UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.
E. SO NOTED (NO RESOLUTION REQUIRED).

DOCUMENT CONTROL NUMBER: ___	PACKAGE NUMBER: - -	REVIEWER: J. HIGBEE	DATE: 10 – 18 - 04
DESCRIPTION: SEGMENT 5- CULVERTS AND BRIDGES 21, 22, 23, 24A, 24B & 25	REVIEW TYPE: FINAL	DISCIPLINE: GEOTECHNICAL	CRM: __- __ - 04

ITEM NO.	DWG. OR ITEM NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
-	- -	Burke (Park) Lane Culverts			
1	V-2034, #1	A. Consider modifying Note 2 to read " . . . BY CONTECH FOR THE **CATEGORY** 1B STRUCTURE. . . AND HORIZONTAL DIRECTION IS **THEREFORE** REQUIRED PER **THE** GEOTECHNCIAL ENGINEER . . " B. Quantities- Should the FD Granular Borrow just be Granular Borrow as per Note 2? Or is FD-GB used someplace else?			
2	V-2034, #2	With this being a "Category 1B" structure, what does this "No. 1" structure number mean?			
3	1-003 & 1-004	This (required minimum) bearing capacity for the Category 1B structure of 2000 psf seems to conflict with the 2700 psf value shown in Note 2 on sht V-2034, #1.			
4	G	Since we're not building a Swiss watch, it would be better to round the metric bearing capacity values to the nearest whole kPa.			

(1) Indicate drawing no./page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.
E. SO NOTED (NO RESOLUTION REQUIRED).

DOCUMENT CONTROL NUMBER: ___	PACKAGE NUMBER: - -	REVIEWER: J. HIGBEE	DATE: 10 – 18 - 04
DESCRIPTION: SEGMENT 5- CULVERTS AND BRIDGES 21, 22, 23, 24A, 24B & 25	REVIEW TYPE: FINAL	DISCIPLINE: GEOTECHNICAL	CRM: __- __ - 04

ITEM NO.	DWG. OR ITEM NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
5	00-012 & 00-019	Note 2: What do these 4000 psf minimum soil bearing pressure references mean (related to comment #3) ?			
6	00-019	The Project already has a spec for Select Backfill (for MSE walls). To avoid confusion, can it be used instead?			
- -		**Bridge 21**			
7	6	As per the final disposition of my comment #3 (follow-up from comment #9 of the level 2 submittal), the pile tip elevations were to be raised.			
8	Vol 2- Ind. Chk Calcs	A. The volume #'s shown on the 2 table-of-content pages were apparently mixed up (1 vs. 2). B. Were independent check calcs performed for the lateral pile analyses? If so, I could not find them.			
- -		**Bridge 22**			
9	Level 3 Supl Com's	Re my comment #2: A "C (Delete Comment)" code with no written response is not an appropriate resolution for the issue of excessive distances between the explorations. Probably should treat it as bridges 15B & 17B stating that			

(1) Indicate drawing no./page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.
E. SO NOTED (NO RESOLUTION REQUIRED).

DOCUMENT CONTROL NUMBER: ___	PACKAGE NUMBER: - -	REVIEWER: J. HIGBEE	DATE: 10 – 18 - 04
DESCRIPTION: SEGMENT 5- CULVERTS AND BRIDGES 21, 22, 23, 24A, 24B & 25	REVIEW TYPE: FINAL	DISCIPLINE: GEOTECHNICAL	CRM: __- __ - 04

ITEM NO.	DWG. OR ITEM NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
		the additional borings are at least advisable in order to the confirm the design assumptions.			
10	Vol 1- A	Please provide the final soil input values that were used here (Bent 3 as well). See Section B- Analysis Input for revised tables.			
11	Vol 1- B. Analysis Input	A. P. 29: Please provide this confirmation from Wall Supplier concerning the assume 50% reduction in soil stiffness for piles near wall face. B. P. 30: It is a bit disconcerting to see this correspondence that talks about sleeving to prevent downdrag on the piles, when it was subsequently eliminated. Please provide follow-up correspondence that discusses the final resolution on this.			
- -		**Bridge 23**			
12	Level 2 SubStr Com's	Re my comment #5: Should probably treat the issue with Bent 2 explorations as for item #9 on Bridge 22.			

(1) Indicate drawing no./page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.
E. SO NOTED (NO RESOLUTION REQUIRED).

DOCUMENT CONTROL NUMBER: ___	PACKAGE NUMBER: - -	REVIEWER: J. HIGBEE	DATE: 10 – 18 - 04
DESCRIPTION: SEGMENT 5- CULVERTS AND BRIDGES 21, 22, 23, 24A, 24B & 25	REVIEW TYPE: FINAL	DISCIPLINE: GEOTECHNICAL	CRM: __- __ - 04

ITEM NO.	DWG. OR ITEM NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
- -		**Bridge 24A**			
13	Level 3 Com's	Re my comment #1 (referencing comment #4 of the Level 2 submittal): I understand the uniqueness of design-build process and FAK's recognition of the need to make field adjustments. My main concern is that UDOT avoids extensive claims for changed conditions levied by the Phase 2 D/B, especially with respect to FAK's surprising submission of a changed subsurface conditions claim for a far less substantive issue in this Segment 5 area.			
- -		**Bridge 24B**			
14	Level 3 Com's & Seismic Design Memo	Re my Level 3 comment #1-B: As per our CR mtg and A-Final Disp., the excessive amount of liquefaction-induced settlement was to be discussed in the final Seismic Design Memo.			

(1) Indicate drawing no./page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.
E. SO NOTED (NO RESOLUTION REQUIRED).

DOCUMENT CONTROL NUMBER: ___	PACKAGE NUMBER: - -	REVIEWER: J. HIGBEE	DATE: 10 – 18 - 04
DESCRIPTION: SEGMENT 5- CULVERTS AND BRIDGES 21, 22, 23, 24A, 24B & 25	REVIEW TYPE: FINAL	DISCIPLINE: GEOTECHNICAL	CRM: __- __ - 04

ITEM NO.	DWG. OR ITEM NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
- -		**All Bridges**			
15	Pile Design Summary tables	As indicated in previous submittal comments and discussions, I feel that the minuet "Estimated Pile Tip Settlement" values (as shown in all of the Pile Capacity Summary tables) are misleading. The values shown are apparently based on the results of short-term pile tip displacement for a pile load test conducted in this general area; when instead we were expecting to see the estimate of long-term settlement for the pile foundations. As per my previous comments for other bridges, if the UniPile settlement analyses are available for these bridges, they should be provided in these final design packages.			
16	Pile Analyses	Headings on the pile response summary graphs would be useful, including identifying the loading conditions for the specific cases presented.			
17	Ind. Check Calcs	For the Independent Check Calculations, I don't feel that the intent of having ind. calculations has been met when not only are the same (or very similar) soil input values used, but probably also the same computer input files (with probably only slight modifications).			

(1) Indicate drawing no./page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

10/ /4 Submittal

Frymstown Creek (both under Jeffrey @ I-15

Prez didn't include any comments from me (but maybe I didn't have any for it - only Sheppard Creek)

Burke Ln Box Culvert (actually a Contech AL arch)

No comments for me here either (pretty sure this is 1st time I've seen it)

It displaced 2000 psf BCap

Bridges

Surprised to see that we apparently didn't have CKW1's (or at least see some final dispositions) until now. But it might be good so as to arch for consistent treatment.

Br 21

? Inc Chk LPiles

Couldn't find any calc, analysis of lateral load on pilings.

Br 23

ON

LPile input show little or no clay from chk when vs original design

Br 25

Seems directly use Kleinfelder input parameters

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES: Ler 4 Final Sub, 10/04
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.
E. SO NOTED (NO RESOLUTION REQUIRED).

DOCUMENT CONTROL NUMBER: 3141 & 3142	PACKAGE NUMBER: 5-BR-22	REVIEWER: J. HIGBEE	DATE: 4 – 11 - 02 CRM 4/22/02
DESCRIPTION: BRIDGE 22 LEVEL 3	REVIEW TYPE: RFC	DISCIPLINE: GEOTECHNICAL	PAGE _ OF 3

ITEM NO.	DWG. NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
1	Revised Geotech Memo	Most of my suggestions made to the memo were incorporated in this 11/01/01 revision, which is appreciated. However, if it is not desired to indicate that the memo covers only liquefaction concerns, then in future memos, consideration should be given to indicate that pile design, abutment embankment settlement, and other geotechnical concerns were performed, with a brief summary given; or that those results are presented elsewhere.	C	The structural memo provides the necessary info for structure design. Roadway embankment settlement/stability etc. are addressed separately in another memo. The final report will combine all of these.	A Will mention pile design in introductions on future memos.
2	Revised Geotech Memo	P.2, 1st par: I see only 8 borings and 2 CPT's (both on the Expl. Location Plan, and on the "Borings Used for Soil Profile" chart on the Pile Summary table.	A	Initialed correction.	A
3	5	I would still like to indicate that the Exploration Location Plan sheets are not as informative as they could be. It would be nice to at least show the proposed walls and embankments; but as a minimum, we understood that the locations of the bridge abutments and bents would be shown.	A	Will show abutment and bent locations.	A

(1) Indicate drawing no./page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.
E. SO NOTED (NO RESOLUTION REQUIRED).

DOCUMENT CONTROL NUMBER: 3141 & 3142	PACKAGE NUMBER: 5-BR-22	REVIEWER: J. HIGBEE	DATE: 4 – 11 - 02 CRM 4/22/02
DESCRIPTION: BRIDGE 22 LEVEL 3	REVIEW TYPE: RFC	DISCIPLINE: GEOTECHNICAL	PAGE _ OF 3

ITEM NO.	DWG. NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
4	Pile Sum. Table	Since the bridge foundations have not been shown on the exploration plan, we can't comment yet on the adequacy of these exploration locations.	D	Added bridge foundation locations.	C/A See attached additional comments
5	Pile Sum. Table	For the upper left capacity values, rather than "Target Geotechnical Capacity", I think that saying "Ultimate Vertical Capacity" might be more appropriate.	C	This is described as a "Target" value as it is the minimum capacity that must be provided by the soil to support the structural loads. Since the soil could provide a greater capacity, in our opinion the term ultimate does not correctly describe this value. "Minimum Required" may be a satisfactory alternate term.	C
6	Pile Sum. Table	For column D, in the past it has been labeled "Estimated Pile Tip Elev", rather than "Target". Which do you feel is more appropriate? The standard for the UDOT Structures & Geotech divisions is Estimated.	A	A revised table is attached.	A
7	5P	The level of lab test results provided for Boring LSB-22-490 looks very good.	E		E
		I forget what SV and H represents for Other Tests; but I imagine H is hydrometer, and SV shear vane- if so, is it a lab shear vane, or field?	C	H does represent a hydrometer analysis. SV indicates a sieve analysis.	C

(1) Indicate drawing no./page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.
E. SO NOTED (NO RESOLUTION REQUIRED).

DOCUMENT CONTROL NUMBER: 3141 & 3142	PACKAGE NUMBER: 5-BR-22	REVIEWER: J. HIGBEE	DATE: 4 – 11 - 02 CRM 4/22/02
DESCRIPTION: BRIDGE 22 LEVEL 3	REVIEW TYPE: RFC	DISCIPLINE: GEOTECHNICAL	PAGE _ OF 3

ITEM NO.	DWG. NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
		lab shear vane, or field? I assume that all the lab results including the strength tests, consols, etc. will be presented in the final Geotechnical Report for the project.	E	analysis.	E
8	6 - 8	I assume that the required driving resistance for Bent 2 will be corrected as per the post-it note.	A		A
9	G	As pointed out in the geotechnical evaluation memo, this bridge site is located within a documented large lateral spread landslide (as are the other bridges at the north interchange area). As such, the soils in the upper strata across the site consist primarily (or entirely) of landslide material. Consideration should be given to annotating the boring logs (using geologic and geotechnical judgment), as to the probable contact with the underlying undisturbed soils. But at this point, I do not expect the boring logs for this bridge to be changed.	E		E

(1) Indicate drawing no./page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

Comments on Revised Exploration Location Plan 4/22/02

1. Include Rev 2 note of 4/19/02- Included Bridge Foundation Locations ~~N/A~~ C
2. The distances from the nearest borings to Abutment 1, Bent 4 and particularly Bent 3 seem excessive. Also, with only one boring in the vicinity of both Bent 3 and 4, it is questionable as to whether the exploration meets the UDOT minimum standard of one exploration per bridge foundation. Note: Railroad tracks being located between Bents 2 and 3, would not have precluded drilling closer to Bents 3 and 4. C
3. Misspelling of **ISSUED** FOR CONST. in lower right corner. A

Br22Lev3FolUpCom#3141-3142.doc

Lv4 Final Sub, 10/04

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.
E. SO NOTED (NO RESOLUTION REQUIRED).

DOCUMENT CONTROL NUMBER: 3997	PACKAGE NUMBER: 5-BR-23	REVIEWER: J. HIGBEE	DATE: 7 – 24 - 02
DESCRIPTION: BRIDGE 23 LEVEL 2 SUBSTRUCTURE	REVIEW TYPE: RFC	DISCIPLINE: GEOTECHNICAL	This final review of Final Disp

ITEM NO.	DWG. NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
1	Geotech Memo	Since this is one of the last bridges at the north interchange, I will defer most of my comments on concerns with the typical memo, to the Level 2 bridge submittal for Bridge 4 at the south interchange.	E		E
2	Geotech Memo	I know that the geotechnical designers transmit their recommended AASHTO soil type to the bridge engineers. But for completeness of the geotechnical memos, could the recommended soil type be given in the Geotechnical Conditions section of the memos?	C	Structural engineers have made the determination. When there is a question geotechnical engineer reviews and recommends.	B [illegible]
3	Geotech Memo	Recommendations: As noted for the last Level 2 bridge submittal, would it be more appropriate to say "the anticipated **average** service load per pile . . . "? Good summary of foundation governing conditions.	C	Wording is appropriate as stated. not really	C
4	Pile Cap. Sum Shts	The listed "Borings Used for Soil Profile" could be adjusted (SB-23-289 should be included for Abutment 1, the later 2 borings for Bent 2 seem to lie an excessive distance away, SC-23-291 should probably be SC-23-290B).	A	Will be corrected for next release	A

(1) Indicate drawing no./page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.
E. SO NOTED (NO RESOLUTION REQUIRED).

DOCUMENT CONTROL NUMBER: 3997	PACKAGE NUMBER: 5-BR-23	REVIEWER: J. HIGBEE	DATE: 7 – 24 - 02
DESCRIPTION: BRIDGE 23 LEVEL 2 SUBSTRUCTURE	REVIEW TYPE: RFC	DISCIPLINE: GEOTECHNICAL	

ITEM NO.	DWG. NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
5	G	RE Bent 2: UDOT does not commonly accept having only a CPT for a pile foundation. Because of the following factors: A) This CPT was terminated 10 m short of the design estimated pile tip elevation, B) The nearest boring was 50 m away from this bent, and C) there are 48 piles for this double pile cap bent, the subsurface information for this bent seems questionable. Was either drill rig access or altered foundation location an issue?	C	The structure was shortened from the original design. There was 6 borings and CPT soundings for this structure and for the adjacent structure.	C
6	G	RE Bent 3: Similarly (although not as drastic concerns as for Bent 2): Sampling for nearest boring began near the estimated tip elevation, nearest CPT terminated 3 m short of ETE, next closest boring didn't begin sampling until 5 m below ETE.	C	See previous response for comment number 5.	C
7	G	The liquefaction/lateral spreading analyses has not yet been provided to us.	A	Will provide if not already done so.	A

(1) Indicate drawing no./page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

Lev 4 FSub, 10/04

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.
E. SO NOTED (NO RESOLUTION REQUIRED).

? CRM

DOCUMENT CONTROL NUMBER: 3998 TO 4000	PACKAGE NUMBER: 5-BR-24A	REVIEWER: J. HIGBEE	DATE: 8 – 06 - 02
DESCRIPTION: BRIDGE 24A LEVEL 3	REVIEW TYPE: RFC	DISCIPLINE: GEOTECHNICAL	PAGE _ OF 2

ITEM NO.	DWG. NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
1	Sht 4/43	RE the response to my comment #4 of the Level 2 package on excessive distances of borings to the foundations: My main concern is not that the characteristics ("types, density, etc.") of the individual soil layers might change significantly between the borings and the foundations; but rather that the depths/elevations will change significantly. People experienced with the Lake Bonneville deposits understand this- even to the point that pile driving conditions can change dramatically within one pile group. Bridge 25 Bent 3 is a perfect case in point of pile driving problems where the nearest boring was located some distance from the foundation.	C	We understand and appreciate the concern. In this design build scenario, the constant – ? right & communication will facilitate any modification that needs to be made to the design or installation. As we have done in the past, reevaluation will be conducted if deemed necessary.	C Right, and who guarantees is those that no [illegible] condition won't be [illegible] ∅
2	Logs	To recite my comment #6: As per previous comments, it would be good to annotate the upper soil layers indicating which are felt to consist of lateral spread material (including the terms possible, probable, etc. as appropriate). The probable contact of the displaced material appears to be more obvious in Boring LSB-24-498. FAK Response: Logs are done ahead of the analysis. Will evaluate.	C	It is not obvious to us from the sample which soils have been disturbed by lateral spreading. For example in LSB-24-498, only about a 2 meter zone, from approximately the CL to 6 meters is potentially liquefiable.	C [illegible] liq. [illegible] layer [illegible] displaced [illegible] CL [illegible] [illegible] layer can "slide" along [illegible] LS layer. [illegible] It would seem [illegible] to [illegible] possible LS [illegible] But [illegible] REC [illegible] UDOT [illegible] C Hill w/o any such indication takes away any truth I'd have

(1) Indicate drawing no./page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

0000172

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.
E. SO NOTED (NO RESOLUTION REQUIRED).

DOCUMENT CONTROL NUMBER: 3998 TO 4000	PACKAGE NUMBER: 5-BR-24A	REVIEWER: J. HIGBEE	DATE: 8 – 06 - 02
DESCRIPTION: BRIDGE 24A LEVEL 3	REVIEW TYPE: RFC	DISCIPLINE: GEOTECHNICAL	PAGE _ OF 2

ITEM NO.	DWG. NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
		The geotechnical analysis need not be done first. But I hope that during the design phase, the geotechnical firm would evaluate the field engineer's logs, examine the samples, and confer with the project geologists in order to develop the most informative final boring logs. I have receive verbal indications that the displaced lateral spread material can be at least mentioned on the final logs; and hopefully in some cases, the likely or possible contact with undisturbed units be indicated.			

000273

(1) Indicate drawing no./page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. *However, it is* the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.
E. SO NOTED (NO RESOLUTION REQUIRED).

DOCUMENT CONTROL NUMBER: 7524	PACKAGE NUMBER: 5-BR-24B	REVIEWER: J. HIGBEE	DATE: 6 – 22 - 04
DESCRIPTION: BRIDGE 24B- LP NB TO I-15 NB OVER I-15	REVIEW TYPE: LEVEL 3	DISCIPLINE: GEOTECHNICAL	CRM: 9/2/04

ITEM NO.	DWG. NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
1	Geotech Memo	A. Good memo again overall; I noted that the estimated range of groundwater that was encountered was given this time.	E	Thank You	E
		B. Up to 194 mm is a substantial amount of liq-induced settlement. Might add a comment as to the possible necessity of slab jacking or other required post-earthquake mitigation if this occurs.	D		A
		C. Since this bridge runs essentially north to south (as did the subsurface explorations), continuity of liquefiable layers in the explorations along the bridge profile for lateral spread assessment is not necessarily a definitive indicator of the continuity conditions in the more important east to west direction (the predominant direction of potential lateral spread movement).	D	Agree. Evaluation included information from adjacent structure boring as well.	D
2	Pile Capacity Summary sheet	Relative to the pile tip elevations shown on this sheet and the subsurface conditions shown on the exploration logs, the following comments are made for consideration: Abutments: With this very high required driving	E		E

(1) Indicate drawing no./page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.
E. SO NOTED (NO RESOLUTION REQUIRED).

DOCUMENT CONTROL NUMBER: 7524	PACKAGE NUMBER: 5-BR-24B	REVIEWER: J. HIGBEE	DATE: 6 – 22 - 04
DESCRIPTION: BRIDGE 24B- LP NB TO I-15 NB OVER I-15	REVIEW TYPE: LEVEL 3	DISCIPLINE: GEOTECHNICAL	CRM: 9/2/04

ITEM NO.	DWG. NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
		resistance of 3500 kN, there is a good chance that capacity might not be achieved in the silty sand layer where the pile tips are specified. It seems likely that the piles will have to penetrate thru the next layer of clay to reach the underlying layer of dense to very dense sand (below EL 1269 for A-1 and below EL 1262 for A-7).			
3	My 4/29/4 comment sheet	Re the response to my comment #8, didn't we used to have a column indicating the governing condition for each foundation? Could you clarify these seismic uplift requirements vs. service loads? The last sentence of the response was left incomplete.	C	As noted on the Pile Design Summary sheet for each of these bents, the seismic uplift requirement controls the design. Need pile length to resist uplift, therefore, the required tip elevations.	C
4	My 4/29/4 comment sheet	Re my comment #9- since the location and log for boring LSB-24-449 was given in this submittal, you might change the response to an A or C, and include a response similar to: *The log for boring LSB-24-449 which was provided subsequently, was drilled and sampled to a sufficient depth for this bent foundation.*	C	Boring LSB 24-449 was subsequently drilled to sufficient depth.	C

(1) Indicate drawing no./page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

Lev 4 F-Sub, 10/01

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.
E. SO NOTED (NO RESOLUTION REQUIRED).

DOCUMENT CONTROL NUMBER: 1964	PACKAGE NUMBER: 5-BR-25	REVIEWER: J. HIGBEE	DATE: 10- 15 - 01
DESCRIPTION: LEVEL 2 SUBSTRUCTURE ADVANCED RFC	REVIEW TYPE: MILESTONE (RFC)	DISCIPLINE: GEOTECHNICAL	PAGE OF 2 CRM 10/26/01 AND 1/23/02

ITEM NO.	DWG. NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
1	1	Design Data Note: See Ray Cook's comment regarding revising the acceleration terminology.	A	Will revise note	A
2	2 - 4	It appears the boring and CPT locations were omitted.	A	Added	A
3	2	Indicate on the cross section whether the zone behind Abut 1 is to be a wall or embankment.	C	Wall is shown correctly	C
4	5 series	Thank you for numbering system of boring logs.	E		E
5	5O	LSB-25-455: For the upper silty sand layer, the dense description does not seem appropriate for all but the near-surface portion of the layer.	A	Corrected	A
6	5P	Sample at 115": Please check to verify whether the corrected blow count is really less than 50.	A	Revised to 31	A
7	6	Show centerline of Abut 1	C	Shown as "CL BRG ABUT 1" per Ray Cook comment .	C

(1) Indicate drawing no./page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.
E. SO NOTED (NO RESOLUTION REQUIRED).

DOCUMENT CONTROL NUMBER: 1964	PACKAGE NUMBER: 5-BR-25	REVIEWER: J. HIGBEE	DATE: 10- 15 - 01
DESCRIPTION: LEVEL 2 SUBSTRUCTURE ADVANCED RFC	REVIEW TYPE: MILESTONE (RFC)	DISCIPLINE: GEOTECHNICAL	PAGE OF 2 CRM 10/26/01 AND 1/23/02

ITEM NO.	DWG. NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
8	8	Show centerline of Abut 7	C	Shown as "CL BRG ABUT 3" per Ray Cook comment	C
9	12	As per previous discussions, we were hoping the "Abutment or Footing" call-outs would be revised to say Pile Cap (as Tim D. had also suggested).	C	After consultation, we have decided to keep the designation as shown	C
10	1&80/259 pile/liq anly pkg	The governing condition for both abutments is identified as "Pile Tip Below Liq. Layer"; however, the Required Driving Resistance appears to be based on the ultimate resistance from the service load.	E/C	Minimum depth governs	E/C
11	16,etc/259 pile/liq anly pkg/ Sheet 6	It appears that the Required Driving Resistance values may not have not been determined properly for the seismic uplift governing condition for all five foundation bents. For example: The 3567 kN RDR determined for Bent 2 does not match the sum of 3449 kN, which corresponds to the required seismic comp. resistance (3135) + est. strength loss due to liq (314).	A	Will revise	A
12	G	Neither the pile design/ liquefaction package or the milestone submittal package included the liquefaction/lateral spread analysis evaluation spread-	A	See memo dated 11/1/01 GDM-STR-006 Rev 2	A

(1) Indicate drawing no./page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.
E. SO NOTED (NO RESOLUTION REQUIRED).

DOCUMENT CONTROL NUMBER: 1964	PACKAGE NUMBER: 5-BR-25	REVIEWER: J. HIGBEE	DATE: 10- 15 - 01
DESCRIPTION: LEVEL 2 SUBSTRUCTURE ADVANCED RFC	REVIEW TYPE: MILESTONE (RFC)	DISCIPLINE: GEOTECHNICAL	PAGE OF 2 CRM 10/26/01 AND 1/23/02

ITEM NO.	DWG. NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
		sheet or evaluation memo.			

(1) Indicate drawing no./page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.

DOCUMENT CONTROL NUMBER: 3150	PACKAGE NUMBER: 5-BR-25	REVIEWER(S): RAY COOK	DATE: 4/04/02
DESCRIPTION: BRIDGE 25: LP NB TO US 89 NB OVER I-15 & UPRR	REVIEW TYPE: L2 RFC FOR STEEL FAB	DISCIPLINE: STRUCTURES	CRM: 4/18/02

ITEM NO.	DWG. NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
1	63	It appears that tolerance is very tight to meet requirement of RFP 3 5 3.1.5 stating that shear studs shall penetrate at least 75 mm into deck and not be less than 75 mm from top of deck. Verify that shear stud length provides enough construction tolerance that there will not be a problem in the field meeting this requirement.	A	Verified	A
2	66, 67	Specification 05120 does not currently address AASHTO M253 bolts. To my knowledge, UDOT has never used this type of bolt. I will verify that there is no problem using them.	A	Re-designing for AASHTO M164M bolts	A
3	66	In View C-C, welding to shorter vertical plate (opposite side of shear key) is not shown.	A	Will correct	A
4	66	Is there room between girder and bent cap to weld (overhead weld)	A	Yes. Approximately 300 mm between top of cap and bottom of girder.	A
5	66	The See Table dimension shown in Longitudinal Seismic Shear Brackets Detail is not to the same point on the bracket as the See Table dimension shown in View C-C.	A	Will correct	A
6	66, 67	Is it correct that it requires less than half the number of bolts on the abutment transverse bracket as on the bent transverse bracket?	A	Yes. Abutment force and moment less	A
7	66	Should a minimum overlap be shown between longitudinal bracket and bent cap as is done on the transverse bracket and shear key?	A	Will add	A

(1) Indicate drawing no /page no. or use "G" for general comment.
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note. The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs. However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

UTAH DEPARTMENT OF TRANSPORTATION
OVERSIGHT REVIEW
COMMENT AND RESOLUTION SHEET

CODES:
A. ACCEPT COMMENT—WILL BE CORRECTED, ADDED, OR CLARIFIED.
B. DESIGNER WILL EVALUATE.
C. DELETE COMMENT
D. DEPARTMENT TO EVALUATE.

DOCUMENT CONTROL NUMBER: 3150	PACKAGE NUMBER: 5-BR-25	REVIEWER(S): RAY COOK	DATE: 4/04/02
DESCRIPTION: BRIDGE 25: LP NB TO US 89 NB OVER I-15 & UPRR	REVIEW TYPE: L2 RFC FOR STEEL FAB	DISCIPLINE: STRUCTURES	CRM: 4/18/02

ITEM NO.	DWG. NO.(1)	COMMENTS	CODE(2)	RESPONSE(2)	FINAL DISPOSITION(3)
8	66, 67	For my benefit, please confirm that transverse brackets are bolted and not welded.	A	Transverse brackets are bolted not welded on this bridge.	A

(1) Indicate drawing no /page no. or use "G" for general comment
(2) To be filled out by Design/Builder.
(3) To be determined in subsequent comment resolution meeting/discussion (list date).

Note: The intended use of this form is to provide a means for the Department to raise issues or concerns associated with the Design/Builder's designs However, it is the Design/Builder's responsibility to determine what action is necessary to resolve those issues in accordance with the contract.

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	21
Support(s)	1,2,3,4
Water Depth (m)	1.5
Finished Grade Elevation (m)	1294.0
Soil Borings Used for Profile	SB-21-282, SC-21-283, SB-21-284, SB-22-285

	Initials	Date
Completed By:	CMH	4/25/02
Checked By:	NM	4/25/02

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m³)	Shear Strength (kN/m²)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m²)		Maximum Tip Resistance (kN/m²)	
									Top	Bottom	Top	Bottom
1	Soft Clay	0.0	1.5	19.6	57	0.034	57,665	-	0	6	0	230
2	Soft Clay	1.5	14.0	9.7	57	0.034	57,665	-	6	34	230	1,180
3	Sand	14.0	30.0	10.5	-	-	25,590	39	81	172	19,040	40,190

Press the "Copy" button to copy this tab to a new spreadsheet. The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies. Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers.

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	21
Support(s)	5
Water Depth (m)	1.5
Finished Grade Elevation (m)	1295.8
Soil Borings Used for Profile	SC-22-286

	Initials	Date
Completed By:	CMH	4/25/02
Checked By:	NM	4/25/02

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Soft Clay	0.0	1.5	19.6	57	0.034	57,665	-	0	6	0	230
2	Soft Clay	1.5	4.7	9.7	57	0.034	57,665	-	6	13	230	470
3	Sand	4.7	30.0	10.5	-	-	25,590	39	32	176	7,620	41,060

Press the "Copy" button to copy this tab to a new spreadsheet. The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies. Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers.

LEGACY PARKWAY

BRIDGE 21 SEISMIC DESIGN STRATEGY

INTRODUCTION

Seismic Design of the bridges for the Legacy Parkway project is primarily based on AASHTO, amended by project specific design criteria, which addresses issues not specifically accounted for by the AASHTO code.

GENERAL STRUCTURE DESCRIPTION

The structure is approximately 258 m long with 6-spans (44.5m, 39.3m, 47.0m, 42.2m, 35.5m and 45.9m, respectively). The substructure consists of seat type abutments and three-column bents with non-integral caps. The abutments are supported by two rows of concrete filled steel pipe piles, 406 mm in diameter, and 9.5 mm in thickness.

The columns are octagonal with a diameter of 1.830 m, supported on pile-group foundations, using similar concrete filled steel pipe piles as abutments. The superstructure consists of prestressed concrete I-Girders with a concrete deck. Superstructure girders are typically supported on electrometric bearings.

LEVEL OF PERFORMANCE

This structure is designed as an "Essential Bridge" under the definition provided by AASHTO (Division 1-A). The seismic performance of the structure is "Serviceability", following minor repairs, which may be required, after the event of "Design Level Earthquake"

SEISMICITY

The structure is designed for PGA = 0 6g. AASHTO curves for Type III soil are used to account for soil amplification.

SEISMIC BEHAVIOR

The seismic design strategy for this structure consists of:

- Shear key restraints of superstructure girders to bent caps, with designed gaps (Longitudinal and transverse)
- Inelastic flexure response of bent columns, after engagement of girder shear keys (Longitudinal and transverse)
- Longitudinal engagement of girders and abutment backwall, and backfill passive resistance upon permitted backwall failure
- Transverse freedom of motion at the abutments, upon fuse-failure of abutment wing wall extension above seat

Abutment piles are essentially protected by allowing the girders to slide over the abutment seat. This flexibility along with designed shear key gaps at bent caps, optimize use of column flexure strength, protecting abutment piles. Column plastic hinging capacity is improved by providing lateral confinement throughout plastic hinging zone, as well as column-bent cap and foundation joints. Column foundations are capacity protected, designed for column plastic hinging strength. Due to depth of ground cover over the footings at Bents 2, 3, and 6, Column Soil Isolations are provided to ensure design level flexibility is maintained.

EXPECTED DAMAGE UNDER DESIGN EVENT

The expected inspection and immediate repair which may be required, following a design level earthquake, will be centering the bridge near it's original position, and temporary repairs over bridge joints to allow for traffic.

Due to the expected fuse at the superstructure – substructure interface, the majority of damage will be localized to the bearing elements, shear keys, and abutment backwall. Damage to the abutments will be limited to the expansion joint and backwall failures. The entire superstructure is expected to displace on the supporting abutments and bents, with no unseating.

Note that smaller gap at the deck-abutment wing wall will be engaged before the fusing and sliding behavior of the bearings, and/or transverse engagement of the shear keys. The wing wall strength however was not designed to resist transverse lateral forces under the design level earthquake. Therefore, while the wing wall may successfully resist response to smaller events, it is expected to fail during the design level earthquake allowing for fused behavior of the bearings and seismic shear key restraints per seismic design strategy.

While the bridge can be opened to traffic following the immediate repair tasks, follow-up repairs can be performed to repair abutment backwall, wing wall, replace damaged bearings, connections and shear keys, and repair columns.

Note that use of isolation bearings, can reduce the extent of bearing damages and/or required repairs, after the event of a design level earthquake.

Table 1. Expected Seismic Performance

Abutments	• Backwall failure and movement in to the soil • Wing wall failure at deck interface • Fused bearings, leading to sliding behavior of the girders, within permitted shear key gaps • Essentially elastic pile response
Shear Keys	• Fused bearings, sliding of the girders within allowed seismic gap before shear keys are engaged
Columns	• R = 4, cracking and spalling, requiring repair by epoxy injection
Foundations	• Capacity protected pile foundation group • Essentially elastic pile response
Joints	• Moderate cracks requiring minor repair such as epoxy injection

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	21
Support(s)	6
Water Depth (m)	1.5
Finished Grade Elevation (m)	1295.0
Soil Borings Used for Profile	SC-22-287, SB-22-288

	Initials	Date
Completed By:	CMH	4/25/02
Checked By:	NM	4/25/02

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	1.5	20.3	-	-	54,900	41	0	17	0	4,420
2	Sand	1.5	30.0	10.5	-	-	31,270	41	17	193	4,420	47,830

Press the "Copy" button to copy this tab to a new spreadsheet. The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies. Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers.

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	21
Support(s)	7
Water Depth (m)	1.5
Finished Grade Elevation (m)	1300.0
Soil Borings Used for Profile	SC-22-287, SB-22-288

	Initials	Date
Completed By:	CMH	4/25/02
Checked By:	NM	4/25/02

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m³)	Shear Strength (kN/m²)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m²)		Maximum Tip Resistance (kN/m²)	
									Top	Bottom	Top	Bottom
1	Silt	0.0	1.5	19.8	44	0.027	38,165	30	0	8	0	670
2	Silt	1.5	5.2	10.0	44	0.027	38,165	30	8	18	670	1,510
3	Sand	5.2	30.0	10.5	-	-	31,270	41	39	192	9,660	47,440

Press the "Copy" button to copy this tab to a new spreadsheet. The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies. Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers.

LEGACY PARKWAY
BRIDGE 21
PILE CAPACITY SUMMARY - PP 406x9.53 (16" x 3/8")
YIELD STRENGTH = 448 MPa

	Initials	Date
Completed By:	CC	6/25/04
Reviewed By:	CMH	6/28/04

A-1 Target Geotechnical Capacity per Pile (2.25xService Load)	2,102	kN
B-2 Target Geotechnical Capacity per Pile (2.25xService Load)	1,503	kN
B-3 Target Geotechnical Capacity per Pile (2.25xService Load)	1,503	kN
B-4 Target Geotechnical Capacity per Pile (2.25xService Load)	1,503	kN
B-5 Target Geotechnical Capacity per Pile (2.25xService Load)	1,503	kN
B-6 Target Geotechnical Capacity per Pile (2.25xService Load)	1,503	kN
A-7 Target Geotechnical Capacity per Pile (2.25xService Load)	2,102	kN

(Target Service Load Provided by Structural Engineer)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Location	Finished Grade Elevation (m)	Bottom of Pile Cap Elevation (m)	Est. Embankm. Height (m)	Estimated Pile Tip Elevation (m)	Minimum Pile Tip Elevation (m)	Service Uplift Load Resistance (kN)	Required Seismic Compression Resistance (kN)	Required Seismic Uplift Resistance (kN)	Service Load (DL + LL) (kN)	Required Driving Resistance (kN)	Est. Pile Length w/ fill (m)	Estimated Maximum Structural Load in Pile (kN) (Service Load + Drag Load)	Est. Elevation of Neutral Plane (m)	Estimated Pile Tip Settlement (mm)
Bridge 21, Abutment 1	1302.8	1298.2	2.0	1272.3	1272.3	873	N/A	N/A	934	2,102	26	2,485	1275.3	1
Bridge 21, Bent 2	1295.0	1290.5	N/A	1273.5	1274.0	666	2,069	1,357	668	2,184	17	2,100	1274.0	1
Bridge 21, Bent 3	1295.1	1291.5	N/A	1271.6	1272.0	658	2,069	1,357	668	2,069	20	2,149	1271.6	1
Bridge 21, Bent 4	1297.8	1293.8	N/A	1263.3	1263.3	745	2,069	1,357	668	2,630	31	2,095	1275.1	1
Bridge 21, Bent 5	1297.0	1293.3	N/A	1266.5	1266.5	1,228	2,069	1,357	668	2,894	27	3,432	1266.5	1
Bridge 21, Bent 6	1298.0	1293.0	N/A	1267.5	1267.5	1,144	2,069	1,357	668	2,961	26	3,244	1267.5	1
Bridge 21, Abutment 7	1305.4	1301.1	0.0	1283.9	1283.9	352	N/A	N/A	934	2,102	18	1,546	1286.1	1

Location	Borings Used for Soil Profile
Bridge 21, Abutment 1	LSB-475, SB-21-282
Bridge 21, Bent 2	SB-21-283, SC-21-283, LSB-21-477
Bridge 21, Bent 3	LSB-21-477, SB-21-284
Bridge 21, Bent 4	SB-22-285
Bridge 21, Bent 5	SC-22-286
Bridge 21, Bent 6	SC-22-287
Bridge 21, Abutment 7	SB-22-288

Description of Information Presented in Each Column:

A: Finished Grade Elevation - Top of approach slab elevation at abutment locations and adjacent ground elevation at bent locations as shown on the structure Plan and Profile drawing provided.

B: Bottom of Pile Cap Elevation - Elevation at the bottom of the pile cap as scaled from the structure Plan and Profile drawing provided.

C: Estimated Embankment Height - Elevation difference between the top of the approach slab and the native ground surface at the abutment as scaled from the structure Plan and Profile drawing provided.

D: Estimated Pile Tip Elevation - Estimated elevation to which the bottom of the pile will need to be driven to develop the required capacity and meet the settlement criteria. (Additional depth may be required to reach required resistance during driving.)

E: Minimum Pile Tip Elevation - Estimated minimum elevation to which the bottom of the pile will need to be driven to meet settlement, minimum length, or minimum depth criteria should the required driving resistance be obtained above the Target Pile Tip Elevat

F: Service Uplift Load Resistance = (Ultimate Friction Resistance)/(FS=2.25) Per comment resolution meeting with UDOT (8/15/01)

G: Seismic Compression Resistance = Ultimate Friction and End Bearing Resistance neglecting the contribution of potentially liquefiable zones. (AASHTO allows the use of the ultimate resistance values to resist seismic loads.)

H: Seismic Uplift Resistance = Ultimate Friction Resistance neglecting the contribution of potentially liquefiable zones. (AASHTO allows the use of the ultimate friction resistance value to resist seismic uplift loads.)

I: Service Load (DL + LL) - The maximum load that can be applied at the top of the pile by the structure provided the pile is driven to the assumed capacity.

J: Required Driving Resistance - The minimum load (service load x 2.25 or required seismic resistance plus estimated loss during liquefaction, whichever is greater) that must be verified in the field by PDA.

K: Estimated Pile Length w/ Fill - The estimated length of pile required. Calculated as (Bottom Of Pile Cap - Estimated Tip Elevation) rounded up to the nearest meter. (Actual lengths may vary depending on driving conditions encountered at each pile location.)

L: Estimated Structural Load in the Pile - The largest load that will develop in the pile due to structural service dead loads and drag loads. This load occurs at the neutral plane where equilibrium exists between the sum of the downward acting permanent load (service load) applied at the top of the pile and drag load due to negative skin friction and the sum of upward acting positive shaft resistance and mobilized toe resistance.

M: Estimated Elevation of Neutral Plane - The level in the pile where relative movement between the pile and soil is zero.

N: Estimated Pile Tip Settlement - The magnitude of pile tip settlement required to mobilize estimated pile tip loads. This does not include elastic compression of the pile.

8

Memorandum

SCANNED 7-9-04

LEGACY

Date: 07/08/2004

To: J Deschamp

From. M D. Cline

REGISTERED PROFESSIONAL ENGINEER
No. 369522-2202
MICHELLE D. CLINE
7/8/04
STATE OF UTAH

File Code: GDM-STR-041
(revised GDM-STR-040)

Subject: Geotechnical Recommendations for Bridge 21 – 2nd Revision

Cc. DocC, Kleinfelder, Farid Nobari

Introduction

This memorandum summarizes our Geotechnical evaluation and recommendations developed in accordance with UDOT's Geotechnical MOI for Bridge 21. Included herein are a summary of general geotechnical conditions at the bridge location, our evaluation of liquefaction concerns, and a summary of geotechnical parameters for pile design Detailed descriptions of our understanding of the project, geology, design analysis, and recommendations will be incorporated into the Segment 5 geotechnical report and submitted along with other documents as part of final submittal for the project This information will be maintained in the project files for reference until being incorporated into the final report

General Geotechnical Conditions

Geotechnical conditions at the site are defined by previous investigations performed for UDOT and information obtained during a subsequent investigation undertaken by FAK The profile at the bridge site can be generally defined as consisting of interbedded medium stiff to stiff silt and clay and loose to very dense sand/gravel layers in the upper 10 to 15 meters. Dense to very dense silty sands, poorly graded sands and poorly graded gravel with stiff to hard layers of silt and clay were encountered below 10 to 15 meters Groundwater was not measured during drilling but is anticipated to be at shallow depths Based on site-specific information, we recommend that AASHTO Soil Type III be used for design of this bridge.

Liquefaction Potential

Bridge 21 is located within the Farmington Siding landslide complex, which consists of liquefaction-induced landslides that date back to latest Pleistocene and Holocene time The bridge site is located within the older mapped portion of this complex, approximately 0 5 to 1 0 km southeast of the mapped contact with the younger portion of the complex UGS studies indicate that susceptibility to liquefaction-induced landsliding may be less than the earlier times due to

lower average lake and associated ground water levels. The study also indicated that above-average precipitation could create locally perched conditions which could liquefy and slide when subject to strong ground motions.

A site-specific evaluation of liquefaction and lateral spread was undertaken for Bridge 21. Information obtained from seven exploratory borings and three CPT soundings located at or near the bridge site were used in this evaluation. Evaluations indicated layers of silts and sands may liquefy under an earthquake of magnitude 7.3 with a peak horizontal ground acceleration of 0 6g. Layers of silt and sand ranging in thickness from approximately 0 5 m to 4 meters at elevations ranging from 1292 to 1279 meters were identified to have a potential to liquefy. Estimated liquefaction-induced settlement in these layers ranged from 0 to 116 mm. Additionally, a poorly graded sand layer in boring SB-21-282 at an elevation from 1288 to 1292 meters was identified to have a potential to laterally spread 4.5 meters. Given that this is an isolated layer in a borehole with no continuity, no mitigation measures are recommended at this bridge site.

Foundation Recommendations

It is our understanding that 406 mm (16 in.) diameter pipe piles are being proposed for the bridge foundations. The target vertical capacity per pile at the abutments is 2,102 kN and at the bents is 1,503 kN Design of abutment foundations is governed by establishment of the pile tip below a potentially liquefiable layer, and design of bent foundations is controlled by seismic compression. Recommended pile capacities and Geotechnical parameters required for analysis and design are presented in the attached table.

Legacy Parkway: Bridge No 21

Group	Element	Reference #	Reference Drawing Title (s):	Sheet No (s)
Substructure	Abutment 1 Piles	1	Foundation Plan	6 of 102

Calculated by: M.V.

Date: 7/13/2004

Description: Abutment 1 Pile Quantity

Location	A Bottom of Pile Cap Elevation (m)	B Pile Embedment Length (m)	C Estimated Pile Tip Elevation (m)	D Pile Length (m)
A1 – 1	1298.23	0.15	1272.3	26.08
A1 – 2	1298.23	0.15	1272.3	26.08
A1 – 3	1298.23	0.15	1272.3	26.08
A1 – 4	1298.23	0.15	1272.3	26.08
A1 – 5	1298.23	0.15	1272.3	26.08
A1 – 6	1298.23	0.15	1272.3	26.08
A1 – 7	1298.23	0.15	1272.3	26.08
A1 – 8	1298.23	0.15	1272.3	26.08
A1 – 9	1298.23	0.15	1272.3	26.08
A1 – 10	1298.23	0.15	1272.3	26.08
A1 – 11	1298.23	0.15	1272.3	26.08
A1 – 12	1298.23	0.15	1272.3	26.08
A1 – 13	1298.23	0.15	1272.3	26.08
A1 – 14	1298.23	0.15	1272.3	26.08
A1 – 15	1298.23	0.15	1272.3	26.08
A1 – 16	1298.23	0.15	1272.3	26.08
A1 – 17	1298.23	0.15	1272.3	26.08
A1 – 18	1298.23	0.15	1272.3	26.08
A1 – 19	1298.23	0.15	1272.3	26.08
A1 – 20	1298.23	0.15	1272.3	26.08
A1 – 21	1298.23	0.15	1272.3	26.08
A1 – 22	1298.23	0.15	1272.3	26.08
A1 – 23	1298.23	0.15	1272.3	26.08
A1 – 24	1298.23	0.15	1272.3	26.08

Total Pile Length /Abutment 1 = 625.920 m

Legacy Parkway: Bridge No 21

Group	Element	Reference #	Reference Drawing Title (s):	Sheet No (s)
Substructure	Abutment 7 Piles	1	Foundation Plan 2	6 of 102

Calculated by: M.V.

Date: 7/13/2004

Description: Abutment 7 Pile Quantity

Location	A Bottom of Pile Cap Elevation (m)	B Pile Embedment Length (m)	C Estimated Pile Tip Elevation (m)	D Pile Length (m)
A7 – 1	1301.045	0.15	1283.9	17.295
A7 – 2	1301.045	0.15	1283.9	17.295
A7 – 3	1301.045	0.15	1283.9	17.295
A7 – 4	1301.045	0.15	1283.9	17.295
A7 – 5	1301.045	0.15	1283.9	17.295
A7 – 6	1301.045	0.15	1283.9	17.295
A7 – 7	1301.045	0.15	1283.9	17.295
A7 – 8	1301.045	0.15	1283.9	17.295
A7 – 9	1301.045	0.15	1283.9	17.295
A7 – 10	1301.045	0.15	1283.9	17.295
A7 – 11	1301.045	0.15	1283.9	17.295
A7 – 12	1301.045	0.15	1283.9	17.295
A7 – 13	1301.045	0.15	1283.9	17.295
A7 – 14	1301.045	0.15	1283.9	17.295
A7 – 15	1301.045	0.15	1283.9	17.295
A7 – 16	1301.045	0.15	1283.9	17.295
A7 – 17	1301.045	0.15	1283.9	17.295
A7 – 18	1301.045	0.15	1283.9	17.295
A7 – 19	1301.045	0.15	1283.9	17.295
A7 – 20	1301.045	0.15	1283.9	17.295
A7 – 21	1301.045	0.15	1283.9	17.295
A7 – 22	1301.045	0.15	1283.9	17.295
A7 – 23	1301.045	0.15	1283.9	16.895
A7 – 24	1301.045	0.15	1283.9	16.895

Total Pile Length (Abutment 7) = 413.880 m

28

214

Legacy Parkway: Bridge No 21

Group	Element	Reference #	Reference Drawing Title (s):	Sheet No (s)
Substructure	Bent 2 Piles	1	Foundation Plan	6 of 102
		2	Piling Plan	5 of 89

Calculated by: M.V.

Date: 7/13/2004

Description: Bent 2 Pile Quantity

Location	A Bottom of Pile Cap Elevation (m)	B Pile Embedment Length (m)	C Pile Tip Elevation (m)	D Pile Length (m)
B2 – 1	1290.5	0.15	1273.5	17.15
B2 – 2	1290.5	0.15	1273.5	17.15
B2 – 3	1290.5	0.15	1273.5	17.15
B2 – 4	1290.5	0.15	1273.5	17.15
B2 – 5	1290.5	0.15	1273.5	17.15
B2 – 6	1290.5	0.15	1273.5	17.15
B2 – 7	1290.5	0.15	1273.5	17.15
B2 – 8	1290.5	0.15	1273.5	17.15
B2 – 9	1290.5	0.15	1273.5	17.15
B2 – 10	1290.5	0.15	1273.5	17.15
B2 – 11	1290.5	0.15	1273.5	17.15
B2 – 12	1290.5	0.15	1273.5	17.15
B2 – 13	1290.5	0.15	1273.5	17.15
B2 – 14	1290.5	0.15	1273.5	17.15
B2 – 15	1290.5	0.15	1273.5	17.15
B2 – 16	1290.5	0.15	1273.5	17.15
B2 – 17	1290.5	0.15	1273.5	17.15
B2 – 18	1290.5	0.15	1273.5	17.15
B2 – 19	1290.5	0.15	1273.5	17.15
B2 – 20	1290.5	0.15	1273.5	17.15
B2 – 21	1290.5	0.15	1273.5	17.15
B2 – 22	1290.5	0.15	1273.5	17.15
B2 – 23	1290.5	0.15	1273.5	17.15
B2 – 24	1290.5	0.15	1273.5	17.15
B2 – 25	1290.5	0.15	1273.5	17.15
B2 – 26	1290.5	0.15	1273.5	17.15
B2 – 27	1290.5	0.15	1273.5	17.15
B2 – 28	1290.5	0.15	1273.5	17.15
B2 – 29	1290.5	0.15	1273.5	17.15
B2 – 30	1290.5	0.15	1273.5	17.15
B2 – 31	1290.5	0.15	1273.5	17.15
B2 – 32	1290.5	0.15	1273.5	17.15
B2 – 33	1290.5	0.15	1273.5	17.15
B2 – 34	1290.5	0.15	1273.5	17.15
B2 – 35	1290.5	0.15	1273.5	17.15
B2 – 36	1290.5	0.15	1273.5	17.15
B2 – 37	1290.5	0.15	1273.5	17.15
B2 – 38	1290.5	0.15	1273.5	17.15
B2 – 39	1290.5	0.15	1273.5	17.15
B2 – 40	1290.5	0.15	1273.5	17.15
B2 – 41	1290.5	0.15	1273.5	17.15
B2 – 42	1290.5	0.15	1273.5	17.15
B2 – 43	1290.5	0.15	1273.5	17.15
B2 – 44	1290.5	0.15	1273.5	17.15
B2 – 45	1290.5	0.15	1273.5	17.15
B2 – 46	1290.5	0.15	1273.5	17.15
B2 – 47	1290.5	0.15	1273.5	17.15
B2 – 48	1290.5	0.15	1273.5	17.15
B2 – 49	1290.5	0.15	1273.5	17.15
B2 – 50	1290.5	0.15	1273.5	17.15
B2 – 51	1290.5	0.15	1273.5	17.15
B2 – 52	1290.5	0.15	1273.5	17.15
B2 – 53	1290.5	0.15	1273.5	17.15
B2 – 54	1290.5	0.15	1273.5	17.15
B2 – 55	1290.5	0.15	1273.5	17.15
B2 – 56	1290.5	0.15	1273.5	17.15
B2 – 57	1290.5	0.15	1273.5	17.15
B2 – 58	1290.5	0.15	1273.5	17.15
B2 – 59	1290.5	0.15	1273.5	17.15
B2 – 60	1290.5	0.15	1273.5	17.15
B2 – 61	1290.5	0.15	1273.5	17.15
B2 – 62	1290.5	0.15	1273.5	17.15
B2 – 63	1290.5	0.15	1273.5	17.15
B2 – 64	1290.5	0.15	1273.5	17.15
B2 – 65	1290.5	0.15	1273.5	17.15
B2 – 66	1290.5	0.15	1273.5	17.15
B2 – 67	1290.5	0.15	1273.5	17.15
B2 – 68	1290.5	0.15	1273.5	17.15
B2 – 69	1290.5	0.15	1273.5	17.15
B2 – 70	1290.5	0.15	1273.5	17.15
B2 – 71	1290.5	0.15	1273.5	17.15
B2 – 72	1290.5	0.15	1273.5	17.15
B2 – 73	1290.5	0.15	1273.5	17.15
B2 – 74	1290.5	0.15	1273.5	17.15
B2 – 75	1290.5	0.15	1273.5	17.15
		Total Pile Length (Bent 2)=	1286.250	m.

