVATION (ft)	DEPTH (ft) (From O.G. Surface)	LAYER THICKNESS (ft)	SOIL UNIT WT.[2] (pcf)	UNDRAINED SHEAR STRENGTH , c (psf)	FRICTION ANGLE, ϕ (degree)	50 PERCENT STRAIN, ε_{50}	SLOPE FOR SOIL MODULUS, k (lb/in^3)
1	1	0 to -3	0 to 3	3	55	250	-	0.02	-
2	4	-3 to -8	3 to 8	5	70	-	33	-	100
3	1	-8 to -14	8 to 14	6	55	250	-	0.02	-
4	1	-14 to -50	14 to 50	36	58	750 at -14 ft 1000 at -50 ft	-	0.01	-
5	4	-50 to -65	50 to 65	15	70	-	35	-	125
6									
7									
8									
9									
10									

[1] SOIL TYPE:

1	SOFT CLAY	4	SAND BELOW WATER TABLE
2	STIFF CLAY BELOW WATER TABLE	5	SAND ABOVE WATER TABLE
3	STIFF CLAY ABOVE WATER TABLE		

[2] Submerged (effective) or moist (total) for soils below or above water table, respectively.

State of California

Business, Transportation and Housing Agency

Memorandum

To: MR. SAAD EL-AZAZY
Office of Structure Design

Date: May 18, 1999

File: 01-HUM-255-0.7
01-296701

Middle Channel Bridge
Bridge No. 04-0229

From: **DEPARTMENT OF TRANSPORTATION**
ENGINEERING SERVICE CENTER
Office of Materials and Foundations - MS 5
Structure Foundations Branch

Subject: Pile Bearing Capacity Under Axial Loading for the Middle Channel Bridge

This memo presents our estimated values of the axial bearing capacities for existing piles for the Middle Channel Bridge with and without considering soil liquefaction. Our estimates are based on a generalized soil profile developed from nine soil borings drilled in 1967, and data on existing piles obtained from the as-built plans. For the case of liquefaction, the potentially liquefiable soil layers as presented in our memo dated March 10, 1999 (copy attached) are considered to provide no axial resistance. Negative skin friction due to post-liquefaction ground settlement was also considered. The estimated axial pile capacities under compression as well as uplift are presented in Table 1.

Table 1
Pile Bearing Capacity Under Axial Loading

Location	Design (Service) Load (kips)	Axial Capacity (kips)			
		No-Liquefaction		Liquefaction	
		Compression	Uplift	Compression	Uplift
Bent M-2	140	300	140	230	115
Bent M-3	400	980	270	980	270
Bent M-4	400	1150	360	1150	360
Bent M-5	400	1060	320	1060	320
Bent M-6	400	1060	290	1060	290
Bent M-7	400	1230	325	1230	325
Bent M-8	140	150	70	140	70
Bent S-9	~~400~~ 140	315	160	315	160

The above axial pile capacities are based on soil resistance only and correspond to 0.5-inch of pile top settlement. The actual load bearing capacities may be limited by the structural capacities of the piles and/or pile cap connections.

If you have any questions or comments, please call Mohammed S. Islam at 227-7094 or Abbas Abghari at 227-7172.

MOHAMMED S. ISLAM
Transportation Engineer

MOHAMMED S. ISLAM
NO: C53333
EXP. 6-30-99

ABBAS ABGHARI, Chief
Geotechnical Earthquake Engineering Section

cc: ELeivas - SFB

State of California

Business, Transportation and Housing Agency

Memorandum

To: MR. TOM POST
Office of Structure Design

Attention: Mr. Saad El-Azazy

Date: March 10, 1999

File: 01-HUM-255-0.7
01-296701

Middle Channel Bridge
Bridge No. 04-0229

From: **DEPARTMENT OF TRANSPORTATION**
ENGINEERING SERVICE CENTER
Office of Materials and Foundations - MS 5
Structure Foundations Branch

Subject: Soil Liquefaction Potential Evaluation for the Middle Channel Bridge

This memo presents the results of our analysis performed to evaluate soil liquefaction potential at the site of the Middle Channel Bridge (Br. No. 04-229).

A vicinity map of the Middle Channel Bridge is shown on Figure 1. A description of the site geology and seismicity including site-specific Acceleration Response Spectra (ARS) was provided in our memo dated December 20, 1994 (attached). Site-specific ARS were later revised and presented in a memo dated February 24, 1999 (attached). The recommended design ARS was revised to correspond to the mean (50th Percentile) Peak Bedrock Acceleration (PBA=0.70g) generated by a Maximum Credible Earthquake (MCE) of moment magnitude, M_w = 7.5 associated with the. Little Salmon fault. This controlling fault is located approximately 5.0 km from the bridge site. Based on the recommended design ARS, a peak horizontal ground surface acceleration of 0.40g should be anticipated at the site due to the mean PBA of 0.70g. Therefore, our liquefaction analysis was based on a mean peak horizontal ground surface acceleration of 0.40g.

A generalized soil profile along the approximate centerline of the Middle Channel Bridge was developed based on nine (9) soil borings drilled in 1967. The generalized soil profile depicting our interpretation of the subsurface conditions at the site is shown on Figure 2. The soil profile at each boring location was analyzed for liquefaction potential in accordance with the procedure suggested by Seed et al (1985).

Results of our analysis indicate the presence of a liquefiable soil layer at the location of Abut M-1 and Pier M-2, as shown on Figure 2. The approximate elevation limits and the total thickness of potentially liquefiable soils at each support location are presented in Table 1. Also included in Table 1 is seismically -induced ground surface settlement estimated based on the procedure suggested by Tokimatsu and Seed (1987) and lateral spread susceptibility at each support location. The elevations in Table 1 are based on the As-Built Log of Test Borings (LOTB), Drawing No. 0229-42, and Contract No. 01-077504.

Table 1, Summary of Liquefaction Potential Evaluation for the Middle Channel Bridge

Support Location	Approx. Elevation of Liquefiable Soils (ft)	Approx. Thickness of Liquefiable Soils (ft)	Estimated Seismically-Induced Ground Surface Settlement (inch)	Lateral Spread Susceptibility	Recommended Lateral Load per Unit Pile Width per Unit Pile Length (Kips/ft/ft)	Recommended Elevation Range for the Application of Uniformly Distributed Lateral Load (ft)
Abutment M-1	-8 to –33	25.0	5.0	Moderate	5.0	+1.0 to –15.0
Pier M-2	-10 to –28	18.0	4.0	Moderate	4.5	-6.0 to –15.0
Pier M-3 thru M-9 and Abutment M-10	None	None	Minimal	None	0.0	N/A

The shear strength of the potentially liquefiable soils should be neglected in evaluating pile axial capacity under earthquake loading. Additional lateral loads due to lateral spreading of the near surface soils should be applied to the Abut. M-1 and Pier M-2 piles as recommended in Table 1. Alternatively, the potentially liquefiable soils can be mechanically improved to increase their resistance to liquefaction and lateral loading. If requested, this office can provide recommendations regarding soil improvement at this site.

If you have any questions or comments, please call Mohammed S. Islam at 227-7094 or Abbas Abghari at 227-7172.

A. Abghari

MOHAMMED S. ISLAM
Transportation Engineer

ABBAS ABGHARI, Chief
Geotechnical Earthquake Engineering Section

Attachments

cc: ELeivas - SFB

REGISTERED PROFESSIONAL ENGINEER
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Exp. 6/30/99
CIVIL
STATE OF CALIFORNIA

State of California

Business, Transportation and Housing Agency

Memorandum

To: MR. SAAD EL-AZAZY
Office of Structure Design

Date: June 21, 1999

File: 01-HUM-255-0.7
01-296701

Middle Channel Bridge
Bridge No. 04-0229

From: **DEPARTMENT OF TRANSPORTATION**
ENGINEERING SERVICE CENTER
Office of Materials and Foundations - MS 5
Structure Foundation Branch

Subject: p-y Curves for the Middle Channel Bridge

As per your request, we have prepared this memo to present p-y curves for the Middle Channel Bridge (Br. No. 04-0229) located in Humboldt County.

An analysis was performed to develop p-y curves for the existing piles in accordance with the general procedure suggested in the computer program GROUP (version 3.0) user manual developed by Ensoft, Inc, Austin, Texas. The input soil parameters for this analysis were presented in our memo dated April 15, 1999. The input pile parameters were obtained from the as-built plans and the information forwarded by you. Soil liquefaction, as presented in our memo dated March 10, 1999, was considered in developing the p-y curves. The resulting p-y curves and the corresponding data are presented in the attached figures and tables, respectively.

No p-reduction factor due to group effect has been applied to the p-y curves or the tabulated data. The center-to-center spacing (S) between the existing piles ranges from 2D to about 4.3D, where D is the pile diameter (or width). We recommend that a p-reduction factor of 0.4 be applied for a pile spacing of 2D. No group reduction is necessary (i.e. p-reduction factor=1.0) for pile spacing of 5D or greater. Use linear interpolation for intermediate pile spacing.

If you have any questions or comments, please call Mohammed S. Islam at 227-7094 or Abbas Abghari at 227-7172.

MOHAMMED S. ISLAM
Transportation Engineer

MOHAMMED S. ISLAM
NO: C53338
EXP. 06/30/03
CIVIL

A. Abghari
ABBAS ABGHARI, Chief
Geotechnical Earthquake Engineering Section

Attachments

cc: ELeivas - SFB

Middle Channel Bridge
(Br. No. 04-229)
EA: 01-296701

Bent M-2

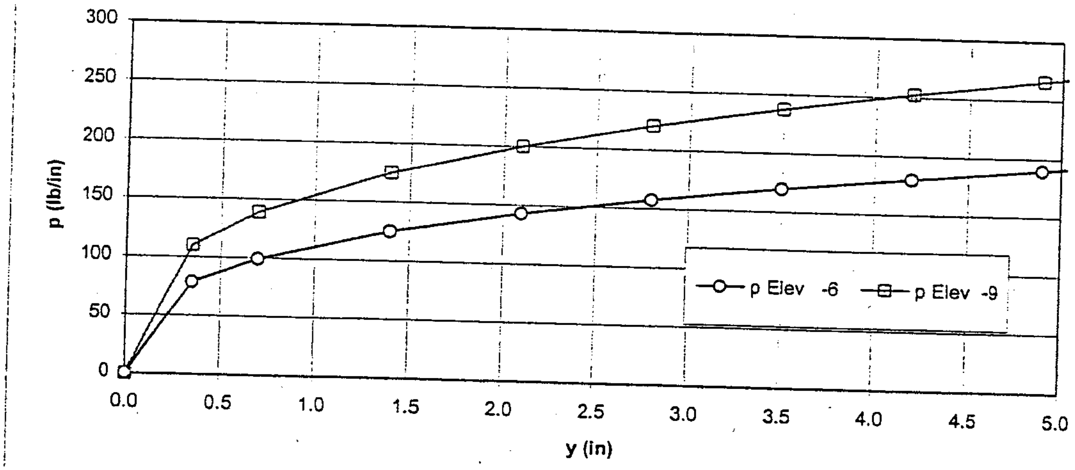
Sta. 0

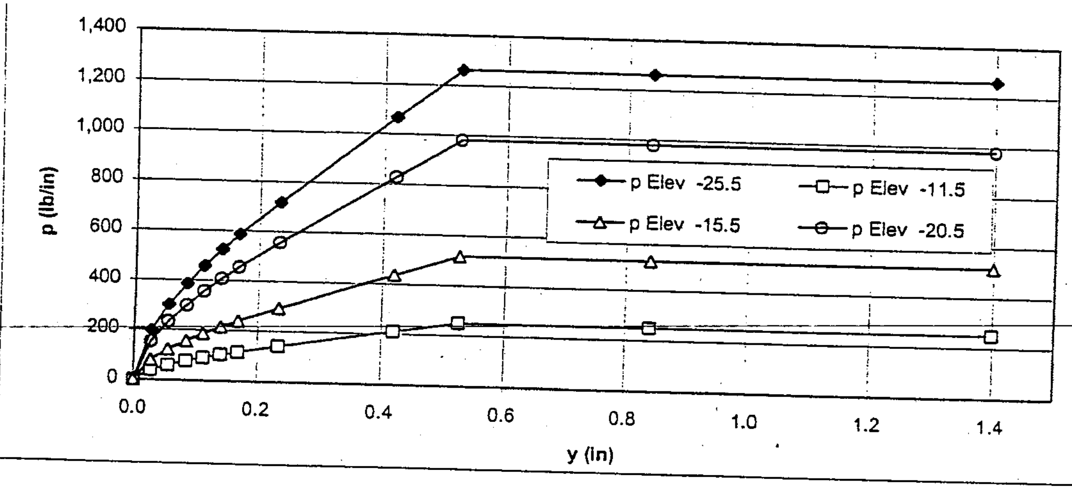
O.G. -4.0

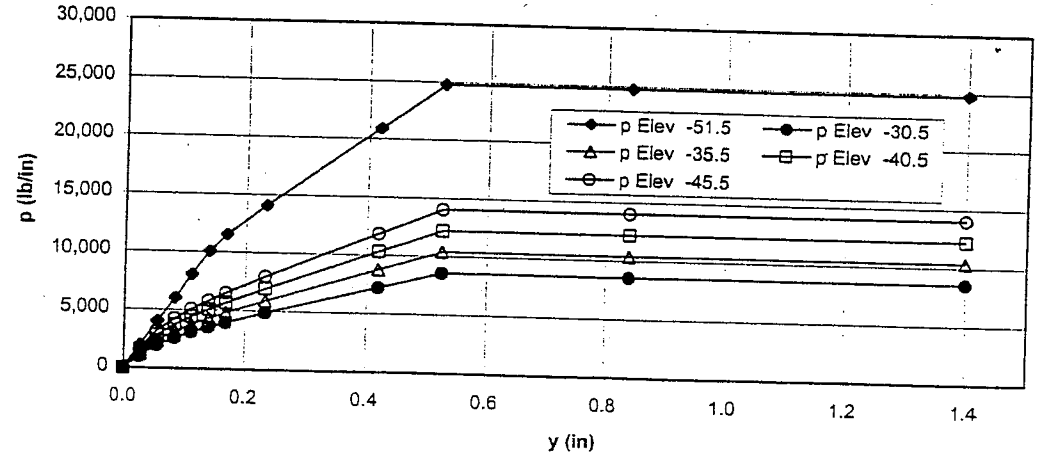
Cut-off -8.0

14" Square Concrete

GWS 0.0







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p-y Curves

m2lcomp.xls .py chart (2)

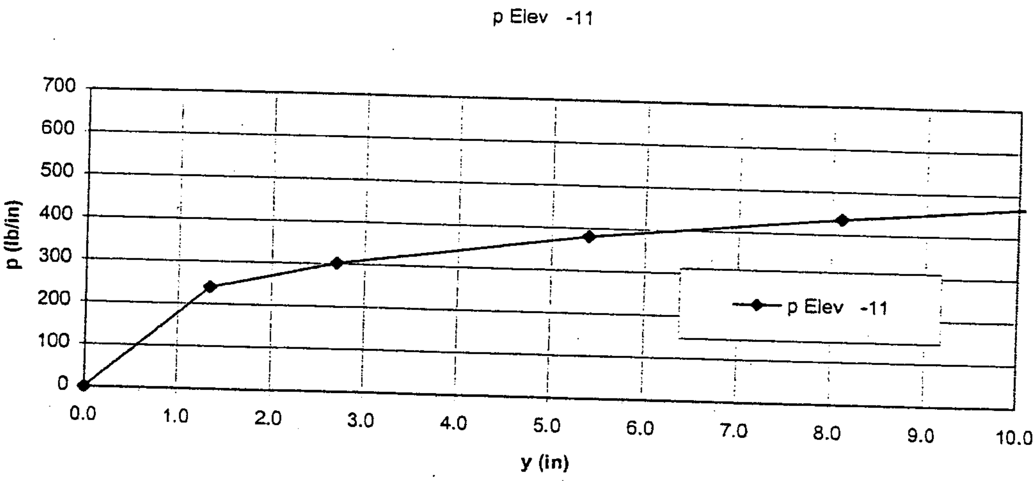
Middle Channel Bridge
(Br. No. 04-229)
EA: 01-296701