Legacy Parkway: Bridge No 21

Group	Element	Reference #	Reference Drawing Title (s):	Sheet No (s)
Substructure	Bent 3 Piles	1	Foundation Plan	6 of 192
		2	Piling Plan	8 of 89

Calculated by: M.V.

Date: 7/13/2004

Description: Bent 3 Pile Quantity

Location	A Bottom of Pile Cap Elevation (m)	B Pile Embedment Length (m)	C Pile Tip Elevation (m)	D Pile Length (m)
B3 – 1	1292.5	0.15	1271.5	21.05
B3 – 2	1292.5	0.15	1271.5	21.05
B3 – 3	1292.5	0.15	1271.5	21.05
B3 – 4	1292.5	0.15	1271.5	21.05
B3 – 5	1292.5	0.15	1271.5	21.05
B3 – 6	1292.5	0.15	1271.5	21.05
B3 – 7	1292.5	0.15	1271.5	21.05
B3 – 8	1292.5	0.15	1271.5	21.05
B3 – 9	1292.5	0.15	1271.5	21.05
B3 – 10	1292.5	0.15	1271.5	21.05
B3 – 11	1292.5	0.15	1271.5	21.05
B3 – 12	1292.5	0.15	1271.5	21.05
B3 – 13	1292.5	0.15	1271.5	21.05
B3 – 14	1292.5	0.15	1271.5	21.05
B3 – 15	1292.5	0.15	1271.5	21.05
B3 – 16	1292.5	0.15	1271.5	21.05
B3 – 17	1292.5	0.15	1271.5	21.05
B3 – 18	1292.5	0.15	1271.5	21.05
B3 – 19	1292.5	0.15	1271.5	21.05
B3 – 20	1292.5	0.15	1271.5	21.05
B3 – 21	1292.5	0.15	1271.5	21.05
B3 – 22	1292.5	0.15	1271.5	21.05
B3 – 23	1292.5	0.15	1271.5	21.05
B3 – 24	1292.5	0.15	1271.5	21.05
B3 – 25	1292.5	0.15	1271.5	21.05
B3 – 26	1292.5	0.15	1271.5	21.05
B3 – 27	1292.5	0.15	1271.5	21.05
B3 – 28	1292.5	0.15	1271.5	21.05
B3 – 29	1292.5	0.15	1271.5	21.05
B3 – 30	1292.5	0.15	1271.5	21.05
B3 – 31	1292.5	0.15	1271.5	21.05
B3 – 32	1292.5	0.15	1271.5	21.05
B3 – 33	1292.5	0.15	1271.5	21.05
B3 – 34	1292.5	0.15	1271.5	21.05
B3 – 35	1292.5	0.15	1271.5	21.05
B3 – 36	1292.5	0.15	1271.5	21.05
B3 – 37	1292.5	0.15	1271.5	21.05
B3 – 38	1292.5	0.15	1271.5	21.05
B3 – 39	1292.5	0.15	1271.5	21.05
B3 – 40	1292.5	0.15	1271.5	21.05
B3 – 41	1292.5	0.15	1271.5	21.05
B3 – 42	1292.5	0.15	1271.5	21.05
B3 – 43	1292.5	0.15	1271.5	21.05
B3 – 44	1292.5	0.15	1271.5	21.05
B3 – 45	1292.5	0.15	1271.5	21.05
B3 – 46	1292.5	0.15	1271.5	21.05
B3 – 47	1292.5	0.15	1271.5	21.05
B3 – 48	1292.5	0.15	1271.5	21.05
B3 – 49	1292.5	0.15	1271.5	21.05
B3 – 50	1292.5	0.15	1271.5	21.05
B3 – 51	1292.5	0.15	1271.5	21.05
B3 – 52	1292.5	0.15	1271.5	21.05
B3 – 53	1292.5	0.15	1271.5	21.05
B3 – 54	1292.5	0.15	1271.5	21.05
B3 – 55	1292.5	0.15	1271.5	21.05
B3 – 56	1292.5	0.15	1271.5	21.05
B3 – 57	1292.5	0.15	1271.5	21.05
B3 – 58	1292.5	0.15	1271.5	21.05
B3 – 59	1292.5	0.15	1271.5	21.05
B3 – 60	1292.5	0.15	1271.5	21.05
B3 – 61	1292.5	0.15	1271.5	21.05
B3 – 62	1292.5	0.15	1271.5	21.05
B3 – 63	1292.5	0.15	1271.5	21.05
B3 – 64	1292.5	0.15	1271.5	21.05
B3 – 65	1292.5	0.15	1271.5	21.05
B3 – 66	1292.5	0.15	1271.5	21.05
B3 – 67	1292.5	0.15	1271.5	21.05
B3 – 68	1292.5	0.15	1271.5	21.05
B3 – 69	1292.5	0.15	1271.5	21.05
B3 – 70	1292.5	0.15	1271.5	21.05
B3 – 71	1292.5	0.15	1271.5	21.05
B3 – 72	1292.5	0.15	1271.5	21.05
B3 – 73	1292.5	0.15	1271.5	21.05
B3 – 74	1292.5	0.15	1271.5	21.05
B3 – 75	1292.5	0.15	1271.5	21.05

Total Pile Length (Bent 3) = 1576.750 m

Legacy Parkway: Bridge No 21

Group	Element	Reference #	Reference Drawing Title (s):	Sheet No (s)
Substructure	Bent 4 Piles	1	Foundation Plan 2	1 of 152
		2	Piling Plan	8 of 89

Calculated by: M.V.

Date: 7/13/2004

Description: Bent 4 Pile Quantity

Location	A Bottom of Pile Cap Elevation (m)	B Pile Embedment Length (m)	C Pile Tip Elevation (m)	D Pile Length (m)
B4 – 1	1293.8	0.15	1263.3	30.65
B4 – 2	1293.8	0.15	1263.3	30.65
B4 – 3	1293.8	0.15	1263.3	30.65
B4 – 4	1293.8	0.15	1263.3	30.65
B4 – 5	1293.8	0.15	1263.3	30.65
B4 – 6	1293.8	0.15	1263.3	30.65
B4 – 7	1293.8	0.15	1263.3	30.65
B4 – 8	1293.8	0.15	1263.3	30.65
B4 – 9	1293.8	0.15	1263.3	30.65
B4 – 10	1293.8	0.15	1263.3	30.65
B4 – 11	1293.8	0.15	1263.3	30.65
B4 – 12	1293.8	0.15	1263.3	30.65
B4 – 13	1293.8	0.15	1263.3	30.65
B4 – 14	1293.8	0.15	1263.3	30.65
B4 – 15	1293.8	0.15	1263.3	30.65
B4 – 16	1293.8	0.15	1263.3	30.65
B4 – 17	1293.8	0.15	1263.3	30.65
B4 – 18	1293.8	0.15	1263.3	30.65
B4 – 19	1293.8	0.15	1263.3	30.65
B4 – 20	1293.8	0.15	1263.3	30.65
B4 – 21	1293.8	0.15	1263.3	30.65
B4 – 22	1293.8	0.15	1263.3	30.65
B4 – 23	1293.8	0.15	1263.3	30.65
B4 – 24	1293.8	0.15	1263.3	30.65
B4 – 25	1293.8	0.15	1263.3	30.65
B4 – 26	1293.8	0.15	1263.3	30.65
B4 – 27	1293.8	0.15	1263.3	30.65
B4 – 28	1293.8	0.15	1263.3	30.65
B4 – 29	1293.8	0.15	1263.3	30.65
B4 – 30	1293.8	0.15	1263.3	30.65
B4 – 31	1293.8	0.15	1263.3	30.65
B4 – 32	1293.8	0.15	1263.3	30.65
B4 – 33	1293.8	0.15	1263.3	30.65
B4 – 34	1293.8	0.15	1263.3	30.65
B4 – 35	1293.8	0.15	1263.3	30.65
B4 – 36	1293.8	0.15	1263.3	30.65
B4 – 37	1293.8	0.15	1263.3	30.65
B4 – 38	1293.8	0.15	1263.3	30.65
B4 – 39	1293.8	0.15	1263.3	30.65
B4 – 40	1293.8	0.15	1263.3	30.65
B4 – 41	1293.8	0.15	1263.3	30.65
B4 – 42	1293.8	0.15	1263.3	30.65
B4 – 43	1293.8	0.15	1263.3	30.65
B4 – 44	1293.8	0.15	1263.3	30.65
B4 – 45	1293.8	0.15	1263.3	30.65
B4 – 46	1293.8	0.15	1263.3	30.65
B4 – 47	1293.8	0.15	1263.3	30.65
B4 – 48	1293.8	0.15	1263.3	30.65
B4 – 49	1293.8	0.15	1263.3	30.65
B4 – 50	1293.8	0.15	1263.3	30.65
B4 – 51	1293.8	0.15	1263.3	30.65
B4 – 52	1293.8	0.15	1263.3	30.65
B4 – 53	1293.8	0.15	1263.3	30.65
B4 – 54	1293.8	0.15	1263.3	30.65
B4 – 55	1293.8	0.15	1263.3	30.65
B4 – 56	1293.8	0.15	1263.3	30.65
B4 – 57	1293.8	0.15	1263.3	30.65
B4 – 58	1293.8	0.15	1263.3	30.65
B4 – 59	1293.8	0.15	1263.3	30.65
B4 – 60	1293.8	0.15	1263.3	30.65
B4 – 61	1293.8	0.15	1263.3	30.65
B4 – 62	1293.8	0.15	1263.3	30.65
B4 – 63	1293.8	0.15	1263.3	30.65
B4 – 64	1293.8	0.15	1263.3	30.65
B4 – 65	1293.8	0.15	1263.3	30.65
B4 – 66	1293.8	0.15	1263.3	30.65
B4 – 67	1293.8	0.15	1263.3	30.65
B4 – 68	1293.8	0.15	1263.3	30.65
B4 – 69	1293.8	0.15	1263.3	30.65
B4 – 70	1293.8	0.15	1263.3	30.65
B4 – 71	1293.8	0.15	1263.3	30.65
B4 – 72	1293.8	0.15	1263.3	30.65
B4 – 73	1293.8	0.15	1263.3	30.65
B4 – 74	1293.8	0.15	1263.3	30.65
B4 – 75	1293.8	0.15	1263.3	30.65
		Total Pile Length (Bent 4)=	2298.750	m

Legacy Parkway: Bridge No 21

Group	Element	Reference #	Reference Drawing Title (s):	Sheet No (s)
Substructure	Bent 5 Piles	1	Foundation Plan	7 of 102
		2	Piling Plan	5 of 69

Calculated by: M.V.

Date: 7/13/2004

Description: Bent 5 Pile Quantity

Location	A Bottom of Pile Cap Elevation (m)	B Pile Embedment Length (m)	C Pile Tip Elevation (m)	D Pile Length (m)
B5 – 1	1293.3	0.15	1266.5	26.95
B5 – 2	1293.3	0.15	1266.5	26.95
B5 – 3	1293.3	0.15	1266.5	26.95
B5 – 4	1293.3	0.15	1266.5	26.95
B5 – 5	1293.3	0.15	1266.5	26.95
B5 – 6	1293.3	0.15	1266.5	26.95
B5 – 7	1293.3	0.15	1266.5	26.95
B5 – 8	1293.3	0.15	1266.5	26.95
B5 – 9	1293.3	0.15	1266.5	26.95
B5 – 10	1293.3	0.15	1266.5	26.95
B5 – 11	1293.3	0.15	1266.5	26.95
B5 – 12	1293.3	0.15	1266.5	26.95
B5 – 13	1293.3	0.15	1266.5	26.95
B5 – 14	1293.3	0.15	1266.5	26.95
B5 – 15	1293.3	0.15	1266.5	26.95
B5 – 16	1293.3	0.15	1266.5	26.95
B5 – 17	1293.3	0.15	1266.5	26.95
B5 – 18	1293.3	0.15	1266.5	26.95
B5 – 19	1293.3	0.15	1266.5	26.95
B5 – 20	1293.3	0.15	1266.5	26.95
B5 – 21	1293.3	0.15	1266.5	26.95
B5 – 22	1293.3	0.15	1266.5	26.95
B5 – 23	1293.3	0.15	1266.5	26.95
B5 – 24	1293.3	0.15	1266.5	26.95
B5 – 25	1293.3	0.15	1266.5	26.95
B5 – 26	1293.3	0.15	1266.5	26.95
B5 – 27	1293.3	0.15	1266.5	26.95
B5 – 28	1293.3	0.15	1266.5	26.95
B5 – 29	1293.3	0.15	1266.5	26.95
B5 – 30	1293.3	0.15	1266.5	26.95
B5 – 31	1293.3	0.15	1266.5	26.95
B5 – 32	1293.3	0.15	1266.5	26.95
B5 – 33	1293.3	0.15	1266.5	26.95
B5 – 34	1293.3	0.15	1266.5	26.95
B5 – 35	1293.3	0.15	1266.5	26.95
B5 – 36	1293.3	0.15	1266.5	26.95
B5 – 37	1293.3	0.15	1266.5	26.95
B5 – 38	1293.3	0.15	1266.5	26.95
B5 – 39	1293.3	0.15	1266.5	26.95
B5 – 40	1293.3	0.15	1266.5	26.95
B5 – 41	1293.3	0.15	1266.5	26.95
B5 – 42	1293.3	0.15	1266.5	26.95
B5 – 43	1293.3	0.15	1266.5	26.95
B5 – 44	1293.3	0.15	1266.5	26.95
B5 – 45	1293.3	0.15	1266.5	26.95
B5 – 46	1293.3	0.15	1266.5	26.95
B5 – 47	1293.3	0.15	1266.5	26.95
B5 – 48	1293.3	0.15	1266.5	26.95
B5 – 49	1293.3	0.15	1266.5	26.95
B5 – 50	1293.3	0.15	1266.5	26.95
B5 – 51	1293.3	0.15	1266.5	26.95
B5 – 52	1293.3	0.15	1266.5	26.95
B5 – 53	1293.3	0.15	1266.5	26.95
B5 – 54	1293.3	0.15	1266.5	26.95
B5 – 55	1293.3	0.15	1266.5	26.95
B5 – 56	1293.3	0.15	1266.5	26.95
B5 – 57	1293.3	0.15	1266.5	26.95
B5 – 58	1293.3	0.15	1266.5	26.95
B5 – 59	1293.3	0.15	1266.5	26.95
B5 – 60	1293.3	0.15	1266.5	26.95
B5 – 61	1293.3	0.15	1266.5	26.95
B5 – 62	1293.3	0.15	1266.5	26.95
B5 – 63	1293.3	0.15	1266.5	26.95
B5 – 64	1293.3	0.15	1266.5	26.95
B5 – 65	1293.3	0.15	1266.5	26.95
B5 – 66	1293.3	0.15	1266.5	26.95
B5 – 67	1293.3	0.15	1266.5	26.95
B5 – 68	1293.3	0.15	1266.5	26.95
B5 – 69	1293.3	0.15	1266.5	26.95
B5 – 70	1293.3	0.15	1266.5	26.95
B5 – 71	1293.3	0.15	1266.5	26.95
B5 – 72	1293.3	0.15	1266.5	26.95
B5 – 73	1293.3	0.15	1266.5	26.95
B5 – 74	1293.3	0.15	1266.5	26.95
B5 – 75	1293.3	0.15	1266.5	26.95
	Total Pile Length (Bent 5) =		2021.250	m

32

Legacy Parkway: Bridge No 21

Group	Element	Reference #	Reference Drawing Title (s):	Sheet No (s)
Substructure	Bent 6 Piles	1	Foundation Plan	7 of 102
		2	Piling Plan	8 of 69

Calculated by: M.V.

Date: 7/13/2004

Description: Bent 6 Pile Quantity

Location	A Bottom of Pile Cap Elevation (m)	B Pile Embedment Length (m)	C Pile Tip Elevation (m)	D Pile Length (m)
B6 – 1	1293	0.15	1267.5	25.65
B6 – 2	1293	0.15	1267.5	25.65
B6 – 3	1293	0.15	1267.5	25.65
B6 – 4	1293	0.15	1267.5	25.65
B6 – 5	1293	0.15	1267.5	25.65
B6 – 6	1293	0.15	1267.5	25.65
B6 – 7	1293	0.15	1267.5	25.65
B6 – 8	1293	0.15	1267.5	25.65
B6 – 9	1293	0.15	1267.5	25.65
B6 – 10	1293	0.15	1267.5	25.65
B6 – 11	1293	0.15	1267.5	25.65
B6 – 12	1293	0.15	1267.5	25.65
B6 – 13	1293	0.15	1267.5	25.65
B6 – 14	1293	0.15	1267.5	25.65
B6 – 15	1293	0.15	1267.5	25.65
B6 – 16	1293	0.15	1267.5	25.65
B6 – 17	1293	0.15	1267.5	25.65
B6 – 18	1293	0.15	1267.5	25.65
B6 – 19	1293	0.15	1267.5	25.65
B6 – 20	1293	0.15	1267.5	25.65
B6 – 21	1293	0.15	1267.5	25.65
B6 – 22	1293	0.15	1267.5	25.65
B6 – 23	1293	0.15	1267.5	25.65
B6 – 24	1293	0.15	1267.5	25.65
B6 – 25	1293	0.15	1267.5	25.65
B6 – 26	1293	0.15	1267.5	25.65
B6 – 27	1293	0.15	1267.5	25.65
B6 – 28	1293	0.15	1267.5	25.65
B6 – 29	1293	0.15	1267.5	25.65
B6 – 30	1293	0.15	1267.5	25.65
B6 – 31	1293	0.15	1267.5	25.65
B6 – 32	1293	0.15	1267.5	25.65
B6 – 33	1293	0.15	1267.5	25.65
B6 – 34	1293	0.15	1267.5	25.65
B6 – 35	1293	0.15	1267.5	25.65
B6 – 36	1293	0.15	1267.5	25.65
B6 – 37	1293	0.15	1267.5	25.65
B6 – 38	1293	0.15	1267.5	25.65
B6 – 39	1293	0.15	1267.5	25.65
B6 – 40	1293	0.15	1267.5	25.65
B6 – 41	1293	0.15	1267.5	25.65
B6 – 42	1293	0.15	1267.5	25.65
B6 – 43	1293	0.15	1267.5	25.65
B6 – 44	1293	0.15	1267.5	25.65
B6 – 45	1293	0.15	1267.5	25.65
B6 – 46	1293	0.15	1267.5	25.65
B6 – 47	1293	0.15	1267.5	25.65
B6 – 48	1293	0.15	1267.5	25.65
B6 – 49	1293	0.15	1267.5	25.65
B6 – 50	1293	0.15	1267.5	25.65
B6 – 51	1293	0.15	1267.5	25.65
B6 – 52	1293	0.15	1267.5	25.65
B6 – 53	1293	0.15	1267.5	25.65
B6 – 54	1293	0.15	1267.5	25.65
B6 – 55	1293	0.15	1267.5	25.65
B6 – 56	1293	0.15	1267.5	25.65
B6 – 57	1293	0.15	1267.5	25.65
B6 – 58	1293	0.15	1267.5	25.65
B6 – 59	1293	0.15	1267.5	25.65
B6 – 60	1293	0.15	1267.5	25.65
B6 – 61	1293	0.15	1267.5	25.65
B6 – 62	1293	0.15	1267.5	25.65
B6 – 63	1293	0.15	1267.5	25.65
B6 – 64	1293	0.15	1267.5	25.65
B6 – 65	1293	0.15	1267.5	25.65
B6 – 66	1293	0.15	1267.5	25.65
B6 – 67	1293	0.15	1267.5	25.65
B6 – 68	1293	0.15	1267.5	25.65
B6 – 69	1293	0.15	1267.5	25.65
B6 – 70	1293	0.15	1267.5	25.65
B6 – 71	1293	0.15	1267.5	25.65
B6 – 72	1293	0.15	1267.5	25.65
B6 – 73	1293	0.15	1267.5	25.65
B6 – 74	1293	0.15	1267.5	25.65
B6 – 75	1293	0.15	1267.5	25.65

Total Pile Length (Bent 2)= 1923.750 m

Legacy Parkway: Bridge No. 21

Group	Element	Reference #	Reference Drawing Title (s):	Sheet No (s)
Superstructure	Concrete Deck	1	Framing Plan	68 of 102

Calculated by: M.V.

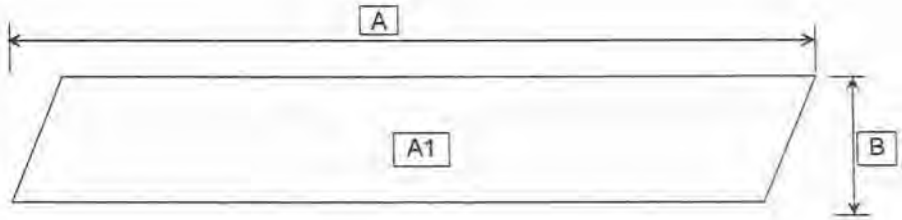
Date: 7/13/2004

Description: Concrete Slab Qty.

Location	A Length EJ to EJ (m)	B Width (m)
Deck	258.11	21.566

Location	C Surface area A1 A1 = A x B (m)	D Deck Depth (m)
Deck	5566.40	0.205

Total Concrete Deck Volume (1) = 1141.11 m3



Description: Additional Concrete Haunch at Prestress Girder

Location	D Dim "A" - Average per Span Conc. Haunch (m)	E Deck Thickness t (m)	F Additional Haunch Concrete at Girder h = D - E (m)	G Width of Haunch wh (m)	H Conc. Area per Haunch ah = F x G (m)	K Total Number of Haunches = # Girders # (m)	L Span Length # (m)	M Haunch Volume (m3)
Span 1	0.287	0.205	0.081818182	1.295	0.106	11	44.5	51.86
Span 2	**0.353**	**0.205**	**0.147545455**	**1.295**	**0.191**	**11**	**39.3**	**82.60**
Span 3	**0.310**	**0.205**	**0.105**	**1.295**	**0.136**	**11**	**47**	**70.30**
Span 4	**0.285**	**0.205**	**0.079727273**	**1.295**	**0.103**	**11**	**42.2**	**47.93**
Span 5	**0.373**	**0.205**	**0.167727273**	**1.295**	**0.217**	**11**	**35.55**	**84.94**
Span 6	**0.332**	**0.205**	**0.127272727**	**1.295**	**0.165**	**11**	**45.945**	**83.30**
								420.93

Total Concrete Deck Volume (1 + 3) = 1562.04 m3

34

52

Ramirez, Carlos

From: Cooper, Tom
Sent: Thursday, May 10, 2001 3:22 PM
To: Ramirez, Carlos; Subrizi, Cris D.; Wang, Fuxin; Nugent, Victoria
Subject: FW: Legacy Parkway - Bridge 28 Abutment

ABUTMENT BACKFILL PROPERTIES

Latest on abutment fill soil data.

—Original Message—
From: Kancheepuram "K" Gunalan [mailto:kgunalan@dot.state.ut.us]
Sent: Thursday, May 10, 2001 12:40 PM
To: Cooper, Tom
Cc: Cchristensen@kleinfelder.com; millern@kleinfelder.com; Nobari, Farid; Showers, Joseph I.
Subject: RE: Legacy Parkway - Bridge 28 Abutment

Tom: Hi! Since the backfill material will be an A-1-a material compacted to 97% in place, I think you could use 50,000KN/m3 for modulus of subgrade reaction value. You will receive directive from Joe on the distance between the wall and center line of pile shortly. You could probabl;y rely on about 50% of soil stiffness when pile moves toward the wall. I will confirm with wall supplier. We have not done anything at the south end yet. Will let you know as soon as we have the LPILE data for Br. 5. Thanks.

>>> "Cooper, Tom" <Cooper@pbworld.com> 05/09/01 04:44PM >>>
Guna,
Thanks for this information. there is some more information that we need for
the abutment analysis:
Is there a modulus of subgrade reaction value available for this material?
We have assumed 32,000kNm/m3 (sand). Please verify this value or provide
another for us to use in the pile design.
I understand that the distance from the cl of the pile to the LOL of the MSE
wall is 3 meters. How much of the soil stiffness can we count on when the
pile is moving toward the MSE wall?
Is soil information (L-pile data) available yet for Bridge 5?

Joe,
Has it been decided to eliminate the piles on the ends of the wingwalls?

Regards,
Tom

*

—Original Message—
From: Kancheepuram "K" Gunalan [mailto:kgunalan@dot.state.ut.us <mailto:kgunalan@dot.state.ut.us>]
Sent: Friday, May 04, 2001 1:25 PM
To: Cooper, Tom
Cc: Showers, Joseph I.
Subject: Re: Legacy Parkway - Bridge 28 Abutment

Tom; I am sorry, I sent the backfill info to Takahiko. Asked him to use a unit weight of 142 pcf, an angle of internal friction of 32 deg. and an active pressure coefficient of 0.3. With regard to down drag, I was under the impression that the piles will be sleeved with a 18 inch sleeve to take care of down drag within the embankment. Hope this is what you were looking for. Thanks.

>>> "Cooper, Tom" <Cooper@pbworld.com> 05/01/01 02:52PM >>>
Taka,
A few questions on the abutment design:

1. Do you have a general layout for the Type A abutment we are to be using for Bridge 28? Please forward to us if you do. We are currently using the layout from the 30% drawings.

2. The DL and LL information you provided to us was per girder. How many girders does Bridge 28 have?
What is the total DL and LL for the structure?

Guna, could you please address the following questions?
3. Have any decisions been made on how to handle downdrag from the fills on the project? Do you know what the assumption will be for downdrag loads on Bridge 28?

4. Do we have soil parameters to use for the engineered fill at the abutments? we need this information to complete the L-pile analysis and determine system stiffness developed by the passive resistance of the soil.

Regards,

Tom

Ramirez, Carlos

From: Cooper, Tom
Sent: Friday, May 04, 2001 5:02 PM
To: Ramirez, Carlos; Wang, Fuxin; Nobari, Farid
Subject: FW: Legacy Parkway - Bridge 28 Abutment

Carlos,
Let me know if you need more information.

Tom

——Original Message——
From: Kancheepuram "K" Gunalan [mailto:kgunalan@dot.state.ut.us]
Sent: Friday, May 04, 2001 1:25 PM
To: Cooper, Tom
Cc: Showers, Joseph I.
Subject: Re: Legacy Parkway - Bridge 28 Abutment

22.31 kN/m³

Tom; I am sorry, I sent the backfill info to Takahiko.. Asked him to use a unti weight of 142 pcf, an angle of internal friction of 32 deg. and an active pressure coefficient of 0.3. With regard to down drag, I was under the impression that the piles will be sleeved with a 18 inch sleeve to take care of down drag within the embankment. Hope this is what you were looking for. Thanks.

What do I assume for E, modulus of subgrade reaction
Sand

>>> "Cooper, Tom" <Cooper@pbworld.com> 05/01/01 02:52PM >>>
Taka,
A few questions on the abutment design:

1. Do you have a general layout for the Type A abutment we are to be using
for Bridge 28? Please forward to us if you do.
We
are currently using the layout from the 30% drawings.

2. The DL and LL information you provided to us was per girder. How many
girders does Bridge 28 have?
What is the total DL and LL for the structure?

Guna, could you please address the following questions?
3. Have any decisions been made on how to handle downdrag from the fills on
the project? Do you know what the assumption will be for downdrag loads on
Bridge 28?

4. Do we have soil parameters to use for the engineered fill at the abutments? we need this information to complete the L-pile analysis and determine system stiffness developed by the passive resistance of the soil.

Regards,

Tom

PILE GROUP ANALYSIS PROGRAM-GROUP
PC VERSION 5.0 (C) COPYRIGHT ENSOFT,INC. 2000

THE PROGRAM WAS COMPILED USING THE MICROSOFT FORTRAN
POWERSTATION 4 0 (C) COPYRIGHT MICROSOFT CORPORATION, 1996.

PILE GROUP ANALYSIS PROGRAM-GROUP
PC VERSION 5.0 (C) COPYRIGHT ENSOFT,INC. 2000

THE PROGRAM WAS COMPILED USING MICROSOFT FORTRAN
POWERSTATION 4.0 (C) COPYRIGHT MICROSOFT CORPORATION, 1996.

Legacy Parkway ===> Bridge 21

***** INPUT INFORMATION *****

* TABLE C * LOAD AND CONTROL PARAMETERS

UNITS--^@^@^@^@

V LOAD, KN	H LOAD, KN	MOMENT, KN- M
0 1686E+05	0 8377E+04	-0.4561E+05

* THE LOADING IS STATIC *

KPYOP = 0 (CODE TO GENERATE P-Y CURVES)

(KPYOP = 1 IF P-Y YES; = 0 IF P-Y NO; = -1 IF P-Y ONLY)

* CONTROL PARAMETERS *

TOLERANCE ON CONVERGENCE OF FOUNDATION REACTION	=	0.254E-06	M
TOLERANCE ON DETERMINATION OF DEFLECTIONS	=	0.254E-06	M
MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS	=	100	
MAXIMUM NO. OF ITERATIONS ALLOWED FOR PILE ANALYSIS	=	100	

* TABLE D * ARRANGEMENT OF PILE GROUPS

GROUP	CONNECT	NO OF PILE	PILE NO	L-S CURVE	P-Y CURVE
1	PIN	5	1	1	0
2	PIN	5	1	1	0
3	PIN	5	1	1	0
4	PIN	5	1	1	0
5	PIN	5	1	1	0

GROUP	VERT, M	HOR, M	SLOPE, M/ M	GROUND, M	SPRING, KN- M
1	0.0000E+00	0.2440E+01	0.0000E+00	-0.3800E+01	0.0000E+00
2	0.0000E+00	0 1220E+01	0 0000E+00	-0.3800E+01	0 0000E+00
3	0 0000E+00	0.0000E+00	0.0000E+00	-0 3800E+01	0.0000E+00
4	0 0000E+00	-0.1220E+01	0.0000E+00	-0.3800E+01	0.0000E+00
5	0.0000E+00	-0.2440E+01	0.0000E+00	-0.3800E+01	0 0000E+00

* TABLE E * PILE GEOMETRY AND PROPERTIES

PILE	SEC	INC	LENGTH, M	E , KN/ M**2
1	1	100	0 3000E+02	0 2000E+09

PILE	FROM, M	TO, M	DIAM, M	AREA, M**2	I, M**4
1	0.0000E+00	0.3000E+02	0.4060E+00	0.2652E-01	0 3710E-03

* THE PILE ABOVE IS OF LINEARLY ELASTIC MATERIAL *

* TABLE F * AXIAL LOAD VS SETTLEMENT

(THE LOAD-SETTLEMENT CURVE IS GENERATED INTERNALLY)

NUM OF CURVES 1

CURVE 1 NUM OF POINTS = 19

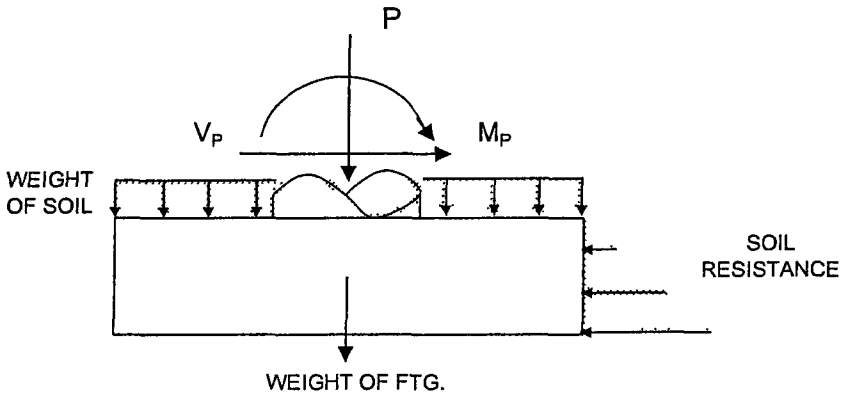
POINT	AXIAL LOAD, KN	SETTLEMENT, M
1	-0 2538E+04	-0 6064E-01
2	-0 2339E+04	-0 3437E-01
3	-0 2239E+04	-0 2123E-01
4	-0 1455E+04	-0.7624E-02
5	-0 1111E+04	-0 4864E-02
6	-0 4604E+03	-0 1444E-02
7	-0 2385E+03	-0 7412E-03

GROUP Analysis

Group VII Loading: 1.0 (1.0D + 1.0E + 1.0B + 1.0SF + 1.0EQ) [AASHTO Table 3.22.1A]

0 0 0

BENT	COLUMN	DIRECTION	D		EQ		+	–
4	1	TRANS	1.0(6 948.2 kN	±	6 878.8 kN)	=	13 827 kN	69 kN
4	2	TRANS	1.0(7 029.4 kN	±	25.9 kN)	=	7 055 kN	7 004 kN
4	3	TRANS	1.0(6 943.2 kN	±	6 861.9 kN)	=	13 805 kN	81 kN
4	1	LONG	1.0(6 948.2 kN	±	3 488.6 kN)	=	10 437 kN	3 460 kN
4	2	LONG	1.0(7 029.4 kN	±	42.7 kN)	=	7 072 kN	6 987 kN
4	3	LONG	1.0(6 943.2 kN	±	3 475.7 kN)	=	10 419 kN	3 468 kN



BENT 4

GROUP Analysis

→ **TRANSVERSE DEMAND AT TOP OF PILES**

Metric

Footing Depth = 2 000 M
Footing Width = 6 100 M
Footing Length = 6.100 M
Column Length = 6.890 M

	Axial	Shear	Moment
Bottom of Column Forces	13 827 kn	8 377 kn	28 857 kn-m
+ Footing Weight	1 753 kn	– kn	– kn-m
+ Soil Weight	1 284 kn	– kn	– kn-m
- Soil Passive Resistance	– kn	– kn	– kn-m
+ Moment due to Shear x (Ftg depth)	– kn	– kn	16 753 kn-m
= Demand @ Top of Piles	**16 864** kn	**8 377** kn	**45 610** kn-m

English

Footing Depth = 6 56 FT
Footing Width = 20.01 FT
Footing Length = 20 01 FT
Column Length = 22 60 FT

	Axial	Shear	Moment
Column Forces	3 108 kips	1 883 kips	21 284 kip-ft
+ Footing Weight	394 kips	– kips	– kip-ft
+ Soil Weight	289 kips	– kips	– kip-ft
- Soil Passive Resistance	– kips	– kips	– kip-ft
+ Moment due to Shear x (Ftg depth)	– kips	– kips	12 356 kip-ft
= Demand @ Top of Piles	**3 791** kips	**1 883** kips	**33 640** kip-ft

Note.

Bottom of Column Demands are due to Column Plastic Hinging .

GROUP Analysis

→ **LONGITUDINAL DEMAND AT TOP OF PILES**

Metric

Footing Depth = 2.000 M
Footing Width = 6.100 M
Footing Length = 6.100 M
Column Length = 6.890 M

	Axial	Shear	Moment
Bottom of Column Forces	10 437 kn	4 029 kn	27 760 kn-m
+ Footing Weight	1 753 kn	– kn	– kn-m
+ Soil Weight	1 284 kn	– kn	– kn-m
- Soil Passive Resistance	– kn	– kn	– kn-m
+ Moment due to Shear x (Ftg depth)	– kn	– kn	8 058 kn-m
= Demand @ Top of Piles	**13 474** kn	**4 029** kn	**35 819** kn-m

English

Footing Depth = 6.56 FT
Footing Width = 20.01 FT
Footing Length = 20.01 FT
Column Length = 22.60 FT

	Axial	Shear	Moment
Column Forces	2 346 kips	906 kips	20 475 kip-ft
+ Footing Weight	394 kips	– kips	– kip-ft
+ Soil Weight	289 kips	– kips	– kip-ft
- Soil Passive Resistance	– kips	– kips	– kip-ft
+ Moment due to Shear x (Ftg depth)	– kips	– kips	5 943 kip-ft
= Demand @ Top of Piles	**3 029** kips	**906** kips	**26 418** kip-ft

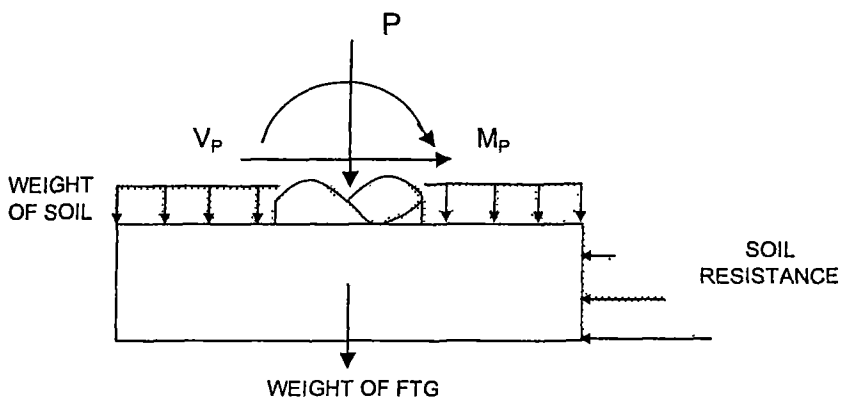
Note:

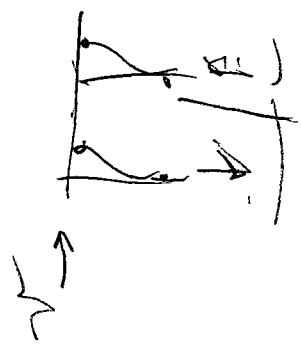
Bottom of Column Demands are due to Column Plastic Hinging .

GROUP Analysis

Group VII Loading: 1.0 (1.0D + ~~1.0E~~ (0) + ~~1.0B~~ (0) + ~~1.0SF~~ (0) + 1.0EQ) [AASHTO Table 3 22 1A]

BENT	COLUMN	DIRECTION	D		EQ		+	−
5	1	TRANS	1.0(5 180.3 kN	±	6 039 8 kN)	=	11 220 kN	- 860 kN
5	2	TRANS	1.0(5 228 3 kN	±	51 6 kN)	=	5 280 kN	5 177 kN
5	3	TRANS	1.0(5 163 6 kN	±	6 050.3 kN)	=	11 214 kN	- 887 kN
5	1	LONG	1.0(5 180.3 kN	±	3 079 9 kN)	=	8 260 kN	2 100 kN
5	2	LONG	1 0(5 228.3 kN	±	129 3 kN)	=	5 358 kN	5 099 kN
5	3	LONG	1.0(5 163 6 kN	±	3 031.9 kN)	=	8 196 kN	2 132 kN





BENT 5

GROUP Analysis

- run Bent 5 28019 Mp
- DL +

→ TRANSVERSE DEMAND AT TOP OF PILES

Metric

Footing Depth = 2 000 M
Footing Width = 6 100 M
Footing Length = 6.100 M
Column Length = 7 310 M

	Axial	Shear	Moment
Bottom of Column Forces	11 220 kn	7 666 kn	28 019 kn-m
+ Footing Weight	1 753 kn	– kn	– kn-m
+ Soil Weight	1 284 kn	– kn	– kn-m
- Soil Passive Resistance	– kn	– kn	– kn-m
+ Moment due to Shear x (Ftg depth)	– kn	– kn	15 332 kn-m
= Demand @ Top of Piles	**14 257** kn	**7 666** kn	**43 351** kn-m

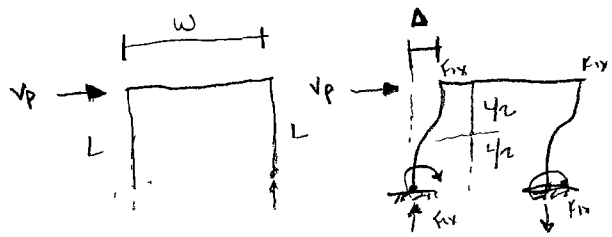
English

Footing Depth = 6.56 FT
Footing Width = 20 01 FT
Footing Length = 20.01 FT
Column Length = 23.98 FT

	Axial	Shear	Moment
Column Forces	2 522 kips	1 723 kips	20 666 kip-ft
+ Footing Weight	394 kips	– kips	– kip-ft
+ Soil Weight	289 kips	– kips	– kip-ft
- Soil Passive Resistance	– kips	– kips	– kip-ft
+ Moment due to Shear x (Ftg depth)	– kips	– kips	11 308 kip-ft
= Demand @ Top of Piles	**3 205** kips	**1 723** kips	**31 974** kip-ft

Note:

Bottom of Column Demands are due to Column Plastic Hinging .



GROUP Analysis

→ **LONGITUDIANL DEMAND AT TOP OF PILES**

Metric

Footing Depth = 2.000 M
Footing Width = 6.100 M
Footing Length = 6 100 M
Column Length = 7.310 M

	Axial	Shear	Moment
Bottom of Column Forces	8 260 kn	3 699 kn	27 036 kn-m
+ Footing Weight	1 753 kn	– kn	– kn-m
+ Soil Weight	1 284 kn	– kn	– kn-m
- Soil Passive Resistance	– kn	– kn	– kn-m
+ Moment due to Shear x (Ftg depth)	– kn	– kn	7 397 kn-m
= Demand @ Top of Piles	**11 297** kn	**3 699** kn	**34 433** kn-m

English

Footing Depth = 6.56 FT
Footing Width = 20.01 FT
Footing Length = 20.01 FT
Column Length = 23.98 FT

	Axial	Shear	Moment
Column Forces	1 857 kips	831 kips	19 941 kip-ft
+ Footing Weight	394 kips	– kips	– kip-ft
+ Soil Weight	289 kips	– kips	– kip-ft
- Soil Passive Resistance	– kips	– kips	– kip-ft
+ Moment due to Shear x (Ftg depth)	– kips	– kips	5 456 kip-ft
= Demand @ Top of Piles	**2 540** kips	**831** kips	**25 397** kip-ft

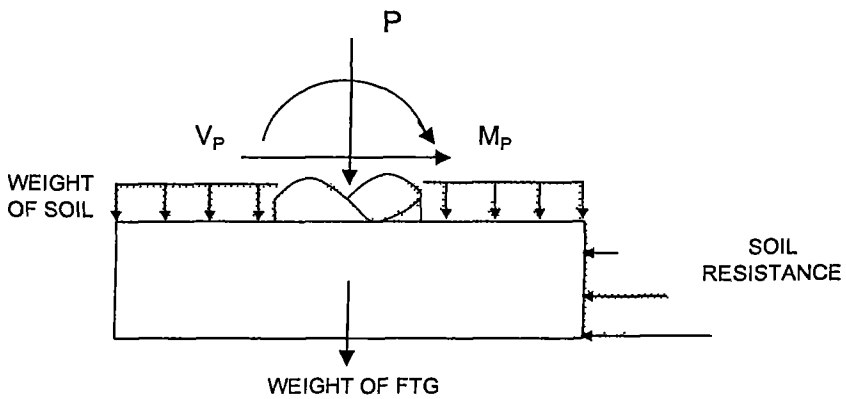
Note.

Bottom of Column Demands are due to Column Plastic Hinging .

GROUP Analysis

Group VII Loading: 1.0 (1.0D + 1.0E + 1.0B + 1.0SF + 1.0EQ) [AASHTO Table 3.22.1A]

BENT	COLUMN	DIRECTION	D		EQ		+	–
6	1	TRANS	1.0(7 068.1 kN	±	10 243.3 kN)	=	17 311 kN	-3 175 kN
6	2	TRANS	1.0(7 177.7 kN	±	77.2 kN)	=	7 255 kN	7 101 kN
6	3	TRANS	1.0(7 109.4 kN	±	10 237.3 kN)	=	17 347 kN	-3 128 kN
6	1	LONG	1.0(7 068.1 kN	±	5 033.4 kN)	=	12 102 kN	2 035 kN
6	2	LONG	1.0(7 177.7 kN	±	148.9 kN)	=	7 327 kN	7 029 kN
6	3	LONG	1.0(7 109.4 kN	±	5 068.1 kN)	=	12 178 kN	2 041 kN



BENT 6

GROUP Analysis

→ TRANSVERSE DEMAND AT TOP OF PILES

Metric

Footing Depth = 2 000 M
Footing Width = 6 000 M
Footing Length = 6 000 M
Column Length = 6 696 M

	Axial	Shear	Moment
Bottom of Column Forces	17 347 kn	8 940 kn	29 930 kn-m
+ Footing Weight	1 696 kn	– kn	– kn-m
+ Soil Weight	1 093 kn	– kn	– kn-m
- Soil Passive Resistance	– kn	– kn	– kn-m
+ Moment due to Shear x (Ftg depth)	– kn	– kn	17 879 kn-m
= Demand @ Top of Piles	**20 136** kn	**8 940** kn	**47 809** kn-m

English

Footing Depth = 6 56 FT
Footing Width = 19 69 FT
Footing Length = 19.69 FT
Column Length = 21.97 FT

	Axial	Shear	Moment
Column Forces	3 900 kips	2 010 kips	22 075 kip-ft
+ Footing Weight	381 kips	– kips	– kip-ft
+ Soil Weight	246 kips	– kips	– kip-ft
- Soil Passive Resistance	– kips	– kips	– kip-ft
+ Moment due to Shear x (Ftg depth)	– kips	– kips	13 187 kip-ft
= Demand @ Top of Piles	**4 527** kips	**2 010** kips	**35 262** kip-ft

Note:

Bottom of Column Demands are due to Column Plastic Hinging .

GROUP Analysis

→ **LONGITUDIANL DEMAND AT TOP OF PILES**

Metric

Footing Depth = 2.000 M
Footing Width = 6.000 M
Footing Length = 6.000 M
Column Length = 6.696 M

	Axial	Shear	Moment
Bottom of Column Forces	12 178 kn	4 231 kn	28 328 kn-m
+ Footing Weight	1 696 kn	– kn	– kn-m
+ Soil Weight	1 093 kn	– kn	– kn-m
- Soil Passive Resistance	– kn	– kn	– kn-m
+ Moment due to Shear x (Ftg depth)	– kn	– kn	8 461 kn-m
= Demand @ Top of Piles	**14 966** kn	**4 231** kn	**36 790** kn-m

English

Footing Depth = 6.56 FT
Footing Width = 19 69 FT
Footing Length = 19 69 FT
Column Length = 21.97 FT

	Axial	Shear	Moment
Column Forces	2 738 kips	951 kips	20 894 kip-ft
+ Footing Weight	381 kips	– kips	– kip-ft
+ Soil Weight	246 kips	– kips	– kip-ft
- Soil Passive Resistance	– kips	– kips	– kip-ft
+ Moment due to Shear x (Ftg depth)	– kips	– kips	6 241 kip-ft
= Demand @ Top of Piles	**3 365** kips	**951** kips	**27 135** kip-ft

Note.

Bottom of Column Demands are due to Column Plastic Hinging .

Abutments

BRIDGE 21: Service Load

Service Load Check:

Total Dead Load =	8,505 kn
Total Live Load =	12,043 kn
Total Service Load =	20,548 kn
Number of Piles =	22 kn
Total Service Load =	934 kn
Factor of Safety =	2.25
Pile Capacity =	6183 kn

Service Load Check :

2.25 X 934 = 2,102 kn < 6,183 kn → *OK*

Structure Capacity Check:

Dead Load Per Pile (DL) =	387 kn
Down Drag Load Load (DD) =	1,551 kn
Structure Capacity =	6183 kn

Factor Load = 1.3DL+1.8DD = 2,792 kN < 6,183 kN → *OK*

Bent

BRIDGE 21: Service Load

Service Load Check:

Total Dead Load =	11000 kn
Total Live Load =	5,700 kn
Total Service Load =	16,700 kn
Number of Piles =	25 kn
Total Service Load =	668 kn
Factor of Safety =	2.25
Pile Capacity =	6183 kn

Service Load Check :

2.25 X 668 = 1,503 kn < 6,183 kn → *OK*

Structure Capacity Check:

Dead Load Per Pile (DL) =	440 kn
Down Drag Load Load (DD) =	2,764 kn
Structure Capacity =	6183 kn

Factor Load = 1.3DL+1.8DD = 4,975 kN < 6,183 kN → *OK*

LEGACY PARKWAY

BRIDGE 22 SEISMIC DESIGN STRATEGY

INTRODUCTION

Seismic Design of the bridges for the Legacy Parkway project is primarily based on AASHTO and amended by project specific design criteria, which, addresses issues not specifically accounted for by the AASHTO code.

GENERAL STRUCTURE DESCRIPTION

The structure is 339.5 m long with six-spans (40.0 m, 62.5 m, 65.0 m, 65.3 m, 63.8 m, 43.0 m). The substructure consists of short seat type abutments and single column bents with non-integral caps. The abutments are supported by two rows of concrete filled steel pipe piles (typical: 406 mm diameter x 10 mm). Columns range in height from 10.5 m to 12.1 m. The columns are octagonal with a diameter of 2.5 m. Each column is supported on individual pile group foundation, with typical concrete filled steel pipe piles. The superstructure consists of 4 built up steel girders made composite with a concrete deck. Superstructure girders are supported on pot bearings, which are welded to the base plate, on top of the bent caps. At the abutments, the elastomeric bearings are allowed to be fused to slide over the seat, and interact with back-fill soil.

LEVEL OF PERFORMANCE

This structure is designed as an "Essential Bridge" under the definition provided by AASHTO (Division 1-A). The seismic performance of the structure is "Serviceability", following minor repairs, which may be required, after the event of "Design Level Earthquake"

SEISMICITY

The structure is designed for PGA = 0.6g AASHTO curves for Type III soil are used to account for soil amplification.