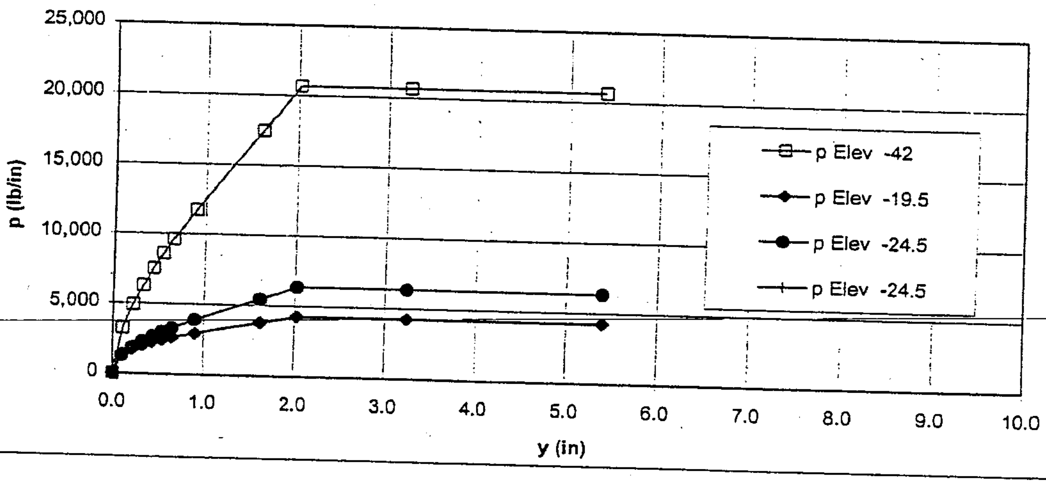
Bent M-3

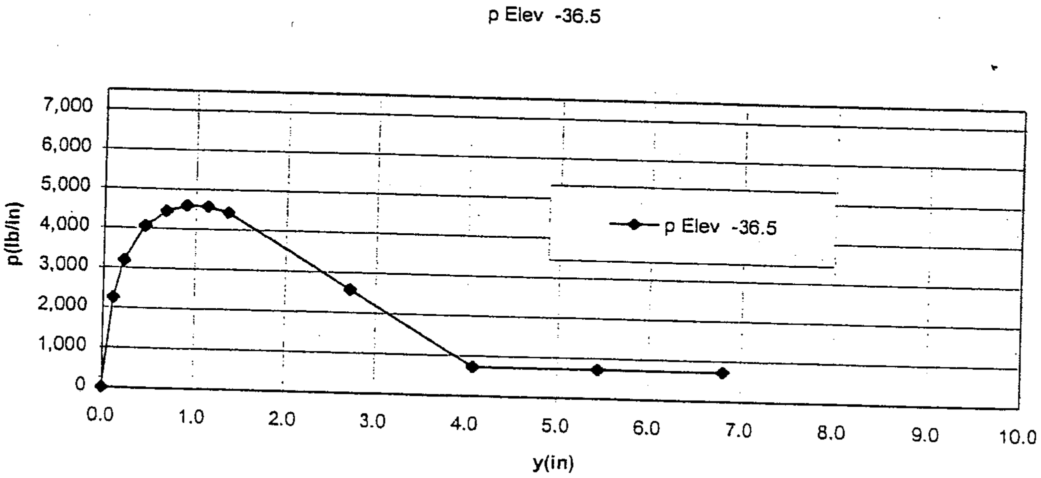
Sta. 0

O.G. -10.0
Cut-off -10.2

54" Dia. Concrete
GWS 0.0







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p-y Curves

Middle Channel Bridge
(Br. No. 04-229)
EA: 01-296701

Bent M-4

Sta. 0

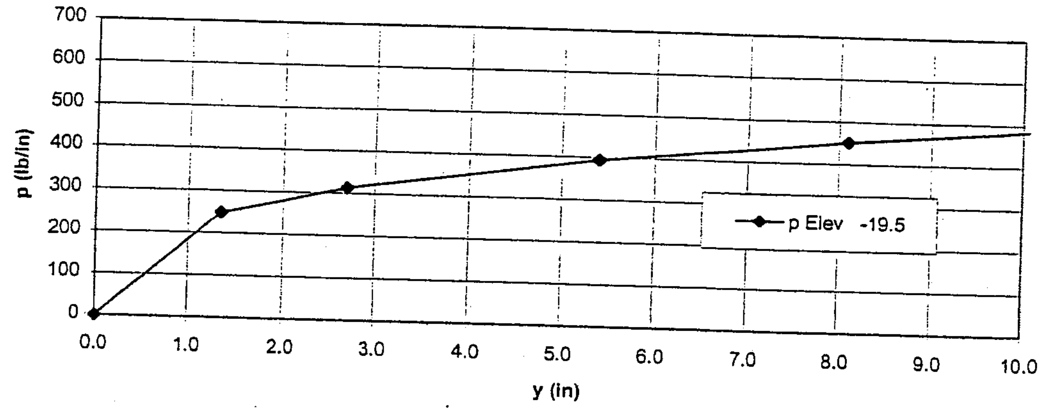
O.G. -18.0

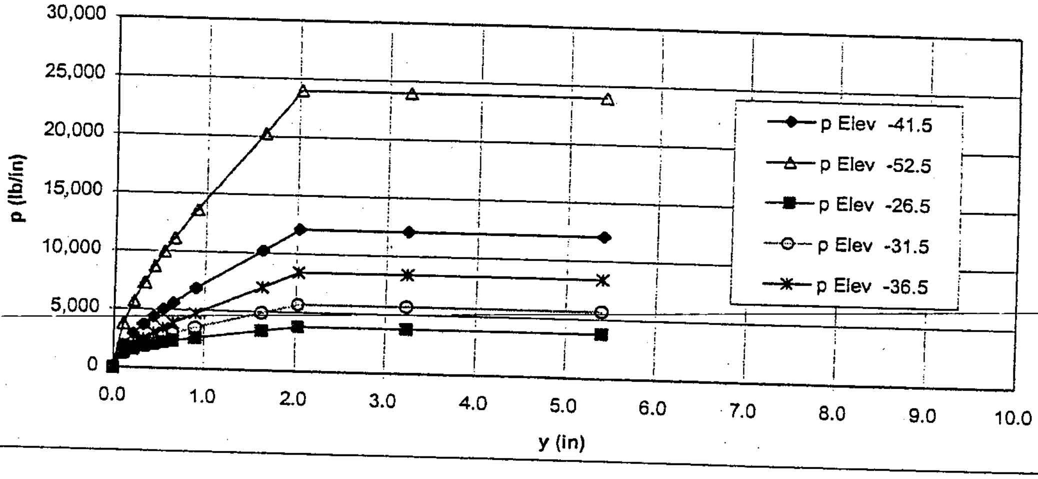
Cut-off -18.0

54" Dia. Concrete

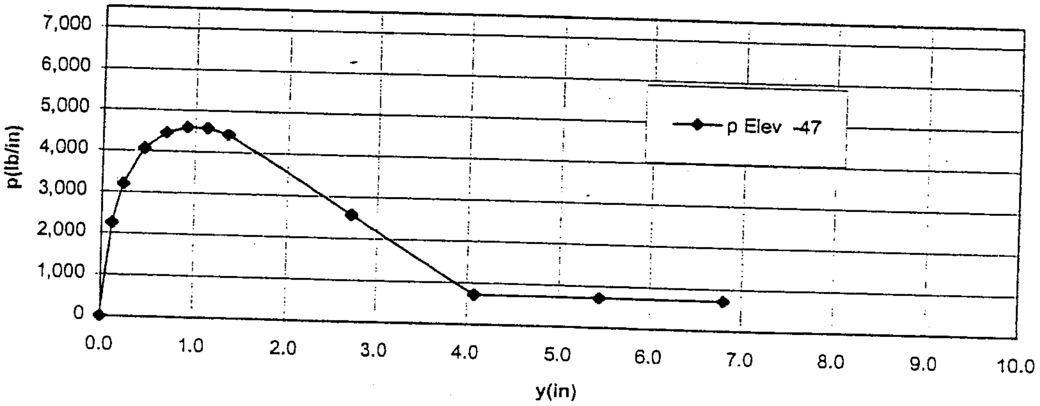
GWS 0.0

p Elev -19.5





p Elev -47



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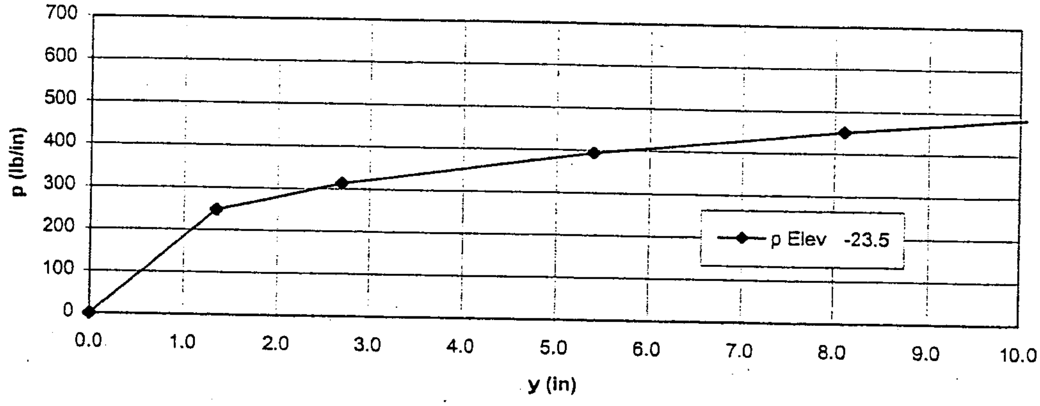
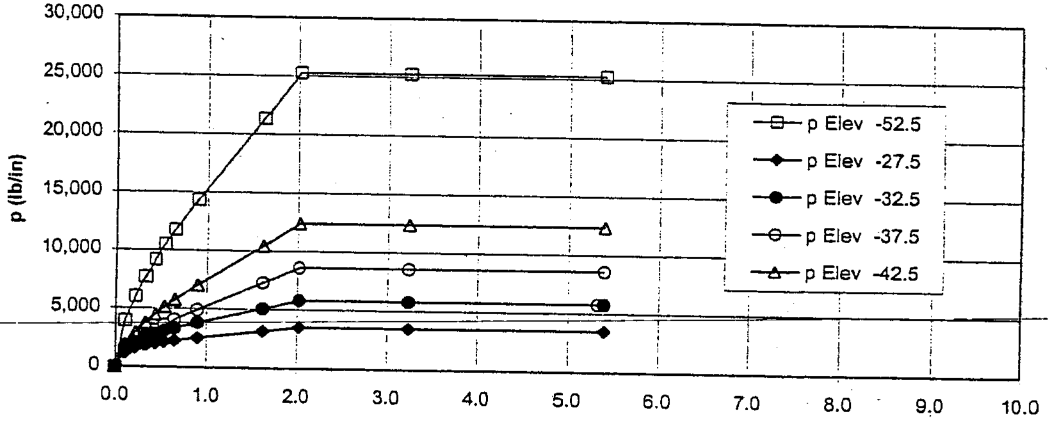
p-y Curves

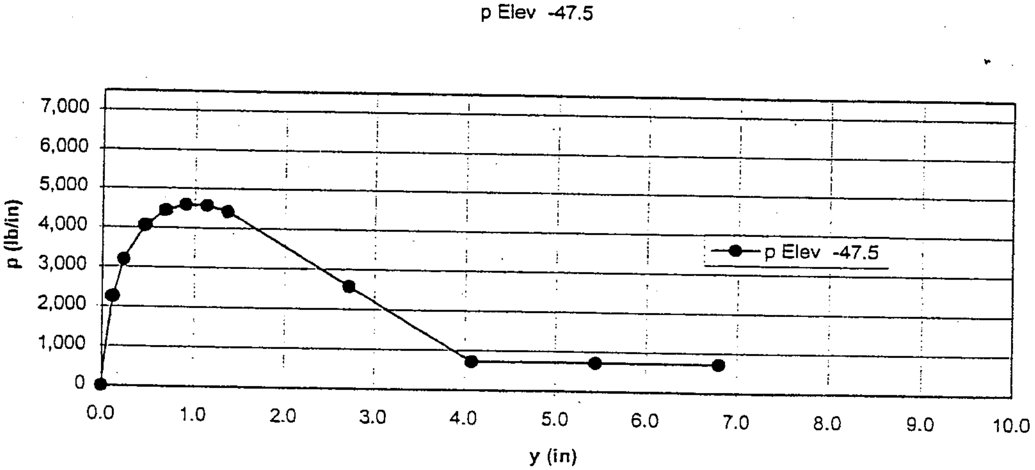
Middle Channel Bridge
(Br. No. 04-229)
EA: 01-296701

Bent M-5

Sta.	0	O.G.	-22.0	54" Dia. Concrete	
		Cut-off	-22.0	GWS	0.0







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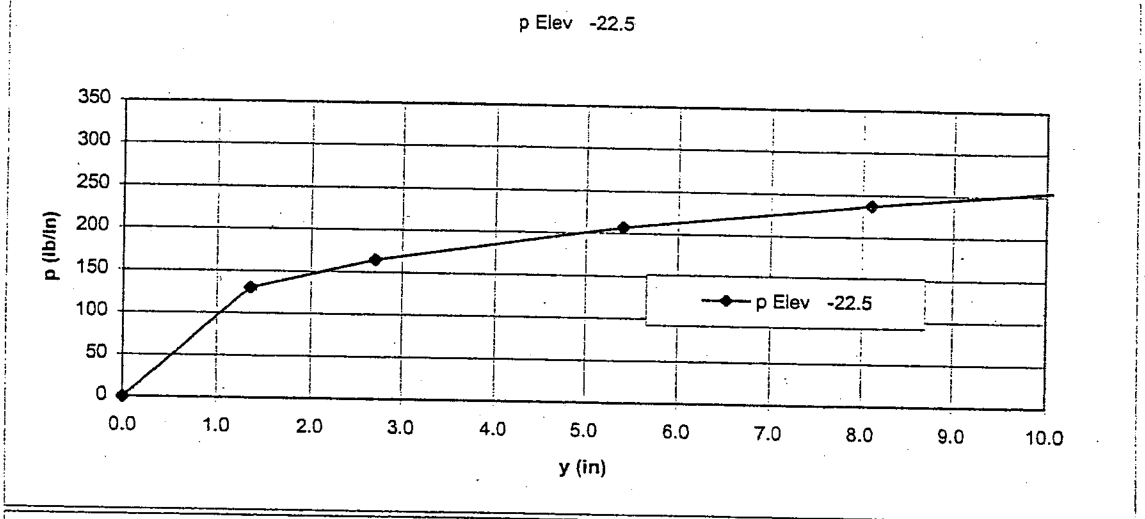
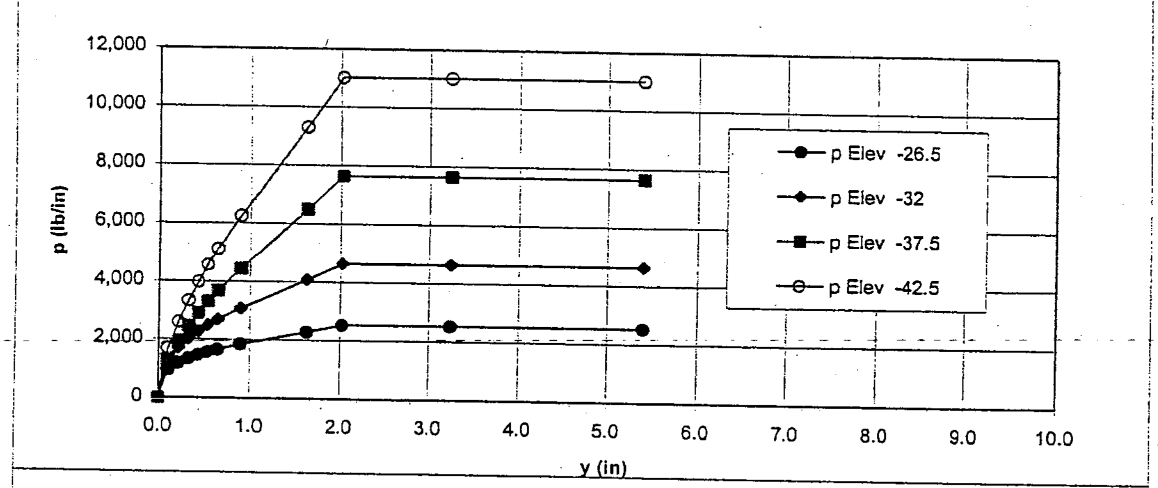
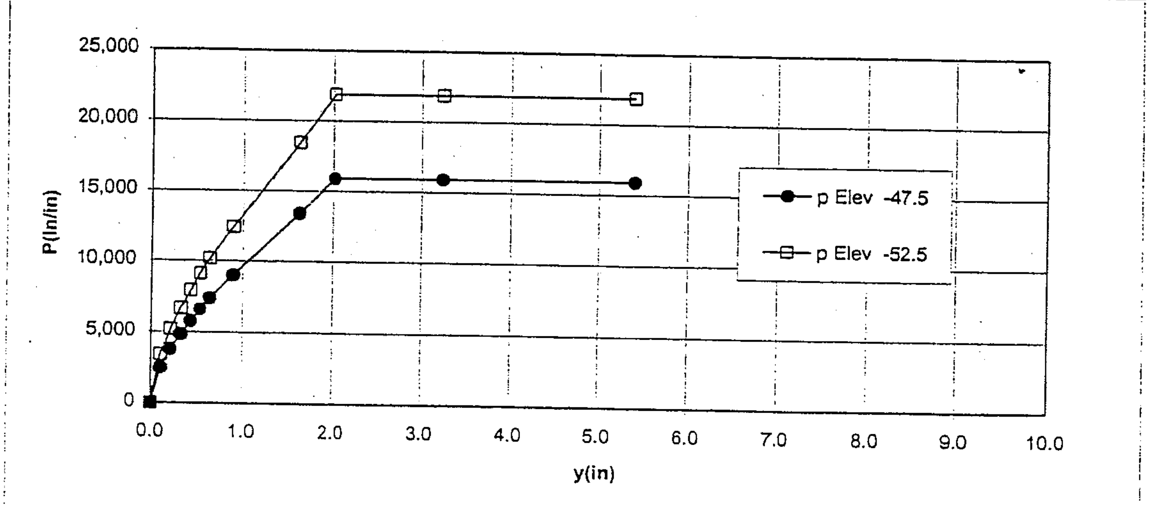
Middle Channel Bridge
(Br. No. 04-229)
EA: 01-296701