SEISMIC BEHAVIOR

Seismic design strategy for this structure consists of:

- Lateral load transfer to piers, via bearings and shear keys
- Mobilization of backfill soil behind the abutments.
- Limited plastic hinging in columns

The strategy includes strength design of bearing connections to resist service loads such as wind, and braking forces, as well as, the design level earthquake. The bearing connections are designed to transfer forces to the substructure The columns were designed using a reduction factor (R) of 3, as permitted by AASHTO for single columns designed for Category D This

design approach results in an estimated maximum top of column deflection of approximately 150 mm.
At the abutments, and primarily in the longitudinal direction, the backfill soil provides additional resistance strength to limit the extent of superstructure movement Backfill contributions has been limited to 7.7 KSF passive resistance.

EXPECTED DAMAGE UNDER DESIGN EVENT

Damage to the abutments will be limited to backwall failure. The superstructure is expected to displace longitudinally on the abutment seats The abutment seats are sized to accommodate the estimated seismic displacements
The expected inspection and immediate repair which may be required, following a design level earthquake, will be centering the bridge near it's original position, and temporary repairs over bridge joints to allow for traffic While the bridge can be opened to traffic following the immediate repair tasks, follow-up repairs may be necessary to replace damaged bearings. Refer to table below for expected seismic performance of various bridge components.

Table 1. Expected Seismic Performance

Abutments	• Damage to backwall possible • Maximum longitudinal displacement ~ 89 mm • Essentially elastic pile response
Bearings	• Fuse feature at abutment, may require bearing replacement or repositioning
Columns	• R = 3, cracking and spalling. Repair by epoxy injection
Foundations	• Piles remain essentially elastic
Joints	• Moderate damage requiring minor repair such as epoxy injection of cracks

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	22
Support(s)	Abut. 1
Water Depth (m)	13.0
Finished Grade Elevation (m)	1307.6
Soil Borings Used for Profile	RB-385; SC-27-341

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	3.8	20.3	-	-	37,350	32	0	39	0	8,790
2	Sand	3.8	11.1	20.3	-	-	37,350	32	39	114	8,790	25,680
3	Sand	11.1	13.0	19.9	-	-	18,450	33	95	112	18,110	21,150
4	Soft Clay	13.0	15.0	10.8	18	0.015	3,500	-	54	59	1,210	1,310
5	Sand	15.0	18.0	10.1	-	-	6,420	31	107	119	17,420	19,270
6	Silt	18.0	22.1	9.7	50	0.034	48,665	30	91	102	7,300	8,230
7	Sand	22.1	26.5	10.5	-	-	22,040	37	181	204	40,460	45,720
8	Sand	26.5	28.6	9.7	-	-	2,160	30	137	144	18,770	19,720
9	Sand	28.6	31.7	10.5	-	-	31,270	41	247	266	61,190	65,910

Press the "Copy" button to copy this tab to a new spreadsheet. The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies. Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers.

A12

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	22
Support(s)	Bent 2
Water Depth (m)	3.0
Finished Grade Elevation (m)	1297.0
Soil Borings Used for Profile	RB-385; SC-27-341

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	2.2	19.9	-	-	18,450	33	0	18	0	3,510
2	Soft Clay	2.2	3.0	20.6	18	0.015	3,500	-	9	12	200	270
3	Soft Clay	3.0	4.5	10.8	18	0.015	3,500	-	12	15	270	350
4	Sand	4.5	7.4	10.1	-	-	6,420	31	28	39	4,670	6,460
5	Silt	7.4	11.5	9.7	50	0.034	48,665	30	30	42	2,450	3,370
6	Sand	11.5	21.1	10.5	-	-	22,040	37	74	125	16,600	28,080
7	Stiff Clay with Free Water	21.1	23.3	9.7	57	0.034	57,665	-	55	60	1,930	2,100
8	Stiff Clay with Free Water	23.3	24.5	9.7	76	0.034	87,665	-	63	65	2,530	2,640
9	Sand	24.5	27.5	10.5	-	-	29,140	40	159	177	38,570	42,910
10	Silt	27.5	30.6	11.4	154	0.063	204,665	34	115	128	9,200	10,240

Press the "Copy" button to copy this tab to a new spreadsheet. The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies. Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers.

A13

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	22
Support(s)	Bent 4
Water Depth (m)	4.9
Finished Grade Elevation (m)	1300.8
Soil Borings Used for Profile	LSB-22-437

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	4.9	19.9	-	-	30,600	36	0	46	0	9,940
2	Sand	4.9	7.7	9.7	-	-	740	29	32	41	4,090	5,230
3	Soft Clay	7.7	10.0	10.8	24	0.015	9,665	-	26	31	640	770
4	Sand	10.0	12.6	9.7	-	-	4,290	30	53	62	8,070	9,430
5	Stiff Clay with Free Water	12.6	14.1	9.7	89	0.034	107,165	-	42	45	1,840	1,990
6	Sand	14.1	15.3	10.1	-	-	8,550	32	74	79	12,940	13,770
7	Sand	15.3	23.2	10.5	-	-	25,590	39	108	153	25,370	35,810
8	Sand	23.2	24.8	10.1	-	-	12,810	34	122	129	23,530	24,870
9	Sand	24.8	27.8	10.1	-	-	14,230	34	133	146	26,310	28,960
10	Sand	27.8	29.3	10.5	-	-	25,590	39	178	187	41,660	43,640

Press the "Copy" button to copy this tab to a new spreadsheet. The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies. Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers.

A14

Legacy Parkway,
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	22
Support(s)	Bent 4
Water Depth (m)	2.4
Finished Grade Elevation (m)	1297.5
Soil Borings Used for Profile	LSB-22-438; SC-27-344

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	2.4	19.5	-	-	900	29	0	15	0	2,070
2	Silt	2.4	3.5	10.0	37	0.027	29,165	29	13	16	1,040	1,290
3	Silt	3.5	10.8	9.7	89	0.034	107,165	31	18	41	1,470	3,300
4	Sand	10.8	18.2	10.9	-	-	32,690	41	77	125	19,340	31,420
5	Silt	18.2	19.4	9.7	89	0.034	107,165	31	67	70	5,360	5,660
6	Sand	19.4	20.2	10.1	-	-	16,360	35	102	105	20,970	21,730
7	Stiff Clay with Free Water	20.2	24.2	11.4	102	0.063	126,665	-	56	68	2,660	3,190
8	Silt	24.2	27.5	11.4	115	0.063	146,165	33	93	106	7,470	8,490
9	Sand	27.5	33.3	10.5	-	-	25,590	39	168	201	39,350	47,020

Press the "Copy" button to copy this tab to a new spreadsheet. The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies. Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers.

A15

Legacy Parkway,
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	22
Support(s)	Bent 6
Water Depth (m)	3.5
Finished Grade Elevation (m)	1297.5
Soil Borings Used for Profile	SB-27-345

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	1.6	19.5	-	-	2,250	30	0	11	0	1,600
2	Soft Clay	1.6	3.5	20.6	18	0.015	3,500	-	6	14	140	320
3	Soft Clay	3.5	9.6	10.8	18	0.015	3,500	-	14	28	320	620
4	Sand	9.6	14.1	9.7	-	-	2,870	30	47	62	6,690	8,840
5	Silt	14.1	15.3	9.7	83	0.034	96,665	31	56	60	4,530	4,820
6	Sand	15.3	20.4	10.1	-	-	15,650	35	87	110	17,690	22,440
7	Sand	20.4	21.7	10.1	-	-	8,550	32	96	101	16,610	17,510
8	Silt	21.7	22.9	11.4	109	0.063	135,665	32	85	90	6,860	7,220
9	Sand	22.9	26.5	10.5	-	-	29,140	40	153	175	37,210	42,420
10	Silt	26.5	29.6	11.4	128	0.063	165,665	33	107	119	8,600	9,590

Press the "Copy" button to copy this tab to a new spreadsheet. The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies. Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers.

A16

LEGACY PARKWAY
BRIDGE 22
PILE CAPACITY SUMMARY - PP 40E (9 5) (16" x 3/8)
YIELD STRENGTH = 440 MPa

A-1	Target Geotechnical Capacity per Pile (2 25xService Load)	2 261	kN
B 2	Target Geotechnical Capacity per Pile (2 25xService Load)	1 391	kN
B 3	Target Geotechnical Capacity per Pile (2 25xService Load)	1 577	kN
B 4	Target Geotechnical Capacity per Pile (2 25xService Load)	1,431	kN
B 5	Target Geotechnical Capacity per Pile (2 25xService Load)	1,020	kN
B 6	Target Geotechnical Capacity per Pile (2 25xService Load)	1,668	kN
A 7	Target Geotechnical Capacity per Pile (2 25xService Load)	3 312	kN

(Target Service Load Provided by Structural Engineer)

	Initials	Date
Completed By	NM	9/18/01
Reviewed By	CC	9/18/01

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Location	Finished Grade Elevation (m)	Bottom of Pile Cap Elevation (m)	Est. Embankm Height (m)	Target Pile Tip Elevation (m)	Minimum Pile Tip Elevation (m)	Service Uplift Load Resistance (kN)	Required Seismic Compression Resistance (kN)	Required Seismic Uplift Resistance (kN)	Service Load (DL + LL) (kN)	Required Driving Resistance (kN)	Est Pile Length w/ fill (m)	Estimated Maximum Structural Load in Pile (Fill) (Service Load + Drag Load)	Est. Elevation of Neutral Plane (m)	Estimated Pile Tip Settlement (mm)
Bridge 22 Abutment 1	1307 5	1302 8	11 0	1262 5	1282.5	740	N/A	N/A	1,005	2 261	21	2,076	1266 4	3
Bridge 22 Bent 2	1297 0	1292.0	-	1266 0	1266 0	1,254	3 070	1,925	618	3,379	26	2,796	1268 8	6
Bridge 22 Bent 3	1297.0	1292 0	-	1271.8	1271 8	832	3 070	1,925	701	3,240	21	2,058	1275 4	3
Bridge 22 Bent 4	1300 8	1293 0	-	1276 0	1276 0	988	3,070	1,925	658	3,360	17	2,206	1278 8	4
Bridge 22 Bent 5	1297 5	1294.4	-	1267 9	1267 9	1,213	3,120	2,170	457	3,665	27	2,445	1271 5	5
Bridge 22, Bent 6	1297 5	1294 4		1271 0	1271.0	1,015	3 070	1,925	750	3 369	24	2 449	1273 2	5
Bridge 22 Abutment 7	1310 1	1305 4	12 1	1285 1	1285 1	771	N/A	N/A	1 472	3 312	21	2,562	1289 2	4

Location	Borings Used for Soil Profile
Bridge 22 Abutment 1	AB-385 SC 27-341, LSB 22 435
Bridge 22 Bent 2	AB 385, SC 27 341; LSB-22-436
Bridge 22 Bent 3	LSB-22-437
Bridge 22 Bent 4	LSB 22-437
Bridge 22 Bent 5	LSB 22-438 SC 27-344
Bridge 22 Bent 6	SB 27 345; LSB 22-439
Bridge 22 Abutment 7	LSB-22-440

Description of Information Presented in Each Column.

A Finished Grade Elevation Top of approach slab elevation at abutment locations and adjacent ground elevation at bent locations as shown on the structure Plan and Profile drawing provided

B Bottom of Pile Cap Elevation - Elevation at the bottom of the pile cap as scaled from the structure Plan and Profile drawing provided

C Estimated Embankment Height Elevation difference between the top of the approach slab and the native ground surface at the abutment as scaled from the structure Plan and Profile drawing provided.

D Target Pile Tip Elevation - Estimated elevation to which the bottom of the pile will need to be driven to develop the required capacity and meet the settlement criteria (Additional depth may be required to reach required resistance during driving)

E Minimum Pile Tip Elevation Estimated minimum elevation to which the bottom of the pile will need to be driven to meet settlement, maximum length, or minimum depth criteria should the required driving resistance be obtained above the Target Pile Tip Elevation

F Service Uplift Load Resistance = (Ultimate Friction Resistance)/(FS=2.25) Per comment resolution meeting with ODOT (8/15/01)

G. Seismic Compression Resistance = Ultimate Friction and End Bearing Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate resistance values to resist seismic loads)

H Seismic Uplift Resistance = Ultimate Friction Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate friction resistance value to resist seismic uplift loads.)

I Service Load (DL + LL) - The maximum load that can be applied at the top of the pile by the structure provided the pile is driven to the assumed capacity

J Required Driving Resistance - The minimum load (service load x 2 25 or required seismic resistance plus estimated loss during liquefaction whichever is greater) that must be verified in the field by PDA

K- Estimated Pile Length w/ Fill - The estimate length of pile required Calculated as (Bottom Of Pile Cap - Estimated Tip Elevation) rounded up to the nearest meter (Actual lengths may vary depending on driving conditions encountered at each pile location)

L Estimated Structural Load in the Pile The largest load that will develop in the pile due to structural service (dead) loads and drag loads This load occurs at the neutral plane where equilibrium exists between the sum of the downward acting permanent load (service load) applied at the top of the pile and drag load due to negative skin friction and the sum of upward acting positive shaft resistance and mobilized toe resistance.

M Estimated Elevation of Neutral Plane - The level in the pile where relative movement between the pile and soil is zero.

N Estimated Pile Tip Settlement - The magnitude of pile tip settlement required to mobilize estimated pile tip loads This does not include elastic compression of the pile

A17

A 18

Memorandum

LEGACY

Date: 11/01/2001 *File Code:* GDM-STR-005Rev.2

To: Joe Showers

From: K. N. Gunalan
Curt Christensen

Subject: Geotechnical Recommendations for Bridge 22

Cc: DocC, Kleinfelder, Tom Cooper

Introduction

This memorandum presents our Geotechnical evaluation and recommendations developed in accordance with UDOT's Geotechnical MOI for Bridge 22. Included herein is our evaluation of liquefaction and lateral spread concerns at the bridge location. Detailed descriptions of our understanding of the project, geology, soils encountered etc. will be incorporated into the project Geotechnical report and submitted along with other documents as part of final submittal for the project. This information will be maintained in the project files for reference until being incorporated into the final report.

General Geotechnical Conditions

Geotechnical conditions at the site are defined by previous investigations performed for UDOT Based on the information obtained during those investigations and a subsequent investigation undertaken by FAK, the profile at the north interchange can be defined as consisting of interbedded medium stiff to stiff silts, clay and loose to medium dense sand and gravel layers in the upper 10 to 15 meters. Dense to very dense silty sands, poorly graded sands and poorly graded gravel with lenses of silts and clays were encountered below 10 to 15 meters. Ground water was encountered at depths ranging from 1 0 to 1 5 meters.

Liquefaction Potential

Bridge 22 falls within the Farmington Siding landslide complex, which consists of liquefaction induced landslides The bridge site is located within the older mapped portion of this complex, approximately 0 5 km southeast of the mapped contact with the younger portion of the complex. These slides date back to latest Pleistocene and Holocene time UGS studies indicate that susceptibility to liquefaction induced land sliding may be less than the earlier times due to lower verage lake and associated ground water levels The study also indicated that above average precipitation could create locally perched conditions which when subject to strong ground

motions could liquefy and slide. Therefore, a study was undertaken to evaluate the potential for liquefaction and lateral spread at Bridge 22. Information obtained from a total of ~~nine~~ eight exploratory borings and ~~four~~ two CPT soundings located at or near the bridge site were used in this evaluation. Evaluations indicated layers of silts and sands may liquefy under an earthquake of magnitude 7.3 with a peak horizontal ground acceleration of 0.6g. SNG 4/19/02

Additionally, soil profiles from the borings at the bridge site were reviewed for liquefaction induced lateral spread potential. Based on the analysis liquefaction induced settlement was determined to range from 73 mm in boring SB-27-345 to 210 mm in boring SB-27-340. The potential for lateral spread was estimated to be negligible in one of the borings, with upto 2.8 m in boring SB-27-340. Lateral spread magnitude determined in boring SB-27-340 was based on field and laboratory data from phase I investigations. It is our opinion that further testing would indicate that the layer contributing to the lateral spread is actually made up of thinner layers and therefore the magnitude would be much smaller.

In general, the layers indicating lateral spread potential along the alignment of this structure are less than 1 m in thickness. The database used for the development of the empirical lateral spread equations presently includes limited data for layers less than 1 meter in thickness. For these thinner layers small displacements were observed. Since the database contains only a few points with layers less than 1 m in thickness and observed displacements were small, the estimated displacement for the layers described above is probably greater than the actual displacement potential and the accuracy of these estimates is questionable. In addition, thinner layers should only be considered a candidate for lateral spread if they appear to be continuous. It is our opinion that such a continuous layer does not appear to be present along the alignment of this structure.

Recommendations

It is our understanding that 406 mm (16 in.) diameter pipe piles are being proposed for the bridge foundations and that the anticipated service load per pile at the abutments 1 and 7 range from 1005 kN to 1472 kN. Service load per pile at the bents 2 through 6 range from 457 kN to 750 kN. Seismic uplift resistance required at bent 2 through 6 range from 1925 kN to 2170 kN. Recommended pile capacities and Geotechnical parameters required for analysis and design are presented in attached table.

Wang, Fuxin

From: Cooper, Tom
Sent: Thursday, May 10, 2001 3:22 PM
: Ramirez, Carlos; Subrizi, Cris D.; Wang, Fuxin; Nugent, Victoria
ubject: FW: Legacy Parkway - Bridge 28 Abutment

Latest on abutment fill soil data.

-----Original Message-----
From: Kancheepuram "K" Gunalan [mailto:kgunalan@dot.state.ut.us]
Sent: Thursday, May 10, 2001 12:40 PM
To: Cooper, Tom
Cc: Cchristensen@kleinfelder.com; millern@kleinfelder.com; Nobari, Farid; Showers, Joseph I.
Subject: RE: Legacy Parkway - Bridge 28 Abutment

Tom: Hi! Since the backfill material will be an A-1-a material compacted to 97% in place, I think you could use 50,000KN/m3 for modulus of subgrade reaction value. You will receive directive from Joe on the distance between the wall and center line of pile shortly. You could probabl;y rely on about 50% of soil stiffness when pile moves toward the wall. I will confirm with wall supplier. We have not done anything at the south end yet. Will let you know as soon as we have the LPILE data for Br. 5. Thanks.

>>> "Cooper, Tom" <Cooper@pbworld.com> 05/09/01 04:44PM >>>
Guna,
Thanks for this information. there is some more information that we need for
the abutment analysis:
 there a modulus of subgrade reaction value available for this aterial?
We have assumed 32,000kNm/m3 (sand). Please verify this value or provide
another for us to use in the pile design.
I understand that the distance from the cl of the pile to the LOL of the MSE
wall is 3 meters. How much of the soil stiffness can we count on when the
pile is moving toward the MSE wall?
Is soil information (L-pile data) available yet for Bridge 5?

Joe,
Has it been decided to eliminate the piles on the ends of the wingwalls?

Regards,
Tom

*

-----Original Message-----
From: Kancheepuram "K" Gunalan [mailto:kgunalan@dot.state.ut.us <mailto:kgunalan@dot.state.ut.us>]
Sent: Friday, May 04, 2001 1:25 PM
To: Cooper, Tom
Cc: Showers, Joseph I.
Subject: Re: Legacy Parkway - Bridge 28 Abutment

m; I am sorry, I sent the backfill info to Takahiko. Asked him to use a

0.082 lb/in.²

unti weight of 142 pcf, an angle of internal friction of 32 deg. and an active pressure coefficient of 0.3. With regard to down drag, I was under the impression that the piles will be sleeved with a 18 inch sleeve to take care of down drag within the embankment. Hope this is what you were looking for. Thanks.

30

>>> "Cooper, Tom" <Cooper@pbworld.com> 05/01/01 02:52PM >>>
Taka,
A few questions on the abutment design:

1. Do you have a general layout for the Type A abutment we are to be using for Bridge 28? Please forward to us if you do. We are currently using the layout from the 30% drawings.

2. The DL and LL information you provided to us was per girder. How many girders does Bridge 28 have?
What is the total DL and LL for the structure?

Guna, could you please address the following questions?
3. Have any decisions been made on how to handle downdrag from the fills on the project? Do you know what the assumption will be for downdrag loads on Bridge 28?

4. Do we have soil parameters to use for the engineered fill at the abutments? we need this information to complete the L-pile analysis and determine system stiffness developed by the passive resistance of the soil.

Regards,

Tom

Wang, Fuxin

From: Baron, Michael J
Sent: Tuesday, July 17, 2001 10.52 AM
To: Elwell, John; Cooper, Tom
Cc: Wang, Fuxin, Ramirez, Carlos; Nobari, Farid
Subject: RE: Br 22 & 25

Gentlemen,

Attached are the BSDI output files for the preliminary run of B22.

Reactions Unit 1 OUT Unit 1 Members OUT

Reactions Unit 2 OUT Unit 2 Members OUT

Unit 1 comprises spans 1 thru 3, while Unit 2 comprises spans 4 thru 6.

NOTE: The reactions for support 4 of unit 1 = reactions for support 1 of unit 2. *Do not add these together.*

Numbering sequence: BSDI 1 = PB GRDR 4

BSDI 2 = PB GRDR 3

BSDI 3 = PB GRDR 2

BSDI 4 = PB GRDR 1

Please contact me if I can be of any other help

Mike Baron

-----Original Message-----
From: Elwell, John
Sent: Tuesday, July 17, 2001 8.52 AM
To: Cooper, Tom
Cc: Wang, Fuxin; Ramirez, Carlos; Nobari, Farid; Baron, Michael J.
Subject: RE: Br 22 & 25

Tom,
MIke Baron is working on the preliminary run in Louisville. He should have some numbers soon.

-----Original Message-----
From: Cooper, Tom
Sent: Monday, July 16, 2001 10:56 PM
To: Elwell, John
Cc: Wang, Fuxin; Ramirez, Carlos; Nobari, Farid
Subject: Br 22 & 25

John,
Recommendations on superstructure properties to use for 22 and 25? Do you have preliminary data we can use - okay to be +/- 20% although I'm sure you are closer.
We've started 22 & 25 modeling - we'll put in updated superstrucrure as it becomes available

Wang, Fuxin

From: Cooper, Tom
Sent: Friday, July 27, 2001 5 43 PM
To: Wang, Fuxin
Cc: Ramirez, Carlos, Nugent, Victoria
Subject: RE. br. 22 & 25 foundation

At one time we were being told to use 250 ton, then 200 ton then but,
SERVICE LOADS WILL NOT CONTROL. 200 TONS is possible. Only use the higher loading capacities if lateral loads are not controlling. Otherwise the effective loads on the piles will not be 150 tons anyway (or 200 tons)
Since these designs are being advanced, please be conservative in assumptions
If we use soil improvment approach then it is possible that there will be an advantage to the 200ton design.

-----Original Message-----
From: Wang, Fuxin
Sent: Friday, July 27, 2001 5:15 PM
To: Cooper, Tom
Subject: RE: br. 22 & 25 foundation

Tom, sorry to bugs you again Victoria mentioned we update our pile capacity from 150ton to 200 ton, is that correct? Just want to confirm that this is the latest information.
Thanks

Frank

Fuxin Wang, PE
Parsons Brinckerhoff

Phone: (916) 567 - 2556
Fax: (916) 925 - 3517

There are no shortcuts to any place worth going

Sircar, Partha

From: Sircar, Partha
Sent: Thursday, August 30, 2001 4:01 PM
To: Nobari, Farid
Subject: RE: Bridge 22- Maximum seismic pile forces

Looks OK, except, you may have reduced the maximum tension to a little less, say 1800kN.

-----Original Message-----
From: Nobari, Farid
Sent: Thursday, August 30, 2001 3:22 PM
To: Curt christensen (E-mail); Nigel Miller (E-mail)
Cc: Showers, Joseph I.; Williams, David (US); Sircar, Partha; Cooper, Tom; Wang, Fuxin; Deschamps, J.D.; Nobari, Farid
Subject: Bridge 22- Maximum seismic pile forces

Nigel/Curt

As per our earlier conversation (Farid+Nigel) , Partha concluded lateral pile group analyses for Bridge 22 Square foundations, to assess maximum compression and tension loads under seismic loads. Bases on diagonal loading conditions, the following seismic loads are recommended for pile tip elevation for Bents 2, 3, 4, and 6 (Normal and skewed SQUARE foundations).

Maximum Tension = 2000 KN
Maximum Compression = 3000 KN

The above values are the governing values for all the square foundations (which were pretty close to eachother, anyway).

If there is anything else you need on this structure, please let me know.

Thanks.

Farid S. Nobari, P.E.
Senior Supervising Engineer
Parsons Brinckerhoff, Sacramento
Ph: (916) 567-2531 Fax: (916) 925-3517

Sircar, Partha

From: Sircar, Partha
ent: Thursday, August 30, 2001 11:57 AM
o: Nobari, Farid
Subject: RE: pile layouts

Here are my results based on rigid body movement of cap and piles:

Normal Loading Direction (Bents 2 & 6): Compression - 2591kN; Tension - 1130kN

Use above for Pile Penetration Elevations

Skewed (Diagonal) Loading Direction (Bents 3 & 4): Corner Piles - Compression - 3362kN; Tension - 1883kN
Next 2 near Corner - Compression - 2840 kN; Tension - 1375kN

Use for Pile Penetration Elevations: 3000kN for Compression; 1883kN for Tension

(Note: I have assigned a slightly lower compression, since only the corner piles are involved. In my GROUP4.0 analyses, Case 2, the capacity was 2800kN and still I had only 24mm of settlement of corner pile)

Please call me to discuss if required.

-----Original Message-----
From: Nobari, Farid
Sent: Thursday, August 30, 2001 9:50 AM
To: Sircar, Partha
Subject: FW: pile layouts

Partha
This is the most recent set of pile layouts.
In short:

Bent 2 Square 6X6 normal
Bent 3 Square 6X6 skewed (Diagonal)
Bent 4 Square 6X6 skewed (diagonal)
Bent 5 Rectangular 4X9 57 degrees skewed
Bent 6=square 6X6 Normal

Suggestion:
Based on diagonal run of a square foundation, e-mail me back with Maximum Compression/Tension force for all square bents (Bents 2,3,4,6). Then you can ask if Klienfelder has the results for Bent 5 (rectangular) or not. The chances are they may already have something from David and we may not have to do much.
Can you send this first e-mail (for square foundations) as soon as possible? Thanks

Farid

-----Original Message-----
From: Deschamps, J.D.
Sent: Wednesday, August 29, 2001 1:07 PM
To: Nobari, Farid
Subject: RE: pile layouts

I did a bit more looking for useful information.

front row pile spacing 1424-2900-2900-2900-2900-1448, 7 piles
back row pile spacing 2900-2900-2900-2900, 5 piles

the piles are designed for SERVICE LOADS ONLY with a 50kip lateral, and 500kip vertical capacities

Eric Leeker

Sircar, Partha

From: Sircar, Partha
ent: Thursday, August 30, 2001 11:57 AM
o: Nobari, Farid
Subject: RE: pile layouts

Here are my results based on rigid body movement of cap and piles:

Normal Loading Direction (Bents 2 & 6): Compression - 2591kN; Tension - 1130kN

Use above for Pile Penetration Elevations

Skewed (Diagonal) Loading Direction (Bents 3 & 4): Corner Piles - Compression - 3362kN; Tension - 1883kN
Next 2 near Corner - Compression - 2840 kN; Tension - 1375kN

Use for Pile Penetration Elevations: 3000kN for Compression; 1883kN for Tension

(Note: I have assigned a slightly lower compression, since only the corner piles are involved. In my GROUP4.0 analyses, Case 2, the capacity was 2800kN and still I had only 24mm of settlement of corner pile)

Please call me to discuss if required.

-----Original Message-----
From: Nobari, Farid
Sent: Thursday, August 30, 2001 9:50 AM
To: Sircar, Partha
Subject: FW: pile layouts

Partha
This is the most recent set of pile layouts.
In short:

Bent 2 Square 6X6 normal
Bent 3 Square 6X6 skewed (Diagonal)
Bent 4 Square 6X6 skewed (diagonal)
Bent 5 Rectangular 4X9 57 degrees skewed
Bent 6=square 6X6 Normal

Suggestion:
Based on diagonal run of a square foundation, e-mail me back with Maximum Compression/Tension force for all square bents (Bents 2,3,4,6). Then you can ask if Klienfelder has the results for Bent 5 (rectangular) or not. The chances are they may already have something from David and we may not have to do much.
Can you send this first e-mail (for square foundations) as soon as possible? Thanks

Farid

-----Original Message-----
From: Deschamps, J.D.
Sent: Wednesday, August 29, 2001 1:07 PM
To: Nobari, Farid
Subject: RE: pile layouts

I did a bit more looking for useful information.

front row pile spacing 1424-2900-2900-2900-2900-1448, 7 piles
back row pile spacing 2900-2900-2900-2900, 5 piles

the piles are designed for SERVICE LOADS ONLY with a 50kip lateral, and 500kip vertical capacities

Eric Leeker

PARSONS BRINCKERHOFF COMPUTATION SHEET

Page ____ of ____

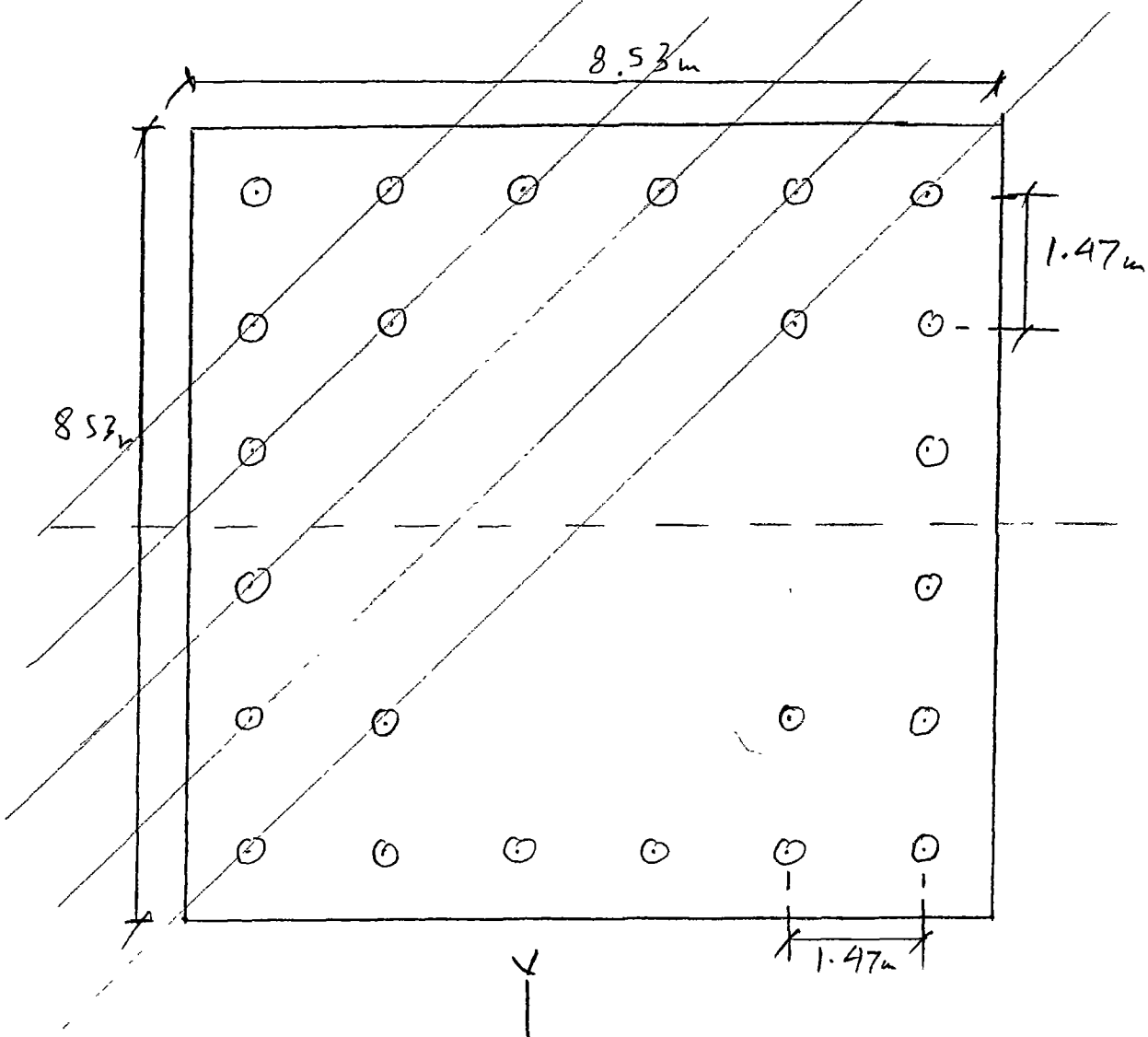
Made by P. Sircar

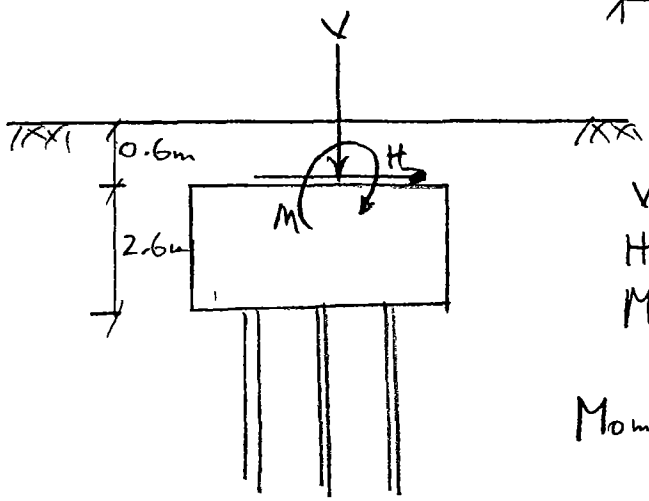
Date 8/30/01

Checked by ____

Date ____

Subject Design Loads on Piles
Legacy - Bridge 22





V = 17530 kN
H = 8400 kN
M = 81,000 kN-m

Moment on top of Piles
= 81000 + 8400 × 2.6 = 102,840 kn

24 Piles

PARSONS BRINCKERHOFF COMPUTATION SHEET

Subject: Design Loads on Piles
Legacy - Bridge 22

Page ____ of ____
Made by: P. Sircau
Date: 8/30/01
Checked by: ____
Date: ____

Normal Loading Direction (Bents 2 & 6)

$$I = 2\left[6\times(3.675)^2 + 4(2.205)^2 + 2(.735)^2\right]$$
$$= 2\left[81.03375 + 19.4481 + 1.08045\right) = 203.1246$$

$$\therefore \text{Maximum Axial Loads on Piles} = \frac{17530}{24} \pm \frac{102{,}840\times 3.675}{203.1246}$$
$$= 730.4 \pm 1860.6$$
$$= 2591 \text{ kN} \quad \text{--- Compression}$$
$$1130 \text{ kN} \quad \text{--- Tension}$$

Skewed (Diagonal) Loading Direction (Bents 3 and 4)

$$I = 2\left[1\times(5.197)^2 + 2(4.158)^2 + 3(3.118)^2 + 2(2.079)^2 + 2(1.0394)^2\right] + 4\times 0$$
$$= 2\left[27.009 + 34.579 + 29.166 + 8.644 + 2.161\right] = 203.118$$

$$\therefore \text{Maximum Axial Loads on Piles} = \frac{17530}{24} \pm \frac{102{,}840\times 5.197}{203.118}$$
$$= 730.4 \pm 2631.3$$
$$= 3362 \text{ kN} \quad \text{--- Compression}$$
$$1883 \text{ kN} \quad \text{--- Tension}$$

For Next row

$$\frac{17530}{24} + \frac{102{,}840\times 4.158}{203.118}$$
$$= 730.4 + 2105.2 = 2840.$$

Use 3,000 kN

Sircar, Partha

From: Sircar, Partha
Sent: Sunday, September 02, 2001 2:59 PM
To: Nobari, Farid
Subject: Maximum axial loads on Bent 5, Bridge No 22 - Legacy

Per my calculations, the maximum loads for a loading direction of 57 degrees to longitudinal are:

Compressive	-	2900kN
Tensile	-	1925kN

The loads usedare the same as that used for the other bents in the bridge

To: Tom Cooper

August 21, 2001

Legacy Parkway, Bridge Foundations
Soil Properties

Soil properties used for the piled-foundation analyses of the bridges were based on the soil parameters provided. Modifications were made where the provided values appeared inconsistent with other soil parameters or beyond the bounds normally experienced. Where changes were made, the suggested values from the GROUP 4.0 User's Manual were adopted. Modifications were undertaken so that there was only one soil layer above the pile heads (problems were encountered using GROUP 4.0 with more than one layer above the pile cap soffit). In this case the existing layers were replaced with a weak sand designed to average the combined lateral resistance of the replaced layers.

In general the silts were replaced with stiff clays with the same cohesion, lower e_{50} values (eg 0.034 was changed to 0.007 corresponding to stiff clay), higher modulus of subgrade reaction, and no friction angle.

A typical example of changes (for Bridge 22, Bent 3) is provided (faxed Table)

1. The value of 900 kN/m^3 for the modulus of subgrade reaction of the top sand layer was replaced with the value suggested for loose sand above the water table, namely 6790 kN/m^3.
2. The unit weight (submerged) of soil for layer 2 (soft clay) was changed from 10.6 to 7.0 kN/m^3.
3. Modulus of subgrade reaction for layers 2, 3, and 4 were increased from 9665, 4290 and 107,000 to 15,000, 5430 and 136,000 respectively, as shown.
4. Strain e_{50} for the stiff clay was reduced from 0.034 to 0.007.

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Values used for GROUP 4.0 Analysis

Structure	22
Support(s)	Bent 3
Water Depth (m)	3.9
Finished Grade Elevation (m)	1297.0
Soil Borings Used for Profile	LSB-22-437

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m³)	Shear Strength (kN/m²)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m²)		Maximum Tip Resistance (kN/m²)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	3.9	19.5	-	-	~~908~~ 6790	29	0	25	0	3,190
2	Soft Clay	3.9	6.2	~~19.8~~ 7.0	24	0.015	~~9,665~~ 15000	-	16	21	390	520
3	Sand	6.2	8.8	9.7	-	-	~~4,290~~ 5430	30	36	45	5,440	6,800
4	Stiff Clay with Free Water	8.8	10.3	9.7	89	~~0.034~~	~~107,155~~ 136000		30	34	1,330	1,480
5	Sand	10.3	11.5	10.1	-	0.007	8,550	32	55	60	9,620	10,450
6	Sand	11.5	19.4	10.5	-	-	25,590	39	82	127	19,250	29,690
7	Sand	19.4	21.0	10.1	-	-	12,810	34	101	108	19,510	20,840
8	Sand	21.0	24.0	10.1	-	-	14,230	34	111	125	22,050	24,700
9	Sand	24.0	25.5	10.5	-	-	25,590	39	152	160	35,540	37,520
10	Sand	25.5	30.1	10.5	-	-	22,040	37	151	176	33,950	39,450

Press the "Copy" button to copy this tab to a new spreadsheet. The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies. Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers.

PB 100 YEARS
FAX TRANSMITTAL

To Tom Cooper			
Fax 916-925-3517	Date 8/21	Pages 2	
From David Williams		Parsons Brinckerhoff	
Phone 415 243-4653	Fax		
Comments			

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	22
Support(s)	Bent 2
Water Depth (m)	3.0
Finished Grade Elevation (m)	1297.0
Soil Borings Used for Profile	RB-385; SC-27-341

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m³)	Shear Strength (kN/m²)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m²)		Maximum Tip Resistance (kN/m²)	
									Top	Bottom	Top	Bottom
							6790					
1	Sand	0.0	~~2.2~~ 3.0	19.9 18	-	-	~~18,450~~	~~25~~ 33	0	18	0	3,510
~~2~~	~~Soft Clay~~	~~2.2~~	~~7.0~~	~~20.6~~	~~18~~	~~0.015~~	~~3,500~~	-	9	12	200	270
3	Soft Clay	3.0	4.5	~~19.6~~ 6.7	18	0.015 .02	~~3,500~~ 8140	-	12	15	270	350
4	Sand	4.5	7.4	10.1	-	-	6,420 5430	31	28	39	4,670	6,460
5	Stiff clay ~~Silt~~	7.4	11.5	9.7	50	~~0.034~~	48,665 136,000	30	30	42	2,450	3,370
6	Sand	11.5	21.1	10.5	-	.007	22,040	37	74	125	16,600	28,080
7	Stiff Clay with Free Water	21.1	23.3	9.7	57	~~0.034~~	~~57,665~~ 136,000	-	55	60	1,930	2,100
8	Stiff Clay with Free Water	23.3	24.5	9.7	76	~~0.034~~	~~87,665~~	-	63	65	2,530	2,640
9	Sand	24.5	27.5	10.5	-	.007	~~29,140~~ 33,900	40	159	177	38,570	42,910
10	Stiff clay ~~Silt~~	27.5	30.6	11.4	154	~~0.063~~ .005	~~204,665~~ 271,000	~~34~~ 0	115	128	9,200	10,240

Press the "Copy" button to copy this tab to a new spreadsheet. The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies. Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers.

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	22
Support(s)	Bent 6
Water Depth (m)	3.5
Finished Grade Elevation (m)	1297.5
Soil Borings Used for Profile	SB-27-345

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m³)	Shear Strength (kN/m²)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m²)		Maximum Tip Resistance (kN/m²)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	~~1.6~~ 3.5	19.5 18	-	-	~~2,250~~ 6790	~~30~~ 20	0	11	0	1,600
2	~~Soft Clay~~	~~1.6~~	~~3.5~~	~~20.6~~	~~48~~	~~0.015~~	~~3,300~~	-	6	14	140	320
3	Soft Clay	3.5	9.6	~~10.8~~ 6.7	18	0.015 .02	3,500 8140	-	14	28	320	620
4	Sand	9.6	14.1	9.7	-	-	2,870 10000	30	47	62	6,690	8,840
5	Stiff ~~Silt~~ Clay	14.1	15.3	9.7	83	0.014 .007	96,665 136000	~~31~~ 0	56	60	4,530	4,820
6	Sand }	15.3	~~20.4~~	10.1	-	-	15,650 16300	35 } 33.5	87	110	17,690	22,440
7	Sand }	~~20.4~~	21.7	10.1	-	-	8,550	32	96	101	16,610	17,510
8	Stiff Silt Clay	21.7	22.9	11.4	109	0.063 .005	135,665 200000	0	85	90	6,860	7,220
9	Sand	22.9	26.5	10.5	-	.005	~~29,140~~ 40000	40	153	175	37,210	42,420
10	Silt	26.5	29.6	11.4	128	0.063	~~165,665~~ 271,000	~~33~~ 0	107	119	8,600	9,590

Press the "Copy" button to copy this tab to a new spreadsheet. The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies. Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers.

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	22
Support(s)	Bent 15
Water Depth (m)	2.4
Finished Grade Elevation (m)	1297.5
Soil Borings Used for Profile	LSB-22-438; SC-27-344

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	~~2.4~~ 3.2	~~19.5~~ 15	-	-	~~980~~ 6190	~~29~~ 20	0	15	0	2,070
2	Soft Clay ~~Silt~~	~~2.4~~ 3.2	3.5	~~10.0~~ 7.0	37	~~0.027~~ .01	~~29,165~~ 27200	~~28~~ 0	13	16	1,040	1,290
3	Stiff Clay ~~Silt~~	3.5	10.8	9.7	89	~~0.034~~ .007	~~107,165~~ 136000	~~34~~	18	41	1,470	3,300
4	Sand	10.8	18.2	10.9	-		~~32,690~~ 33900	40	77	125	19,340	31,420
5	Stiff clay ~~Silt~~	18.2	19.4	9.7	89	~~0.034~~ .007	~~107,165~~ 136000	~~34~~ 0	67	70	5,360	5,660
6	Sand	19.4	20.2	10.1	-		16,360 33900	35	102	105	20,970	21,730
7	Stiff Clay with Free Water	20.2	~~24.2~~ 22.5	11.4	102	~~0.063~~ .005	~~126,665~~ 271,000		56	68	2,660	3,190
8	~~Silt~~	~~24.2~~	~~27.5~~	11.4	115	~~0.063~~	~~148,183~~	~~33~~	93	106	7,470	8,490
9	Sand	27.5	33.3	10.5	-	-	~~25,590~~ 33400	39	168	201	39,350	47,020

Press the "Copy" button to copy this tab to a new spreadsheet. The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies. Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers.

PARSONS BRINCKERHOFF COMPUTATION SHEET

Subject: Legacy Foundation Design - Soil Parameters

Page ____ of ____ 345

Made by: DW

Date: 8/23/01

Checked by: ____

Date: ____

Bridge 22.

Comparison of soil parameters assumed for Group 4.0 analyses with revised parameters provided by Kleinfelder.
Modulus of subgrade reaction k generally fell within range provided

Major difference is with ϵ_{50}. Kleinfelder values for stiff clays is 0.02.
We used 0.007 and 0.005.

Resolution.

Perform comparitive analysis using 0.02 for ϵ_{50}

Use Bent No 2 of Bridge 22.
Stiff clay from +7.4 to 11.5 m depth (highest layer in Bents 2 and 3).

Result - no appreciable difference.

ACTION. Check Bent 5.
Stiff clay layer from (-)3.5 to 10.8 m OK.

346

KLEINFELDER

Salt Lake City

FAX * FAX * FAX

PROJECT NO:

To: [redacted]

From: Nigel Miller

Kleinfelder, Inc.
2677 East Parley's Way
Salt Lake City, UT 84109
Phone: 801-466-6769
Fax: 801-466-6788

Date: 8/23/01

Re: LPILE

Fax: 415-243-9501

Total Pages: 3
(Including cover sheet)

COMMENTS:

We will call shortly.

WARNING: Information provided via electronic media is not guaranteed against defects, including translation and transmission errors. In addition, this electronic communication and its attachments are forwarded to you without passing through our standard review process. Design data and recommendations included herein should not be used for final design. If the reader is not the intended recipient, you are hereby notified that any dissemination, distribution or copying of this communication is strictly prohibited. If you have received this information in error, please notify the sender immediately.

If there are any problems receiving this transmission please call the above number.