Bent M-6

Sta.	0	O.G.	-21.0	54" Dia. Concrete	
		Cut-off	-21.0	GWS	0.0


p Elev -22.5





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p-y Curves

Middle Channel Bridge
(Br. No. 04-229)
EA: 01-296701

Bent M-7

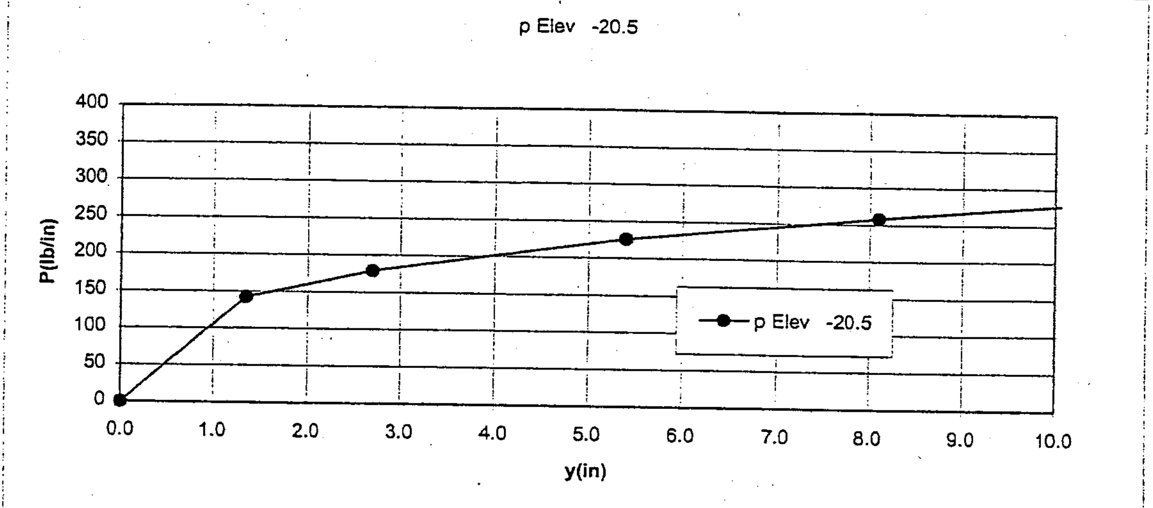
Sta. 0

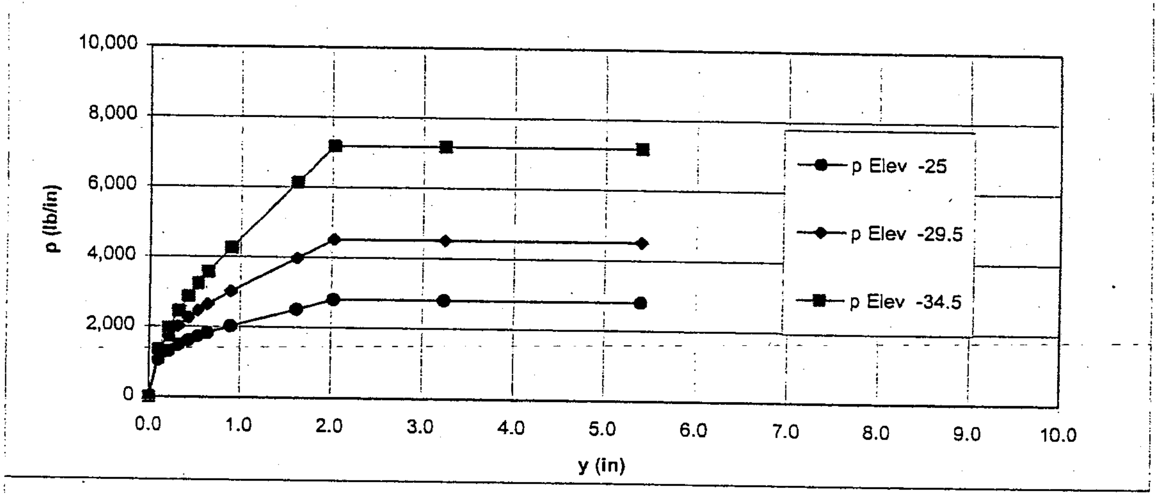
O.G. -18.0

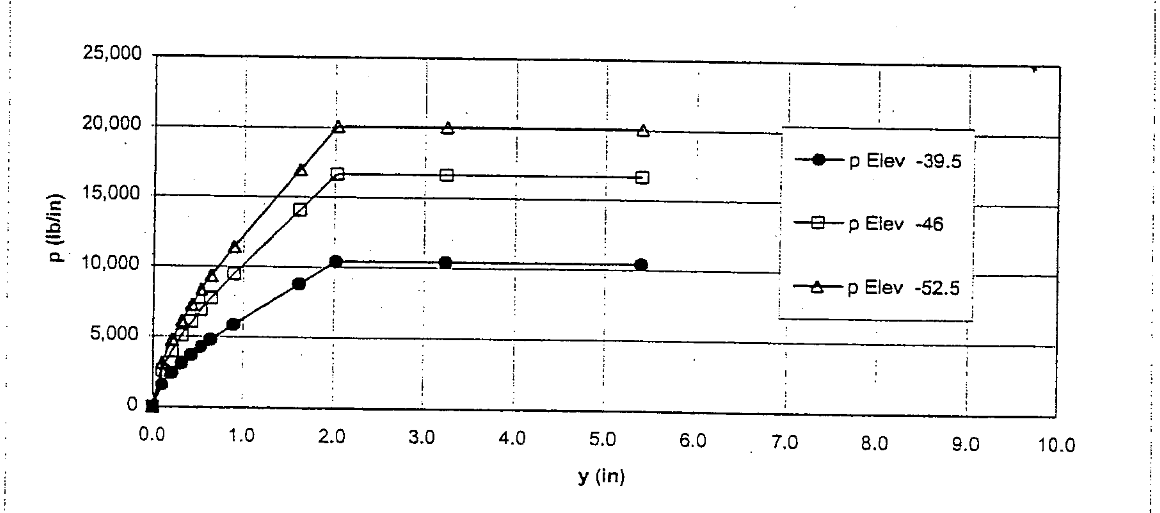
Cut-off -18.0

54" Dia. Concrete

GWS 0.0







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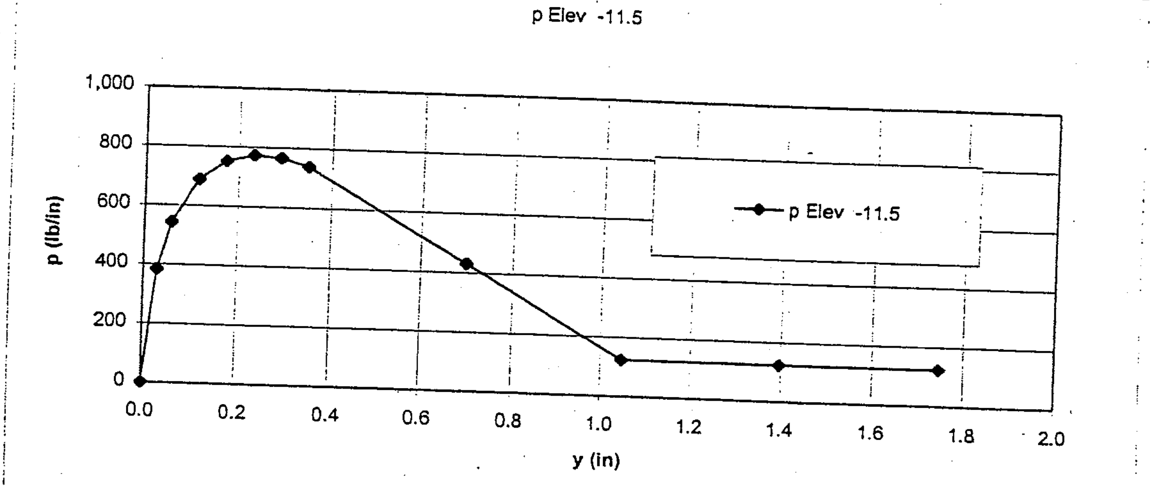
Middle Channel Bridge
(Br. No. 04-229)
EA: 01-296701