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	22
Support(s)	Bent 3
Water Depth (m)	3.9
Finished Grade Elevation (m)	1297.0
Soil Borings Used for Profile	LSB-22-437

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m³)	Shear Strength (kN/m²)	Strain, ε_{50}	Range for Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, φ (degrees)	Maximum Side Friction (kN/m²)		Maximum Tip Resistance (kN/m²)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	3.9	19.9	-	-	6,790 - 7,650	31	0	29	0	4,740
2	Soft Clay	3.9	6.2	9.2	24	0.015	9,665 - 45,990	-	16	20	400	500
3	Sand	6.2	8.8	9.7	-	-	3,600 - 4,290	30	35	44	5,330	6,690
4	Stiff Clay with Free Water	8.8	10.3	9.7	89	0.020	107,165 - 240,990	-	29	33	1,300	1,460
5	Sand	10.3	11.5	10.1	-	-	8,550 - 11,700	32	54	59	9,470	10,800
6	Sand	11.5	19.4	10.5	-	-	25,590 - 44,100	39	81	126	18,980	29,420
7	Sand	19.4	21.0	10.1	-	-	12,810 - 19,800	34	100	107	19,330	20,670
8	Sand	21.0	24.0	10.1	-	-	14,230 - 22,500	34	110	124	21,870	24,520
9	Sand	24.0	25.5	10.5	-	-	25,590 - 44,100	39	151	159	35,270	37,250
10	Sand	25.5	30.1	10.5	-	-	22,040 - 37,350	37	150	175	33,700	39,200

S-22-3

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

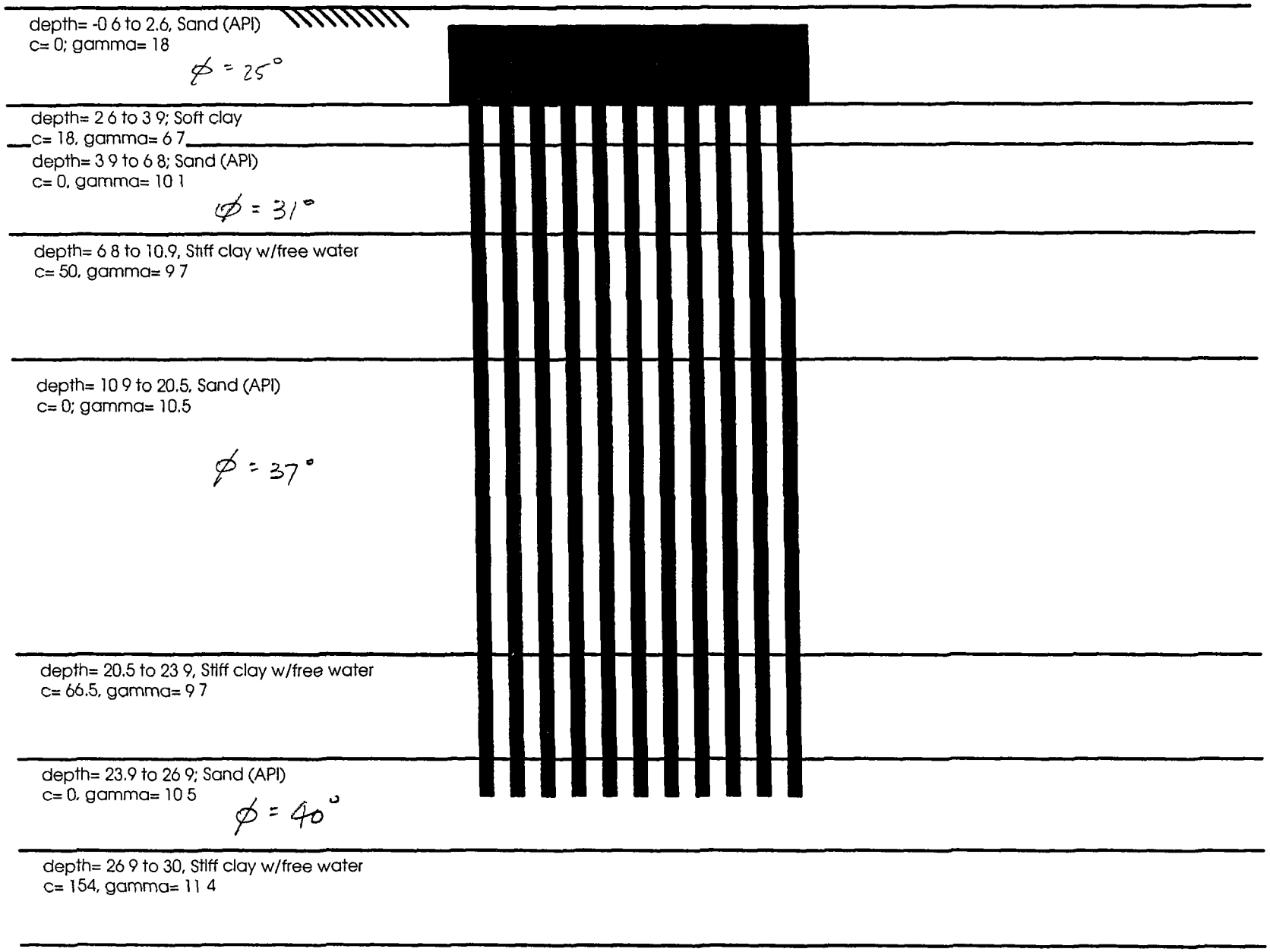
Structure	22
Support(s)	Bent 2
Water Depth (m)	3.0
Finished Grade Elevation (m)	1297.0
Soil Borings Used for Profile	RB-395; SC-27-341

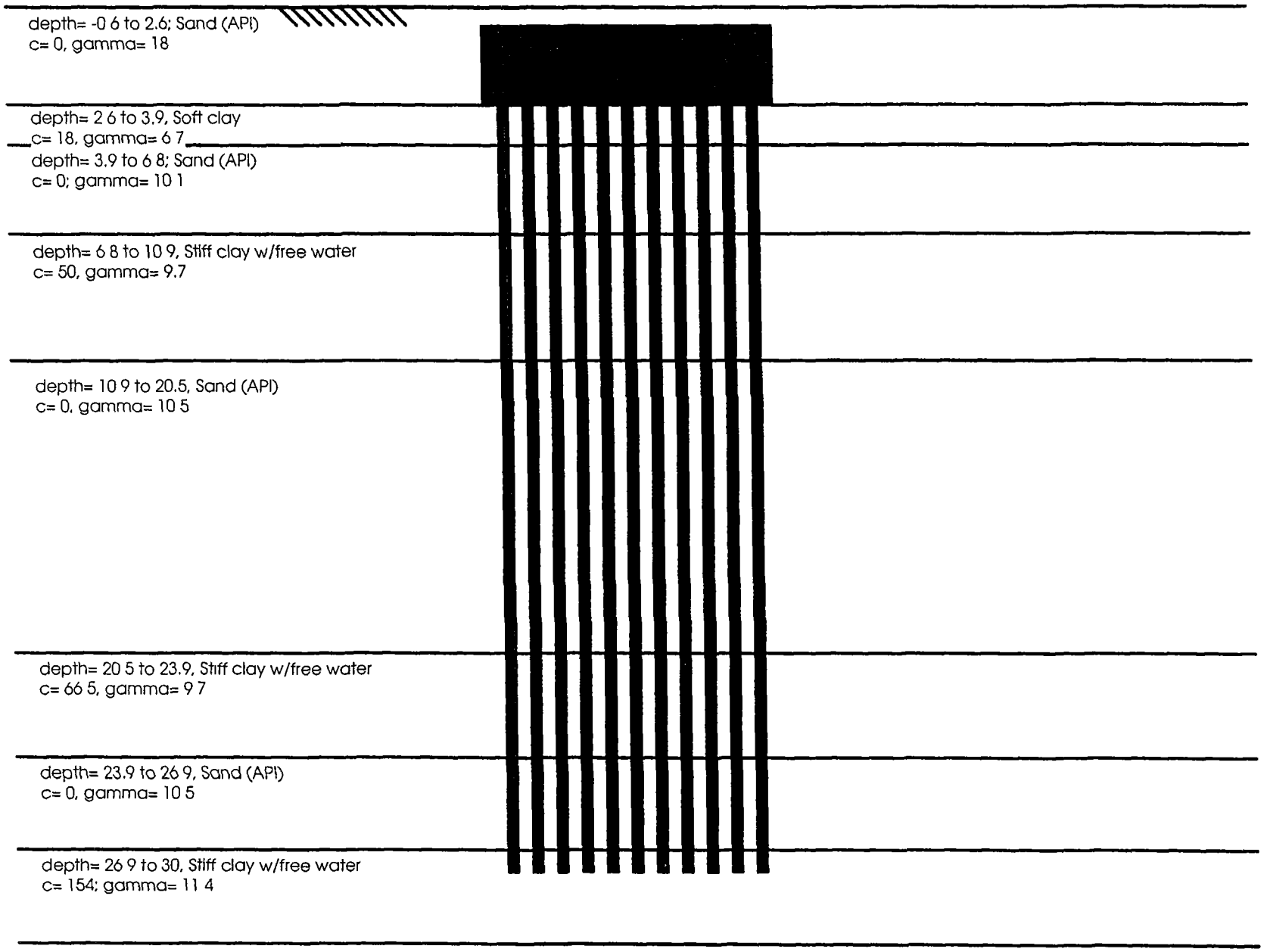
	Initials	Date
Completed By:		
Checked By:		

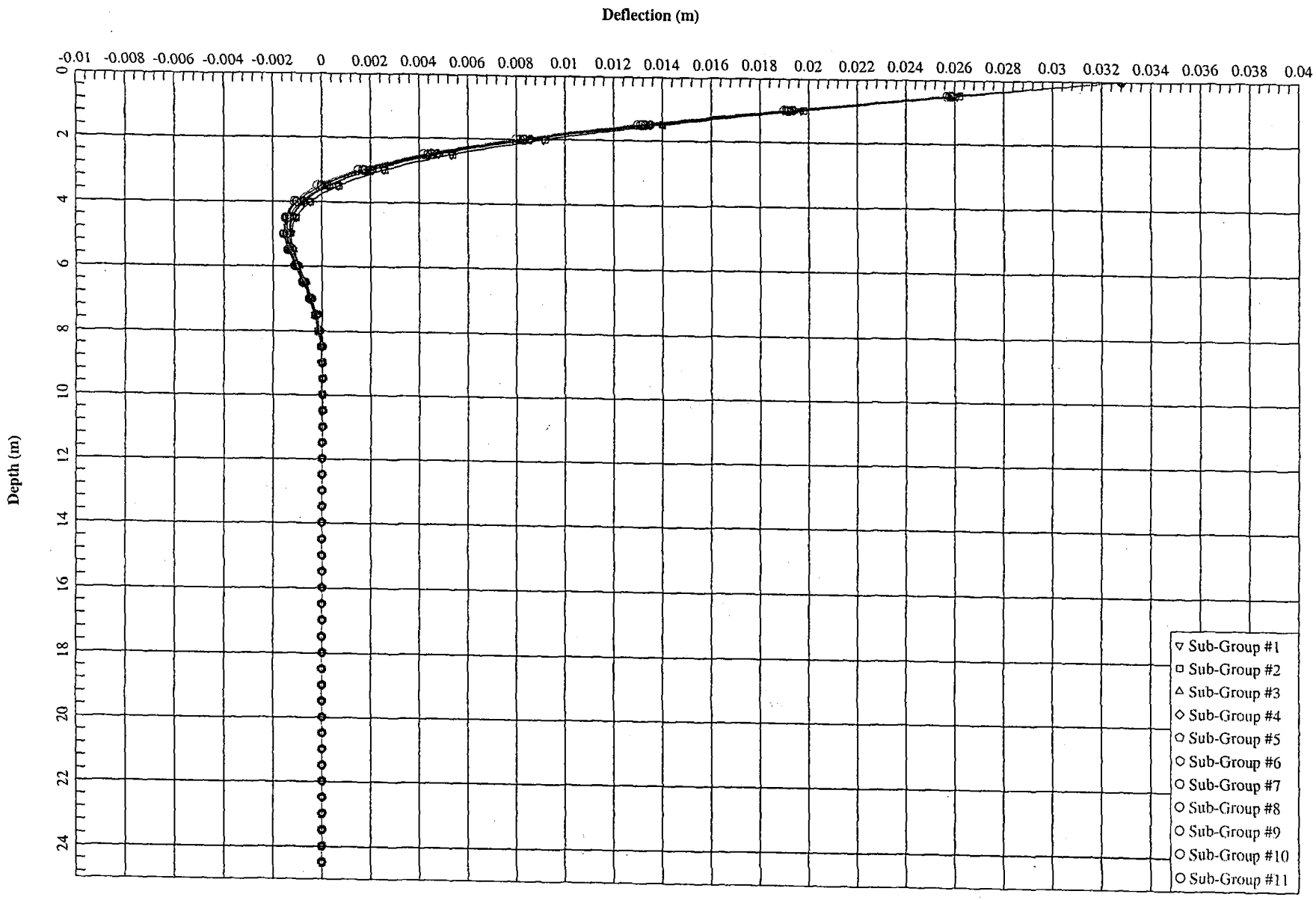
Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m³)	Shear Strength (kN/m²)	Strain, ε_{50}	Range for Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m²)		Maximum Tip Resistance (kN/m²)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	2.2	19.9	-	-	12,100 - 18,450	33	0	18	0	3,510
2	Soft Clay	2.2	3.0	19.0	38	0.015	30,665 - 87,990	-	9	12	270	360
3	Soft Clay	3.0	4.5	9.2	38	0.015	30,665 - 87,990	-	12	15	360	450
4	Sand	4.5	7.4	10.1	-	-	6,420 - 7,660	31	27	38	4,450	6,240
5	Stiff Clay with Free Water	7.4	11.5	9.7	50	0.020	48,665 - 123,990	-	22	31	740	1,030
6	Sand	11.5	21.1	10.5	-	-	22,040 - 37,350	37	72	123	16,180	27,660
7	Stiff Clay with Free Water	21.1	23.3	9.7	57	0.020	57,665 - 144,890	-	55	59	1,900	2,070
8	Stiff Clay with Free Water	23.3	24.5	9.7	76	0.020	67,665 - 201,990	-	62	65	2,500	2,610
9	Sand	24.5	27.5	10.5	-	-	29,140 - 50,850	40	157	175	38,060	42,400
10	Stiff Clay with Free Water	27.5	30.6	11.4	154	0.020	204,665 - 435,890	-	83	93	4,900	5,460

Note: Layer 5, 9, and 10 are estimated from other borings in the area.

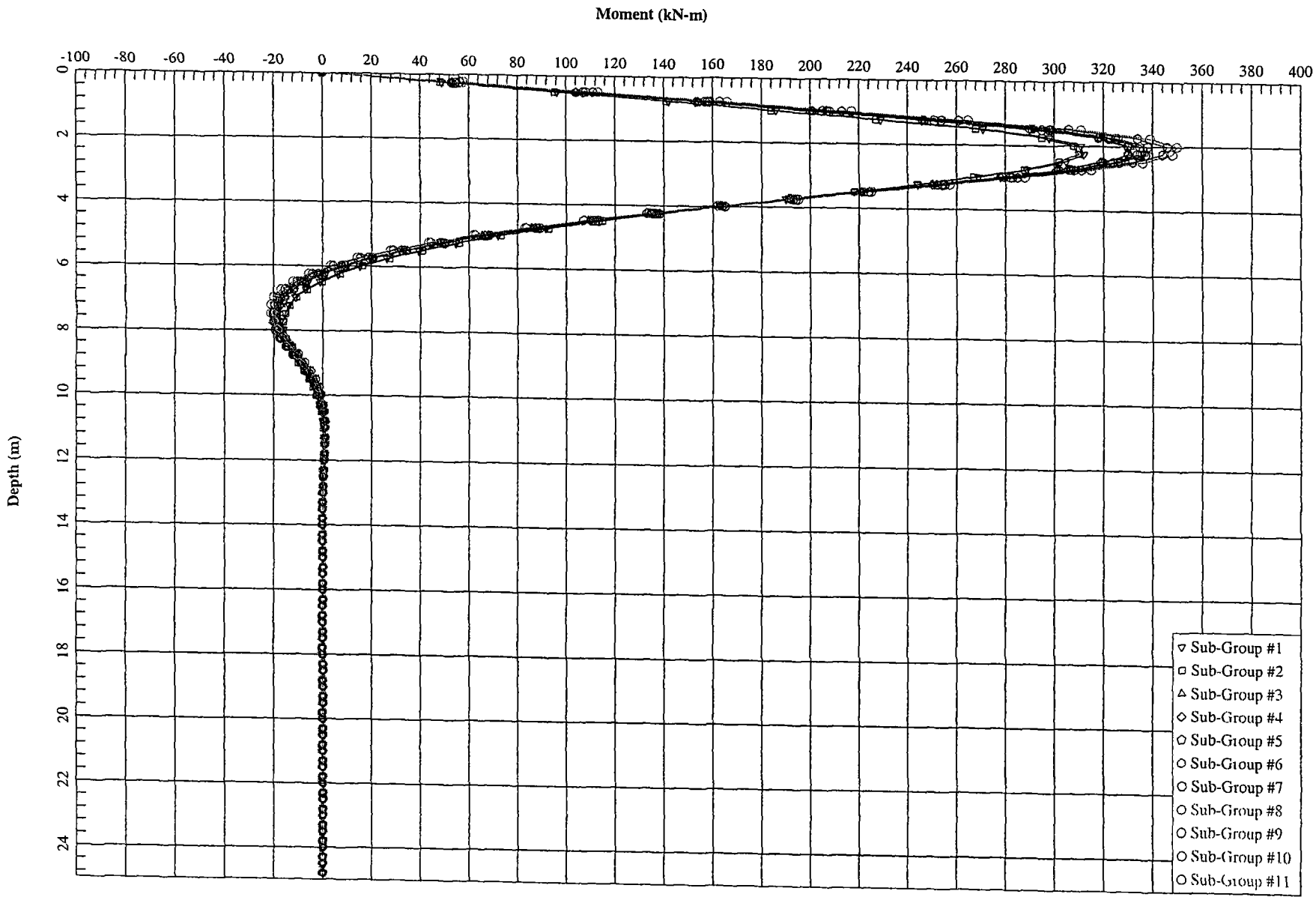
S-22-2


depth= -0 6 to 2.6, Sand (API)
c= 0; gamma= 18
$\phi = 25°$
depth= 2 6 to 3 9; Soft clay
c= 18, gamma= 6 7
depth= 3 9 to 6 8; Sand (API)
c= 0, gamma= 10 1
$\phi = 31°$
depth= 6 8 to 10.9, Stiff clay w/free water
c= 50, gamma= 9 7
depth= 10 9 to 20.5, Sand (API)
c= 0; gamma= 10.5
$\phi = 37°$
depth= 20.5 to 23 9, Stiff clay w/free water
c= 66.5, gamma= 9 7
depth= 23.9 to 26 9; Sand (API)
c= 0, gamma= 10 5
$\phi = 40°$
depth= 26 9 to 30, Stiff clay w/free water
c= 154, gamma= 11 4


depth= -0 6 to 2.6; Sand (API)
c= 0, gamma= 18
depth= 2 6 to 3.9, Soft clay
c= 18, gamma= 6 7
depth= 3.9 to 6 8; Sand (API)
c= 0; gamma= 10 1
depth= 6 8 to 10 9, Stiff clay w/free water
c= 50, gamma= 9.7
depth= 10 9 to 20.5, Sand (API)
c= 0, gamma= 10 5
depth= 20 5 to 23.9, Stiff clay w/free water
c= 66 5, gamma= 9 7
depth= 23.9 to 26 9, Sand (API)
c= 0, gamma= 10 5
depth= 26 9 to 30, Stiff clay w/free water
c= 154; gamma= 11 4



Legacy - Bridge No 22 - Bent 2 - 24 Piles - Diagonal Load - Case 1



Legacy - Bridge No 22 - Bent 2 - 24 Piles - Diagonal Load - Case 1

PARSONS BRINCKERHOFF COMPUTATION SHEET

Page ____ of ____ 391

Made by DW

Date 9/6/01

Checked by

Date

Subject Legacy Parkway - Bridge 22 Foundation Springs

Bent 3 - 24 piles

Horiz K = 8400/0.015
= 560,000 kN/m

Rotation $K_{\theta\theta}$ = 81,000 kN m/0.00146 (max)
≃ 6×10^7 kN.m/rad

Equiv. $K_{\theta\theta}$ including off-diagonal term $K_{\theta TM}$

K_r = 81,000/(0.00146 + 0.0003)
≃ 4.5×10^7 kN m/rad

Williams, David (US)

From: Williams, David (US)
Sent: Wednesday, August 15, 2001 5:01 PM
To: Wang, Fuxin
Subject: RE: Legacy, Bridge 22 - Foundation Analyses

Done. Outputs for the Bent 5, Transverse and Longitudinal direction; and Bent 3, 24-pile copied to your folder. Note that the results for Bent 2 are not the same as the ones I sent summary of before. We made a change to the input (correction) and reran these. The displacements and pile stresses all reduced but the axial loads were about the same. The revised summary is as follows:

(Natural Soil Profiles)

	Bent 3		Bent 2	
	32-pile	24-pile	32-pile	24-pile
The pile head displacement (mm)	15	20	30	40
The max moment in pile (kN-m)	110	140	260	345
The max stress in pile (MPa)	135	165	220	275
Max pile axial loads (kN)	-1250	-1350	-1250	-1400
	+2000	+2300	+2000	+2300

Any questions, please let me know.

—Original Message—
From: Wang, Fuxin
Sent: Wednesday, August 15, 2001 3:41 PM
To: Williams, David (US)
Subject: RE: Legacy, Bridge 22 - Foundation Analyses

By the way, if it is hard to email. You can copy those file
to WAN: Sacramento\wangf
I can access there to get them out.

Frank

Fuxin Wang, PE
Parsons Brinckerhoff

Phone: (916) 567 - 2556
Fax: (916) 925 - 3517

There are no shortcut to any place worth going

—Original Message—
From: Williams, David (US)
Sent: Wednesday, August 15, 2001 3:35 PM
To: Wang, Fuxin
Cc: Cooper, Tom
Subject: Legacy, Bridge 22 - Foundation Analyses

Frank,

Summary of results for Bents 5 and 6.

As before for Bents 2 and 3, the results for the unimproved soil are acceptable for all configurations and thus we did not investigate soil improvement for these foundations. Again note the high axial capacity requirements (required to resist the high overturning moment). This may determine the requirement for number of piles, and soil improvement will have negligible effect on the axial load condition. Again, I believe the pile length will be based on axial tension capacity for seismic-induced plastic moment. Assuming this can be met (and I think this will be a challenge), then the 24-pile arrangement is satisfactory for the 28' square footings and the 36-pile arrangement is satisactory for the 18' x 36' footing at Bent 5.

(Natural Soil Profiles)

	Bent 6		Bent 5 (36-pile)	
	32-pile	24-pile	Trans	Long
The pile head displacement (mm)	50	70	20	10
The max moment in pile (kN-m)	180	240	180	190
The max stress in pile (MPa)	170	220	200	170
Max pile axial loads (kN)	-1350	-1500	-1800	-1000
	+1900	+2200	+2550	+1700

Any questions, please let me know.

Regarding GROUP output, we have several runs for most bents. Do you want output for all cases?

David

-----Original Message-----
From: Wang, Fuxin
Sent: Wednesday, August 15, 2001 2:08 PM
To: Williams, David (US)
Subject: group

David, could you email me the output file for the 24 and 32 pile group analysis you did for bridge 22

Frank

Fuxin Wang, PE
Parsons Brinckerhoff

Phone: (916) 567 - 2556
Fax: (916) 925 - 3517

There are no shortcut to any place worth going

PARSONS BRINCKERHOFF COMPUTATION SHEET

Subject: Legacy Parkway Bridge 22 Foundation Design.

Page ____ of ____

Made by: DW

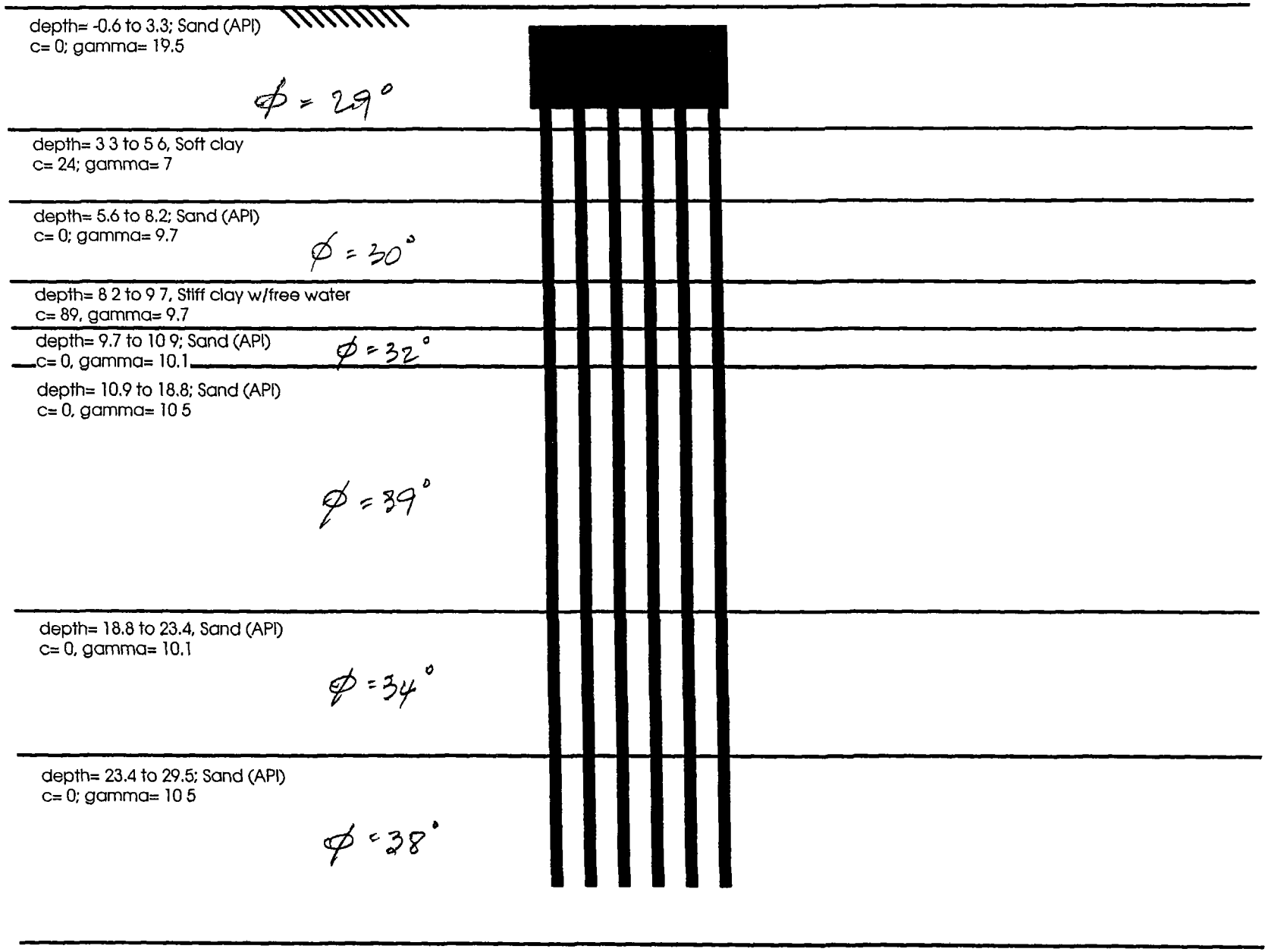
Date: 8/10/01

Checked by: ____

Date: ____

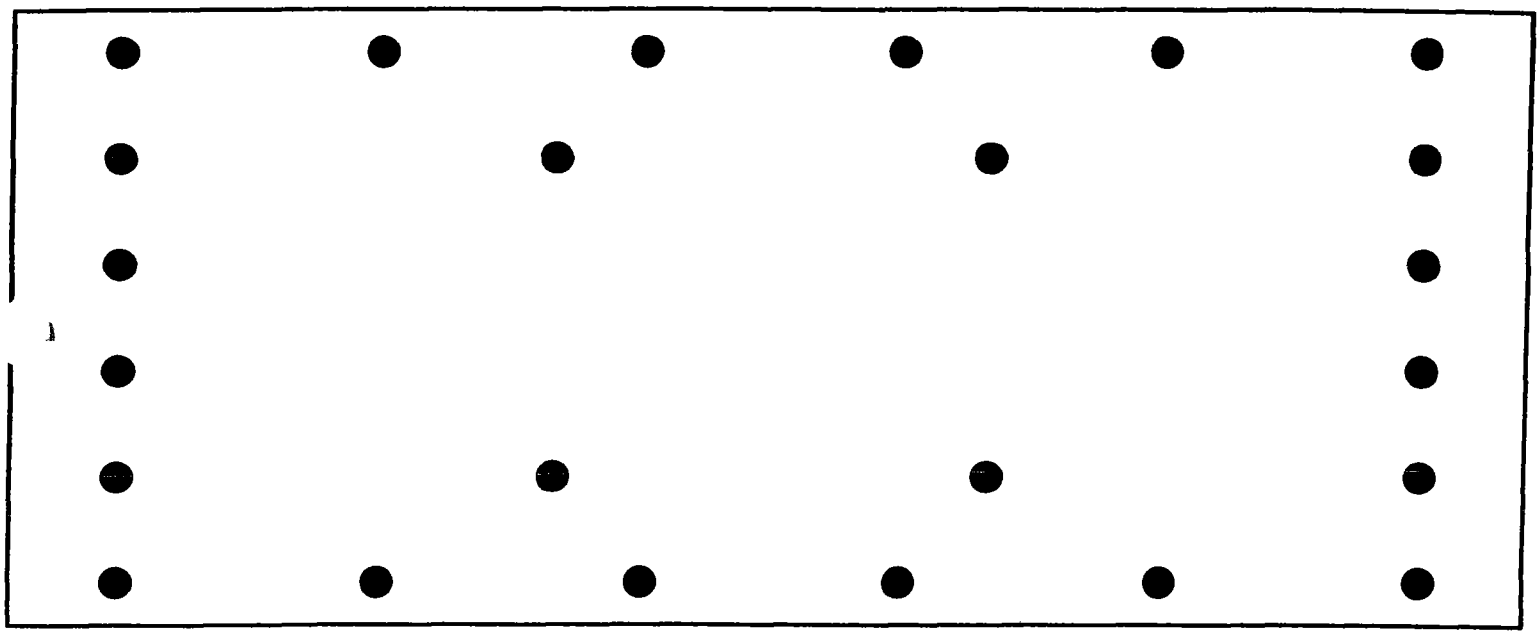
Summary of GROUP Results

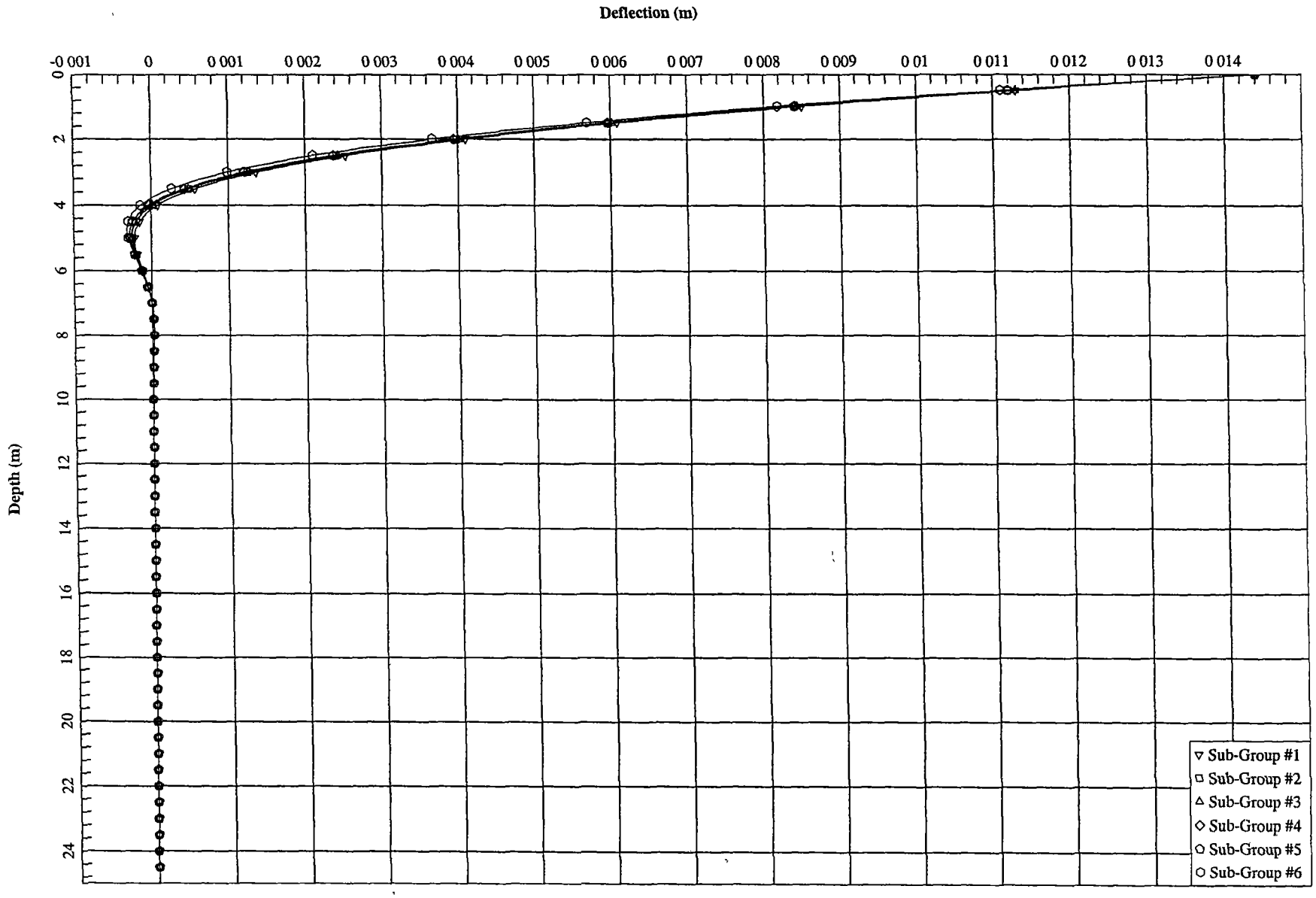
	Bent 3 Soil (natural) 32-pile	Bent 3 Soil (natural) 24-pile	Bent 2 Soil 32-pile	Bent 2 Soil 24-pile
Horiz Δ (mm) θ (rad)	16 (.0019)	21 (.0027)	28 (.0019)	38 (.0028)
M_{max} (kN-m)	110	139	259	345
f_{max} (MPa)	135	164	217	275
Axial − (kN)	−1260	−1330	−1230	−1390
+ (kN)	1970	2310	1980	2260



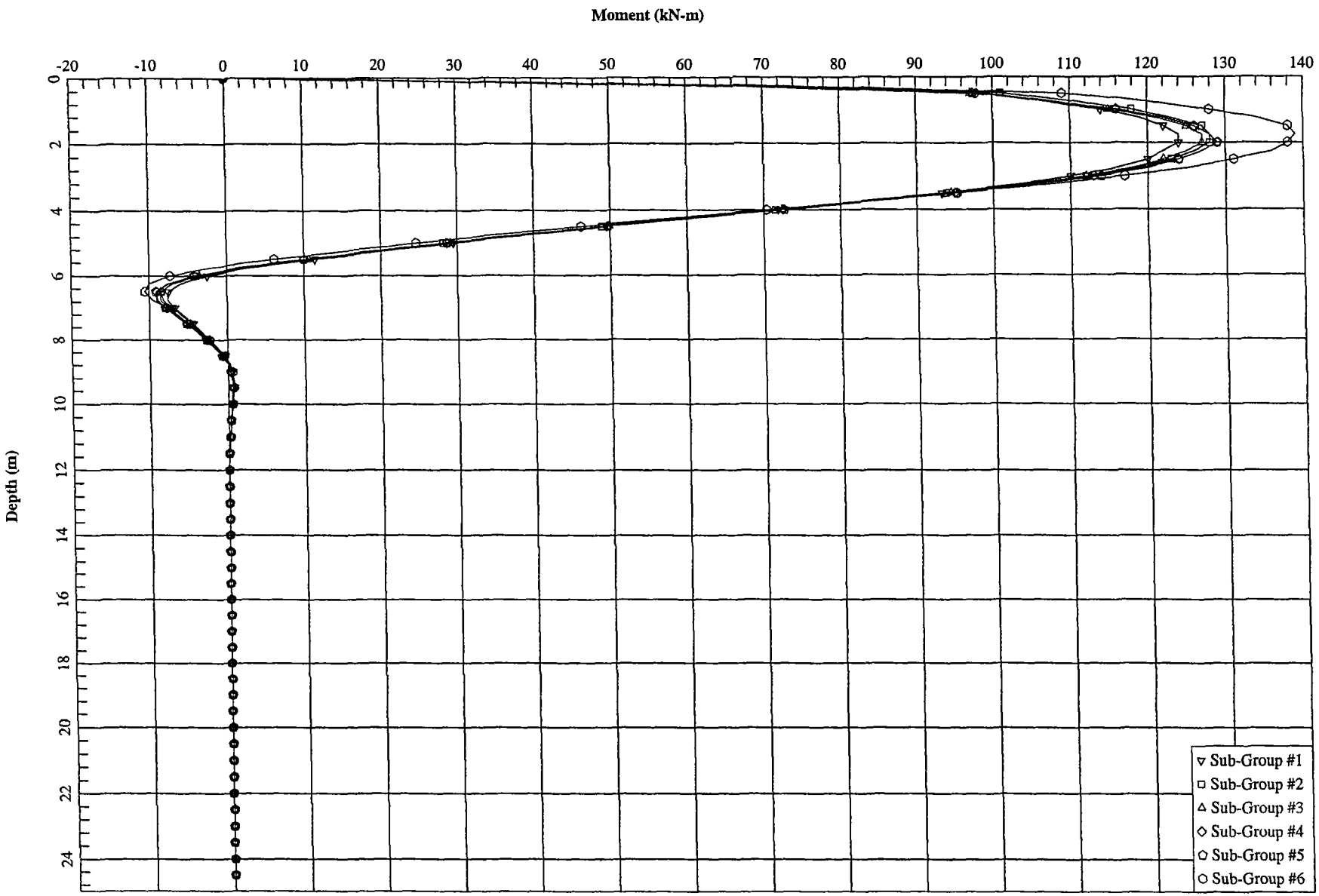
Legacy Bridge Mock
Bent 3
24 Piles
Revised Loads

395

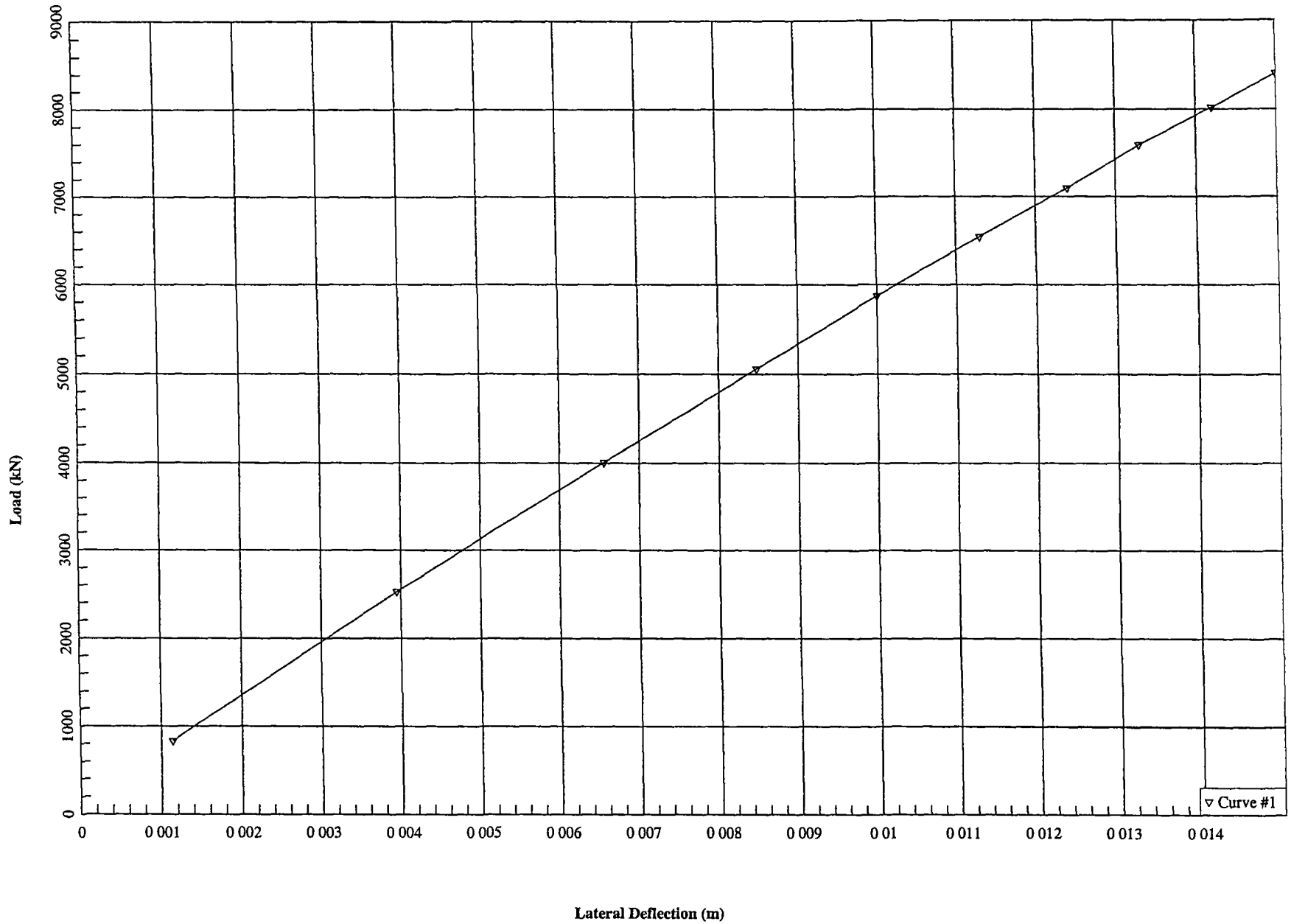




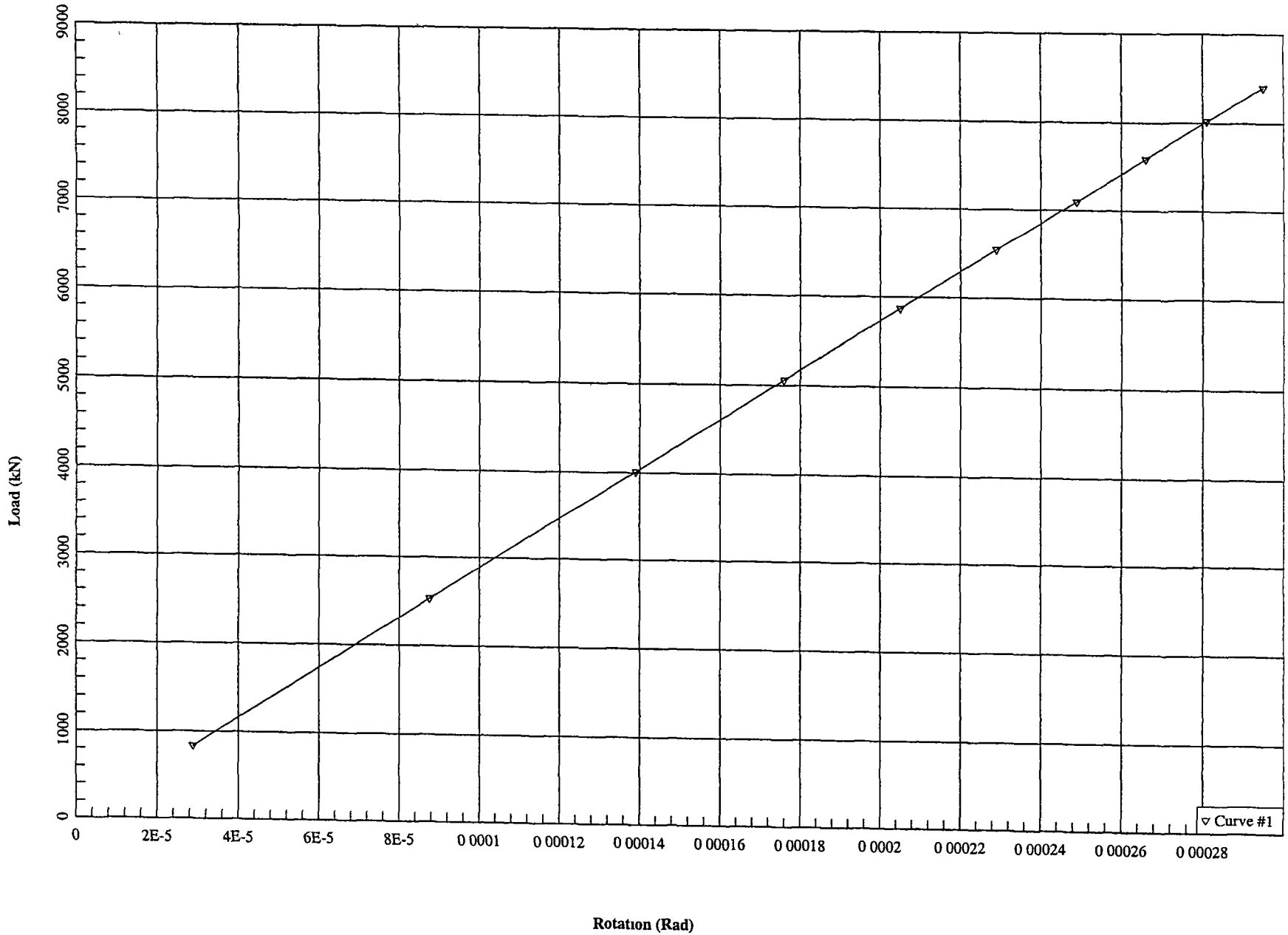
Legacy - Bridge No 22 - Bent 3 - 24 Piles



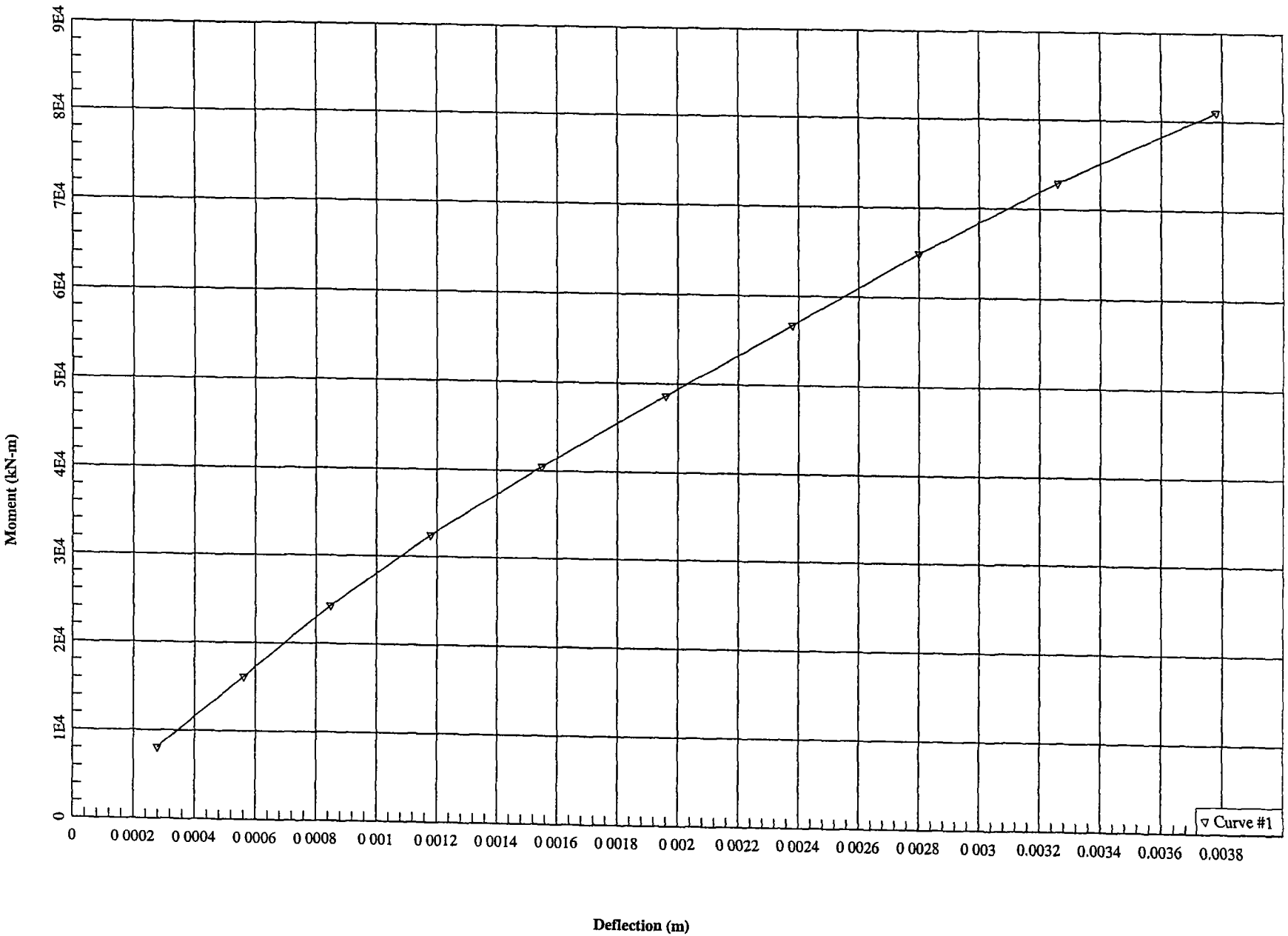
Legacy _ Bridge Mo 22 - Bent 3 - 24 Piles



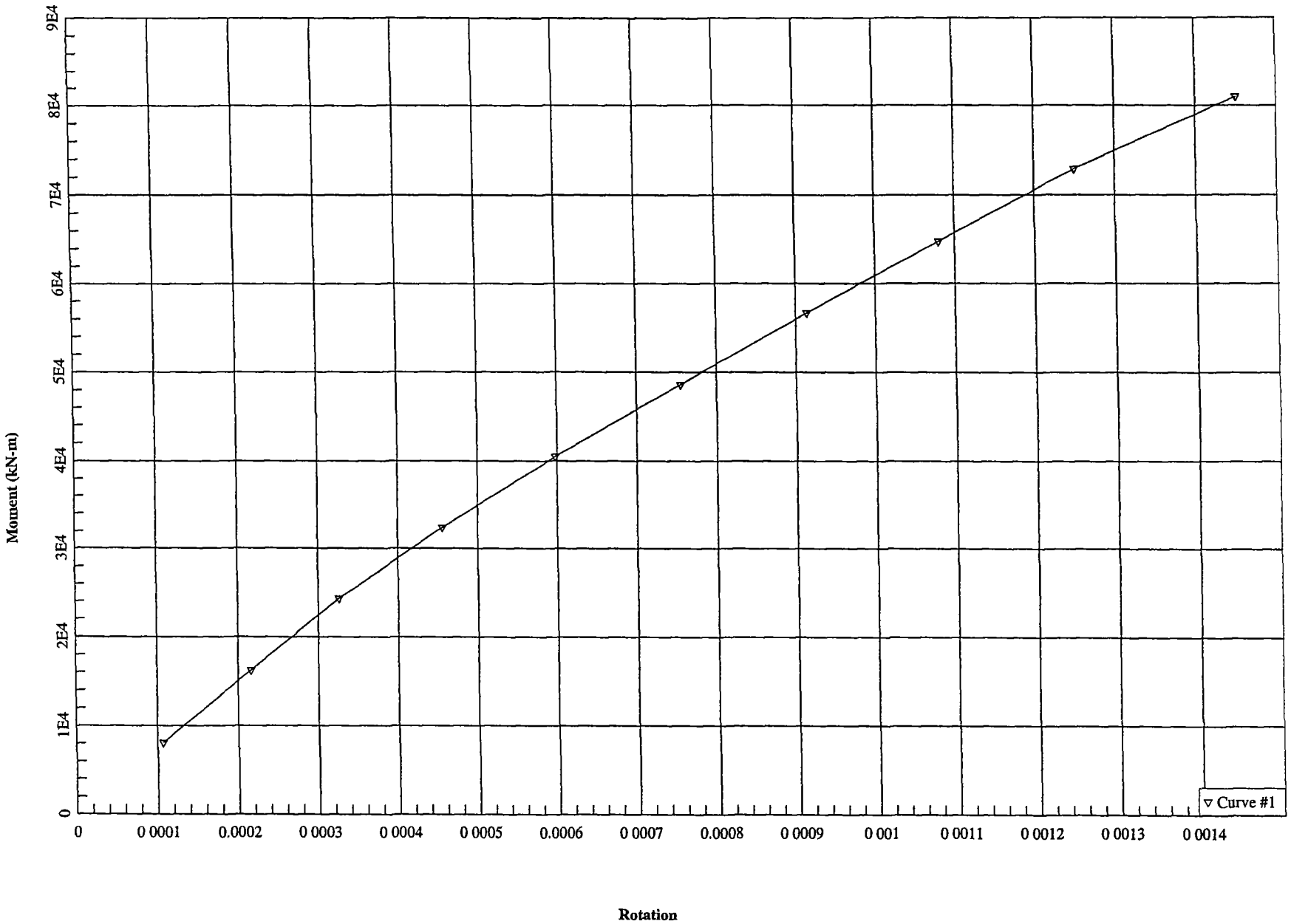
Legacy - Bridge No 22 - Bent 3 - 24 Piles



Legacy - Bridge No 22 - Bent 3 - 24 Piles



Legacy - Bridge No 22 - Bent 3 - 24 Piles



Legacy - Bridge No 22 - Bent 3 - 24 Piles

depth= -0.6 to 2.6; Sand (API)
c= 0; gamma= 18

$\phi = 25°$

depth= 2.6 to 3.9; Soft clay
c= 18, gamma= 6.7

depth= 3.9 to 6.8; Sand (API)
c= 0, gamma= 10.1

$\phi = 31°$

depth= 6.8 to 10.9; Stiff clay w/free water
c= 50; gamma= 9.7

depth= 10 9 to 20.5; Sand (API)
c= 0, gamma= 10.5

$\phi = 37°$

depth= 20 5 to 23 9, Stiff clay w/free water
c= 66 5, gamma= 9.7

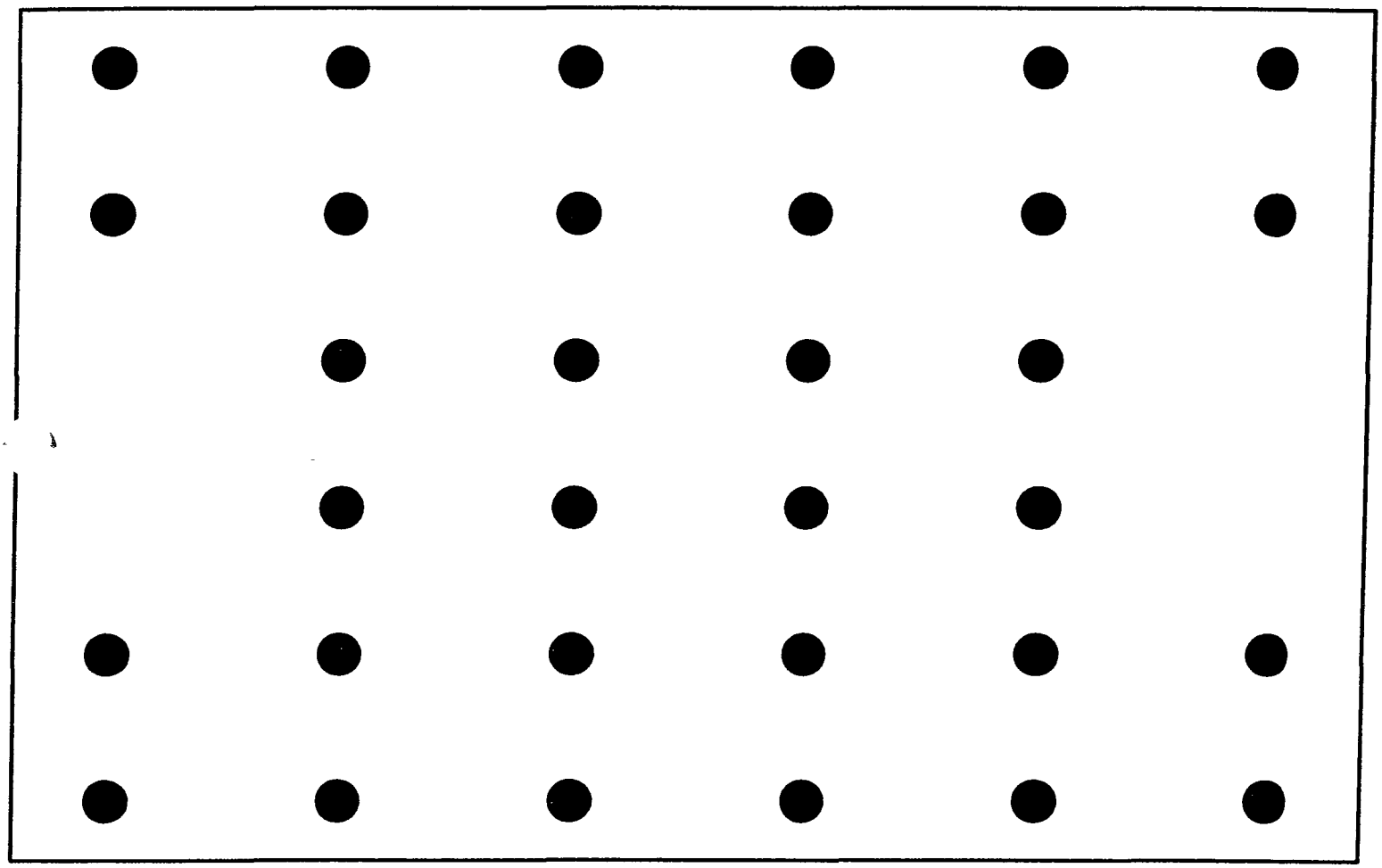
depth= 23 9 to 26.9, Sand (API)
c= 0; gamma= 10 5

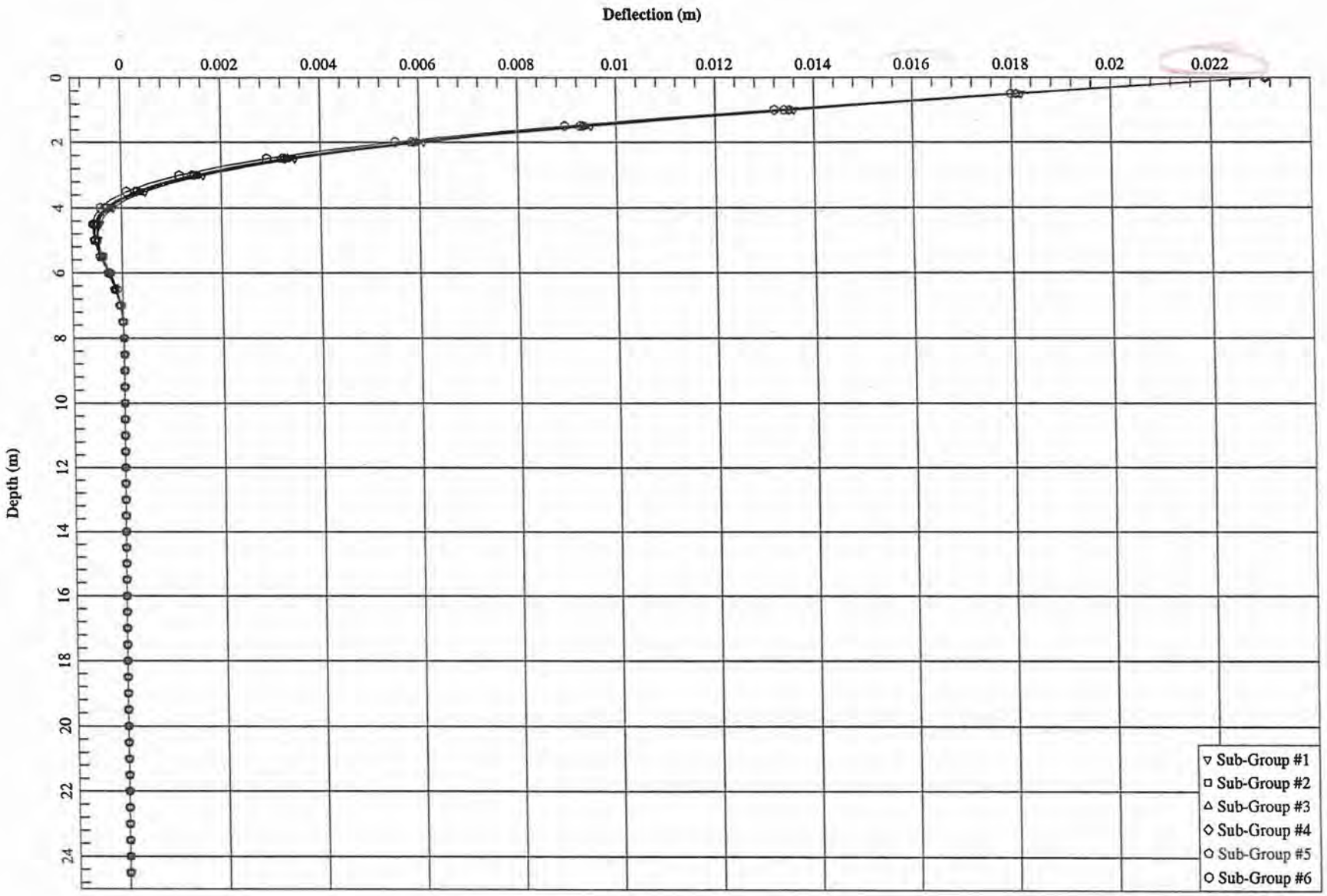
$\phi = 40°$

depth= 26.9 to 30; Stiff clay w/free water
c= 154, gamma= 11.4

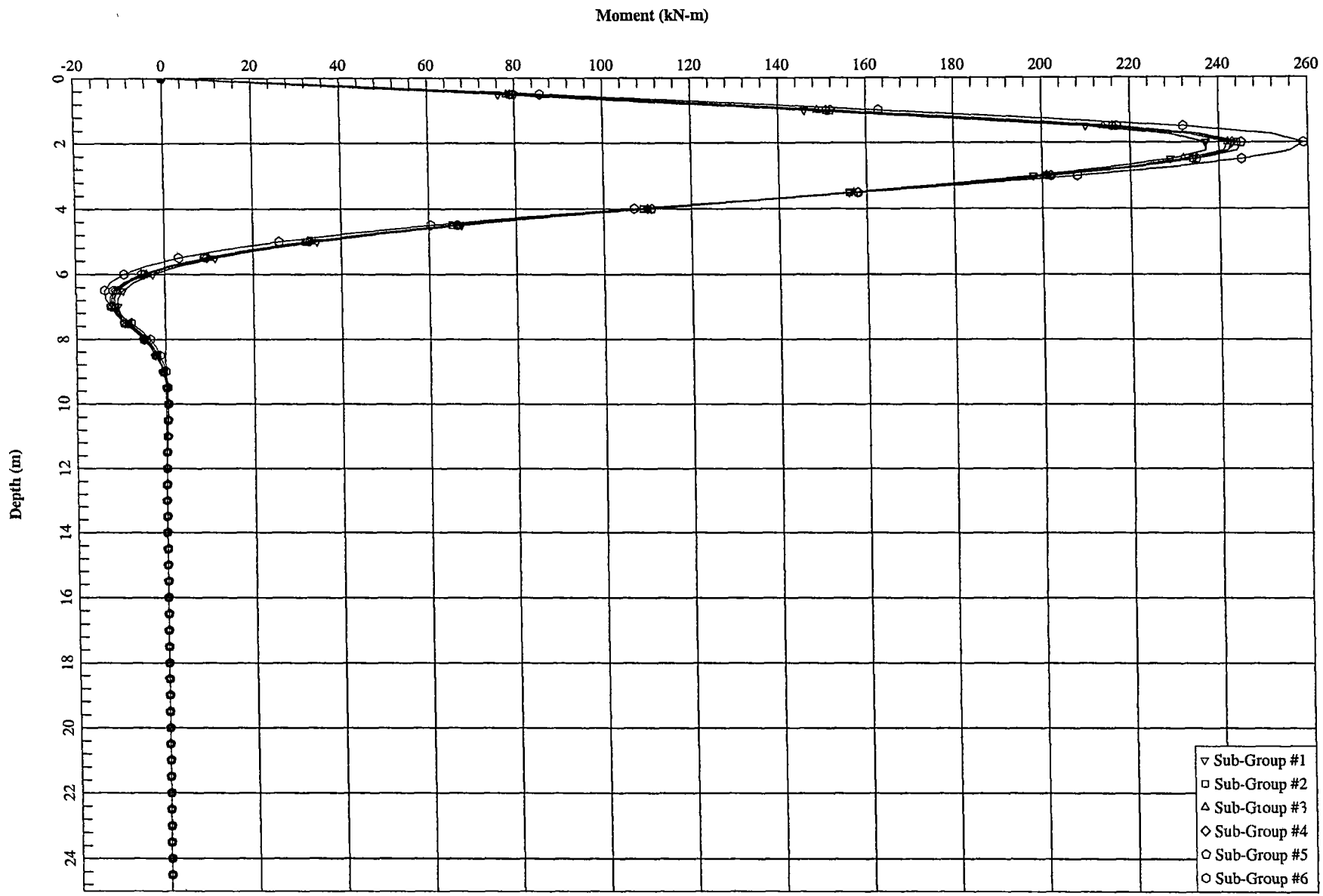
Legacy Bridge No 2
Buff
32 piles
Revised Loads

415

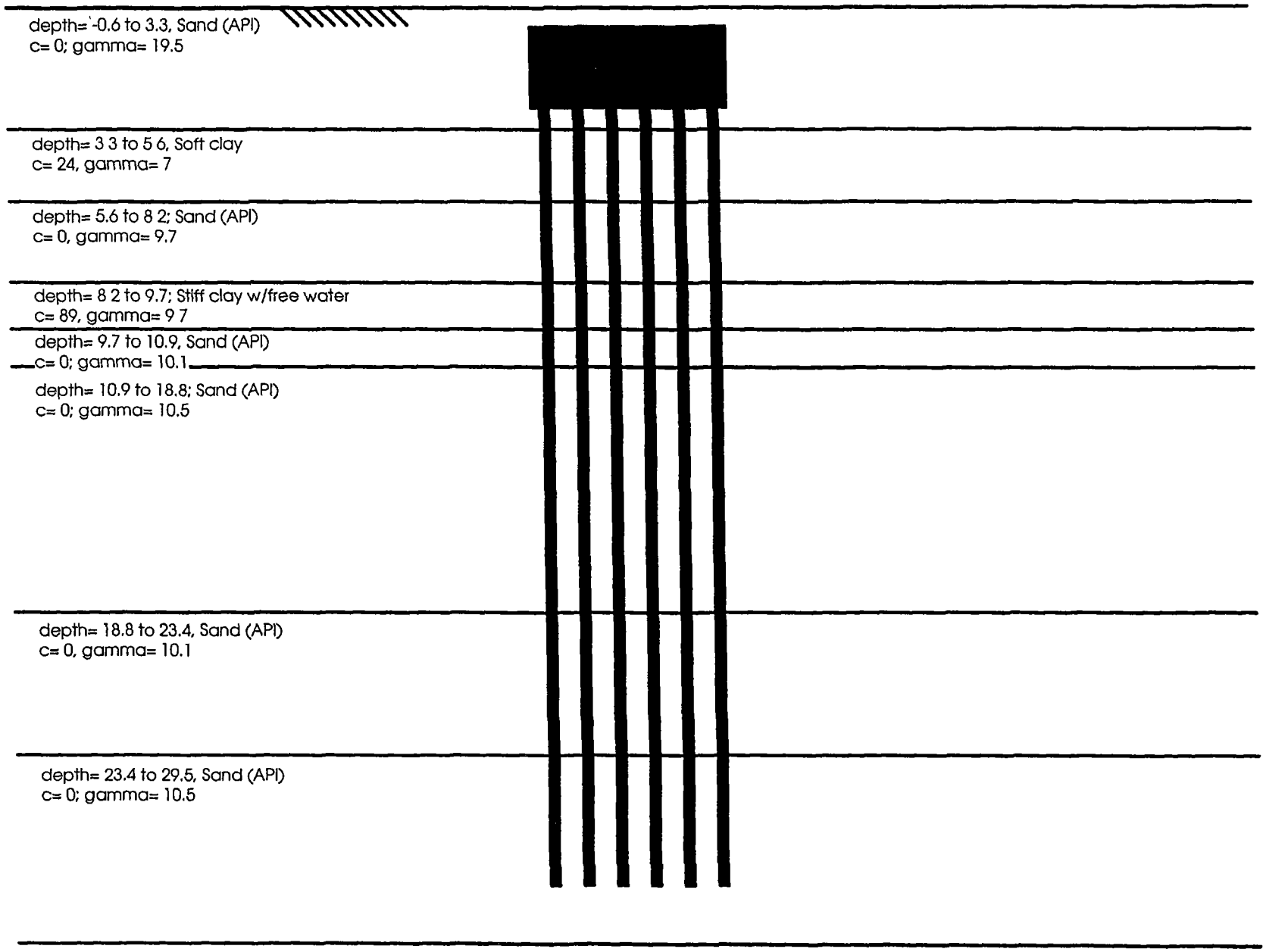




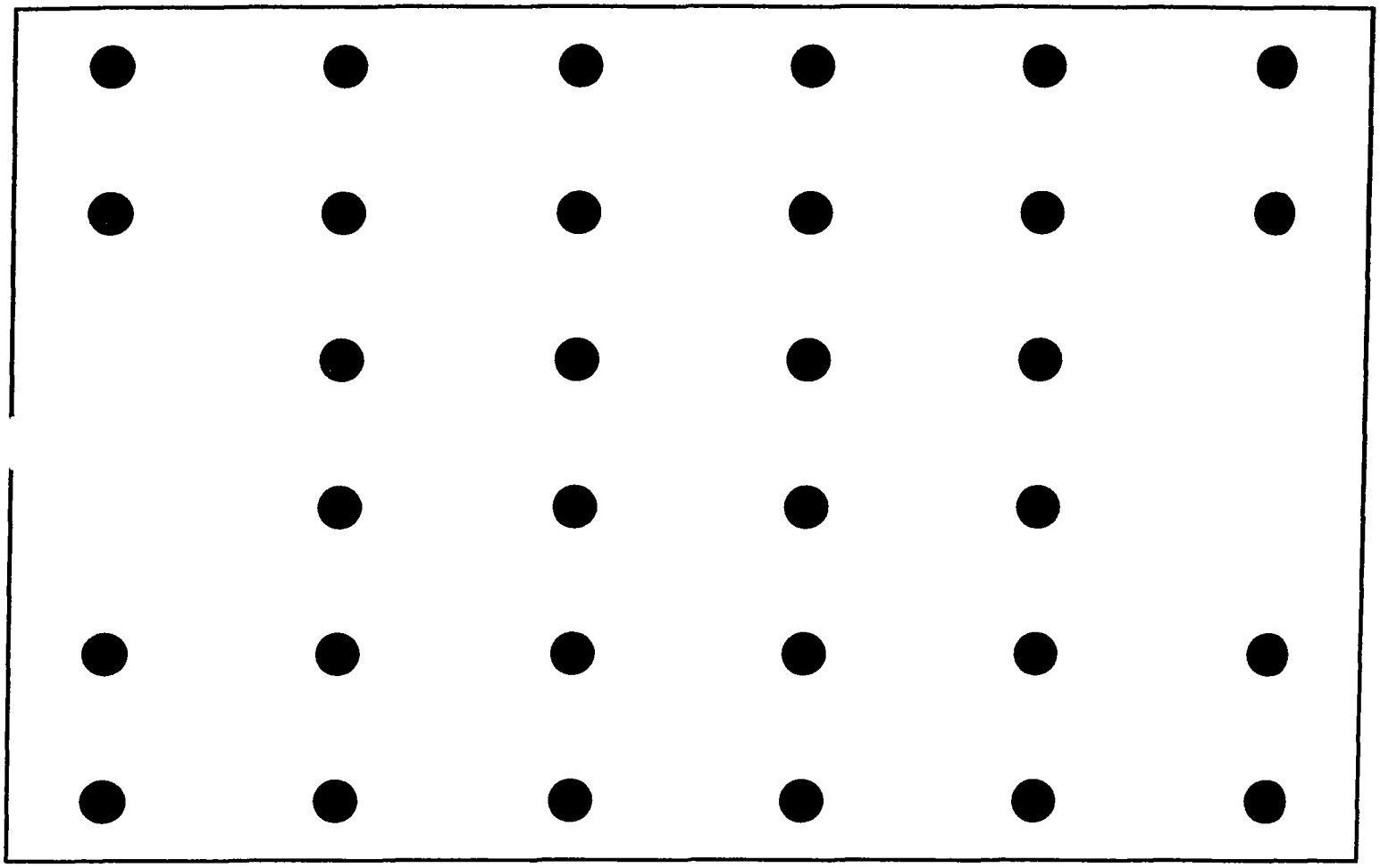
Legacy - Bridge No 22 - Bent 2 - 32 Piles

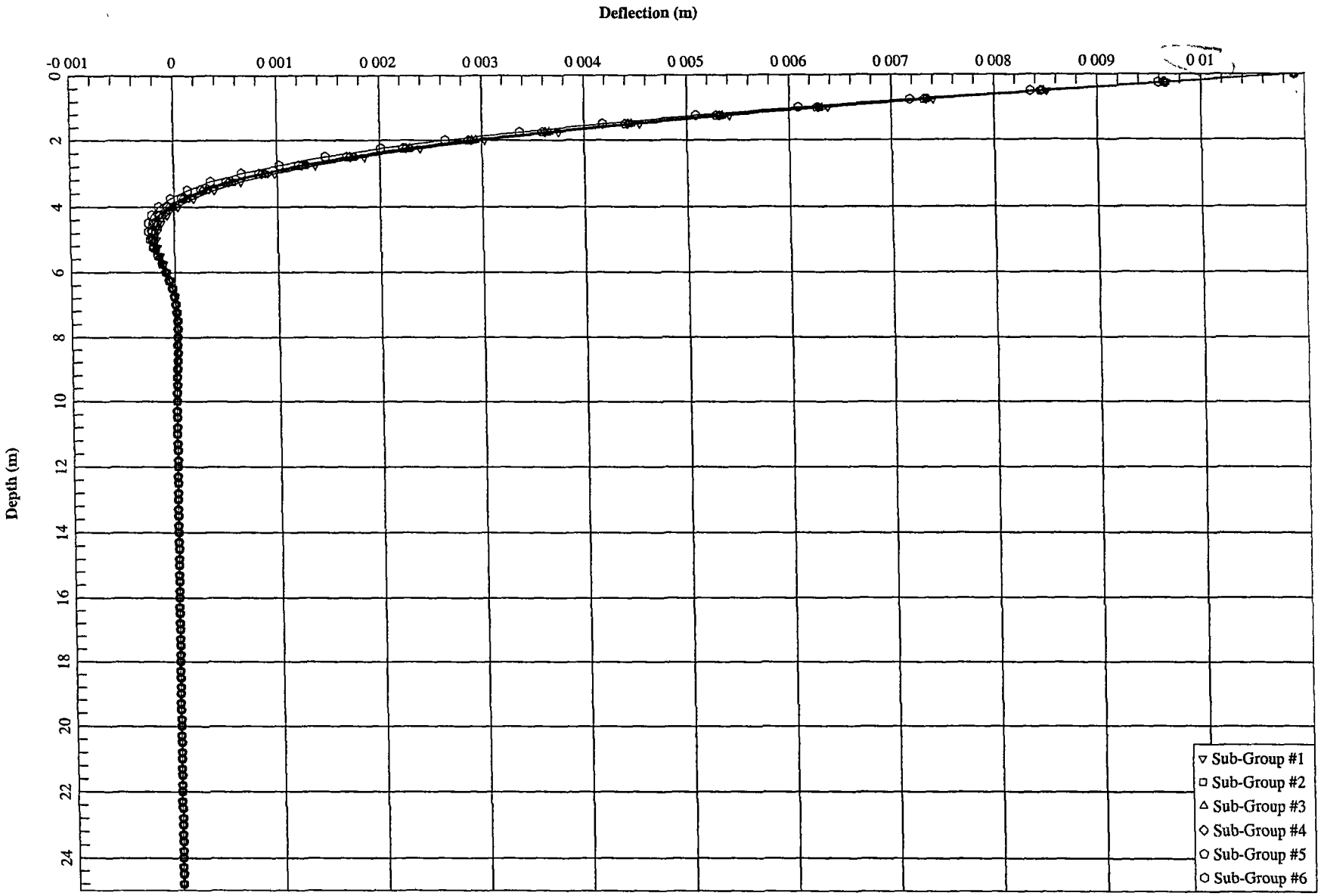


Legacy - Bridge No 22 - Bent 2 - 32 Piles

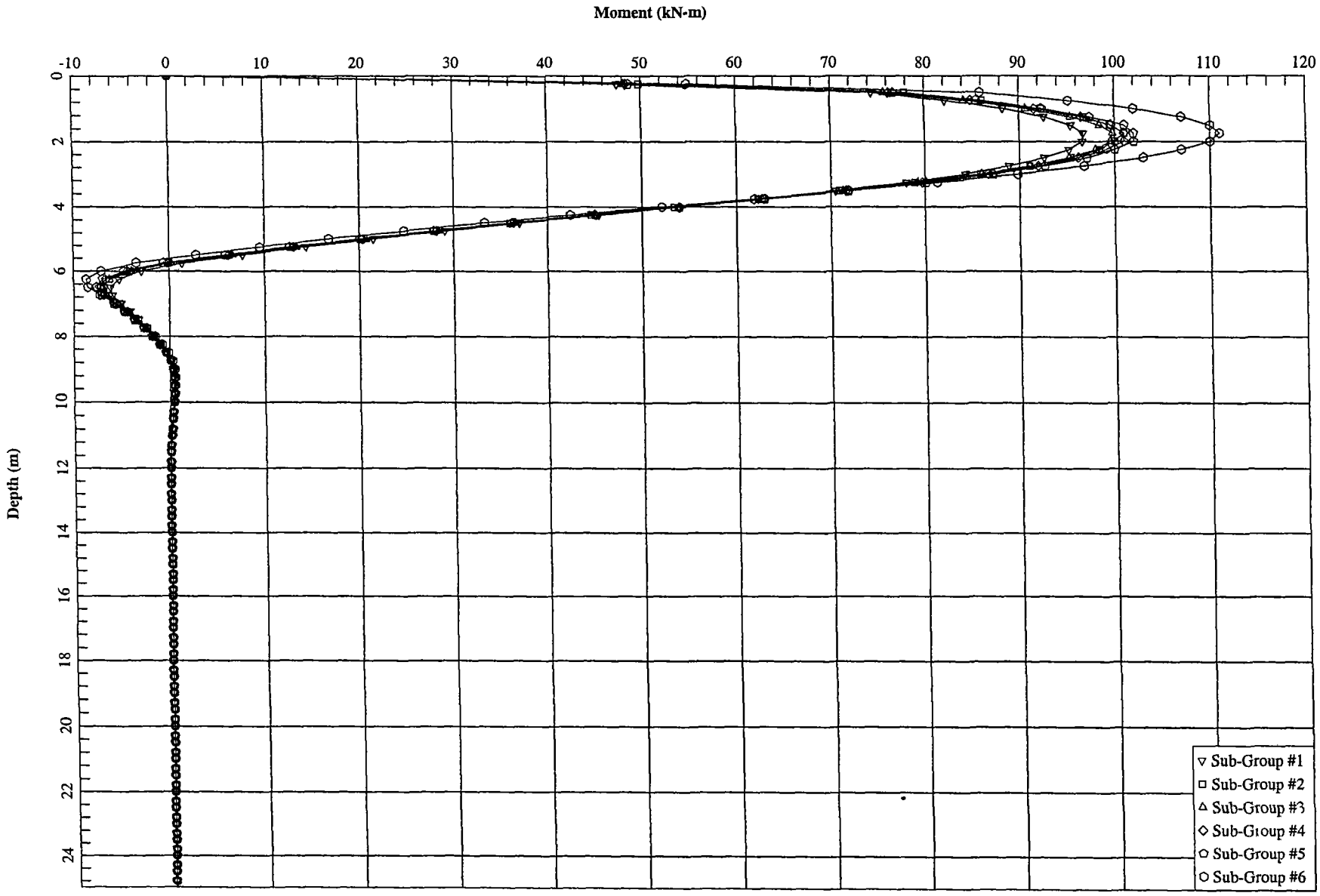


Legacy Bridge No 26
Bent 3
32 Piles
Revised Loads

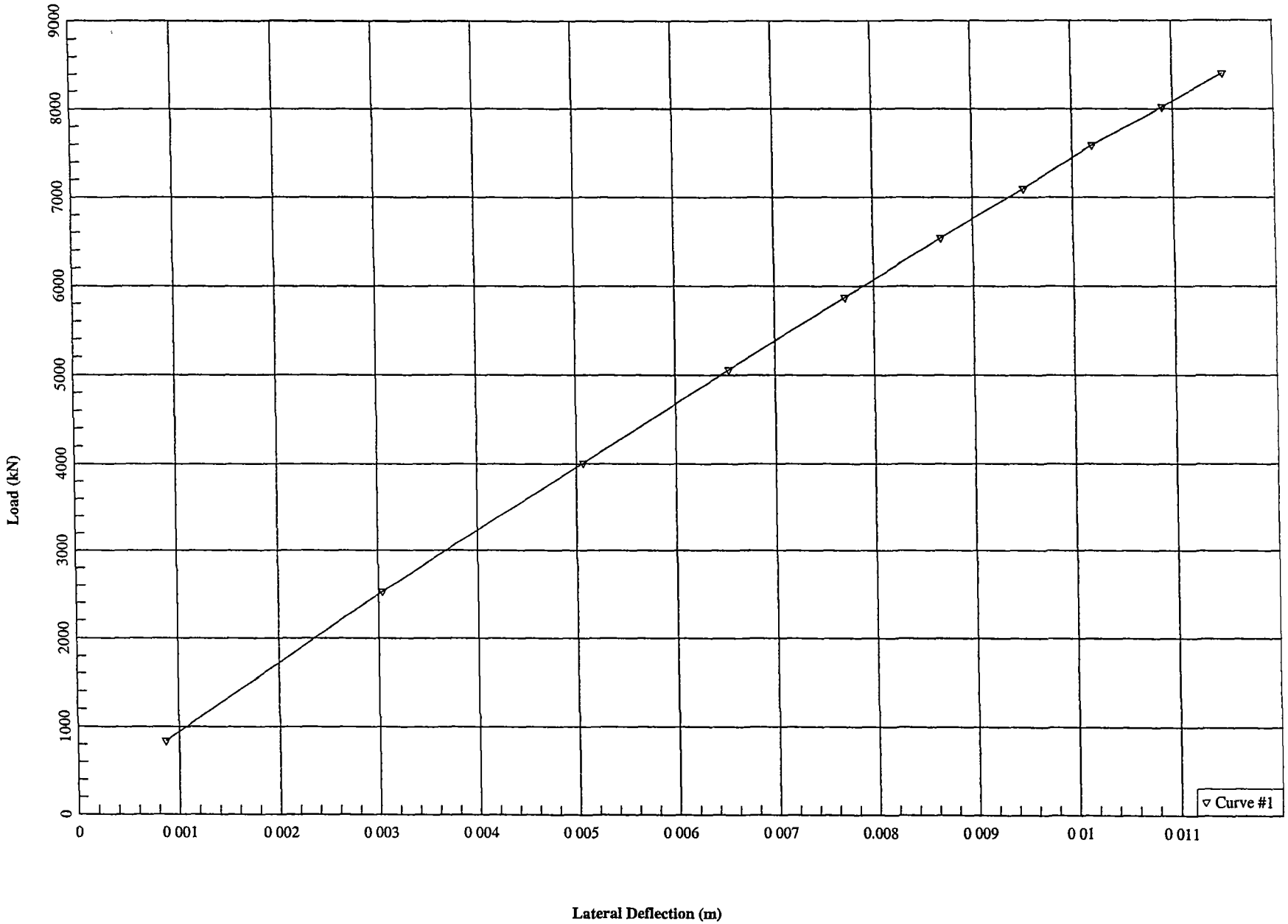




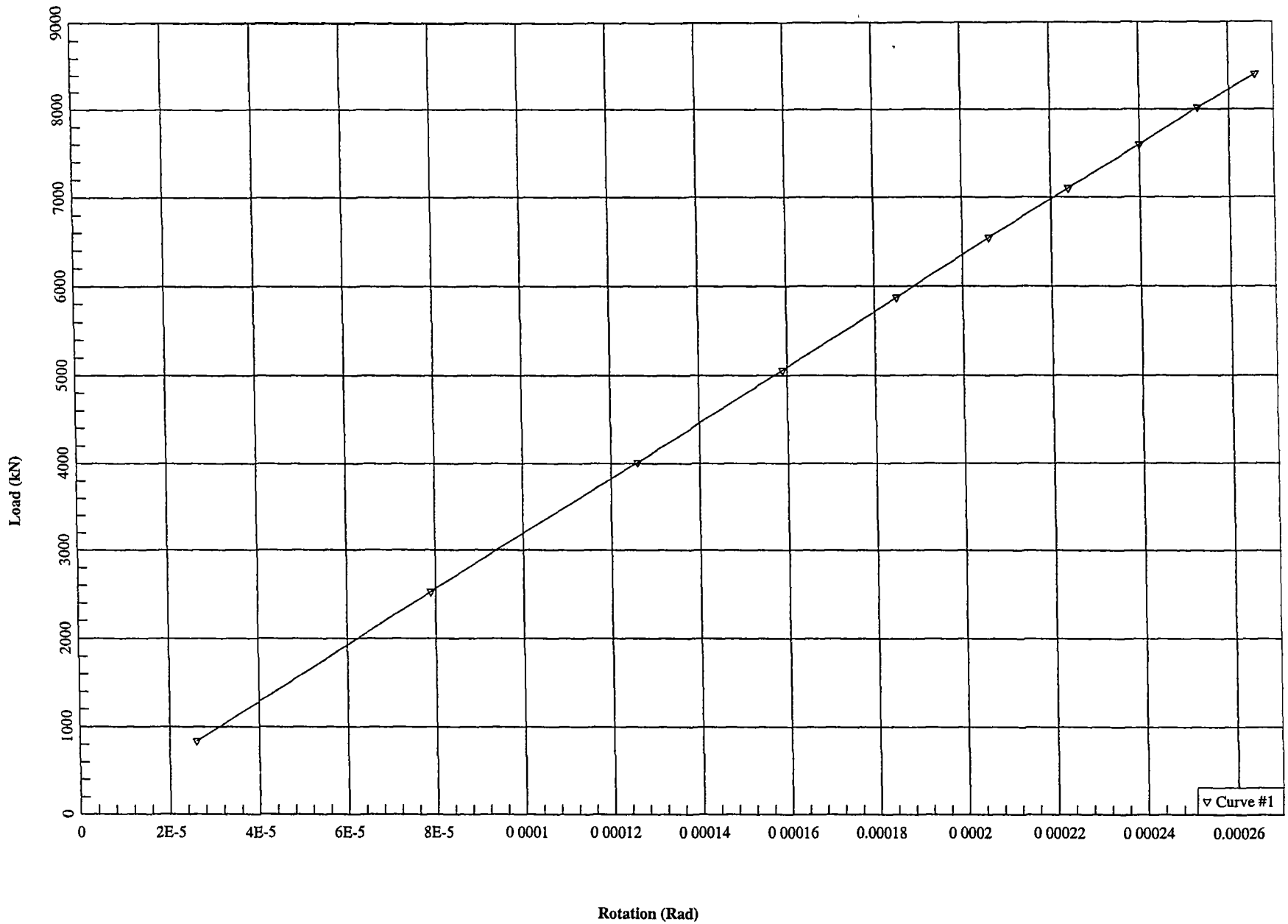
Legacy - Bridge No 22 - Bent 3 - 32 Piles



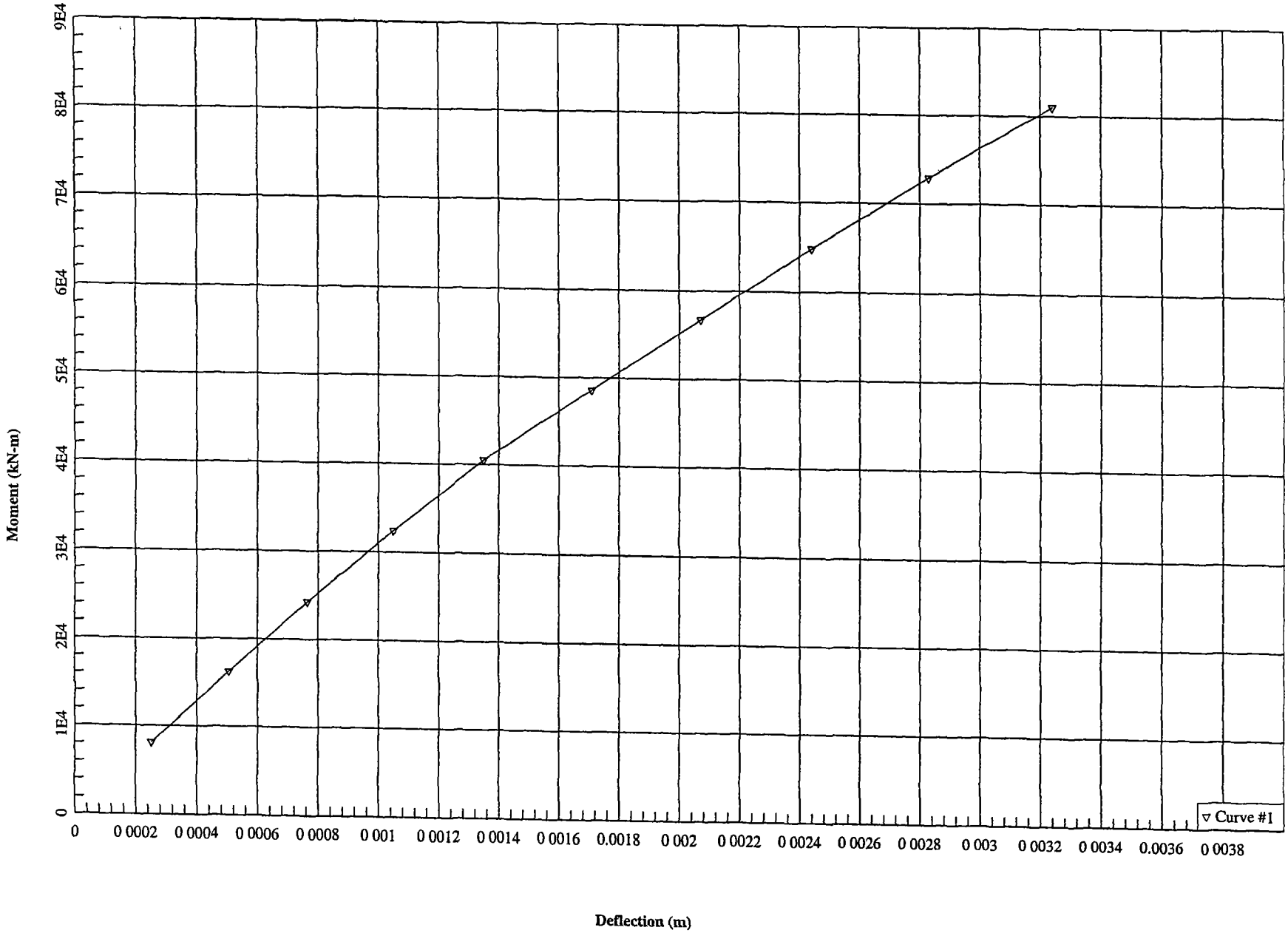
Legacy - Bridge No 22 - Bent 3 - 32 Piles



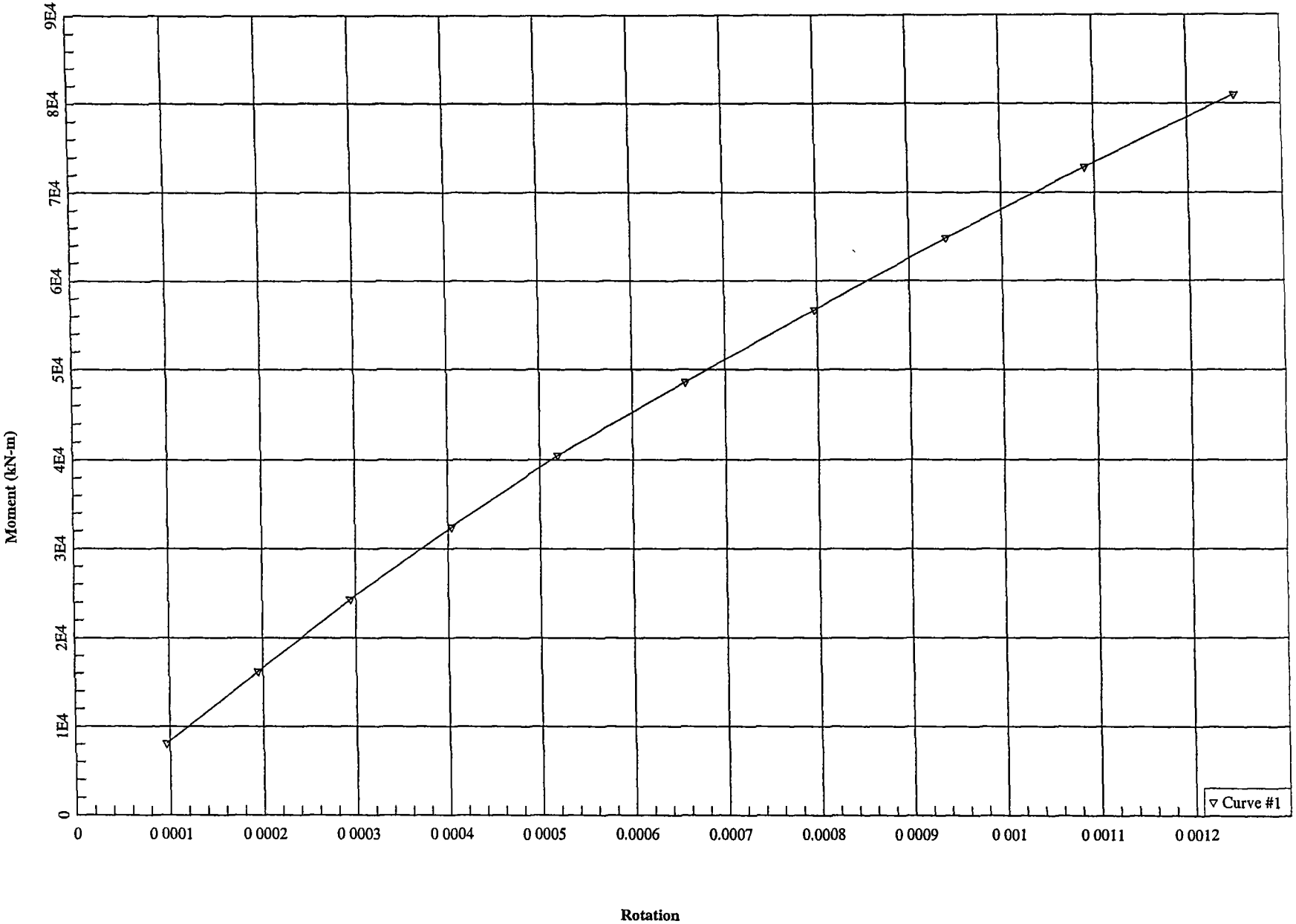
Legacy - Bridge No 22 - Bent 3 - 32 Piles



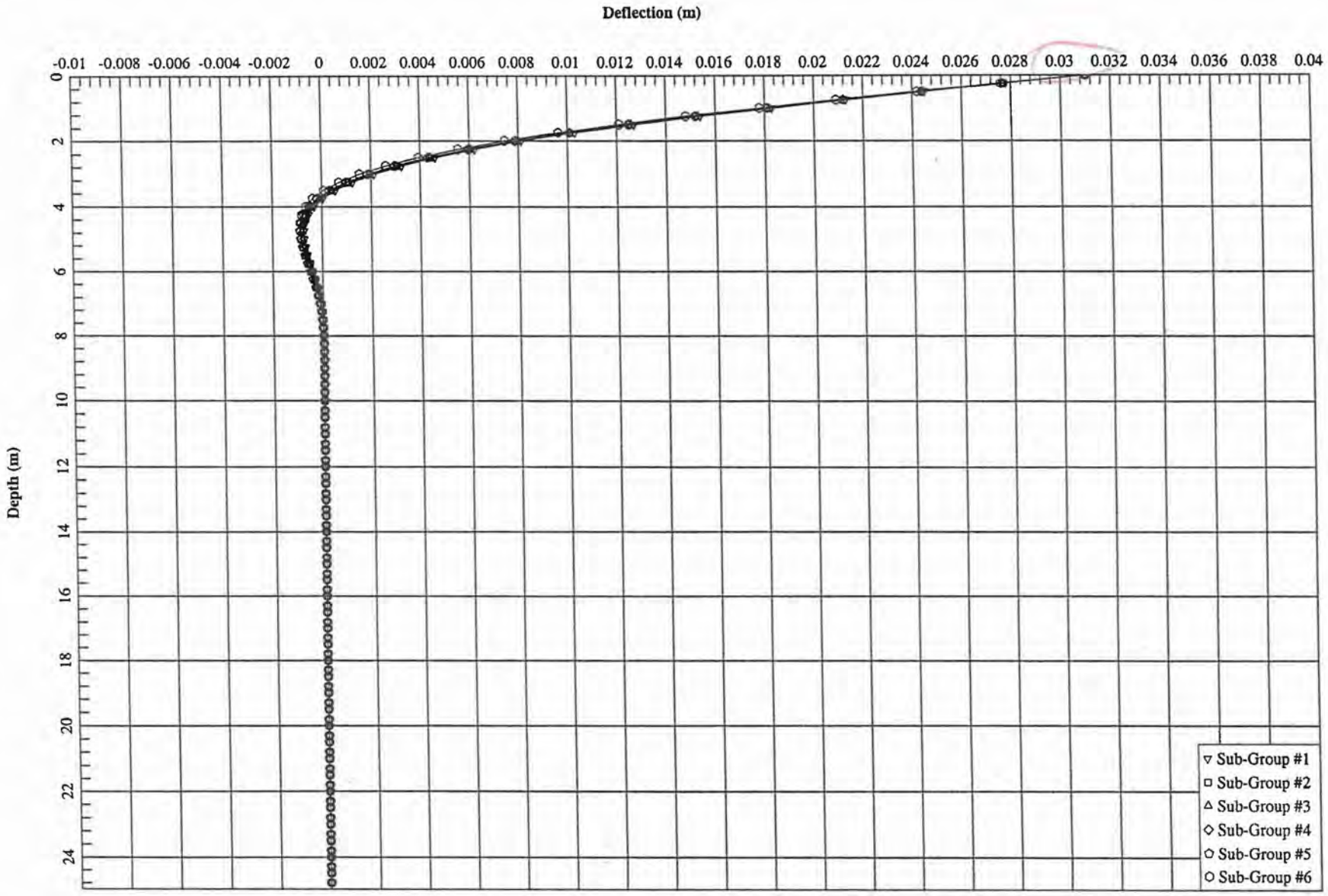
Legacy - Bridge No 22 - Bent 3 - 32 Piles



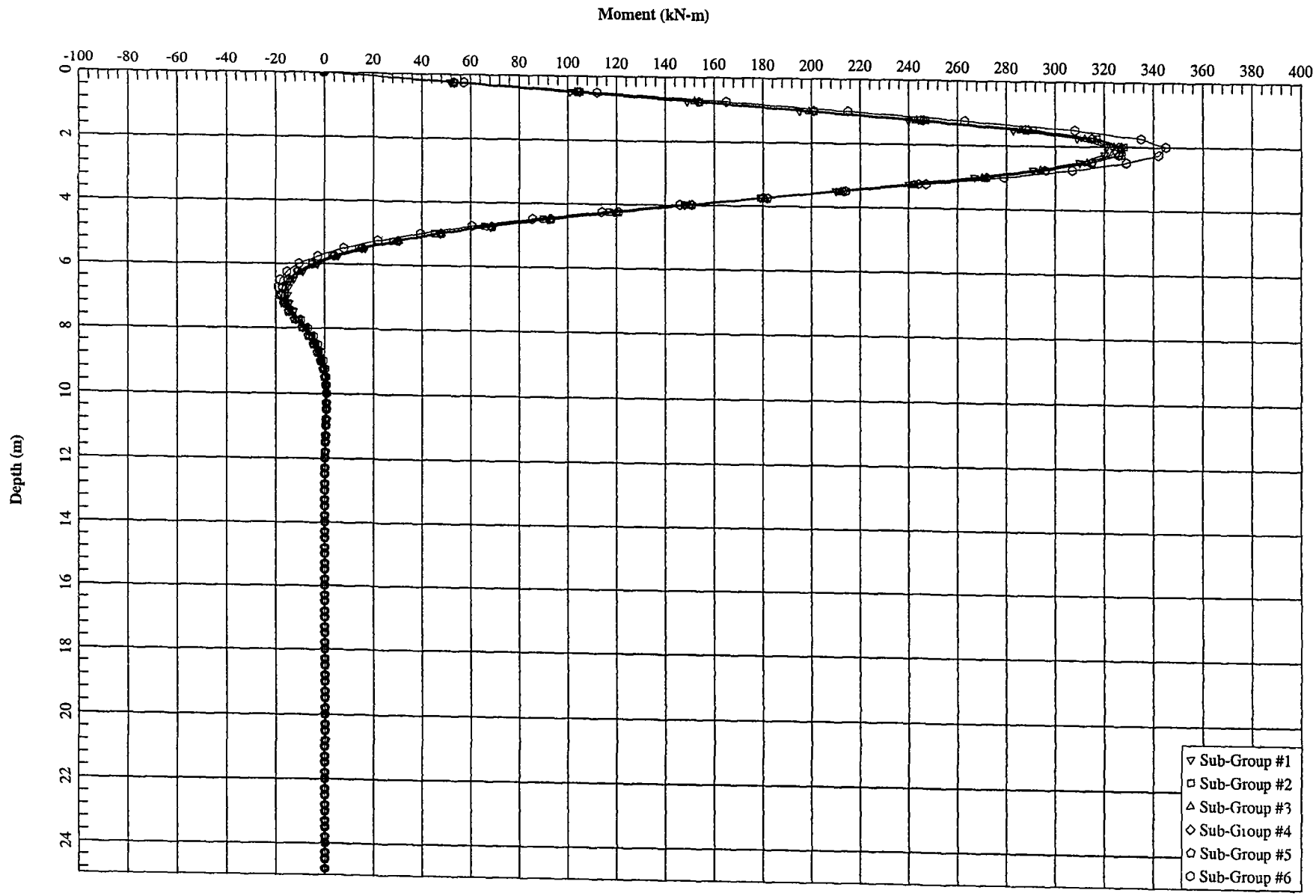
Legacy Bridge No 22 - Bent 3 - 32 Piles



Legacy - Bridge No 22 - Bent 3 - 32 Piles



Legacy - Bridge No 22 - Bent 2 - 24 Piles



Legacy - Bridge No 22 - Bent 2 - 24 Piles

PARSONS BRINCKERHOFF COMPUTATION SHEET

Page ____ of ____ 459

Made by DW

Date 8/14/07

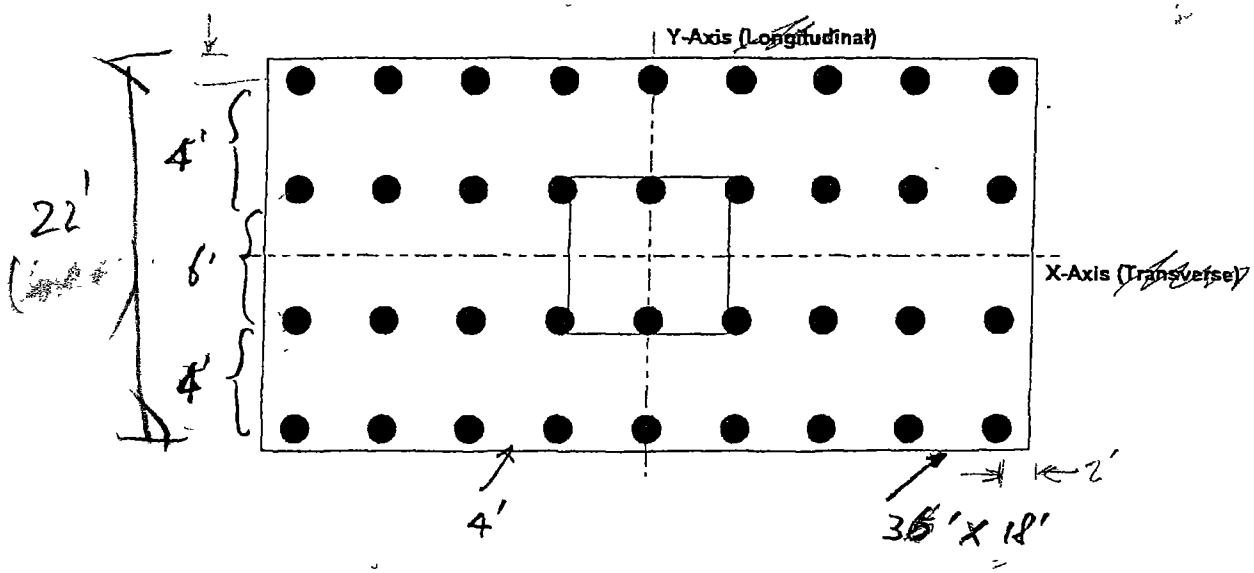
Checked by

Date

Subject Legacy Bridge 22
Foundation, Bent 5

Bent 5

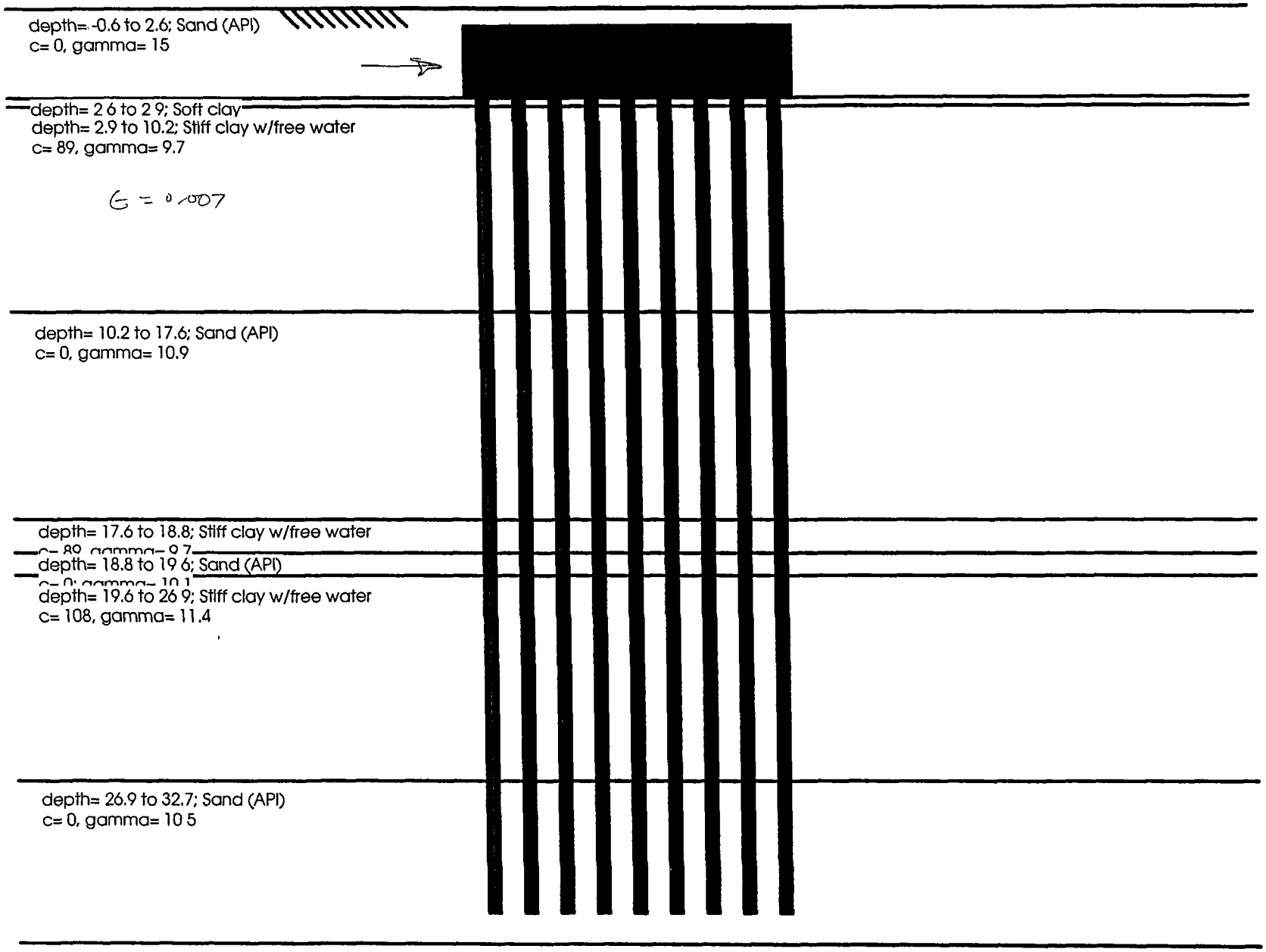
	Trans.		Long	
Δ (mm)	17		11	
M (kN·m)	179		187	
f_{max} (MPa)	195		168	
Axial (kN)	−1800	(−5mm)	−1010	(−2mm)
	2550	+8.5mm.	1730	(4mm)