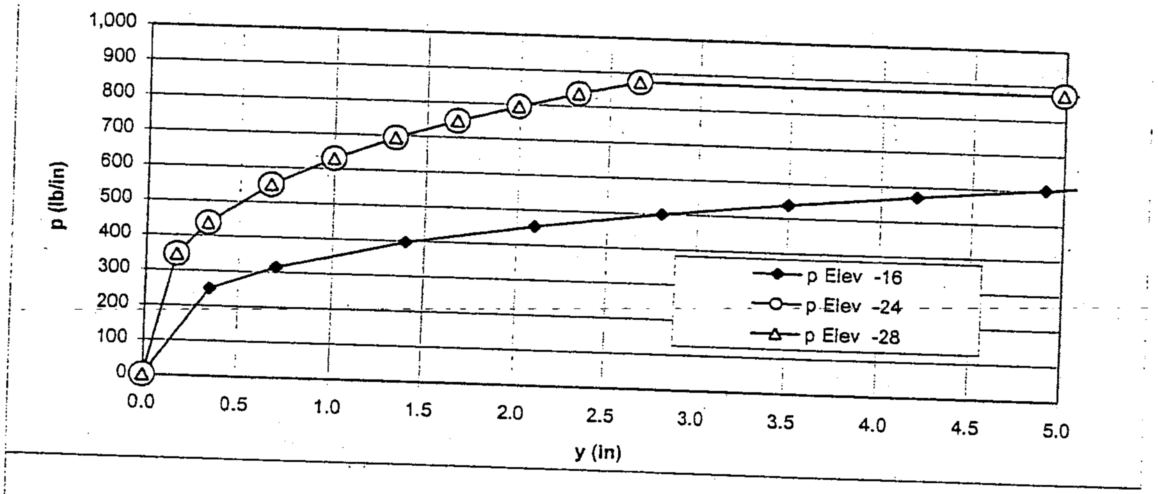
Bent M-8

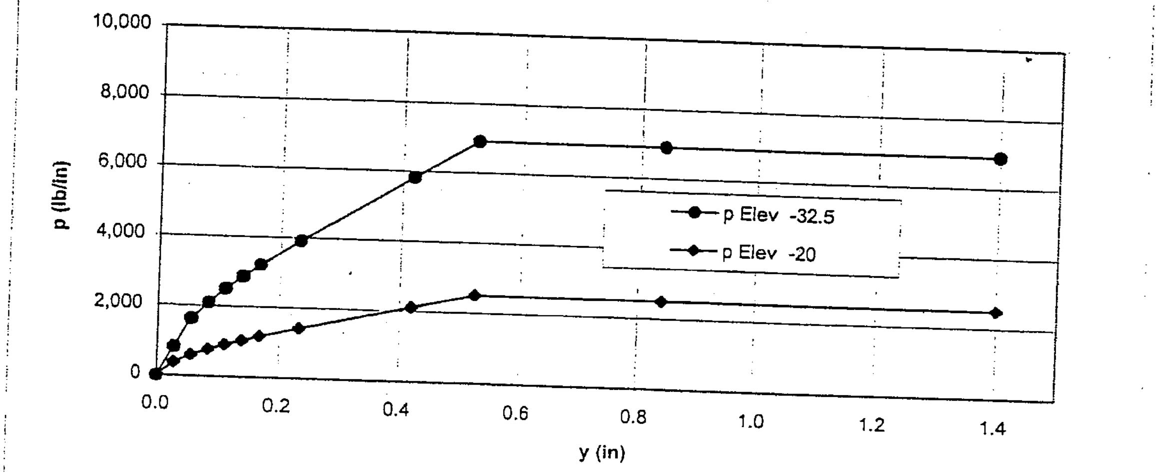
Sta. 0

O.G. -6.0
Cut-off -11.0

14" Square Concrete
GWS 0.0





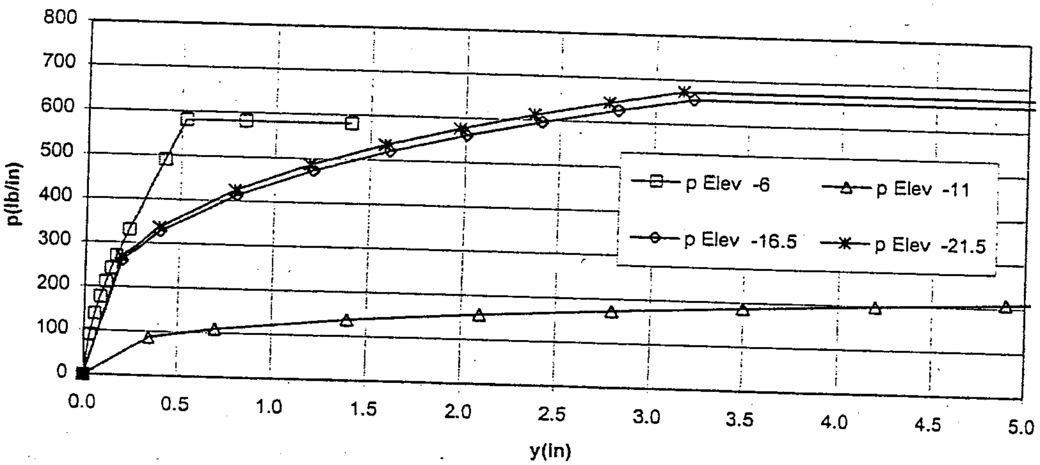


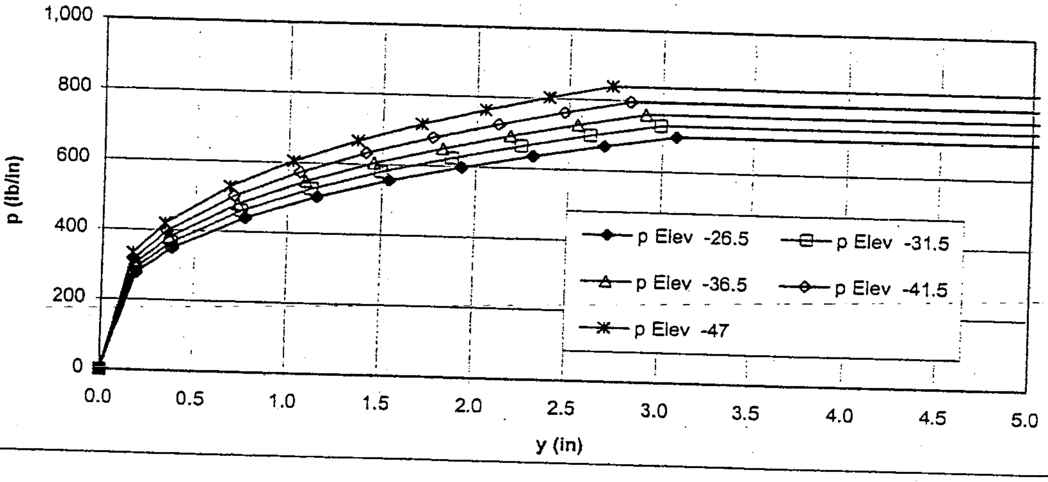
0 0 6/16/99

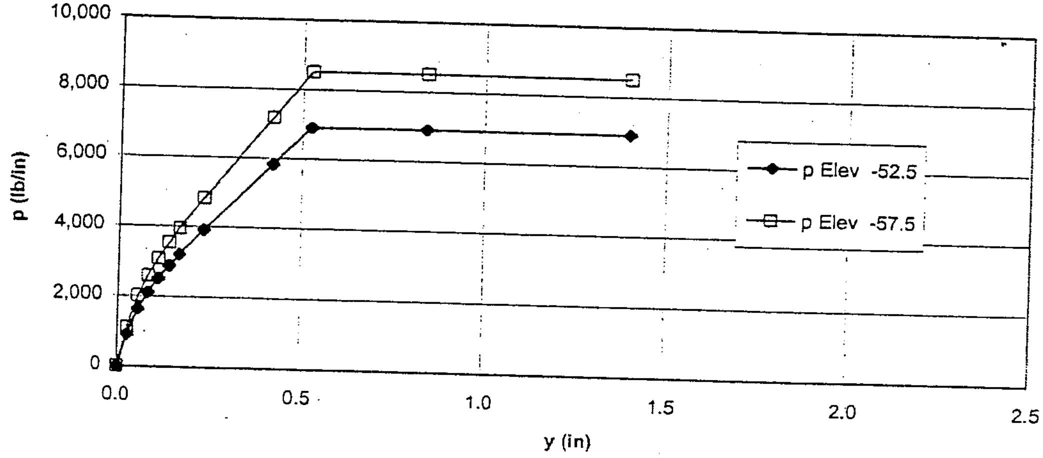
Middle Channel Bridge
(Br. No. 04-229)
EA: 01-296701

Bent M-9

Sta.	0	O.G.	0.0	14" Square Concrete
		Cut-off	-6.0	GWS 0.0







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Middle Channel Bridge
(Br. No. 04-229)
EA: 01-296701