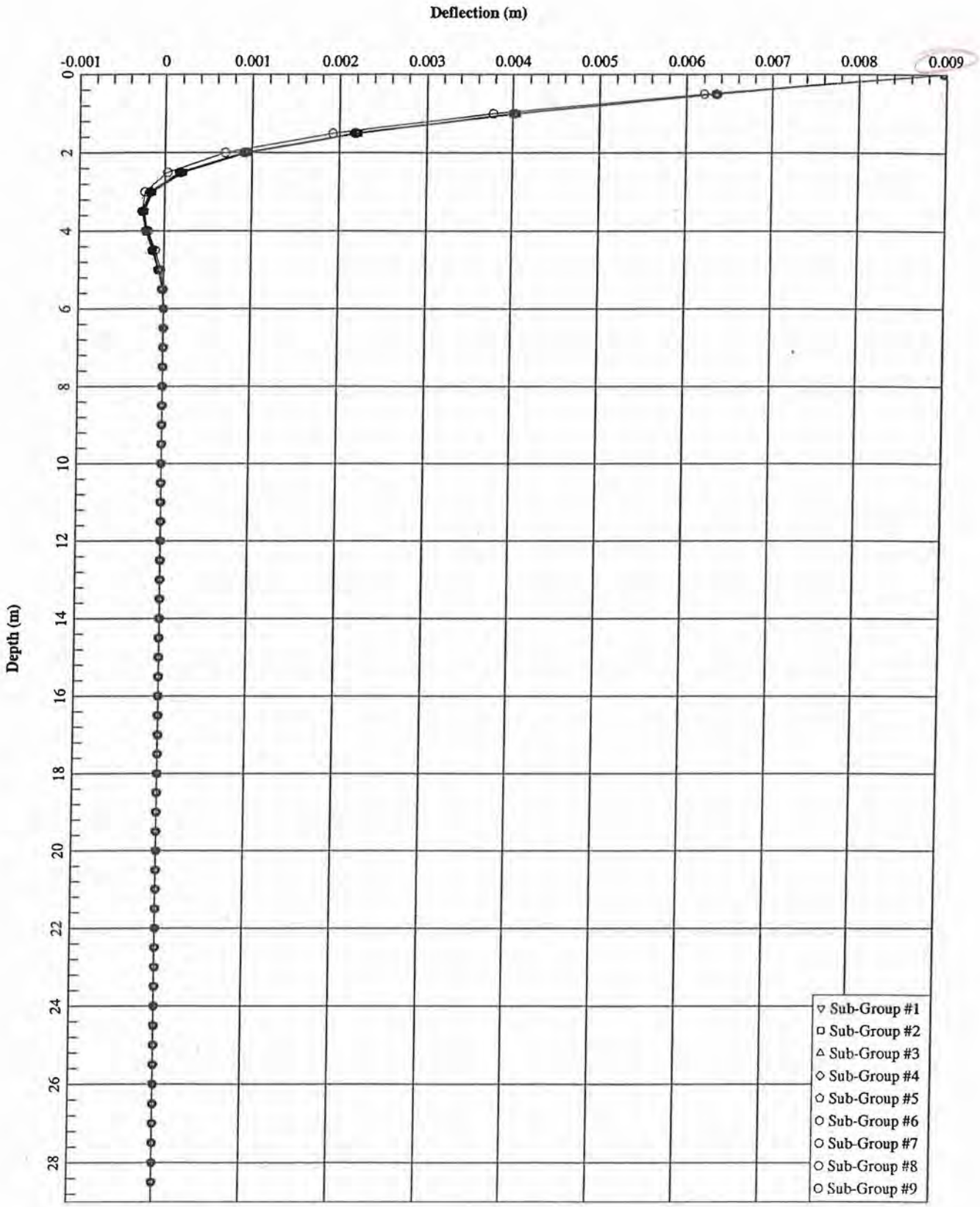
Br #22, p=3.0% (36piles, Mp, 2ft cover)

18,

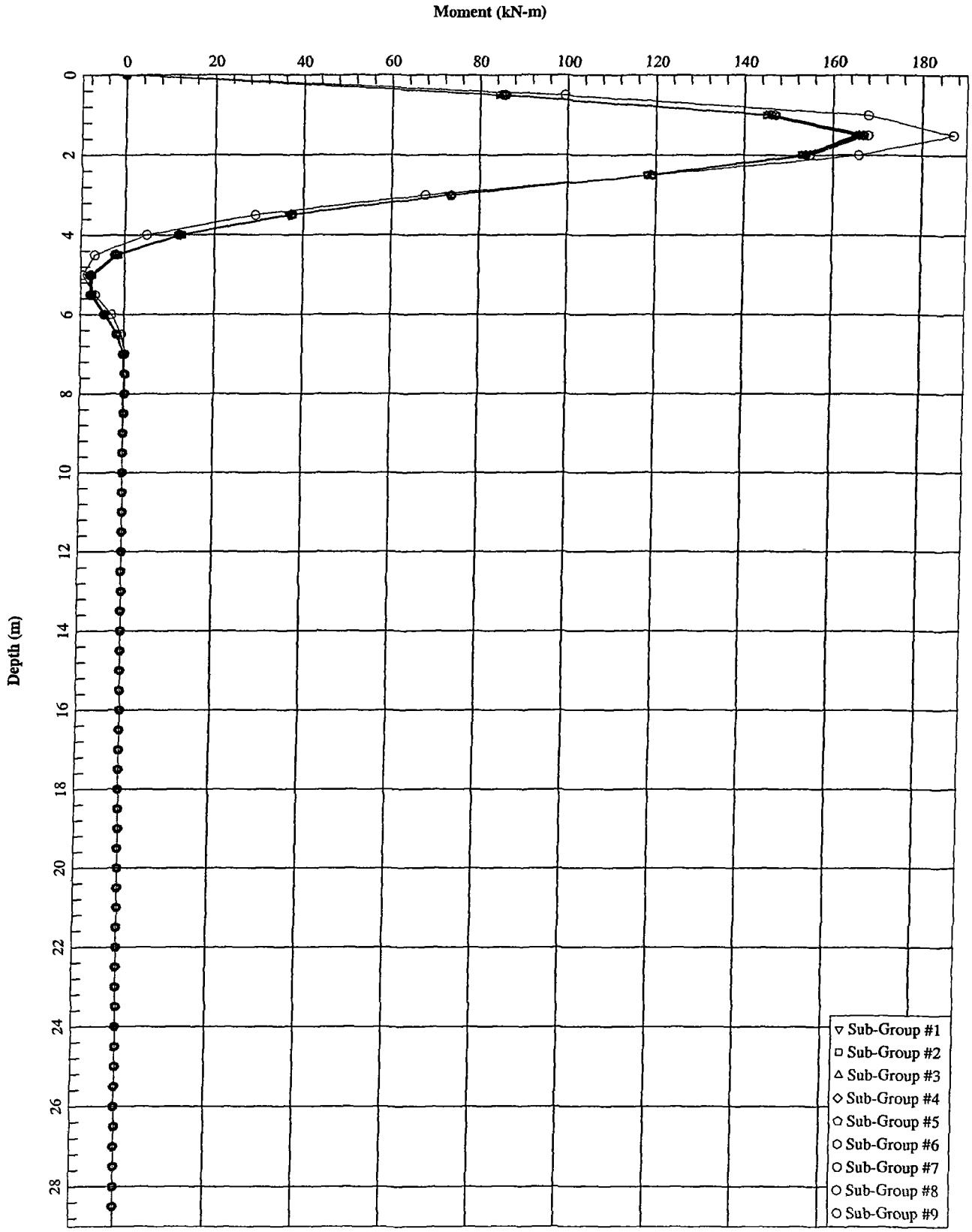
Bent.



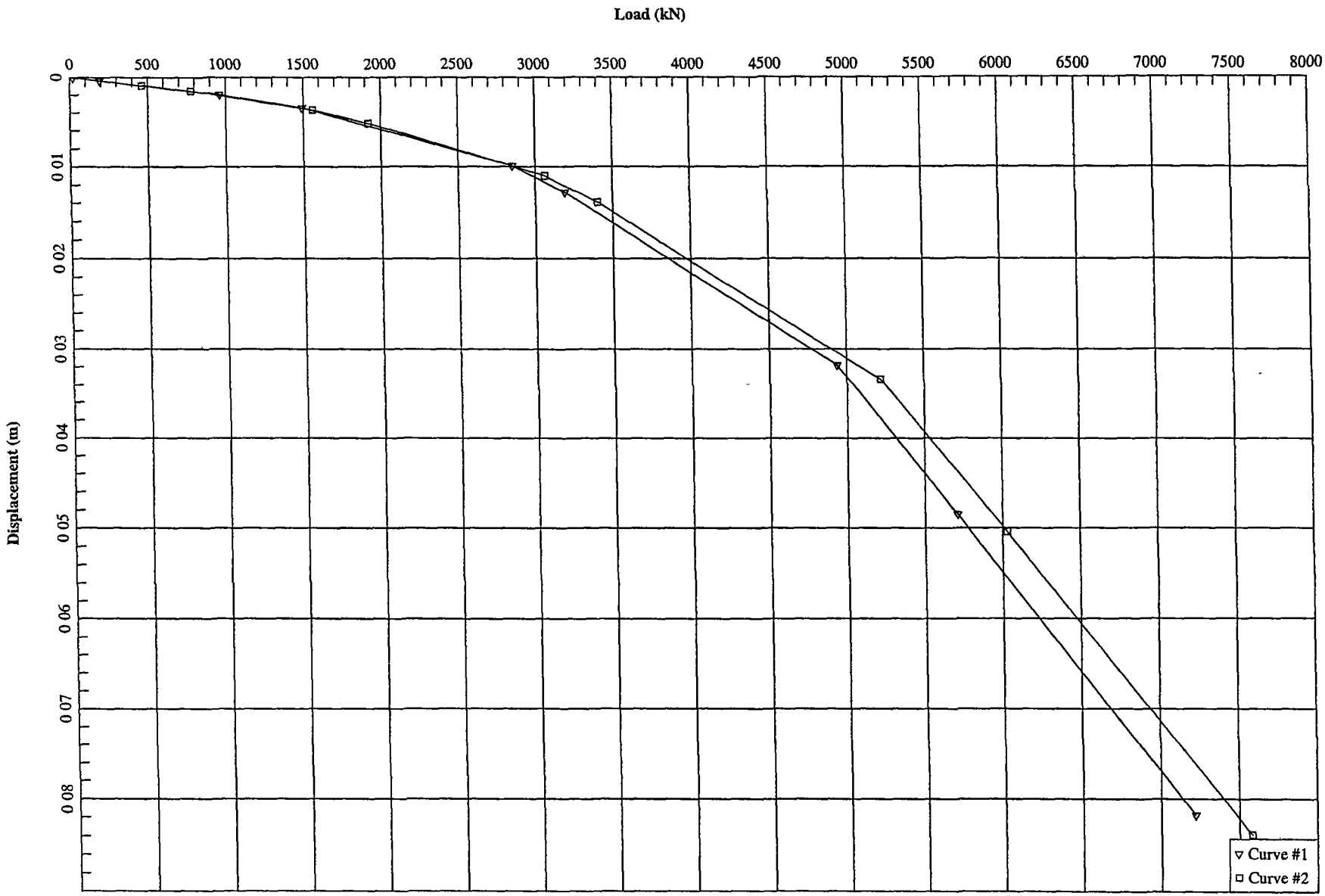
Bridge No 22 46 1
Bent 5
Longitud.
Revised Loads
36 piles



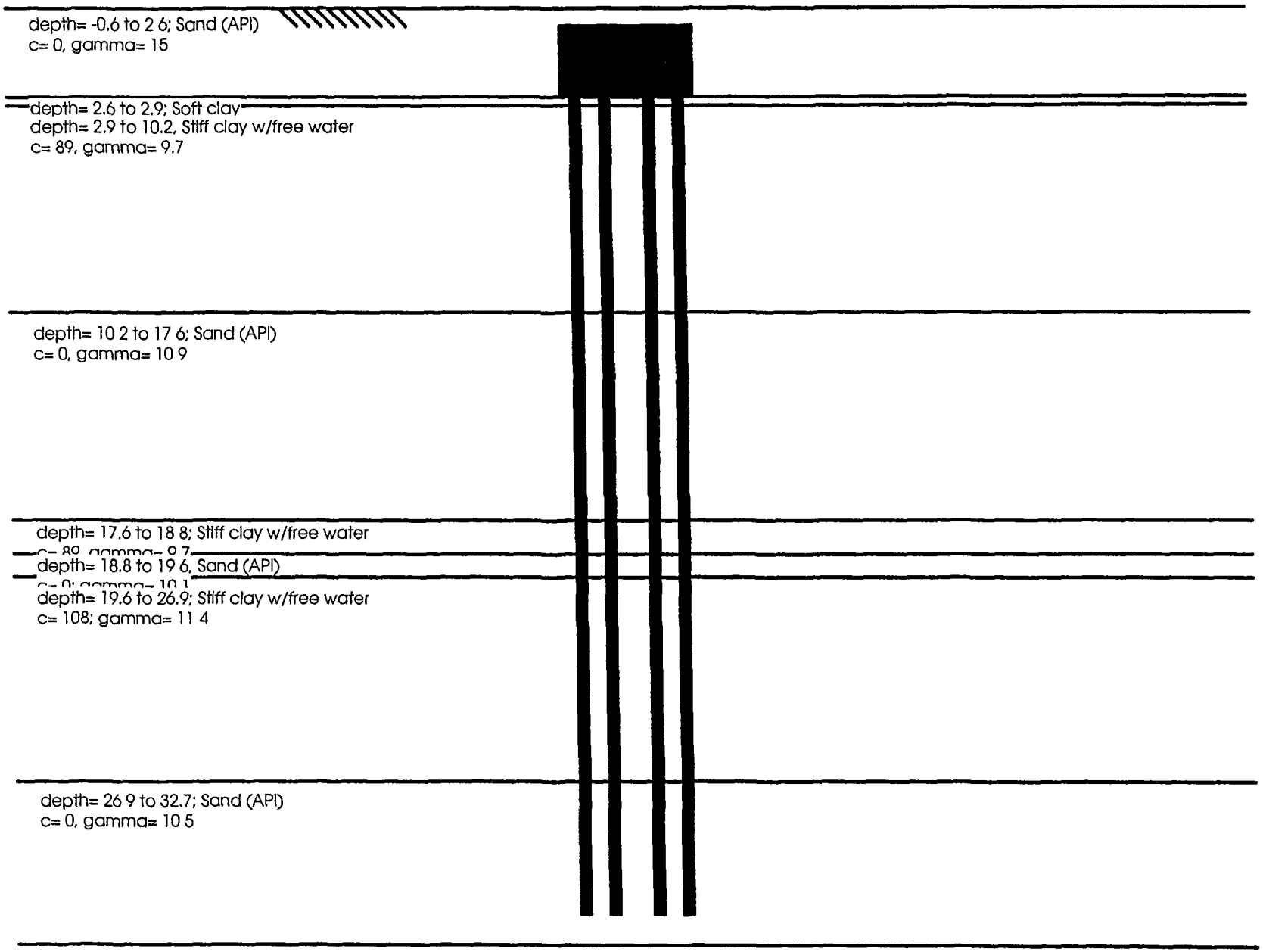
Legacy - Bridge No 22 - Bent 5 - Transverse



Legacy - Bridge No 22 - Bent 5 - Transverse



Legacy - Bridge No 22 - Bent 5



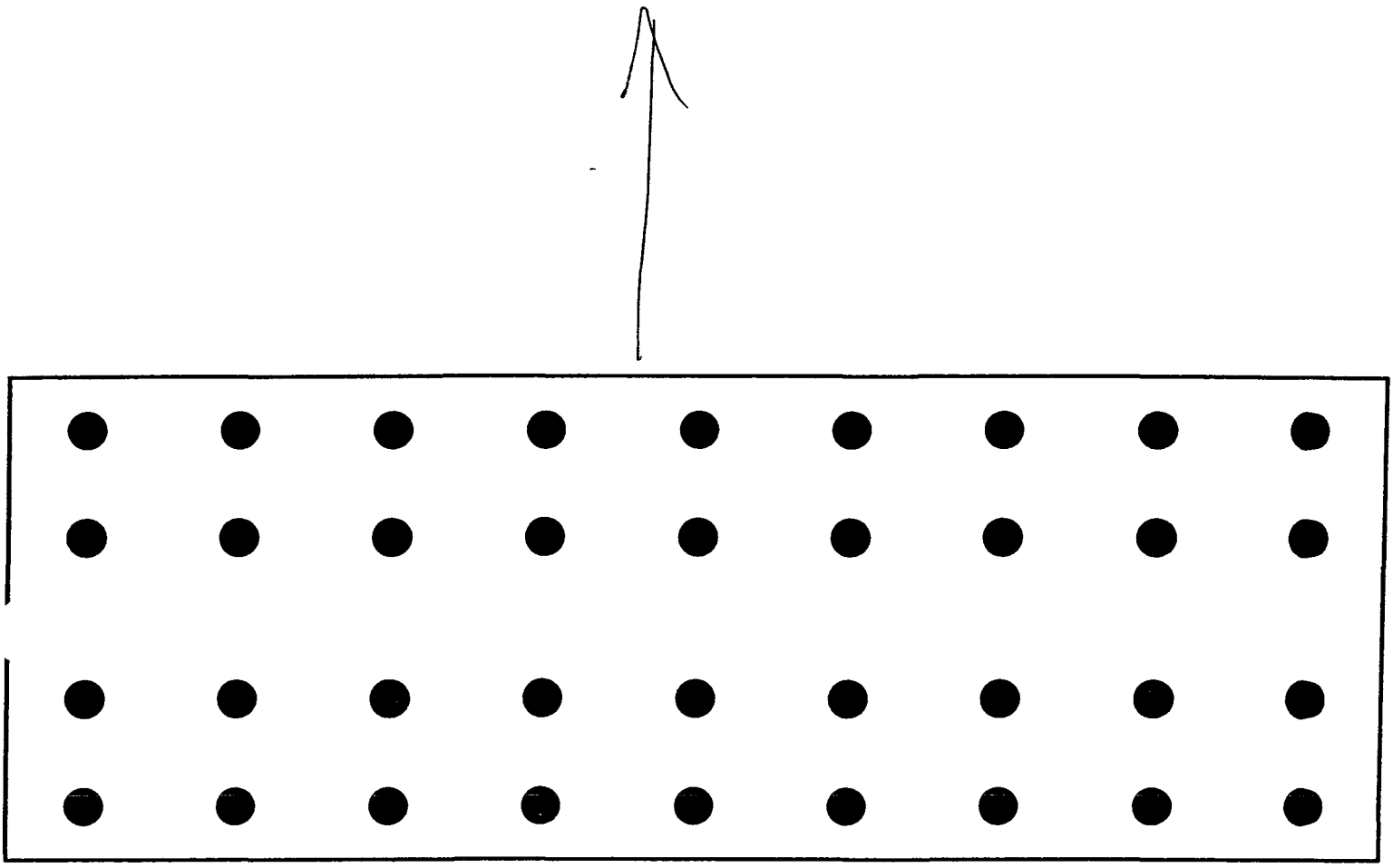
Bridge No 22 4215

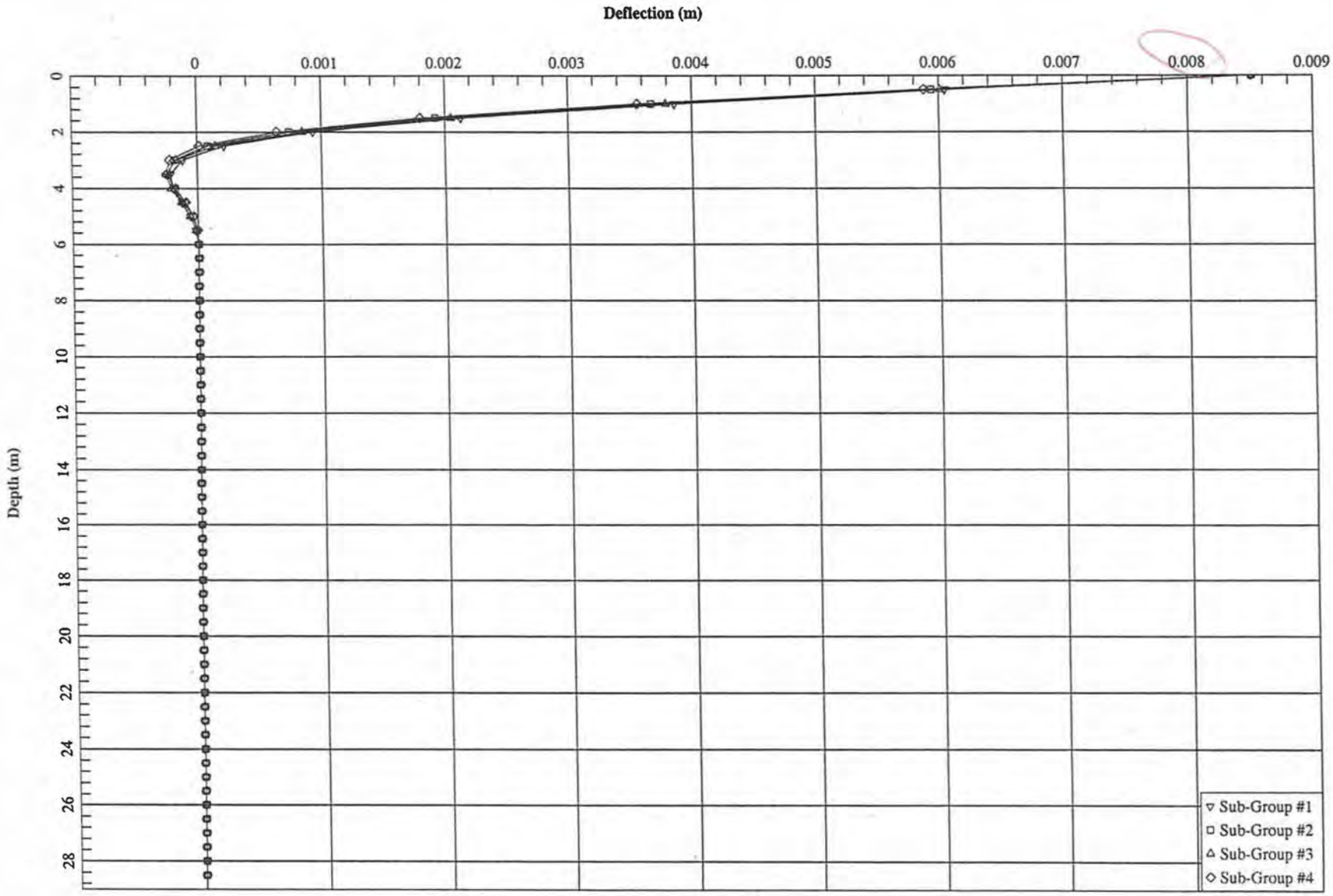
Bent 5

36 piles

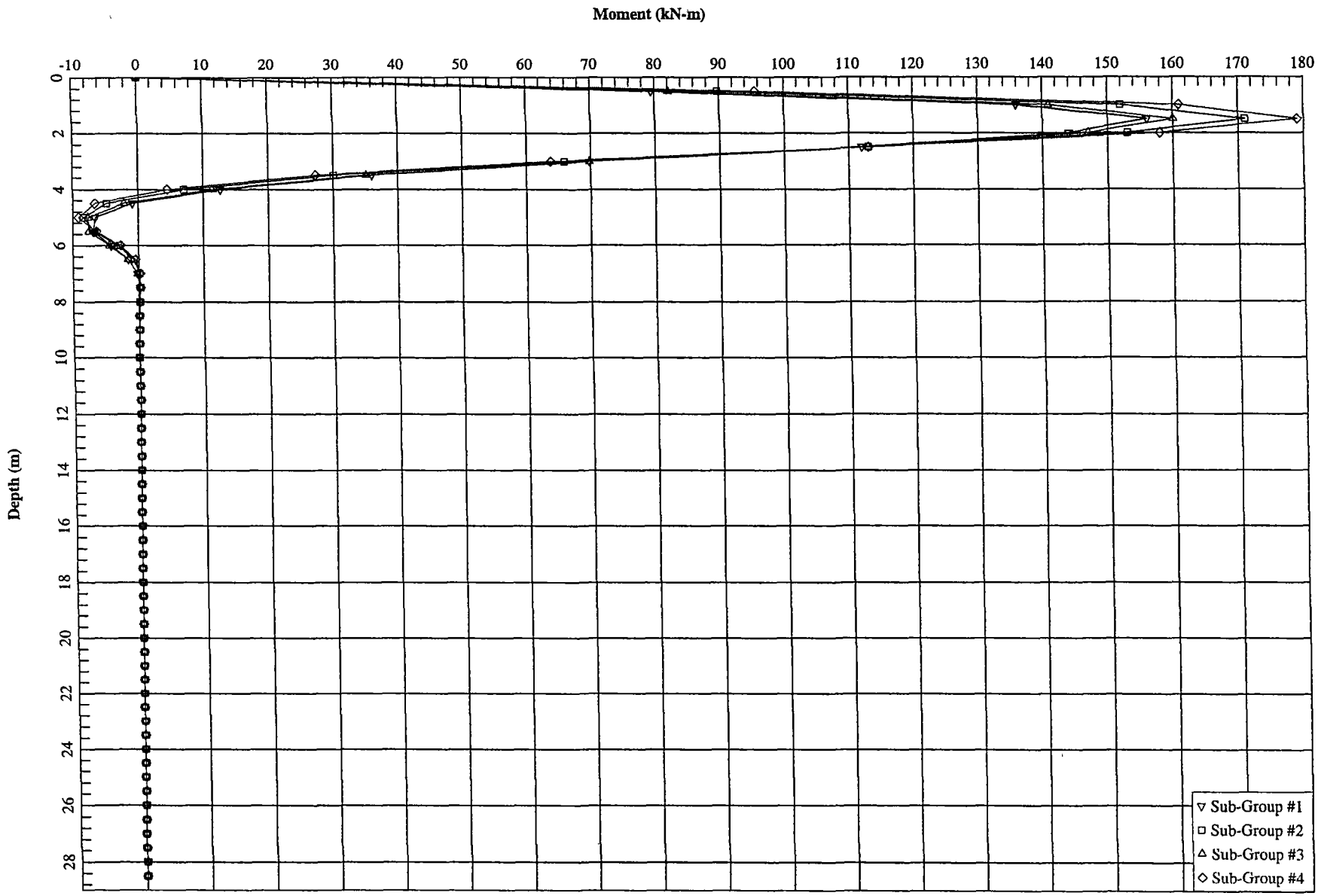
Transverse

Pinned heads

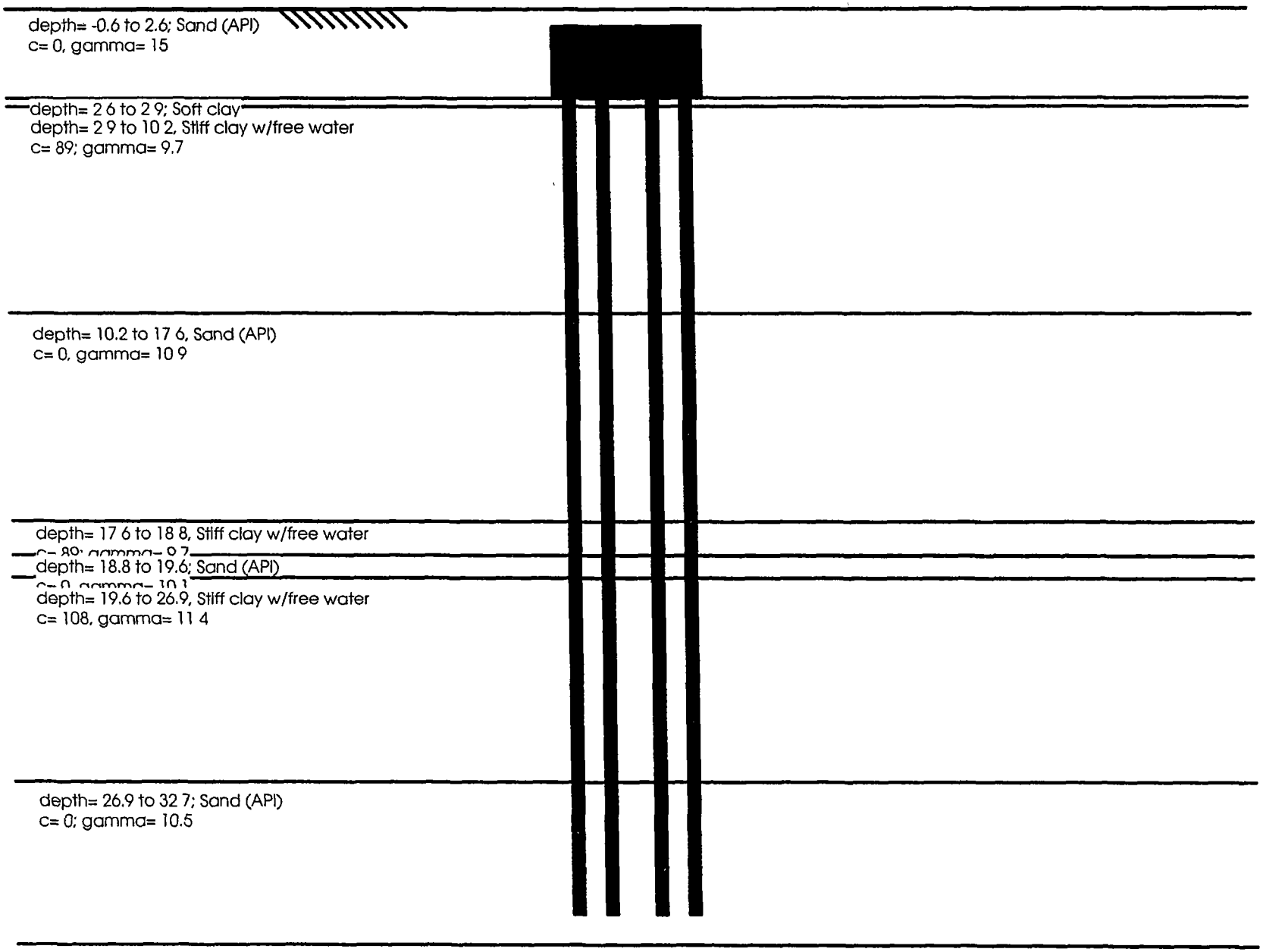


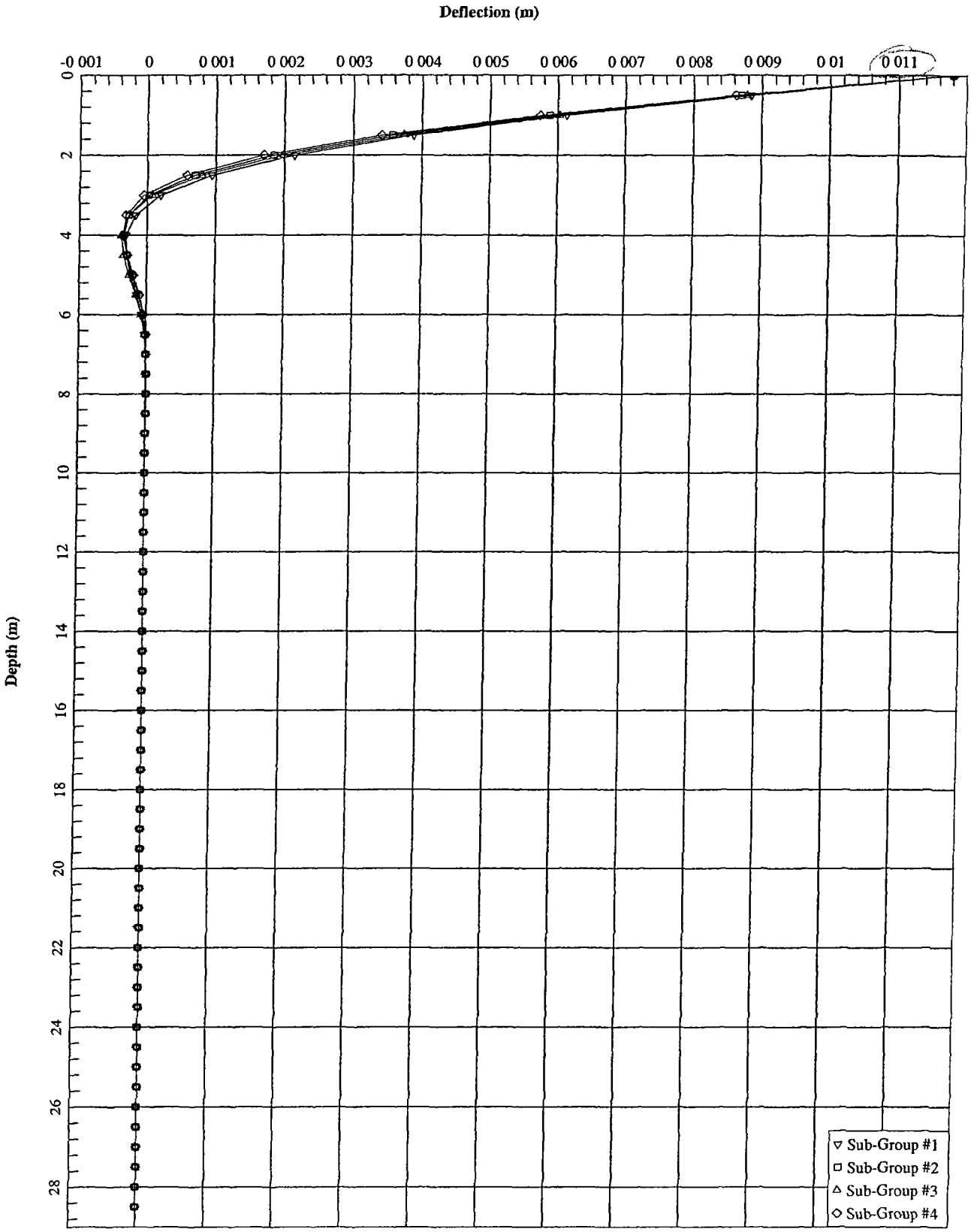


Legacy - Bridge No 22 - Bent 5 - Longitudinal

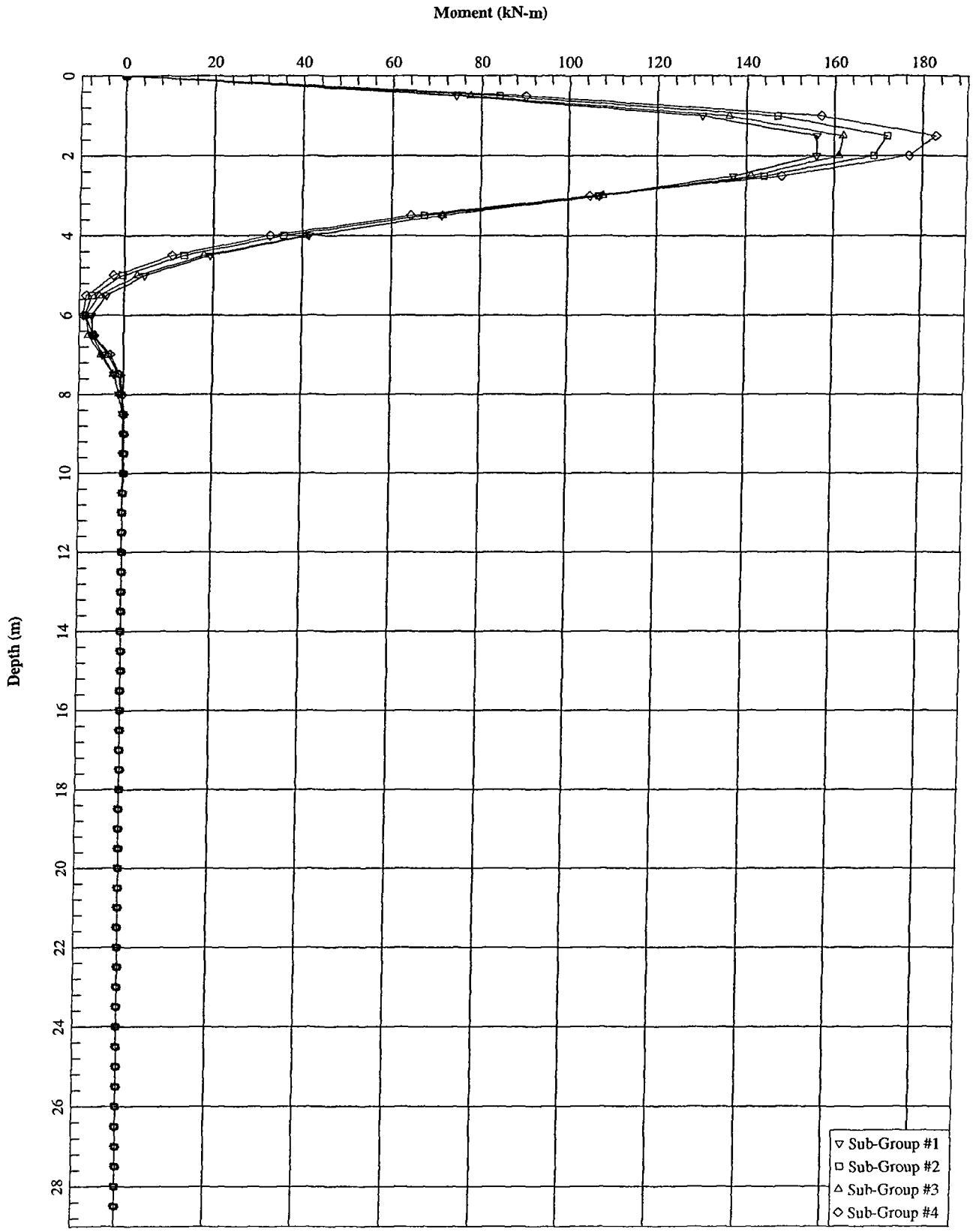


Legacy - Bridge No 22 - Bent 5 - Transverse

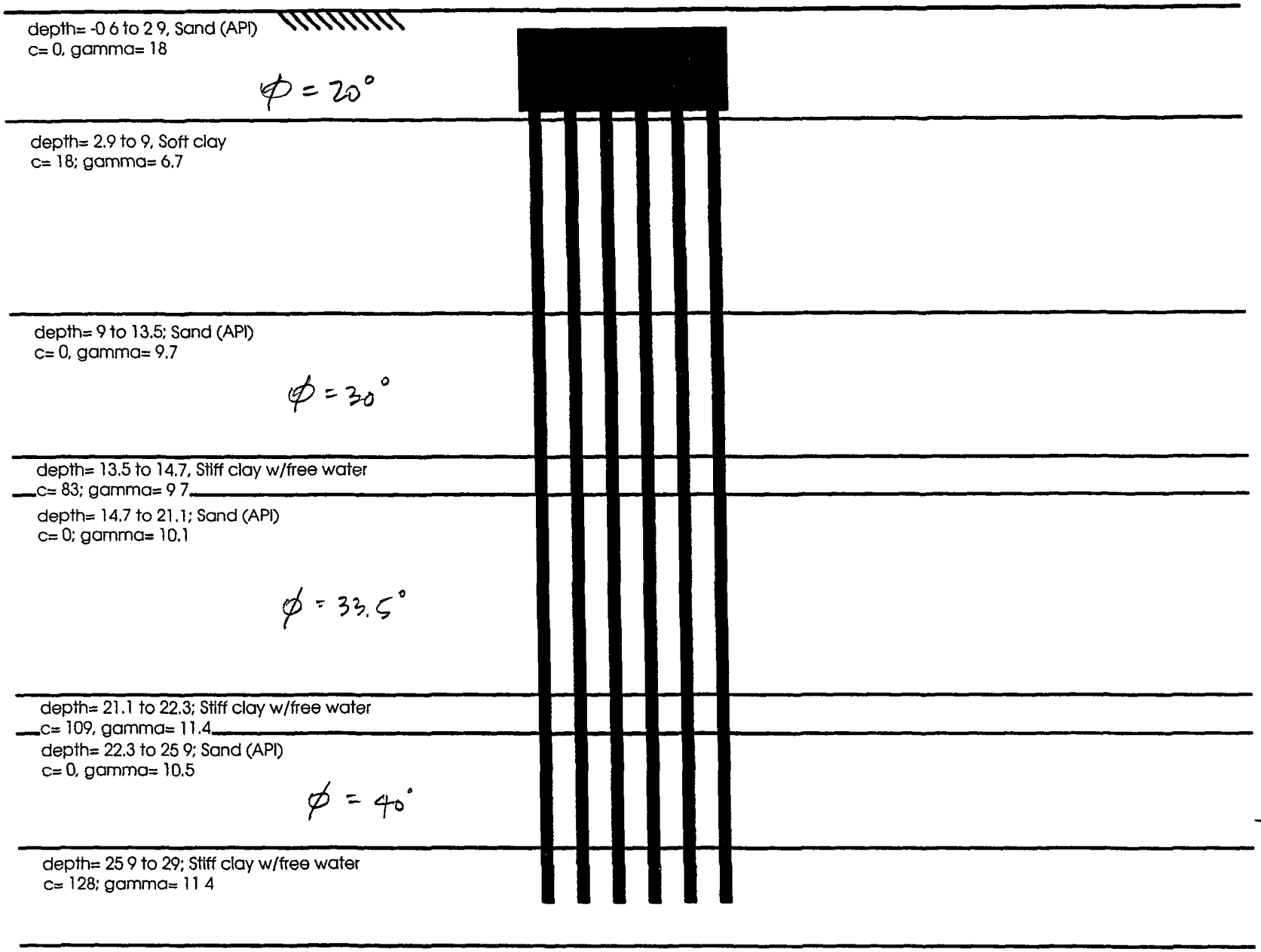

depth= -0.6 to 2.6; Sand (API)
c= 0, gamma= 15
depth= 2 6 to 2 9; Soft clay
depth= 2 9 to 10 2, Stiff clay w/free water
c= 89; gamma= 9.7
depth= 10.2 to 17 6, Sand (API)
c= 0, gamma= 10 9
depth= 17 6 to 18 8, Stiff clay w/free water
depth= 18.8 to 19.6; Sand (API)
depth= 19.6 to 26.9, Stiff clay w/free water
c= 108, gamma= 11 4
depth= 26.9 to 32 7; Sand (API)
c= 0; gamma= 10.5



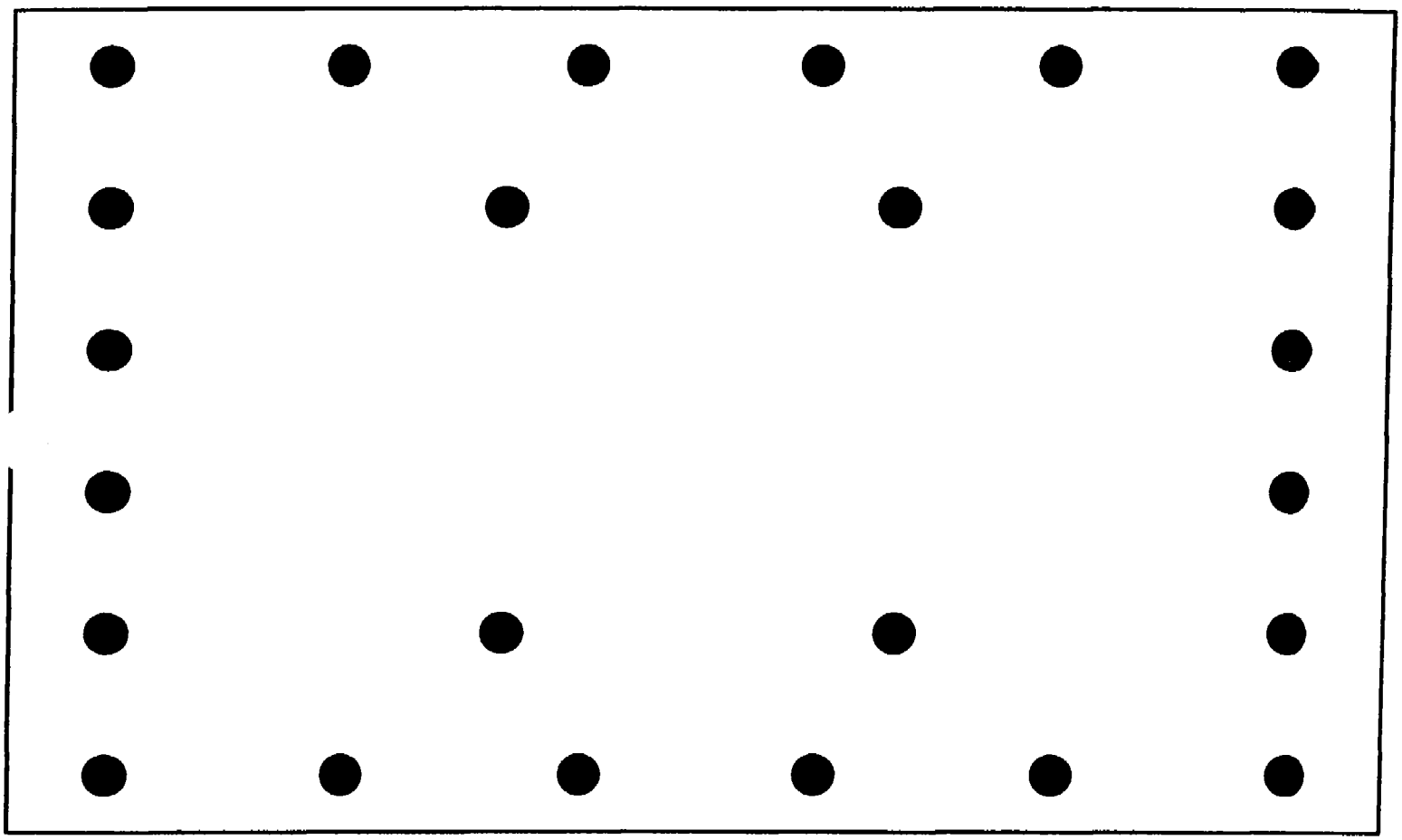
Legacy - Bridge No 22 - Test Case - E50 = 0.02

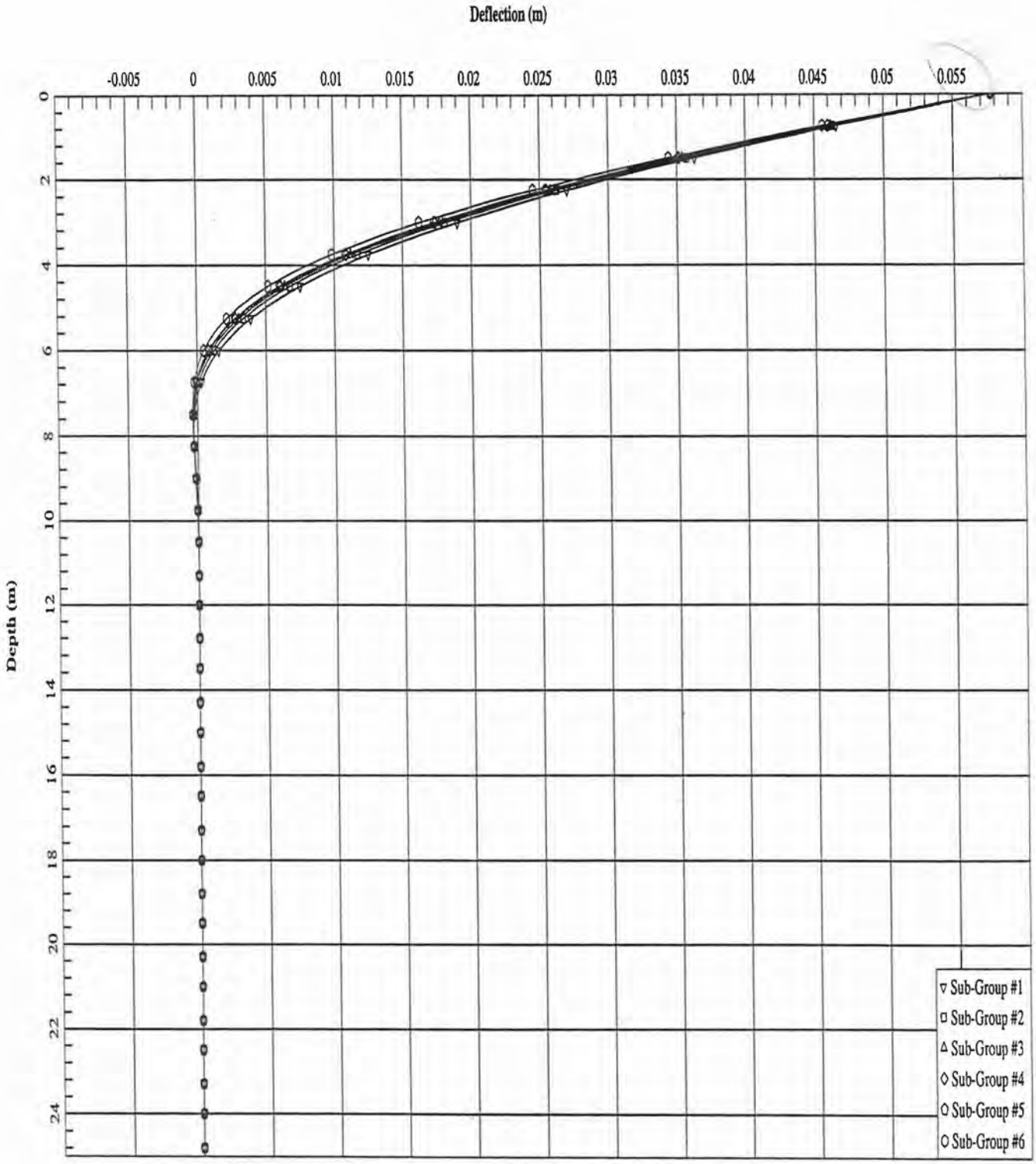


Legacy - Bridge No 22 - Bent 5 - Test Case - E50 = 0.02

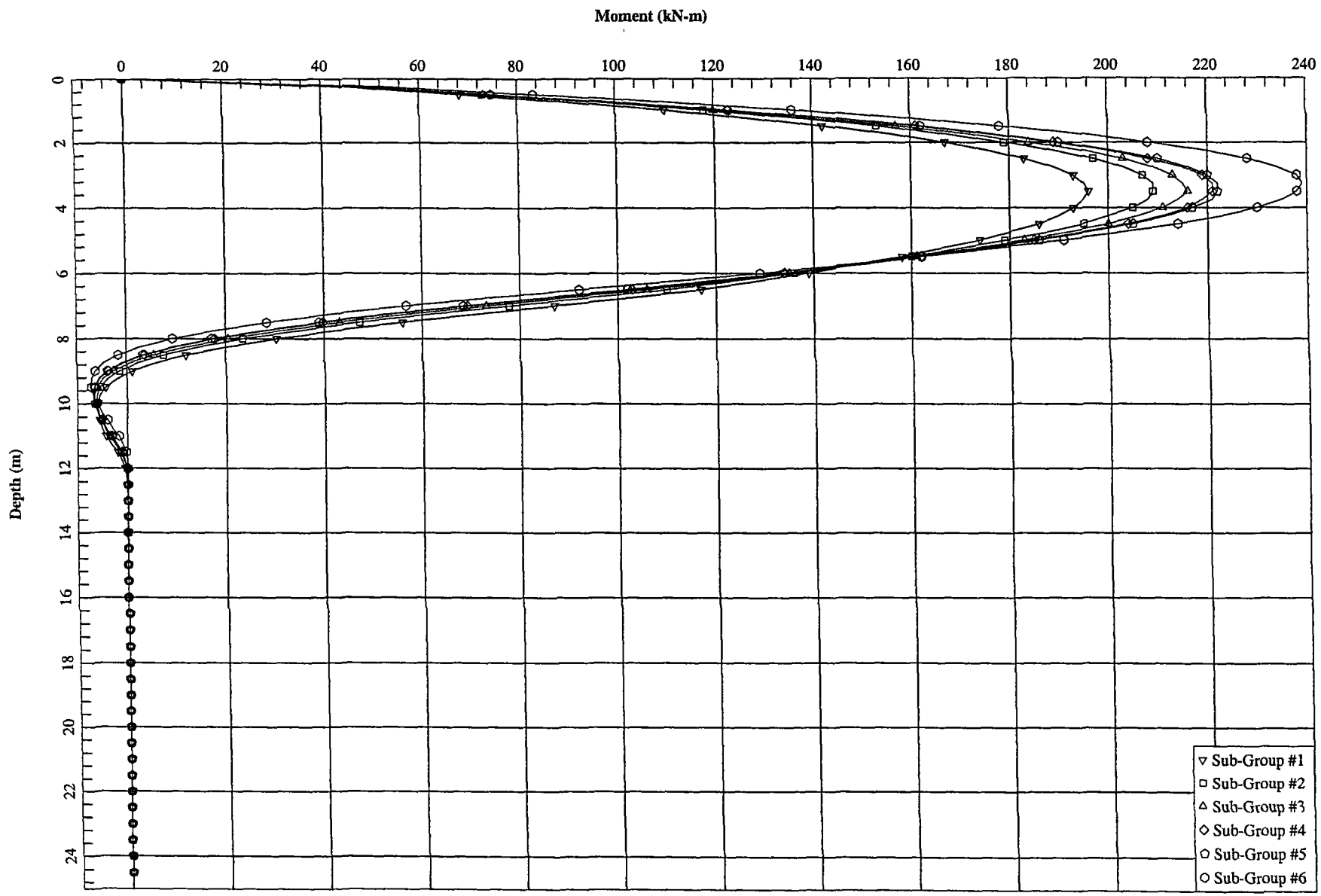


Legacy Bridge No 2
Bent 6
24 Piles
Revised Loads
Crummy Soils





Legacy - Bridge No 22 - Bent 6 - Crummy Soil - 24 Piles



Legacy - Bridge No 22 - Bent 6 - Crummy Soil - 24 Piles

depth= -0 6 to 2 9; Sand (API)
c= 0; gamma= 18

$\phi = 20^\circ$

depth= 2.9 to 9; Soft clay
c= 18; gamma= 6 7

depth= 9 to 13.5, Sand (API)
c= 0, gamma= 9.7

$\phi = 30^\circ$

depth= 13 5 to 14.7, Stiff clay w/free water
c= 83, gamma= 9.7

depth= 14.7 to 21 1, Sand (API)
c= 0, gamma= 10.1

$\phi = 33.5^\circ$

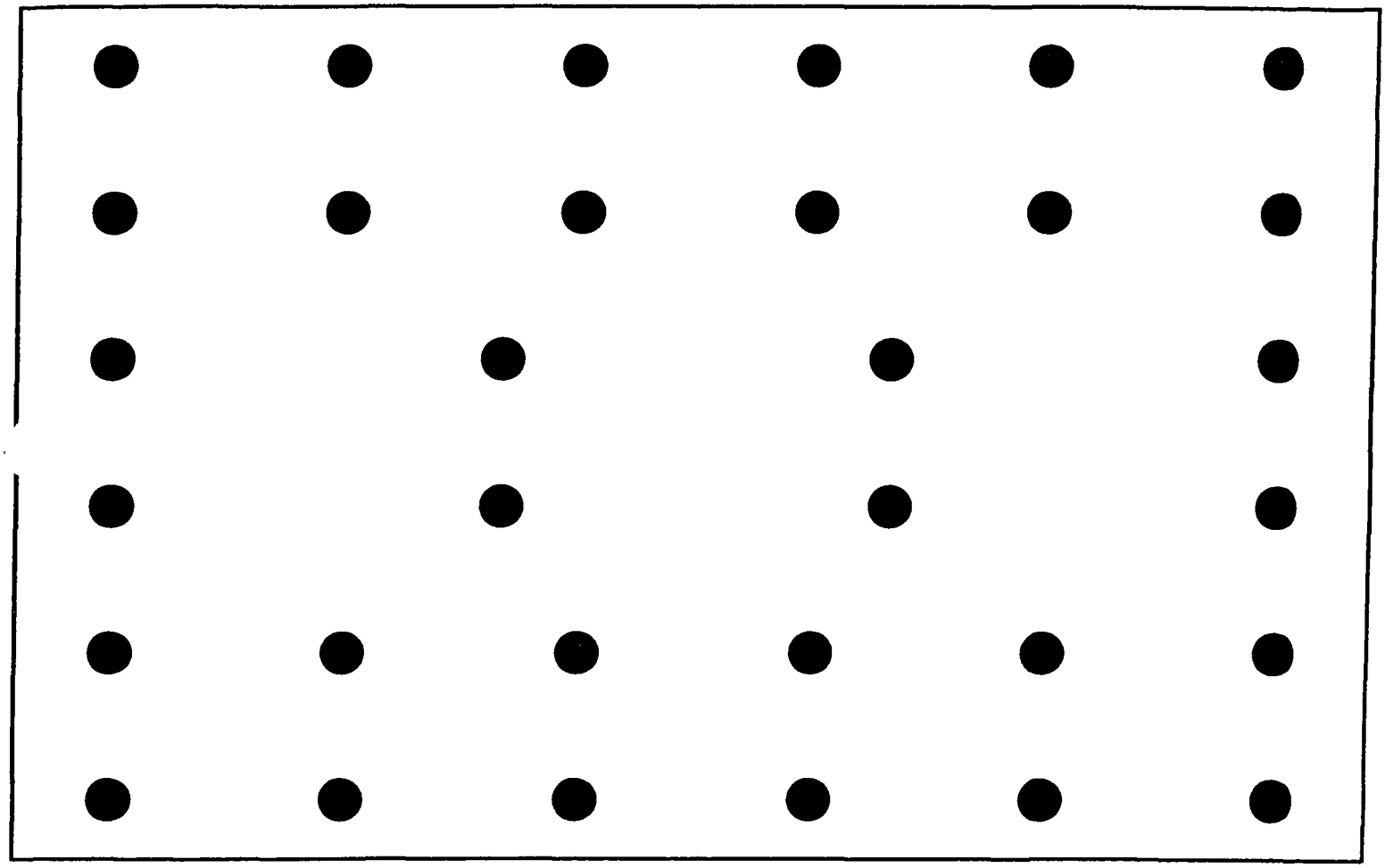
depth= 21.1 to 22.3; Stiff clay w/free water
c= 109, gamma= 11 4

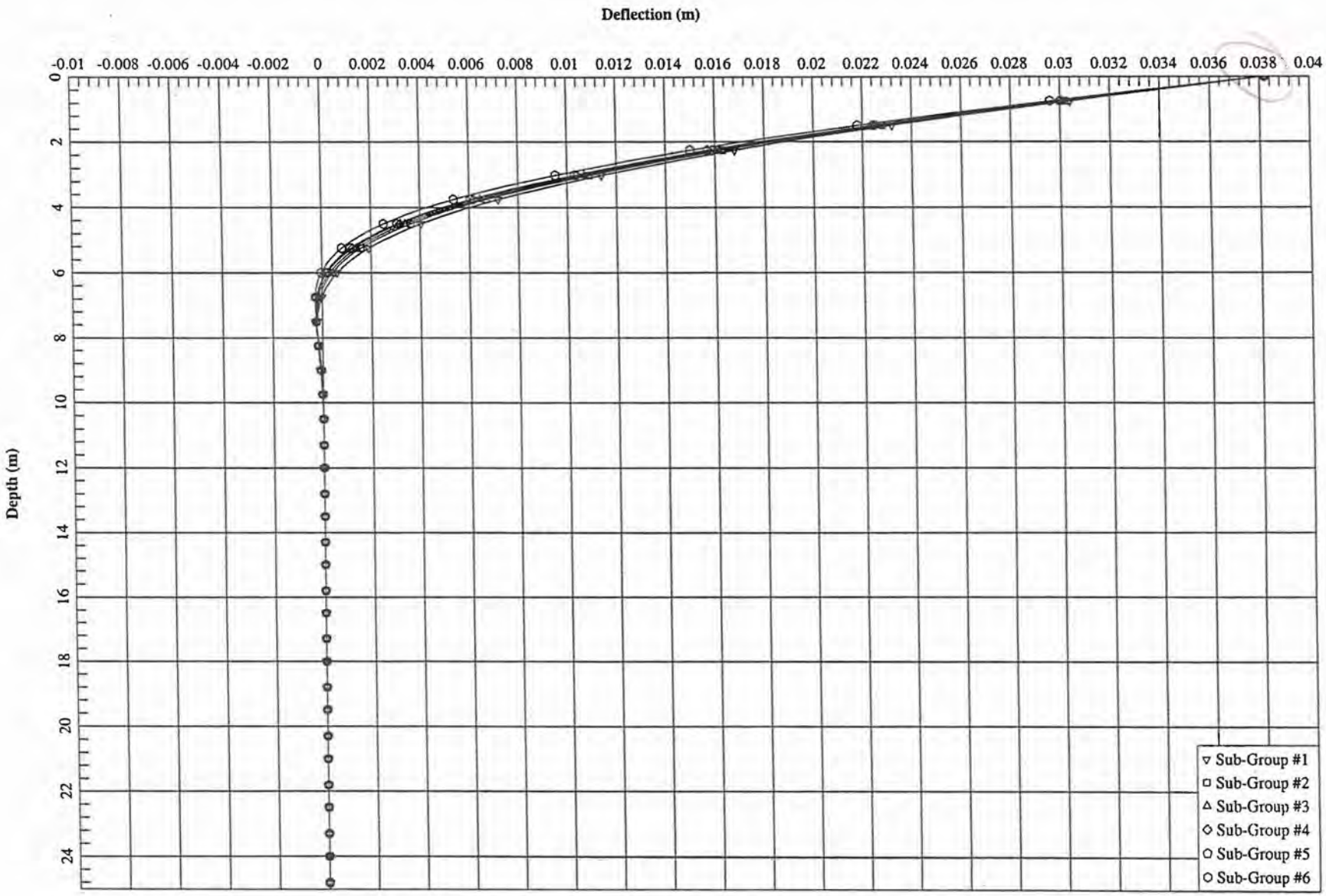
depth= 22.3 to 25.9, Sand (API)
c= 0; gamma= 10 5

$\phi = 40^\circ$

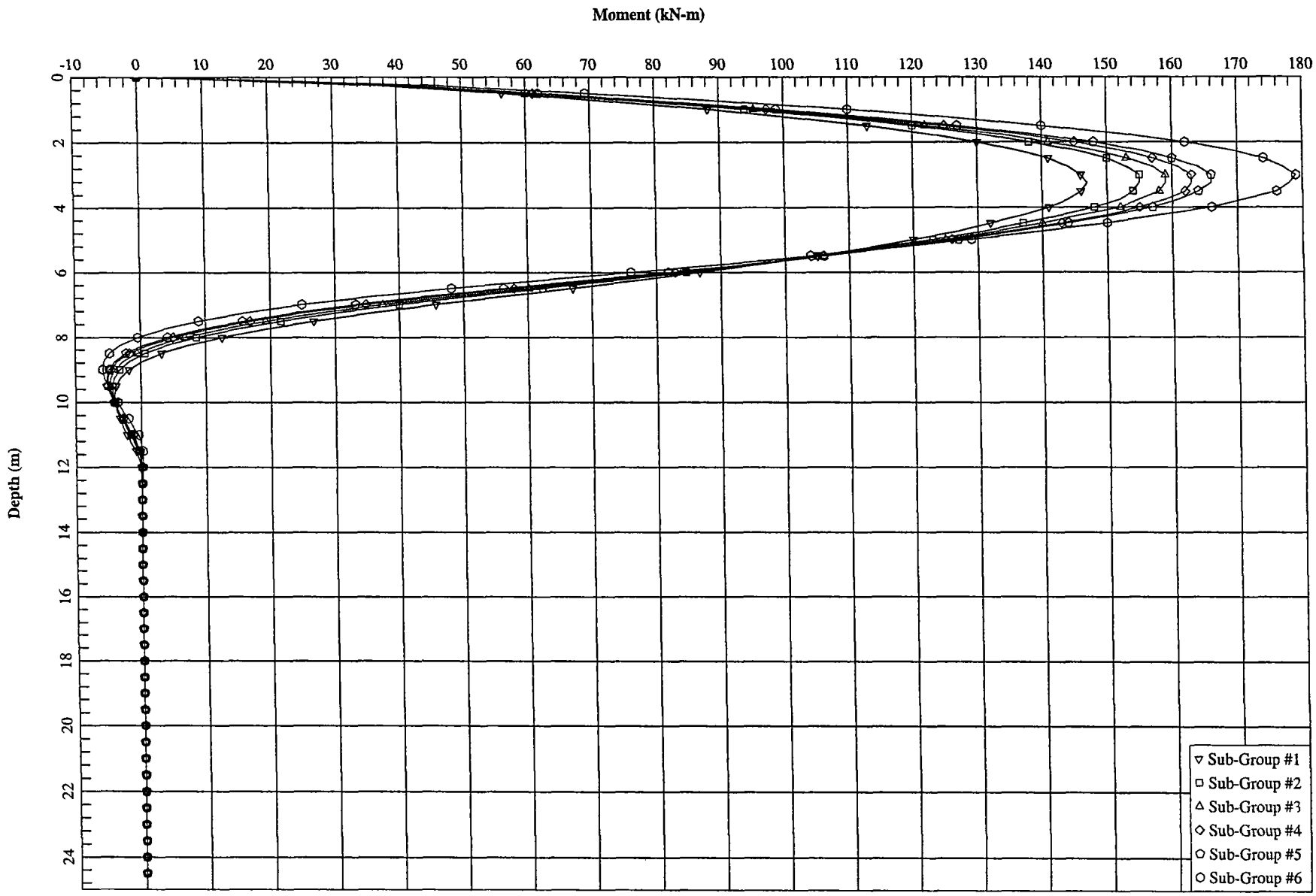
depth= 25.9 to 29; Stiff clay w/free water
c= 128; gamma= 11 4

510 Legacy Village No 2 —
Bent 6
32 Piles
Revised Loads
Crummy Soils.





Legacy - Bridge No 22 - Bent 6 - Crummy Soil - 32 Piles



Legacy - Bridge No 22 - Bent 6 - Crummy Soil - 32 Piles

FAX

Parsons Brinckerhoff
303 2nd Street, Suite 700N
San Francisco, CA 94107
415-243-4600
Fax: 415-243-9501

to Frank Wang

from Partha Sircar

date 8/28/01

telephone no. 415-243-4761

job no.

fax no. 916-925-3517

no. of pages (including this page) 3

comments

Frank:

I am sending my results. I recommend using 25°. The profile I used is also attached

If you have any problems with transmission and/or did not receive all of the pages, please call (415)243-4600

CALCULATION SHEET

PB 100 YEARS

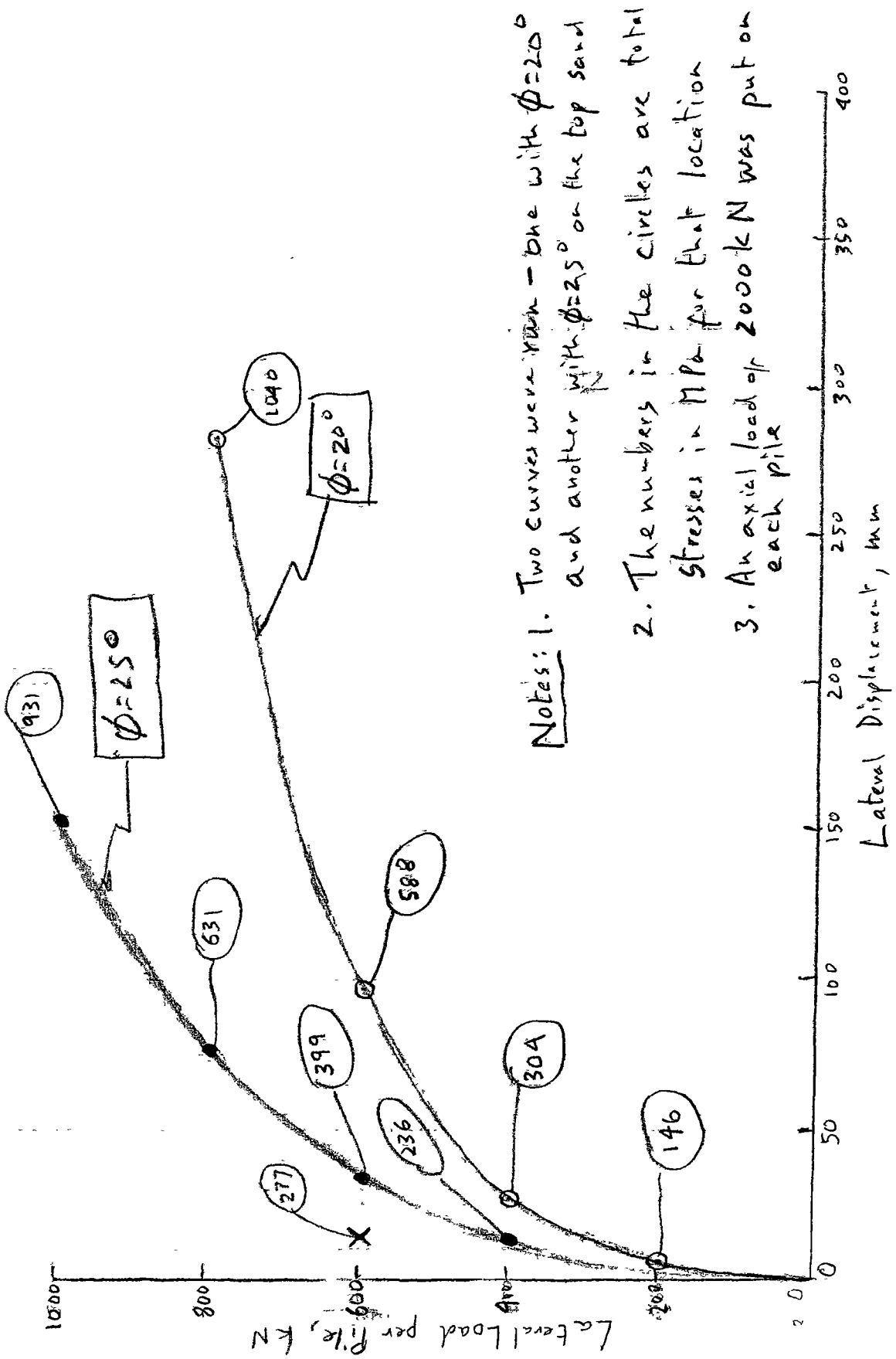
Page ____ of ____ | 554

Project Title: Legacy | Project No.:

Subject: Load-deformation curves for Bridge 22, Abutment 1 piles | Made by: P. Sircar | Date: 8/28/01

Checked by: | Date:

Reference

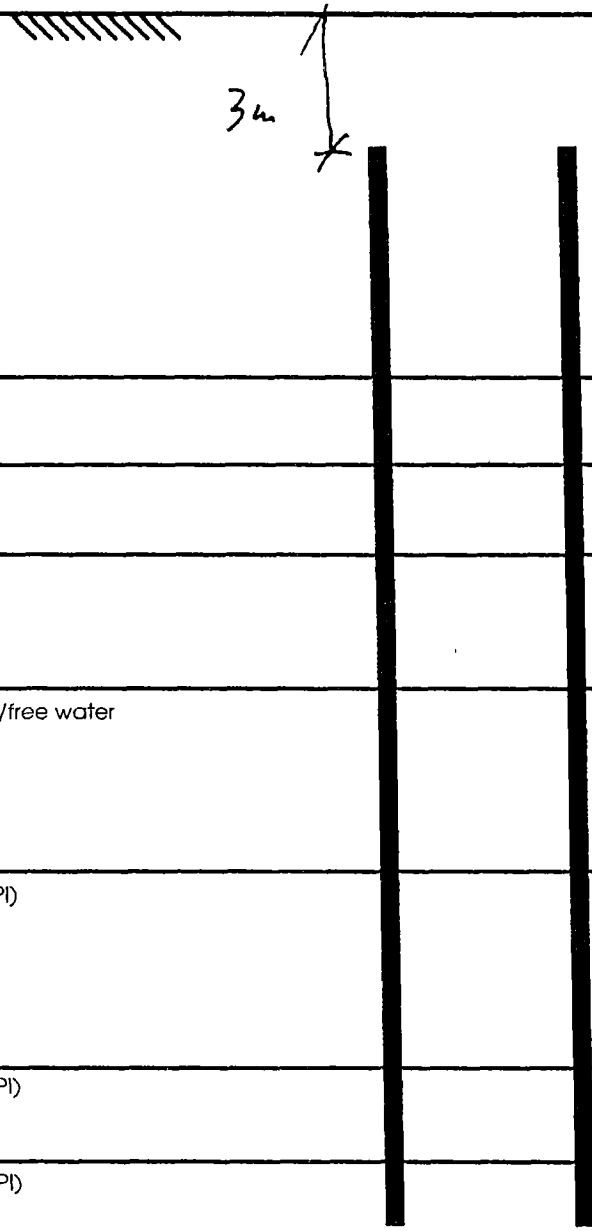


Notes: 1. Two curves were run – one with φ=20° and another with φ=25° on the top sand

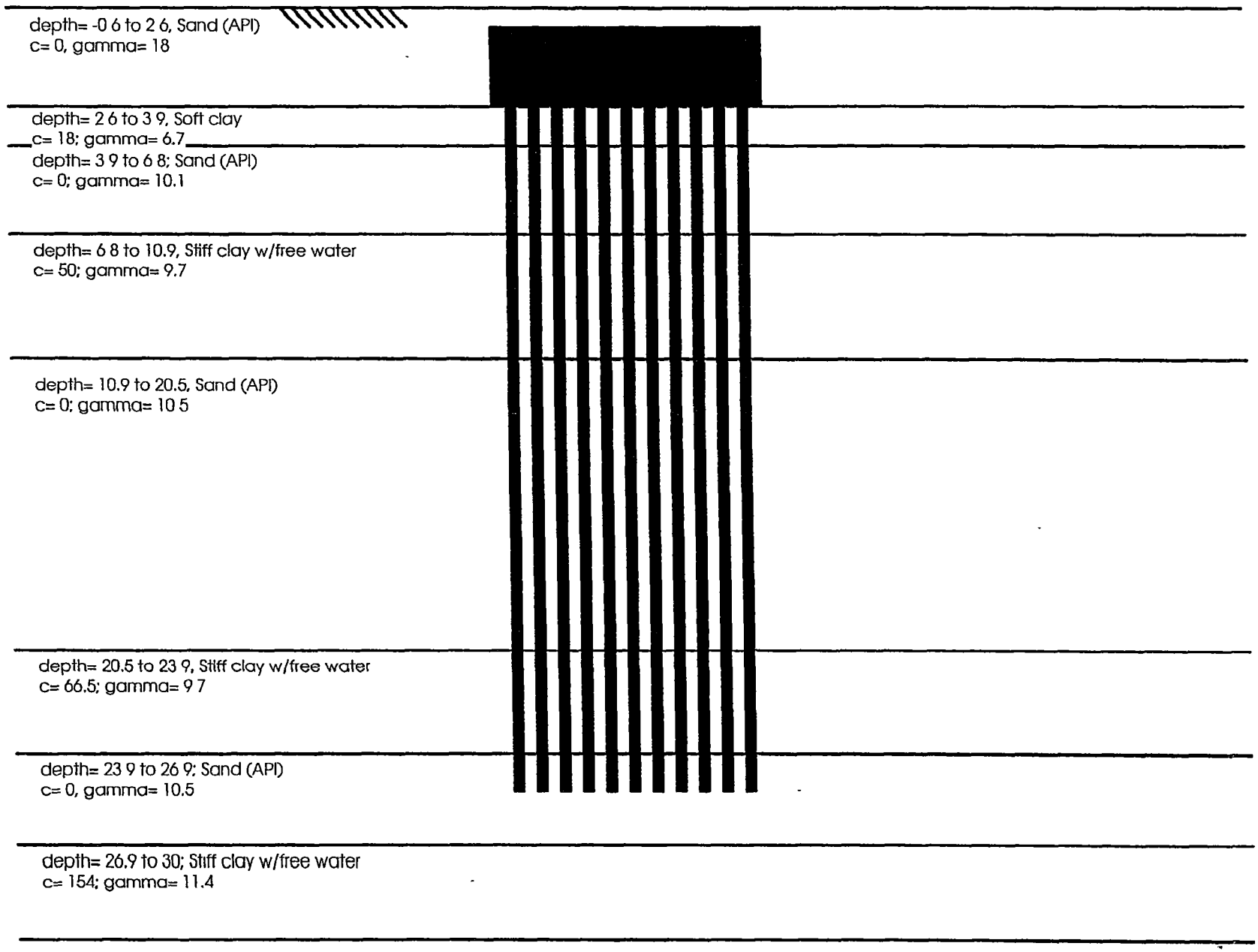
2. The numbers in the circles are total stresses in MPa for that location

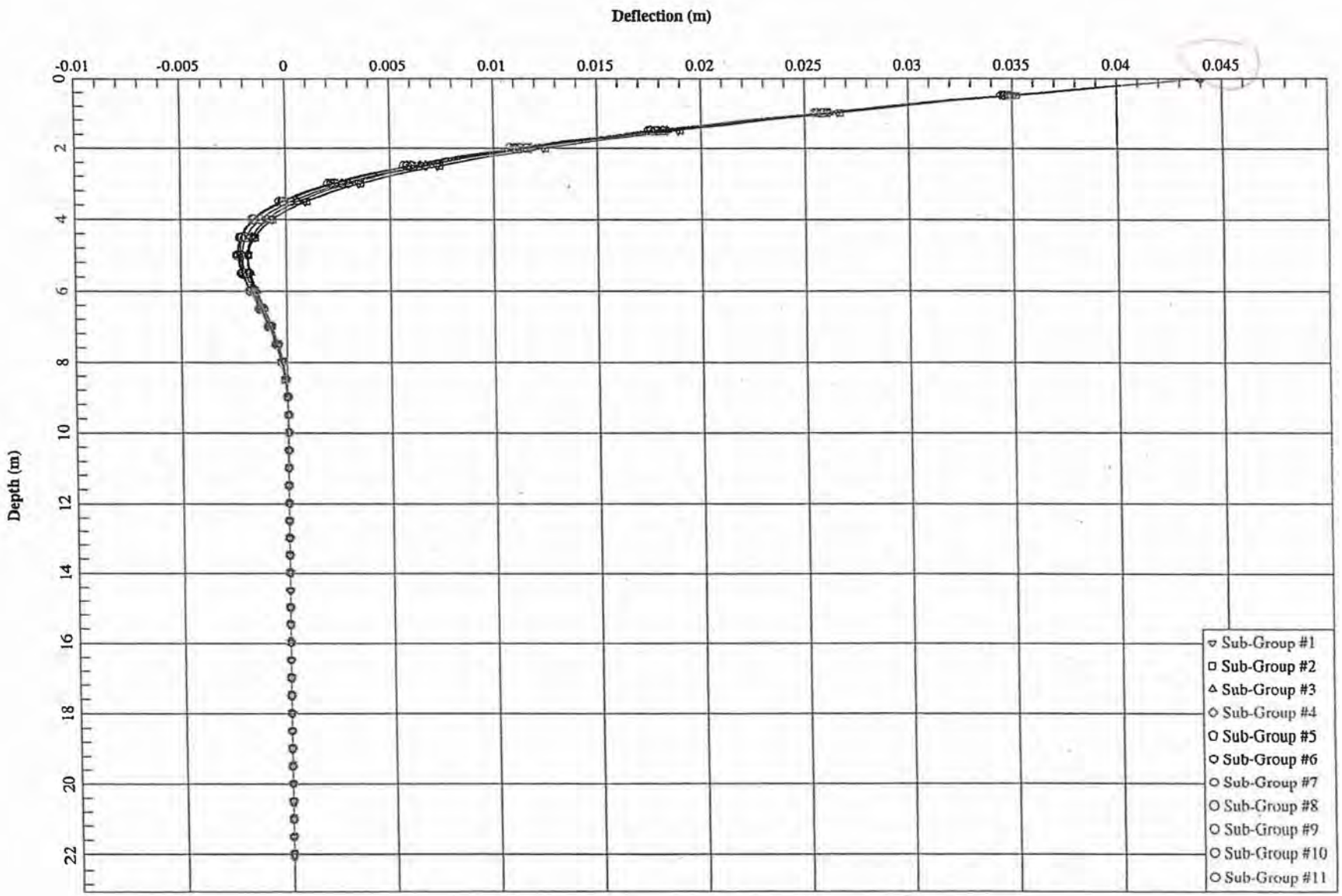
3. An axial load of 2000 kN was put on each pile

X – No reduction of top layer (φ=32°, K unchanged)

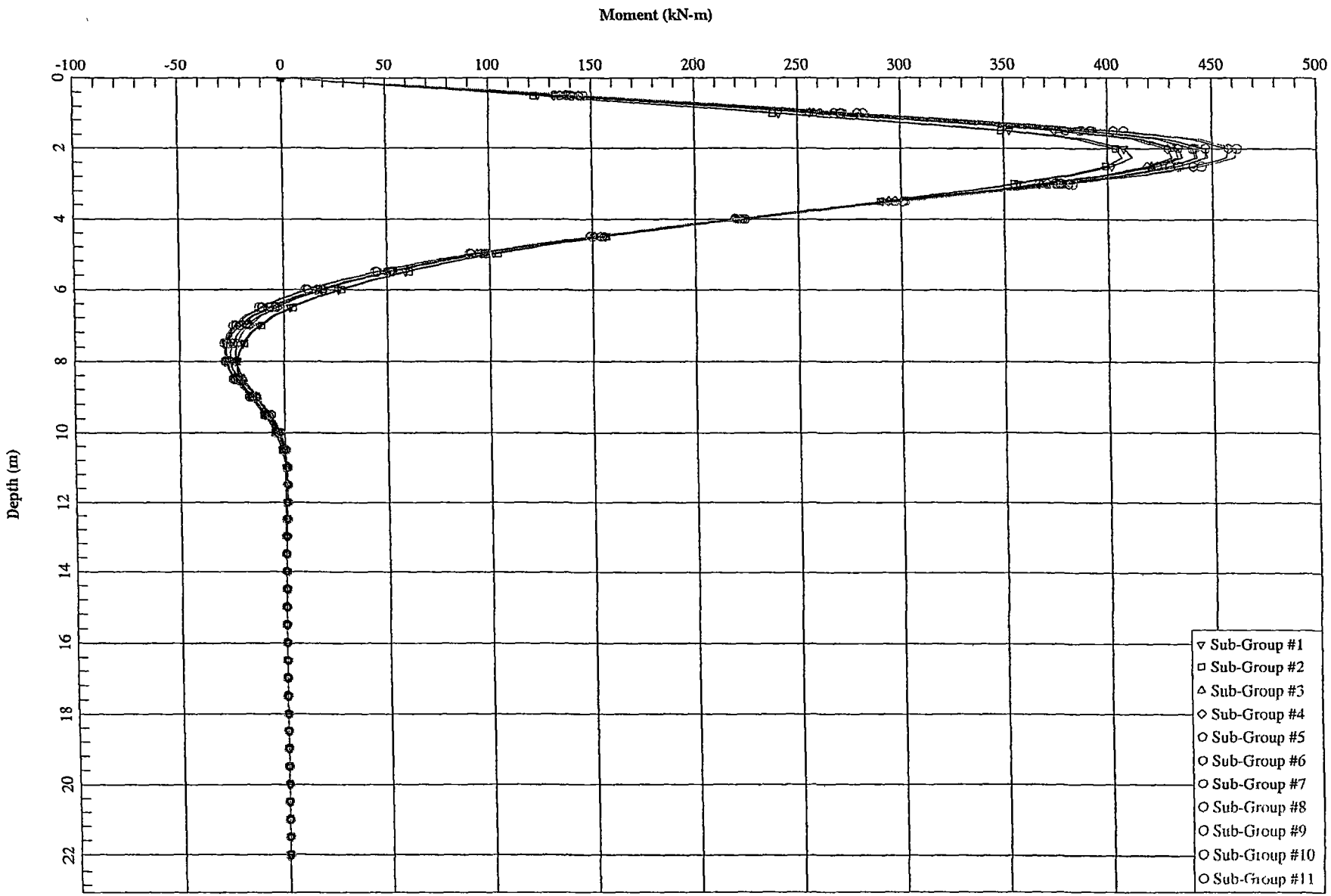


	ϕ	K
depth= -3 to 5.1, Sand (API) c= 0, gamma= 20 3	25° or 20°	18700
depth= 5.1 to 7, Sand (API) c= 0, gamma= 19 9	33°	18500
depth= 7 to 9, Soft clay c= 18, gamma= 6 7	—	8140
depth= 9 to 12, Sand (API) c= 0, gamma= 10 1	31°	6420
depth= 12 to 16 1, Stiff clay w/free water c= 50, gamma= 9 7	—	136000
depth= 16 1 to 20 5; Sand (API) c= 0, gamma= 10 5	37°	33900
depth= 20.5 to 22 6, Sand (API) c= 0, gamma= 9 7	30°	5430
depth= 22 6 to 25 7, Sand (API) c= 0, gamma= 10 5	41°	33900

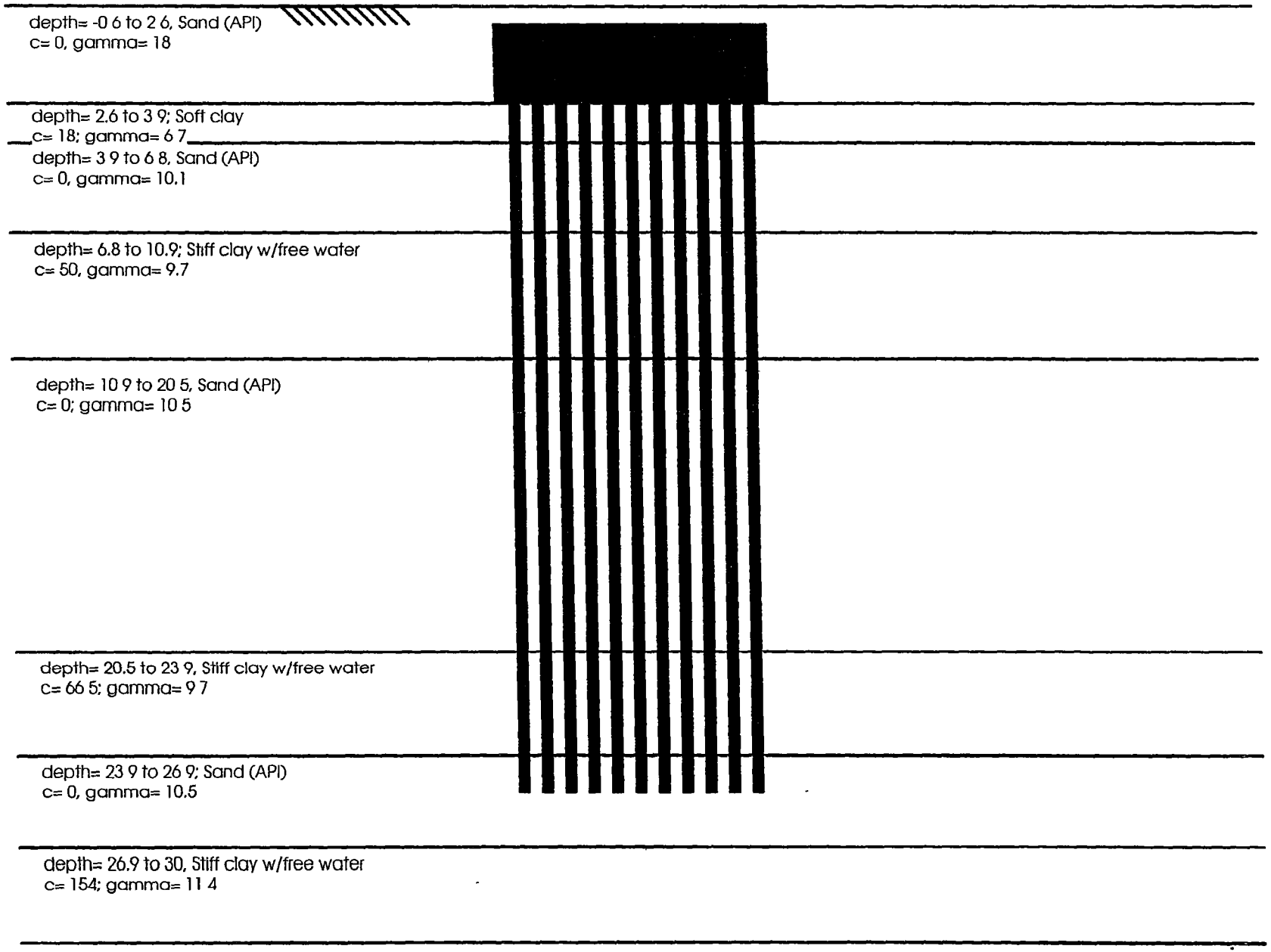

depth= -0 6 to 2 6, Sand (API)
c= 0, gamma= 18
depth= 2 6 to 3 9, Soft clay
c= 18; gamma= 6.7
depth= 3 9 to 6 8; Sand (API)
c= 0; gamma= 10.1
depth= 6 8 to 10.9, Stiff clay w/free water
c= 50; gamma= 9.7
depth= 10.9 to 20.5, Sand (API)
c= 0; gamma= 10 5
depth= 20.5 to 23 9, Stiff clay w/free water
c= 66.5; gamma= 9 7
depth= 23 9 to 26 9; Sand (API)
c= 0, gamma= 10.5
depth= 26.9 to 30; Stiff clay w/free water
c= 154; gamma= 11.4

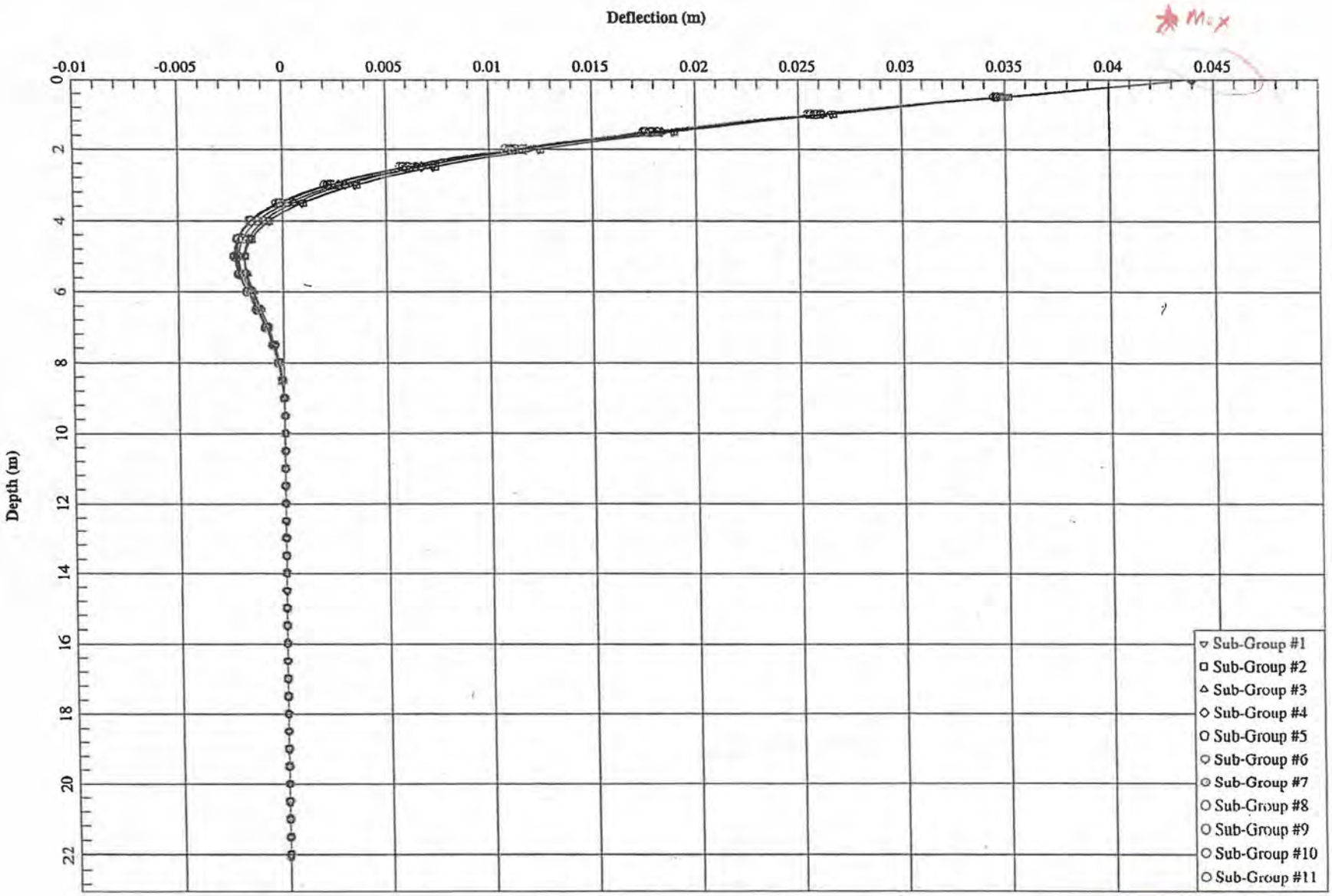


Legacy - Bridge No 22 - Bent 2 - 24 Piles - Diagonal Load - Case 2A

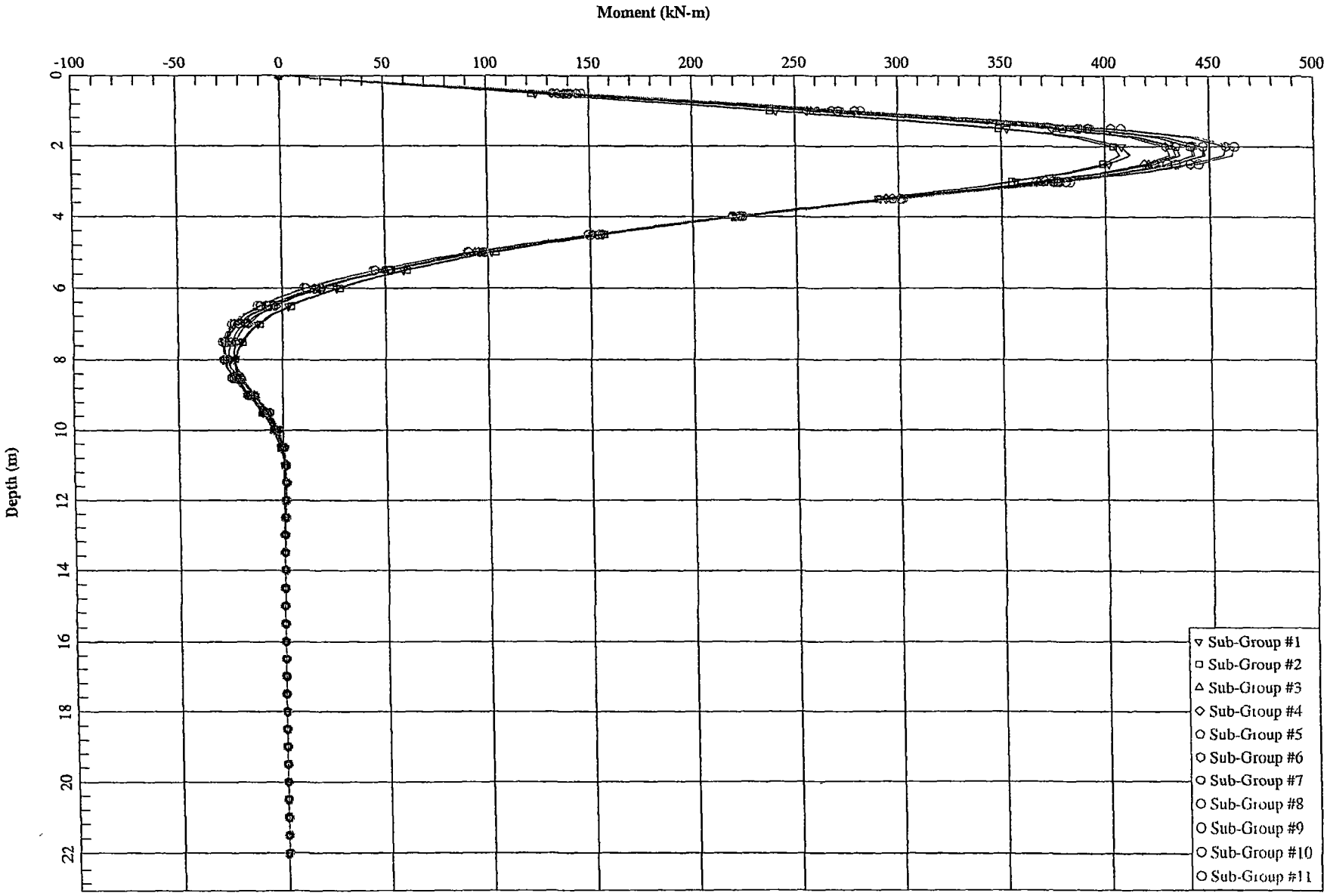


Legacy - Bridge No 22 - Bent 2 - 24 Piles - Diagonal Load - Case 2A


depth= -0 6 to 2 6, Sand (API)
c= 0, gamma= 18
depth= 2.6 to 3 9; Soft clay
c= 18; gamma= 6 7
depth= 3 9 to 6 8, Sand (API)
c= 0, gamma= 10.1
depth= 6.8 to 10.9; Stiff clay w/free water
c= 50, gamma= 9.7
depth= 10 9 to 20 5, Sand (API)
c= 0; gamma= 10 5
depth= 20.5 to 23 9, Stiff clay w/free water
c= 66 5; gamma= 9 7
depth= 23 9 to 26 9; Sand (API)
c= 0, gamma= 10.5
depth= 26.9 to 30, Stiff clay w/free water
c= 154; gamma= 11 4



Legacy - Bridge No 22 - Bent 2 - 24 Piles - Diagonal Load - Case 2A



Legacy - Bridge No 22 - Bent 2 - 24 Piles - Diagonal Load - Case 2A

LEGACY PARKWAY

BRIDGE 23 SEISMIC DESIGN STRATEGY

INTRODUCTION

Seismic Design of the bridges for the Legacy Parkway project is primarily based on AASHTO, amended by project specific design criteria, which addresses issues not specifically accounted for by the AASHTO code

GENERAL STRUCTURE DESCRIPTION

The structure is approximately 190 m long with three-spans (55 0, 79 8, and 53.2 m) Three of the supports are skewed, with a maximum skew of 25 degrees at Bent 3 The substructure consists of short seat type abutments and multi-column bents with non-integral caps. The abutments are supported by two rows of concrete filled steel pipe (410 mm diameter x 10 mm) piles. The columns are octagonal with a long dimension of 1830 mm. Each column is supported on individual pile footings, using concrete filled steel pipe piles The superstructure consists of built up steel girders made composite with a concrete deck. Superstructure girders are typically supported on pot bearings or elastomeric bearings.