Bent M-2
Sta. 0

Middle Channel Bridge

O.G. -4.0
Cut-off -7.0

14" Square Con
GWS 0.0

y (in)	p Elev -6	y (in)	p Elev -9	y (in)	p Elev -11.5	y (in)	p Elev -15.5	y (in)	p Elev -20.5
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.35	79	0.35	110	0.03	39	0.03	81	0.03	154
0.70	99	0.70	139	0.06	60	0.06	124	0.06	234
1.40	125	1.40	175	0.08	76	0.08	158	0.08	300
2.10	143	2.10	200	0.11	91	0.11	188	0.11	357
2.80	158	2.80	221	0.14	104	0.14	216	0.14	409
3.50	170	3.50	238	0.17	117	0.17	241	0.17	457
4.20	181	4.20	253	0.23	142	0.23	294	0.23	558
4.90	190	4.90	266	0.42	211	0.42	437	0.42	829
5.60	199	5.60	278	0.53	250	0.53	518	0.53	981
10.50	199	10.50	278	0.84	250	0.84	518	0.84	981
17.50	199	17.50	278	1.40	250	1.40	518	1.40	981

y (in)	p Elev -25.5	y (in)	p Elev -30.5	y (in)	p Elev -35.5	y (in)	p Elev -40.5	y (in)	p Elev -45.5
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.03	198	0.03	989	0.03	1,199	0.03	1,409	0.03	1,619
0.06	301	0.06	1,977	0.06	2,397	0.06	2,817	0.06	3,237
0.08	386	0.08	2,619	0.08	3,175	0.08	3,731	0.08	4,288
0.11	459	0.11	3,119	0.11	3,782	0.11	4,445	0.11	5,107
0.14	526	0.14	3,573	0.14	4,331	0.14	5,090	0.14	5,849
0.17	588	0.17	3,991	0.17	4,839	0.17	5,687	0.17	6,535
0.23	718	0.23	4,874	0.23	5,909	0.23	6,944	0.23	7,980
0.42	1,067	0.42	7,244	0.42	8,783	0.42	10,322	0.42	11,861
0.53	1,263	0.53	8,578	0.53	10,400	0.53	12,222	0.53	14,044
0.84	1,263	0.84	8,578	0.84	10,400	0.84	12,222	0.84	14,044
1.40	1,263	1.40	8,578	1.40	10,400	1.40	12,222	1.40	14,044

y (in)	p Elev -51.5	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev
0.00	0								
0.03	2,016								
0.06	4,031								
0.08	6,047								
0.11	8,062								
0.14	10,078								
0.17	11,540								
0.23	14,092								
0.42	20,946								
0.53	24,801								
0.84	24,801								
1.40	24,801								

Note - p (lb/in)

0 0 6/9/99

Middle Channel Bridge
(Br. No. 04-229)
EA: 01-296701

Bent M-3 Middle Channel Bridge

Sta. 0

O.G. -10.0

Cut-off -7.0

GWS 0.0

54" Dia. Concr

y (in)	p Elev -11	y (in)	p Elev -14.5	y (in)	p Elev -19.5	y (in)	p Elev -24.5	y (in)	p Elev -30
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
1.35	240	0.14	299	0.11	1,369	0.11	1,314	0.11	1,472
2.70	302	0.27	377	0.22	1,756	0.22	1,874	0.22	2,263
5.40	381	0.54	475	0.32	2,031	0.32	2,306	0.32	2,909
8.10	436	0.81	543	0.43	2,252	0.43	2,672	0.43	3,477
10.80	480	1.08	598	0.54	2,440	0.54	2,995	0.54	3,993
13.50	517	1.35	644	0.65	2,605	0.65	3,288	0.65	4,470
16.20	550	1.62	685	0.90	2,931	0.90	3,890	0.90	5,480
18.90	579	1.89	721	1.62	3,773	1.62	5,483	1.62	8,196
21.60	605	2.16	753	2.03	4,246	2.03	6,379	2.03	9,725
40.50	605	4.05	753	3.24	4,246	3.24	6,379	3.24	9,725
67.50	605	6.75	753	5.40	4,246	5.40	6,379	5.40	9,725

y (in)	p Elev -36.5	y (in)	p Elev -42	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev
0.00	0	0.00	0						
0.11	2,259	0.11	3,236						
0.23	3,195	0.22	4,933						
0.45	4,065	0.32	6,312						
0.68	4,455	0.43	7,518						
0.91	4,599	0.54	8,611						
1.13	4,578	0.65	9,620						
1.36	4,434	0.90	11,747						
2.72	2,581	1.62	17,460						
4.08	725	2.03	20,674						
5.44	725	3.24	20,674						
6.80	725	5.40	20,674						

y (in)	p Elev	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev

Note - p (lb/in)

0 0 6/16/99

Middle Channel Bridge
(Br. No. 04-229)
EA: 01-296701

Bent M-4

Middle Channel Bridge

Sta. 0

O.G. -18.0
Cut-off -18.0
GWS 0.0
54" Dia. Concr

y (in)	p Elev -19.5	y (in)	p Elev -22.5	y (in)	p Elev -26.5	y (in)	p Elev -31.5	y (in)	p Elev -36.5
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
1.35	248	0.14	299	0.11	1,250	0.11	1,219	0.11	1,259
2.70	313	0.27	377	0.22	1,594	0.22	1,723	0.22	1,941
5.40	394	0.54	475	0.32	1,839	0.32	2,110	0.32	2,500
8.10	452	0.81	543	0.43	2,034	0.43	2,437	0.43	2,992
10.80	497	1.08	598	0.54	2,200	0.54	2,724	0.54	3,440
13.50	535	1.35	644	0.65	2,346	0.65	2,984	0.65	3,855
16.20	569	1.62	685	0.90	2,633	0.90	3,516	0.90	4,733
18.90	599	1.89	721	1.62	3,373	1.62	4,922	1.62	7,098
21.60	626	2.16	753	2.03	3,789	2.03	5,713	2.03	8,428
40.50	626	4.05	753	3.24	3,789	3.24	5,713	3.24	8,428
67.50	626	6.75	753	5.40	3,789	5.40	5,713	5.40	8,428

y (in)	p Elev -41.5	y (in)	p Elev -47	y (in)	p Elev -52.5	y (in)	p Elev	y (in)	p Elev
0.00	0	0.00	0	0.00	0				
0.11	1,895	0.11	2,259	0.11	3,756				
0.22	2,889	0.23	3,195	0.22	5,724				
0.32	3,697	0.45	4,065	0.32	7,325				
0.43	4,403	0.68	4,455	0.43	8,725				
0.54	5,043	0.91	4,599	0.54	9,992				
0.65	5,634	1.13	4,578	0.65	11,164				
0.90	6,880	1.36	4,434	0.90	13,632				
1.62	10,226	2.72	2,581	1.62	20,262				
2.03	12,109	4.08	725	2.03	23,992				
3.24	12,109	5.44	725	3.24	23,992				
5.40	12,109	6.80	725	5.40	23,992				

y (in)	p Elev	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev

Note - p (lb/in)

0 0 6/16/99

Middle Channel Bridge
(Br. No. 04-229)
EA: 01-296701

Bent M-5

Middle Channel Bridge

Sta. 0

O.G. -22.0

Cut-off -22.0

GWS 0.0

54" Dia. Concr

y (in)	p Elev -23.5	y (in)	p Elev -27.5	y (in)	p Elev -32.5	y (in)	p Elev -37.5	y (in)	p Elev -42.5
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
1.35	248	0.11	1,180	0.11	1,569	0.11	1,378	0.11	1,934
2.70	313	0.22	1,613	0.22	2,097	0.22	2,090	0.22	2,950
5.40	394	0.32	1,831	0.32	2,485	0.32	2,665	0.32	3,777
8.10	452	0.43	2,003	0.43	2,804	0.43	3,168	0.43	4,500
10.80	497	0.54	2,148	0.54	3,078	0.54	3,622	0.54	5,156
13.50	535	0.65	2,274	0.65	3,323	0.65	4,041	0.65	5,761
16.20	569	0.90	2,521	0.90	3,813	0.90	4,922	0.90	7,038
18.90	599	1.62	3,152	1.62	5,091	1.62	7,287	1.62	10,469
21.60	626	2.03	3,507	2.03	5,810	2.03	8,617	2.03	12,398
40.50	626	3.24	3,507	3.24	5,810	3.24	8,617	3.24	12,398
67.50	626	5.40	3,507	5.40	5,810	5.40	8,617	5.40	12,398

y (in)	p Elev -47.5	y (in)	p Elev -52.5	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev
0.00	0	0.00	0						
0.11	2,259	0.11	3,956						
0.23	3,195	0.22	6,030						
0.45	4,065	0.32	7,715						
0.68	4,455	0.43	9,190						
0.91	4,599	0.54	10,525						
1.13	4,578	0.65	11,759						
1.36	4,434	0.90	14,359						
2.72	2,581	1.62	21,343						
4.08	725	2.03	25,271						
5.44	725	3.24	25,271						
6.80	725	5.40	25,271						

y (in)	p Elev	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev

Note - p (lb/in)

0 0 6/16/99

Middle Channel Bridge
(Br. No. 04-229)
EA: 01-296701

Bent M-6 Middle Channel Bridge O.G. -21.0 54" Dia. Concr
Sta. 0 Cut-off -7.0 GWS 0.0

y (in)	p Elev -22.5	y (in)	p Elev -26.5	y (in)	p Elev -32	y (in)	p Elev -37.5	y (in)	p Elev -42.5
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
1.35	131	0.11	970	0.11	1,299	0.11	1,307	0.11	1,705
2.70	165	0.22	1,197	0.22	1,722	0.22	1,950	0.22	2,607
5.40	207	0.32	1,353	0.32	2,031	0.32	2,464	0.32	3,342
8.10	237	0.43	1,476	0.43	2,283	0.43	2,909	0.43	3,986
10.80	261	0.54	1,579	0.54	2,500	0.54	3,309	0.54	4,570
13.50	282	0.65	1,669	0.65	2,693	0.65	3,676	0.65	5,110
16.20	299	0.90	1,843	0.90	3,077	0.90	4,443	0.90	6,249
18.90	315	1.62	2,289	1.62	4,079	1.62	6,494	1.62	9,311
21.60	329	2.03	2,540	2.03	4,642	2.03	7,648	2.03	11,033
40.50	329	3.24	2,540	3.24	4,642	3.24	7,648	3.24	11,033
67.50	329	5.40	2,540	5.40	4,642	5.40	7,648	5.40	11,033

y (in)	p Elev -47.5	y (in)	p Elev -52.5	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev
0.00	0	0.00	0						
0.11	2,491	0.11	3,426						
0.22	3,797	0.22	5,221						
0.32	4,859	0.32	6,681						
0.43	5,787	0.43	7,958						
0.54	6,628	0.54	9,114						
0.65	7,405	0.65	10,183						
0.90	9,042	0.90	12,434						
1.62	13,441	1.62	18,482						
2.03	15,915	2.03	21,884						
3.24	15,915	3.24	21,884						
5.40	15,915	5.40	21,884						

y (in)	p Elev	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev

Note - p (lb/in)

0 0 6/9/99

Middle Channel Bridge
(Br. No. 04-229)
EA: 01-296701

Bent M-7 Middle Channel Bridge O.G. -18.0 54" Dia. Concr
Sta. 0 Cut-off -18.0 GWS 0.0

y (in)	p Elev -20.5	y (in)	p Elev -25	y (in)	p Elev -29.5	y (in)	p Elev -34.5	y (in)	p Elev -39.5
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
1.35	142	0.11	1,049	0.11	1,304	0.11	1,346	0.11	1,591
2.70	179	0.22	1,300	0.22	1,716	0.22	1,964	0.22	2,441
5.40	226	0.32	1,474	0.32	2,016	0.32	2,449	0.32	3,135
8.10	259	0.43	1,612	0.43	2,259	0.43	2,864	0.43	3,745
10.80	285	0.54	1,727	0.54	2,468	0.54	3,234	0.54	4,298
13.50	306	0.65	1,828	0.65	2,653	0.65	3,572	0.65	4,810
16.20	326	0.90	2,024	0.90	3,022	0.90	4,272	0.90	5,892
18.90	343	1.62	2,525	1.62	3,980	1.62	6,132	1.62	8,802
21.60	358	2.03	2,807	2.03	4,519	2.03	7,179	2.03	10,439
40.50	358	3.24	2,807	3.24	4,519	3.24	7,179	3.24	10,439
67.50	358	5.40	2,807	5.40	4,519	5.40	7,179	5.40	10,439

y (in)	p Elev -46	y (in)	p Elev -52.5	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev
0.00	0	0.00	0						
0.11	2,610	0.11	3,147						
0.22	3,978	0.22	4,797						
0.32	5,091	0.32	6,137						
0.43	6,064	0.43	7,311						
0.54	6,945	0.54	8,373						
0.65	7,759	0.65	9,354						
0.90	9,474	0.90	11,422						
1.62	14,082	1.62	16,978						
2.03	16,674	2.03	20,104						
3.24	16,674	3.24	20,104						
5.40	16,674	5.40	20,104						

y (in)	p Elev	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev

Note - p (lb/in) 0 0 6/16/99

Bent M-8 Middle Channel Bridge O.G. -6.0 14" Square Con
Sta. 0 Cut-off -11.0 GWS 0.0

y (in)	p Elev -7.5	y (in)	p Elev -11.5	y (in)	p Elev -16	y (in)	p Elev -20	y (in)	p Elev -24
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.35	38	0.03	384	0.35	250	0.03	388	0.17	347
0.70	48	0.06	544	0.70	315	0.06	600	0.33	438
1.40	61	0.12	689	1.40	397	0.08	768	0.67	551
2.10	70	0.17	753	2.10	454	0.11	914	1.00	631
2.80	77	0.23	774	2.80	500	0.14	1,047	1.33	694
3.50	83	0.29	767	3.50	539	0.17	1,170	1.66	748
4.20	88	0.35	739	4.20	572	0.23	1,429	2.00	795
4.90	92	0.70	432	4.90	603	0.42	2,124	2.33	837
5.60	97	1.05	124	5.60	630	0.53	2,514	2.66	875
10.50	97	1.40	124	10.50	630	0.84	2,514	4.99	875
17.50	97	1.75	124	17.50	630	1.40	2,514	8.31	875

y (in)	p Elev -28	y (in)	p Elev -32.5	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev
0.00	0	0.00	0						
0.17	347	0.03	831						
0.33	438	0.06	1,648						
0.67	551	0.08	2,109						
1.00	631	0.11	2,512						
1.33	694	0.14	2,877						
1.66	748	0.17	3,214						
2.00	795	0.23	3,925						
2.33	837	0.42	5,834						
2.66	875	0.53	6,908						
4.99	875	0.84	6,908						
8.31	875	1.40	6,908						

y (in)	p Elev	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev

Note - p (lb/in)

0 0 6/16/99

Middle Channel Bridge
(Br. No. 04-229)
EA: 01-296701

Bent M-9 Middle Channel Bridge O.G. 0.0 14" Square Con
Sta. 0 Cut-off -6.0 GWS 0.0

y (in)	p Elev -2	y (in)	p Elev -6	y (in)	p Elev -11	y (in)	p Elev -16.5	y (in)	p Elev -21.5
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.41	41	0.03	91	0.35	87	0.20	260	0.20	267
0.82	52	0.06	139	0.70	109	0.40	328	0.39	337
1.64	66	0.08	177	1.40	138	0.80	413	0.79	424
2.46	75	0.11	211	2.10	158	1.20	473	1.18	486
3.28	83	0.14	242	2.80	174	1.60	521	1.58	535
4.10	89	0.17	270	3.50	187	2.01	561	1.97	576
4.92	95	0.23	330	4.20	199	2.41	596	2.37	612
5.74	100	0.42	490	4.90	209	2.81	628	2.76	644
6.56	104	0.53	581	5.60	219	3.21	656	3.15	674
12.31	104	0.84	581	10.50	219	6.02	656	5.91	674
20.52	104	1.40	581	17.50	219	10.03	656	9.86	674

y (in)	p Elev -26.5	y (in)	p Elev -31.5	y (in)	p Elev -36.5	y (in)	p Elev -41.5	y (in)	p Elev -47
0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
0.19	278	0.19	290	0.18	302	0.18	316	0.17	333
0.38	350	0.37	365	0.36	381	0.35	398	0.34	420
0.77	441	0.75	460	0.73	480	0.71	502	0.68	529
1.15	505	1.12	527	1.09	549	1.06	574	1.02	606
1.54	556	1.50	580	1.46	604	1.41	632	1.37	667
1.92	598	1.87	625	1.82	651	1.77	681	1.71	718
2.31	636	2.24	664	2.18	692	2.12	723	2.05	763
2.69	670	2.62	699	2.55	728	2.48	762	2.39	803
3.08	700	2.99	731	2.91	761	2.83	796	2.73	840
5.77	700	5.61	731	5.46	761	5.30	796	5.12	840
9.62	700	9.35	731	9.10	761	8.84	796	8.54	840

y (in)	p Elev -52.5	y (in)	p Elev -57.5	y (in)	p Elev	y (in)	p Elev	y (in)	p Elev
0.00	0	0.00	0						
0.03	905	0.03	1,115						
0.06	1,647	0.06	2,029						
0.08	2,108	0.08	2,597						
0.11	2,511	0.11	3,093						
0.14	2,876	0.14	3,543						
0.17	3,213	0.17	3,958						
0.23	3,923	0.23	4,833						
0.42	5,831	0.42	7,184						
0.53	6,905	0.53	8,506						
0.84	6,905	0.84	8,506						
1.40	6,905	1.40	8,506						

Note - p (lb/in) 0 0 6/17/99