LEVEL OF PERFORMANCE

This structure is designed as an "Essential Bridge" under the definition provided by AASHTO (Division 1-A). The seismic performance of the structure is "Serviceability", following minor repairs, which may be required, after the event of "Design Level Earthquake"

SEISMICITY

The structure is designed for PGA = 0.6g. AASHTO curves for Type III soil are used to account for soil amplification.

SEISMIC BEHAVIOR

The seismic design strategy for this structure consists of

- Fused lateral load transfer to piers, via bearings
- Superstructure sliding over support seats
- Bearing restraints at designed seismic gaps.

The strategy includes strength design of bearing connections to resist service loads such as wind, and braking forces, as well as a qualitative assessment for more frequent seismic loadings. In the event of design level earthquakes, the bearing connections are designed to fail and therefore act as a fuse limiting force transfer to the substructure Bearing lateral restraints are provided at designed seismic gap values (500mm to 600mm), both longitudinally and transversely. The sliding fused bearings will reduce seismic lateral loads to substructure. The restraints will prohibit unseating of the girders.

Upon failure of the bearing connections, the load transfer through the bearings (i e friction) is conservatively assumed to be 40% of vertical dead load acting on the bearings. This essentially establishes the upper bound of expected seismic loads applied to the substructure, which is well within capacity of the pier columns (1.5% to 2.6% longitudinal reinforcement ratio).

The "fused" bearing behavior results in superstructure sliding over the girder seats, for which adequate width is provided to prohibit unseating at the abutment. At the abutments, and primarily in the longitudinal direction, the backfill soil provides additional resistance strength to limit the extent of superstructure movement. In the transverse direction, at the abutments, the bearings are allowed to be fused and slide over the pile cap, with restraints at specific design seismic gap values The objective of the strategy at the abutments is to limit load transfer to the substructure piles and prohibit their damage The strategy at the abutments, allows for failure of backwalls to mobilize the backfill resistance in the longitudinal direction.

Fused behavior of the bearings is conservatively assumed to correspond to 40% friction force transfer

EXPECTED DAMAGE UNDER DESIGN EVENT

Due to the expected fused bearing behavior at the superstructure – substructure interface, the majority of damage will be localized to the bearing elements and restraints. Damage to the abutments will be limited to backwall failure. The entire superstructure is expected to displace on the supporting abutments and bents, however unseating will not occur.

The expected inspection and immediate repair which may be required, following a design level earthquake, will be centering the bridge near it's original position, and temporary repairs over bridge joints to allow for traffic. While the bridge can be opened to traffic following the immediate repair tasks, follow-up repairs can be performed to replace damaged bearings connections, and bridge joints.

Table 1. Expected Seismic Performance

Abutments	• Damage to back-wall possible • Maximum superstructure longitudinal displacement ~ 600 mm • Essentially elastic pile response
Bearings	• Fuse at 40% vertical dead load, with shear keys/restraints with 500mm to 600mm seismic gaps • Fuse feature at abutment, may require bearing replacement or repositioning
Columns	• Cracking and spalling. Repair by epoxy injection Bearings to fuse.
Foundations	• Piles remain essentially elastic
Joints (Structural)	• Moderate damage requiring minor repair such as epoxy injection of cracks

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	23
Support(s)	1,2
Water Depth (m)	1.5
Finished Grade Elevation (m)	1295.4
Soil Borings Used for Profile	RB-365; SC-23-290A

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Soft Clay	0.0	1.5	18.7	60	0.020	63,665	-	0	6	0	220
2	Soft Clay	1.5	3.0	8.9	60	0.020	63,665	-	6	9	250	360
3	Sand	3.0	8.7	10.1	-	-	17,070	35	19	46	4,020	9,610
4	Soft Clay	8.7	10.1	9.9	27	0.020	14,165	-	24	28	1,200	1,370
5	Sand	10.1	15.0	10.5	-	-	22,750	38	58	84	13,120	19,100

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	23
Support(s)	3,4
Water Depth (m)	2 1
Finished Grade Elevation (m)	1297 9
Soil Borings Used for Profile	SB-23-290C, SC-23-291

	Initials	Date
Completed By		
Checked By		

FOR LPILE 1) C_{MAX} = 59
2)

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m³)	Shear Strength (kN/m²)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m²)		Maximum Tip Resistance (kN/m²)	
									Top	Bottom	Top	Bottom
	FILL			21.99			50,000	32				
1	Sand	0 0	2 1	19 9	59	-	13,050	32	0	16	0	2,950
2	Soft Clay	2 1	5 0	9 7	~~60~~	0 020	63,665	-	11	18	640	1,080
3	Silt	5 0	9 8	10 0	40	0 020	33,665	31	21	35	1,700	2,870
4	Soft Clay	9 8	12 6	10 8	24	0 020	9,665	-	25	31	600	760
5	Sand	12 6	15 0	10 9	-	-	32,690	41	88	104	22,220	26,140

Press the "Copy" button to copy this tab to a new spreadsheet The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers

LEGACY PARKWAY
BRIDGE 23
PILE CAPACITY SUMMARY - PP 406x8 53 (16" x 3/8")
YIELD STRENGTH = 448 MPa

	Initials	Date
Completed By:	NM	12/14/01
Reviewed By:	CC	12/14/01

A-1 Target Geotechnical Capacity per Pile (2 25x Service Load) 3,503 kN
(Target Service Load Provided by Structural Engineer)

Location	A Finished Grade Elevation (m)	B Bottom of Pile Cap Elevation (m)	C Est Embankm Height (m)	D Target Pile Tip Elevation (m)	E Minimum Pile Tip Elevation (m)	F Service Uplift Load Resistance (kN)	G Required Seismic Compression Resistance (kN)	H Required Seismic Uplift Resistance (kN)	I Service Load (DL + LL) (kN)	J Required Driving Resistance (kN)	K Est Pile Length w/ fill (m)	L Estimated Maximum Structural Load in Pile (kN) (Service Load + Drag Load)	M Est Elevation of Neutral Plane (m)	N Estimated Pile Tip Settlement (mm)
Bridge 23, Abutment 1	1310 7	1305 1	15 6	1281 7	1281 7	934	N/A	N/A	1,557	3,503	23	3,138	1285 2	4

Location	Borings Used for Soil Profile
Bridge 23, Abutment 1	RB-365

Description of Information Presented In Each Column

A: Finished Grade Elevation - Top of approach slab elevation at abutment locations and adjacent ground elevation at bent locations as shown on the structure Plan and Profile drawing provided

B Bottom of Pile Cap Elevation - Elevation at the bottom of the pile cap as scaled from the structure Plan and Profile drawing provided

C Estimated Embankment Height - Elevation difference between the top of the approach slab and the native ground surface at the abutment as scaled from the structure Plan and Profile drawing provided

D Target Pile Tip Elevation - Estimated elevation to which the bottom of the pile will need to be driven to develop the required capacity and meet the settlement criteria (Additional depth may be required to reach required resistance during driving)

E Minimum Pile Tip Elevation - Estimated minimum elevation to which the bottom of the pile will need to be driven to meet settlement, minimum length, or minimum depth criteria should the required driving resistance be obtained above the Target Pile Tip

F Service Uplift Load Resistance = (Ultimate Friction Resistance)/(FS=2 25) Per comment resolution meeting with UDOT (8/15/01)

G Seismic Compression Resistance = Ultimate Friction and End Bearing Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate resistance values to resist seismic loads)

H Seismic Uplift Resistance = Ultimate Friction Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate friction resistance value to resist seismic uplift loads)

I Service Load (DL + LL) - The maximum load that can be applied at the top of the pile by the structure provided the pile is driven to the assumed capacity

J Required Driving Resistance - The minimum load (service load x 2 25 or required seismic resistance plus estimated loss during liquefaction, whichever is greater) that must be verified in the field by PDA

K Estimated Pile Length w/ Fill - The estimated length of pile required Calculated as (Bottom Of Pile Cap - Estimated Tip Elevation) rounded up to the nearest meter (Actual lengths may vary depending on driving conditions encountered at each pile location)

L Estimated Structural Load in the Pile - The largest load that will develop in the pile due to structural service dead loads and drag loads This load occurs at the neutral plane where equilibrium exists between the sum of the downward acting permanent load (service load) applied at the top of the pile and drag load due to negative skin friction and the sum of upward acting positive shaft resistance and mobilized toe resistance

M. Estimated Elevation of Neutral Plane - The level in the pile where relative movement between the pile and soil is zero

N Estimated Pile Tip Settlement - The magnitude of pile tip settlement required to mobilize estimated pile tip loads. This does not include elastic compression of the pile

LEGACY PARKWAY
BRIDGE 23
PILE CAPACITY SUMMARY - PP 406x9 53 (16" x 3/8")
YIELD STRENGTH = 448 MPa

	Initials	Date
Completed By	NM	5/31/02
Reviewed By	[illegible]	5/31/02

A = Target Geotechnical Capacity per Pile (2.25xService Load) 3,503 kN
(Target Service Load Provided by Structural Engineer)

Location	A Finished Grade Elevation (m)	B Bottom of Pile Cap Elevation (m)	C Est. Embankm. Height (m)	D Estimated Pile Tip Elevation (m)	E Minimum Pile Tip Elevation (m)	F Service Uplift Load Resistance (kN)	G Required Seismic Compression Resistance (kN)	H Required Seismic Uplift Resistance (kN)	I Service Load (DL + LL) (kN)	J Required Driving Resistance (kN)	K Est. Pile Length w/ fill (m)	L Estimated Maximum Structural Load in Pile (kN) (Service Load + Drag Load)	M Est. Elevation of Neutral Plane (m)	N Estimated Pile Tip Settlement (mm)
Bridge 23, Abutment 4	1307.0	1301.2	10.0	1282.8	1283.0	525	N/A	N/A	1,557	3,503	20	2,612	1283.6	3

Location	Borings Used for Soil Profile	
Bridge 23 Abutment 4	SB-23-290C LSB-23-445	

Description of Information Presented in Each Column

A Finished Grade Elevation - Top of approach slab elevation at abutment locations and adjacent ground elevation at bent locations as shown on the structure Plan and Profile drawing provided

B Bottom of Pile Cap Elevation - Elevation at the bottom of the pile cap as scaled from the structure Plan and Profile drawing provided

C Estimated Embankment Height - Elevation difference between the top of the approach slab and the native ground surface at the abutment as scaled from the structure Plan and Profile drawing provided

D Estimated Pile Tip Elevation - Estimated elevation to which the bottom of the pile will need to be driven to develop the required capacity and meet the settlement criteria (Additional depth may be required to reach required resistance during driving.)

E Minimum Pile Tip Elevation - Estimated minimum elevation to which the bottom of the pile will need to be driven to meet settlement, minimum length, or minimum depth criteria should the required driving resistance be obtained above the Target Pile Tip Elevation

F Service Uplift Load Resistance = (Ultimate Friction Resistance)/(FS=2.25) Per comment resolution meeting with UDOT (8/15/01)

G Seismic Compression Resistance = Ultimate Friction and End Bearing Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate resistance values to resist seismic loads.)

H Seismic Uplift Resistance = Ultimate Friction Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate friction resistance value to resist seismic uplift loads.)

I Service Load (DL + LL) The maximum load that can be applied at the top of the pile by the structure provided the pile is driven to the assumed capacity

J Required Driving Resistance - The minimum load (service load x 2.25 or required seismic resistance plus estimated loss during liquefaction whichever is greater) that must be verified in the field by PDA.

K Estimated Pile Length w/ Fill - The estimated length of pile required Calculated as (Bottom Of Pile Cap - Estimated Tip Elevation) rounded up to the nearest meter (Actual lengths may vary depending on driving conditions encountered at each pile location.)

L Estimated Structural Load in the Pile - The largest load that will develop in the pile due to structural service dead loads and drag loads This load occurs at the neutral plane where equilibrium exists between the sum of the downward acting permanent load (service load) applied at the top of the pile and drag load due to negative skin friction and the sum of upward acting positive shaft resistance and mobilized toe resistance

M Estimated Elevation of Neutral Plane - The level in the pile where relative movement between the pile and soil is zero

N Estimated Pile Tip Settlement - The magnitude of pile tip settlement required to mobilize estimated pile tip loads This does not include elastic compression of the pile

LEGAC

BRIDGE 23

PILE CAPACITY SUMMARY - PP 406x9.53 (16" x 3/8")

YIELD STRENGTH = 448 MPa

	Initials	Date
Completed By:	NM	5/1/02
Reviewed By:	cc	5/7/02

B-2 Target Geotechnical Capacity per Pile (2.25xService Load): 1,481 kN

B-3 Target Geotechnical Capacity per Pile (2.25xService Load): 1,100 kN

(Target Service Load Provided by Structural Engineer)

Location	A Finished Grade Elevation (m)	B Bottom of Pile Cap Elevation (m)	C Est. Embankm. Height (m)	D Estimated Pile Tip Elevation (m)	E Minimum Pile Tip Elevation (m)	F Service Uplift Load Resistance (kN)	G Required Seismic Compression Resistance (kN)	H Required Seismic Uplift Resistance (kN)	I Service Load (DL + LL) (kN)	J Required Driving Resistance (kN)	K Est. Pile Length w/ fill (m)	L Estimated Maximum Structural Load in Pile (kN) (Service Load + Drag Load)	M Est. Elevation of Neutral Plane (m)	N Estimated Pile Tip Settlement (mm)
Bridge 23, Bent 2	1295.0	1292.2	N/A	1272.5	1273.5	573	1,873	636	658	2,058	20	1,319	1277.7	1
Bridge 23, Bent 3	1287.5	1294.4	N/A	1279.4	1279.4	421	1,597	583	439	1,748	15	1,334	1279.4	1

Location	Borings Used for Soil Profile
Bridge 23, Bent 2	SC-23-290A; SB-23-289; LSB-23-443
Bridge 23, Bent 3	SC-23-291; LSB-23-444

Description of Information Presented in Each Column:

A: Finished Grade Elevation - Top of approach slab elevation at abutment locations and adjacent ground elevation at bent locations as shown on the structure Plan and Profile drawing provided.

B: Bottom of Pile Cap Elevation - Elevation at the bottom of the pile cap as scaled from the structure Plan and Profile drawing provided.

C: Estimated Embankment Height - Elevation difference between the top of the approach slab and the native ground surface at the abutment as scaled from the structure Plan and Profile drawing provided.

D: Estimated Pile Tip Elevation - Estimated elevation to which the bottom of the pile will need to be driven to develop the required capacity and meet the settlement criteria. (Additional depth may be required to reach required resistance during driving.)

E: Minimum Pile Tip Elevation - Estimated minimum elevation to which the bottom of the pile will need to be driven to meet settlement, minimum length, or minimum depth criteria should the required driving resistance be obtained above the Target Pile Tip

F: Service Uplift Load Resistance = (Ultimate Friction Resistance)/(FS=2.25) Per comment resolution meeting with ODOT (5/15/01)

G: Seismic Compression Resistance = Ultimate Friction and End Bearing Resistance neglecting the contribution of potentially liquefiable zones. (AASHTO allows the use of the ultimate resistance values to resist seismic loads.)

H: Seismic Uplift Resistance = Ultimate Friction Resistance neglecting the contribution of potentially liquefiable zones. (AASHTO allows the use of the ultimate friction resistance value to resist seismic uplift loads.)

I: Service Load (DL + LL) - The maximum load that can be applied at the top of the pile by the structure provided the pile is driven to the assumed capacity.

J: Required Driving Resistance - The minimum load (service load x 2.25 or required seismic resistance plus estimated loss during liquefaction, whichever is greater) that must be verified in the field by PDA.

K: Estimated Pile Length w/ Fill - The estimated length of pile required. Calculated as (Bottom Of Pile Cap - Estimated Tip Elevation) rounded up to the nearest meter. (Actual lengths may vary depending on driving conditions encountered at each pile location.)

L: Estimated Structural Load in the Pile - The largest load that will develop in the pile due to structural service dead loads and drag loads. This load occurs at the neutral plane where equilibrium exists between the sum of the downward acting permanent load (service load) applied at the top of the pile and drag load due to negative skin friction and the sum of upward acting positive shaft resistance and mobilized toe resistance.

M: Estimated Elevation of Neutral Plane - The level in the pile where relative movement between the pile and soil is zero.

N: Estimated Pile Tip Settlement - The magnitude of pile tip settlement required to mobilize estimated pile tip loads. This does not include elastic compression of the pile.

05/28/2002 10:34 0817051108 HLUUR AMES KRAEMER PAGE 03/03

LEGACY PARKWAY
BRIDGE 23
PILE CAPACITY SUMMARY - PP 406x9 53 (16" x 3/8")
YIELD STRENGTH = 448 MPa

	Initials	Date
Completed By	NM	8/28/02
Reviewed By	[illegible]	8/28/02

A 1 Target Geotechnical Capacity per Pile (2 25xService Load)	*3,503*	*kN*
B-2 Target Geotechnical Capacity per Pile (2 25xService Load)	*1 481*	*kN*
B-3 Target Geotechnical Capacity per Pile (2 25xService Load)	*1,100*	*kN*
A-4 Target Geotechnical Capacity per Pile (2 25xService Load)	*3 503*	*kN*

(Target Service Load Provided by Structural Engineer)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Location	Finished Grade Elevation (m)	Bottom of Pile Cap Elevation (m)	Est Embankm. Height (m)	Estimated Pile Tip Elevation (m)	Minimum Pile Tip Elevation (m)	Service Uplift Load Resistance (kN)	Required Seismic Compression Resistance (kN)	Required Seismic Uplift Resistance (kN)	Service Load (DL + LL) (kN)	Required Driving Resistance (kN)	Est Pile Length w/ fill (m)	Estimated Maximum Structural Load in Pile (kN) (Service Load + Drag Load)	Est Elevation of Neutral Plane (m)	Estimated Pile Tip Settlement (mm)
Bridge 23, Abutment 1	1310 7	1305.1	15 6	1281.7	1281 7	934	N/A	N/A	1,557	3,503	23	3,138	1285.2	4
Bridge 23, Bent 2	1295 0	1292.2	N/A	1272 5	1273 5	573	1,873	636	658	2,058	20	1,319	1277 7	1
Bridge 23, Bent 3	1297 5	1294 4	N/A	1279 4	1279.4	421	1,597	583	489	1,748	15	1,334	1279 4	1
Bridge 23, Abutment 4	1307 0	1301.2	10 0	1282 0	1283 0	625	N/A	N/A	1,557	3,503	20	2,812	1283 0	3

Location	Borings Used for Soil Profile
Bridge 23 Abutment 1	RB-365, SB-23-289
Bridge 23 Bent 2	SC-23-290A, SB-23-289, LSB-23-443
Bridge 23 Bent 3	SC-23-290B, LSB-23-444
Bridge 23 Abutment 4	SB-23 290C LSB-23-445

Description of Information Presented In Each Column

A. **Finished Grade Elevation** - Top of approach slab elevation at abutment locations and adjacent ground elevation at bent locations as shown on the structure Plan and Profile drawing provided

B. **Bottom of Pile Cap Elevation** - Elevation at the bottom of the pile cap as scaled from the structure Plan and Profile drawing provided

C **Estimated Embankment Height** - Elevation difference between the top of the approach slab and the native ground surface at the abutment as scaled from the structure Plan and Profile drawing provided

D **Estimated Pile Tip Elevation** - Estimated elevation to which the bottom of the pile will need to be driven to develop the required capacity and meet the settlement criteria (Additional depth may be required to reach required resistance during driving)

E. **Minimum Pile Tip Elevation** - Estimated minimum elevation to which the bottom of the pile will need to be driven to meet settlement, minimum length, or minimum depth criteria should the required driving resistance be obtained above the Target Pile Tip Elevati

F **Service Uplift Load Resistance** = (Ultimate Friction Resistance)(FS=2 25) Per comment resolution meeting with UDOT (8/15/01)

G: **Seismic Compression Resistance** = Ultimate Friction and End Bearing Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate resistance values to resist seismic loads)

H. **Seismic Uplift Resistance** = Ultimate Friction Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate friction resistance value to resist seismic uplift loads)

I **Service Load (DL + LL)** - The maximum load that can be applied at the top of the pile by the structure provided the pile is driven to the assumed capacity

J **Required Driving Resistance** - The minimum load (service load x 2 25 or required seismic resistance plus estimated loss during liquefaction, whichever is greater) that must be verified in the field by PDA.

K **Estimated Pile Length w/ Fill** - The estimated length of pile required Calculated as (Bottom Of Pile Cap - Estimated Tip Elevation) rounded up to the nearest meter (Actual lengths may vary depending on driving conditions encountered at each pile location)

L. **Estimated Structural Load in the Pile** - The largest load that will develop in the pile due to structural service dead loads and drag loads This load occurs at the neutral plane where equilibrium exists between the sum of the downward acting permanent load (service load) applied at the top of the pile and drag load due to negative skin friction and the sum of upward acting positive shaft resistance and mobilized toe resistance

M **Estimated Elevation of Neutral Plane** - The level in the pile where relative movement between the pile and soil is zero

N **Estimated Pile Tip Settlement** - The magnitude of pile tip settlement required to mobilize estimated pile tip loads This does not include elastic compression of the pile

18B

Memorandum

LEGACY

Date: 07/01/2002 *File Code:* GDM-STR-013Rev1

To: Joe Showers

From: K. N. Gunalan
Curt Christensen

Subject: Geotechnical Recommendations for Bridge 23

Cc: DocC, Kleinfelder, Tom Cooper

Introduction

This memorandum presents our Geotechnical evaluation and recommendations developed in accordance with UDOT's Geotechnical MOI for Bridge 23. Included herein is our evaluation of liquefaction concerns at the bridge abutment location. Detailed descriptions of our understanding of the project, geology, soils encountered etc. will be incorporated into the project Geotechnical report and submitted along with other documents as part of final submittal for the project. This information will be maintained in the project files for reference until being incorporated into the final report.

General Geotechnical Conditions

Geotechnical conditions at the site are defined by previous investigations performed for UDOT. Based on the information obtained during those investigations and a subsequent investigation undertaken by FAK, the general profile at the north interchange can be defined as consisting of interbedded medium stiff to stiff silts, clay and loose to medium dense sand and gravel layers in the upper 10 to 15 meters. Dense to very dense silty sands, poorly graded sands and poorly graded gravel with lenses of silts and clays were encountered below 10 to 15 meters. Ground water was encountered at depths ranging from 1.0 to 1.5 meters.

Liquefaction Potential

Bridge 23 falls within the Farmington Siding landslide complex, which consists of liquefaction induced landslides. The bridge abutment is located within the older mapped portion of this complex, approximately 1 0 km southeast of the mapped contact with the younger portion of the complex. These slides date back to latest Pleistocene and Holocene time. UGS studies indicate that susceptibility to liquefaction induced land sliding may be less than the earlier times due to lower average lake and associated ground water levels The study also indicated that above average precipitation could create locally perched conditions which when subject to strong

ground motions could liquefy and slide. Therefore, a study was undertaken to evaluate the potential for liquefaction at Bridge 23. Information obtained from exploratory borings RB-365, SB-23-289, LSB-23-443, LSB-23-444, SB-23-290C, LSB-23-445 and cone soundings SC-23-290A and SC-23-290B located near the bridge abutment was used in this evaluation. Evaluations indicated layers of silts and sands may liquefy under an earthquake of magnitude 7.3 with a peak horizontal ground acceleration of 0.6g.

Liquefaction potential was evaluated at this bridge site and was found to include silt, sand and gravel layers ranging in thickness from approximately 0.2 m to 2.0 m and at depths ranging from 2 m to approximately 15 m below existing grade. Liquefaction induced settlements were found to range from 18 mm to 92 mm and lateral spread from 0 to 0.6 m. Based on the potential of an isolated silt layer less than 2 m thick in borehole SB-23-289 laterally spreading, it is our opinion that the potential impact to the structure would be negligible.

Recommendations

It is our understanding that 406 mm (16 in.) diameter pipe piles are being proposed for the bridge foundation and that the anticipated service load per pile at the abutments is 1557 kN. The service loads at the bents range from 489 to 658 kN. The governing condition for pile design at abutment 1 is locating the pile tip below liquefiable layers; for abutment 4 it is the service load and for bents 2 and 3 it is the axial seismic compression. Recommended pile capacity and Geotechnical parameters required for analysis and design are presented in attached table.

745

KLEINFELDER
An employee owned company

Transmittal

To K. N. Gunalan
Parsons Brinckerhoff
360 North 700 West, Suite F
North Salt Lake, Utah 84054

Date: May 14, 2002
Files: 35-8440-06.002
Copies: 2

RECEIVED
MAY 14 2002
Parsons Brinckerhoff
Legacy Parkway Project

Subject: Legacy Parkway Pile Design

We are sending the following: ☒ Attached ☐ Under separate cover

Pile Design Calculations for Structure 23, Bent 2 and 3.

Via:
- ☒ Messenger
- ☐ First Class Mail
- ☐ Air
- ☐ Fed Ex
- ☐ United Parcel
- ☐ Air Freight
- ☐

Transmitted:
- ☒ As Requested
- ☐ For Approval
- ☐ For Your Use
- ☐ For Review & Comment

Remarks:

File # OBCNK	Doc. # 235
Route to:	
SCANNED: 5/15/02	

By Nigel Miller
Nigel Miller

Parsons Brinckerhoff\35-8440-06 002\3502T059 May 14, 2002

Copyright 2002 Kleinfelder, Inc.

KLEINFELDER 2677 East Parley's Way, Salt Lake City, UT 84109-1617 (801) 466-6769 (801) 466-6788 fax

LEGACY PA
BRIDGE 23
PILE CAPACITY SUMMARY - PP 406x9.53 (16" x 3/8")
YIELD STRENGTH = 448 MPa

	Initials	Date
Completed By:	NM	5/1/02
Reviewed By:	cc	5/7/02

B-2 Target Geotechnical Capacity per Pile (2.25xService Load) 1,481 kN
B-3 Target Geotechnical Capacity per Pile (2.25xService Load) 1,100 kN
(Target Service Load Provided by Structural Engineer)

Location	A Finished Grade Elevation (m)	B Bottom of Pile Cap Elevation (m)	C Est. Embankm Height (m)	D Estimated Pile Tip Elevation (m)	E Minimum Pile Tip Elevation (m)	F Service Uplift Load Resistance (kN)	G Required Seismic Compression Resistance (kN)	H Required Seismic Uplift Resistance (kN)	I Service Load (DL + LL) (kN)	J Required Driving Resistance (kN)	K Est. Pile Length w/ fill (m)	L Estimated Maximum Structural Load in Pile (kN) (Service Load + Drag Load)	M Est. Elevation of Neutral Plane (m)	N Estimated Pile Tip Settlement (mm)
Bridge 23, Bent 2	1285.0	1282.2	N/A	1272.5	1273.5	573	1,873	635	658	2,058	20	1,319	1277.7	1
Bridge 23, Bent 3	1287.6	1284.4	N/A	1279.4	1279.4	421	1,597	583	439	1,748	15	1,334	1278.4	1

Location	Borings Used for Soil Profile
Bridge 23, Bent 2	SC-23-280A; SB-23-269, LSB-23-443
Bridge 23, Bent 3	SC-23-281; LSB-23-444

Description of Information Presented in Each Column:

A Finished Grade Elevation - Top of approach slab elevation at abutment locations and adjacent ground elevation at bent locations as shown on the structure Plan and Profile drawing provided

B. Bottom of Pile Cap Elevation - Elevation at the bottom of the pile cap as scaled from the structure Plan and Profile drawing provided

C: Estimated Embankment Height - Elevation difference between the top of the approach slab and the native ground surface at the abutment as scaled from the structure Plan and Profile drawing provided

D Estimated Pile Tip Elevation - Estimated elevation to which the bottom of the pile will need to be driven to develop the required capacity and meet the settlement criteria (Additional depth may be required to reach required resistance during driving)

E: Minimum Pile Tip Elevation - Estimated minimum elevation to which the bottom of the pile will need to be driven to meet settlement, minimum length, or minimum depth criteria should the required driving resistance be obtained above the Target Pile Tip

F: Service Uplift Load Resistance = (Ultimate Friction Resistance)/(FS=2 25) Per comment resolution meeting with UDOT (8/15/01)

G: Seismic Compression Resistance = Ultimate Friction and End Bearing Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate resistance values to resist seismic loads)

H Seismic Uplift Resistance = Ultimate Friction Resistance neglecting the contribution of potentially liquefiable zones. (AASHTO allows the use of the ultimate friction resistance value to resist seismic uplift loads.)

I Service Load (DL + LL) - The maximum load that can be applied at the top of the pile by the structure provided the pile is driven to the assumed capacity

J Required Driving Resistance - The minimum load (service load x 2 25 or required seismic resistance plus estimated loss during liquefaction, whichever is greater) that must be verified in the field by PDA

K: Estimated Pile Length w/ Fill - The estimated length of pile required Calculated as (Bottom Of Pile Cap - Estimated Tip Elevation) rounded up to the nearest meter (Actual lengths may vary depending on driving conditions encountered at each pile location)

L: Estimated Structural Load in the Pile - The largest load that will develop in the pile due to structural service dead loads and drag loads. This load occurs at the neutral plane where equilibrium exists between the sum of the downward acting permanent load (service load) applied at the top of the pile and drag load due to negative skin friction and the sum of upward acting positive shaft resistance and mobilized toe resistance

M: Estimated Elevation of Neutral Plane - The level in the pile where relative movement between the pile and soil is zero

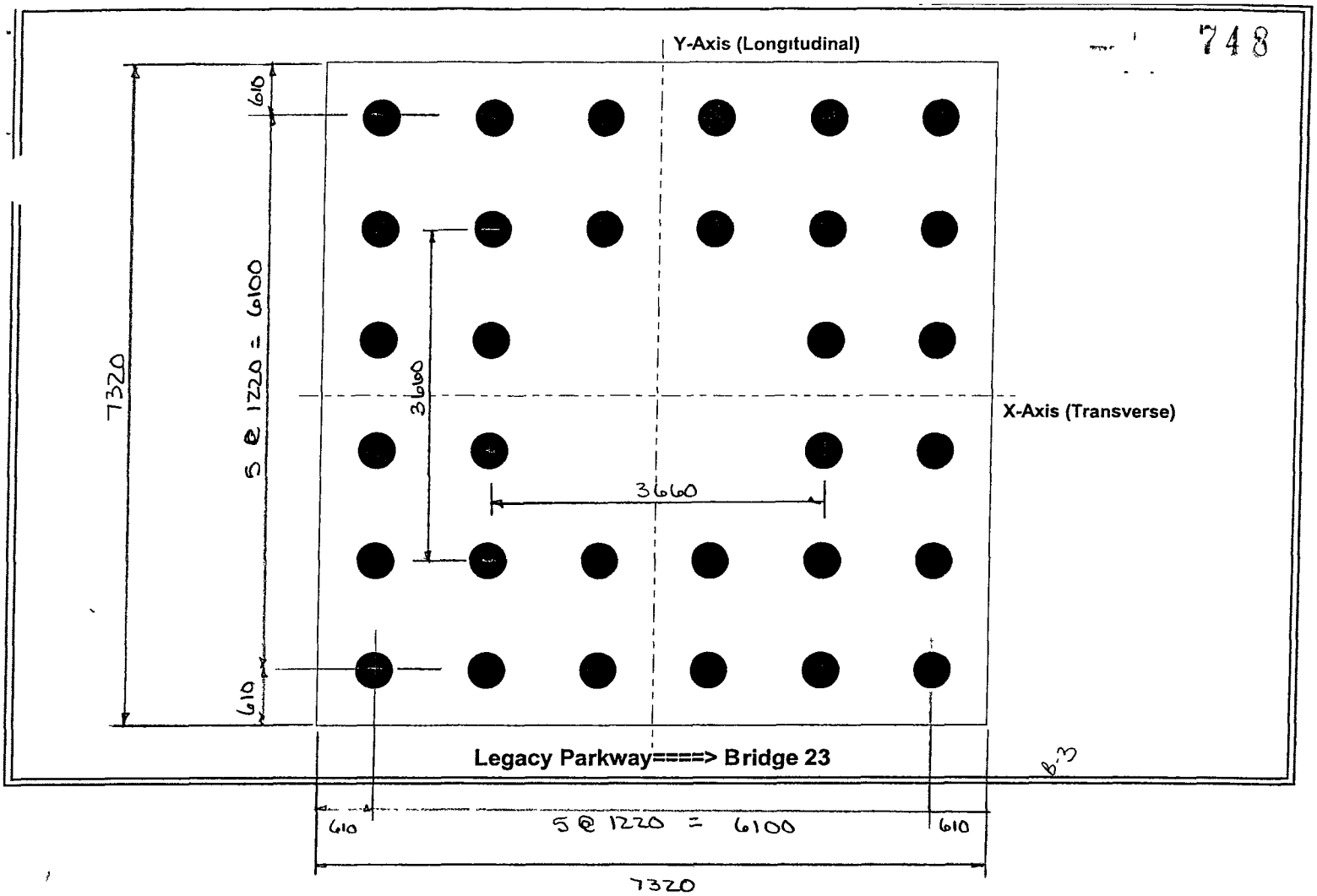
N: Estimated Pile Tip Settlement - The magnitude of pile tip settlement required to mobilize estimated pile tip loads This does not include elastic compression of the pile

PARSONS BRINCKERHOFF	Page	
COMPUTATION SHEET	Made by	V. Gouge
	Date	11-Apr-02
Subject Legacy Parkway - Bridge 23	Checked by	SAW
Pile Loads	Date	4/16/02

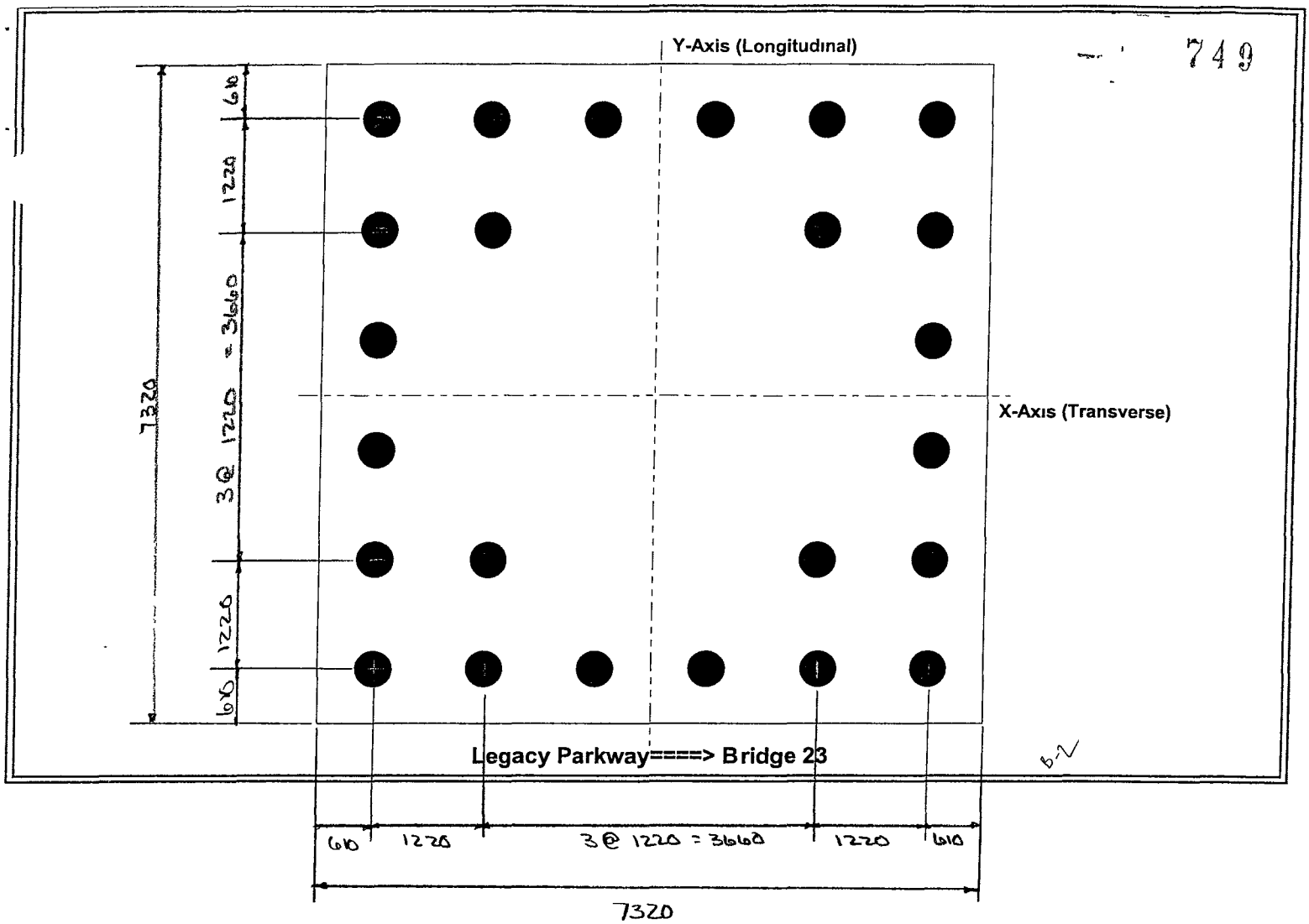
Bridge 23: Service and Seismic Loads per Pile

Pier	DL (kip)	LL (kip)	Seismic Compression (kip)	Seismic Tension (kip)	Number of Piles
A1	-	-	-	-	-
2	~~229~~ 119	~~91~~ 12	~~441~~ 484	143 ~~93~~	~~20~~ 24
3	~~237~~ 67	~~94~~ 23	~~452~~ 259	~~90~~ 131	~~20~~ ~~28~~ 32
A5	-	-	-	-	-

Note: Load values presented in the table above are representative of the maximum values for a single pile in a pile group. This does not reresent the value of every pile in the foundation. Each pile may have a different tension or compression value in the footing.


Y-Axis (Longitudinal)
X-Axis (Transverse)
610
5 @ 1220 = 6100
7320
3660
3660
610
Legacy Parkway====> Bridge 23
B-3
610
5 @ 1220 = 6100
610
7320

BENT 3


Y-Axis (Longitudinal)
X-Axis (Transverse)
Legacy Parkway====> Bridge 23
610
1220
3@1220 = 3660
1220
610
7320
610
1220
3@1220 = 3660
1220
610
7320

BENT 2

PARSONS BRINCKERHOFF COMPUTATION SHEET

Subject: Legacy Parkway

Page 1 of 1 | 750

Made by: V. Gouge

Date: 1/25/01

Checked by:

Date:

Heights of the columns at bent 3 were decreased from 24.61ft to 18.5ft. The column steel was modified on January ~~24~~ 25, 2002 from longitudinal steel of 76-#36 bars to 40-#36 bars this decreased the % steel from 2.76% to 1.45%. The reason for the changes above were 1.) During the independent check it was noticed that the column heights vary from 18.5ft to 22.5ft. 2.) The reduction factor was way below R= 4. These changes were necessary because in order for the pile layout at bent 3 to accommodate the shears from the shorter column with a % steel of 2.76, the four (4) center piles of the 6 x 6 pile layout were required. By requiring the center four (4) piles there may be a possible conflict with the column steel and the center piles. GROUP was re-run for the worst case to determine if any modifications were required. As a result of the column changes the center four (4) piles o f the 6 x 6 pile layout were removed.

From Gouge, Vickie
Sent Friday, January 25, 2002 12 14 PM
To. Deschamps, J D , Nobari, Farid
Subject· RE Legacy Parkway ===> Bridge 23

Farid and JD,

I looked into keeping the column reinforcing the same and changing the footing size Also, I conferred with Ali W to see how the independent check was going Based on Ali's independent check the column heights at bent 2 were changed from 32 8ft to 35 4ft this resulted increasing the % steel from 2 61 to 2 76 (76-#36) I increased the footing size to 7320mm x 7320mm below is the resulting pile layouts

Bent 2 pile layout
% Steel = 2 76

```
X  X  X  X  X  X
X  X           X  X
X                 X
X                 X
X  X           X  X
X  X  X  X  X  X
```

Bent 3 pile layout.
% Steel = 2 76

```
X  X  X  X  X  X
X  X  X  X  X  X
X  X  X  X  X  X
X  X  X  X  X  X
X  X  X  X  X  X
X  X  X  X  X  X
```

By using this layout the center piles will possibly interfere with the column steel Column 3 can be reduced to a % steel of 1 45% (40-#36) By reducing the steel the center piles can be removed for the layout below

Below is a summary of the results.

	Reduction factor	% steel	D/C	Pile stress Kn/m^2	Allowable stress Kn/m^2	
Bent 2 Column 1	5 0	1 81	1 02	4 16E5	6 72E5	
Bent 2 Column 1	4 0	2 61	1 01	5 78E5	6 72E5	
Bent 3 Column 1	4 0	1 81	1 24	5 63E5	6 72E5	
Bent 3 column 1	3 0	2 61	1 34	8 90e5	6 72E5	===> No Good!

As you can see from the above results a % steel of 2 61 does not work for bent 3 There are two reasons for this

1) The columns at bent 3 are shorter than at bent 2 by about 14 feet This causes the plastic shear to be greater in the columns of bent 3
2) The top soil layer at bent 3 is a sand with a stiffness of 13050kPa/m compared to a top soil layer of clay with a stiffness of 63665kPa/m at bent 2

Based on the above results, would it be okay to use 72-#36 bars (% steel =2 61) for the columns at bent 2 and 50-#36 (% steel =1 81) at bent 3?
This will keep the reduction modification factor of R=4 for the columns at both bents

PB 100 YEARS	**PARSONS BRINCKERHOFF COMPUTATION SHEET**	Page
		Made by VLG
		Date 1/25/02
	Subject Legacy Parkway - Bridge S23	Checked by
	GROUP Analysis	Date

GROUP Analysis
Determine Demand @ Top of Piles

BENT 2

footing depth = 6.56 ft = 2 00 m

	Axial		Shear		Moment	
	kips	kN	kips	kN	k-ft	kN-m
Demand @ Bottom of Column	4340	19304	1595	7095	26116	35407
+ Footing Weight	394	1753	-	-	-	-
+ Soil Weight	89	396	-	-	-	-
- Soil Passive Resistance	-	-	171	761	-	-
+ Moment due to Shear x (Ftg depth)	-	-	-	-	9344	12668
= Demand @ Top of Piles	**4823**	**21453**	**1424**	**6334**	**35460**	**48075**

note.
Bottom of Column Demands are due to Column Plastic Hinging .

GROUP Analysis
Determine Demand @ Top of Piles

BENT 3

footing depth = 6 56 ft = 2 00 m

	Axial		Shear		Moment	
	kips	kN	kips	kN	k-ft	kN-m
Demand @ Bottom of Column	3039	13517	2154	9581	19926	27015
+ Footing Weight	394	1753	-	-	-	-
+ Soil Weight	89	396	-	-	-	-
- Soil Passive Resistance	-	-	171	761	-	-
+ Moment due to Shear x (Ftg depth)	-	-	-	-	13012	17641
= Demand @ Top of Piles	**3522**	**15666**	**1983**	**8820**	**32938**	**44655**

note.
Bottom of Column Demands are due to Column Plastic Hinging

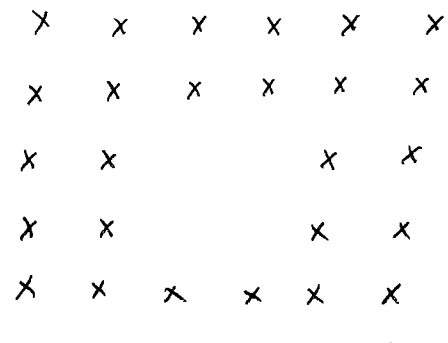
753

PILE GROUP ANALYSIS PROGRAM-GROUP
PC VERSION 5.0 (C) COPYRIGHT ENSOFT,INC. 2000

THE PROGRAM WAS COMPILED USING MICROSOFT FORTRAN
POWERSTATION 4 0 (C) COPYRIGHT MICROSOFT CORPORATION, 1996.

PILE LAY OUT

Legacy Parkway ===> Bridge 23, Bent 3



***** INPUT INFORMATION *****

* TABLE C * LOAD AND CONTROL PARAMETERS

UNITS--

V LOAD, KN	H LOAD, KN	MOMENT, KN- M
.1567E+05	.8820E+04	.4466E+05

* THE LOADING IS STATIC *

KPYOP = 0 (CODE TO GENERATE P-Y CURVES)

(KPYOP = 1 IF P-Y YES; = 0 IF P-Y NO; = -1 IF P-Y ONLY)

* CONTROL PARAMETERS *

TOLERANCE ON CONVERGENCE OF FOUNDATION REACTION	=	.254E-06	M
TOLERANCE ON DETERMINATION OF DEFLECTIONS	=	.254E-06	M
MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS	=	100	
MAXIMUM NO. OF ITERATIONS ALLOWED FOR PILE ANALYSIS	=	100	

* TABLE D * ARRANGEMENT OF PILE GROUPS

GROUP	CONNECT	NO OF PILE	PILE NO	L-S CURVE	P-Y CURVE
1	PIN	6	1	1	0
2	PIN	6	1	1	0
3	PIN	2	1	1	0
4	PIN	2	1	1	0
5	PIN	2	1	1	0
6	PIN	2	1	1	0
7	PIN	6	1	1	0
8	PIN	6	1	1	0

GROUP	VERT, M	HOR, M	SLOPE, M/ M	GROUND, M	SPRING, KN- M
1	.0000E+00	.3050E+01	.0000E+00	.2600E+01	.0000E+00
2	.0000E+00	.1830E+01	.0000E+00	.2600E+01	.0000E+00
3	.0000E+00	.6100E+00	.0000E+00	.2600E+01	.0000E+00
4	.0000E+00	.6100E+00	.0000E+00	.2600E+01	.0000E+00
5	.0000E+00	-.6100E+00	.0000E+00	.2600E+01	.0000E+00
6	.0000E+00	-.6100E+00	.0000E+00	.2600E+01	.0000E+00
7	.0000E+00	-.1830E+01	.0000E+00	2600E+01	.0000E+00
8	.0000E+00	-.3050E+01	.0000E+00	.2600E+01	.0000E+00

* TABLE E * PILE GEOMETRY AND PROPERTIES

PILE	SEC	INC	LENGTH, M	E , KN/ M**2
1	1	100	.3000E+02	.2000E+09

PILE	FROM, M	TO, M	DIAM, M	AREA, M**2	I, M**4
1	.0000E+00	.3000E+02	4060E+00	.2700E-01	.3700E-03

* THE PILE ABOVE IS OF LINEARLY ELASTIC MATERIAL *

PB 100 YEARS	**PARSONS BRINCKERHOFF COMPUTATION SHEET**	Page
		Made by VLG
		Date 1/23/02
	Subject: Legacy Parkway - Bridge S23	Checked by
	GROUP Analysis	Date

GROUP Analysis
Determine Demand @ Top of Piles

BENT 2

footing depth = 6.56 ft = 2 00 m

	Axial		Shear		Moment	
	kips	kN	kips	kN	k-ft	kN-m
Demand @ Bottom of Column	4340	19304	1524	6779	26933	36514
+ Footing Weight	394	1753	-	-	-	-
+ Soil Weight	89	396	-	-	-	-
- Soil Passive Resistance	-	-	171	761	-	-
+ Moment due to Shear x (Ftg depth)	-	-	-	-	8878	12036
= Demand @ Top of Piles	**4823**	**21453**	**1353**	**6018**	**35811**	**48551**

note.
Bottom of Column Demands are due to Column Plastic Hinging

GROUP Analysis
Determine Demand @ Top of Piles

BENT 3

footing depth = 6 56 ft = 2 00 m

	Axial		Shear		Moment	
	kips	kN	kips	kN	k-ft	kN-m
Demand @ Bottom of Column	3039	13517	2217	9861	27278	36982
+ Footing Weight	394	1753	-	-	-	-
+ Soil Weight	89	396	-	-	-	-
- Soil Passive Resistance	-	-	171	761	-	-
+ Moment due to Shear x (Ftg depth)	-	-	-	-	13425	18201
= Demand @ Top of Piles	**3522**	**15666**	**2046**	**9101**	**40703**	**55183**

note.
Bottom of Column Demands are due to Column Plastic Hinging

PARSONS BRINCKERHOFF COMPUTATION SHEET

Page _____ of _____

Made by V. Lowe

Date 18 - Jan - 02

Checked by _____

Date _____

Subject LEGACY PARKWAY

ALLOWABLE PILE STRESS:

1.5 (65 ksi) = 97.5 ksi => 6.72E5 kN/m²

PARSONS BRINCKERHOFF
COMPUTATION SHEET

Page	
Made by	VLG
Date	1/18/02
Checked by	
Date	

Subject: Legacy Parkway - Bridge S23
GROUP Analysis

GROUP Analysis
Determine Demand @ Top of Piles

BENT 2

footing depth = 6.56 ft = 2.00 m

	Axial		Shear		Moment	
	kips	kN	kips	kN	k-ft	kN-m
Demand @ Bottom of Column	4340	19304	1595	7095	26116	35407
+ Footing Weight	394	1753	-	-	-	-
+ Soil Weight	89	396	-	-	-	-
- Soil Passive Resistance	-	-	171	761	-	-
+ Moment due to Shear x (Ftg depth	-	-	-	-	9344	12668
= Demand @ Top of Piles	**4823**	**21453**	**1424**	**6334**	**35460**	**48075**

note:
Bottom of Column Demands are due to Column Plastic Hinging .

GROUP Analysis
Determine Demand @ Top of Piles

BENT 3

footing depth = 6.56 ft = 2.00 m

	Axial		Shear		Moment	
	kips	kN	kips	kN	k-ft	kN-m
Demand @ Bottom of Column	3039	13517	2152	9572	26479	35899
+ Footing Weight	394	1753	-	-	-	-
+ Soil Weight	89	396	-	-	-	-
- Soil Passive Resistance	-	-	171	761	-	-
+ Moment due to Shear x (Ftg depth	-	-	-	-	12999	17623
= Demand @ Top of Piles	**3522**	**15666**	**1981**	**8811**	**39478**	**53522**

note:
Bottom of Column Demands are due to Column Plastic Hinging .

806

Gouge, Vickie

From: Deschamps, J.D
Sent: Saturday, January 19, 2002 11:14 AM
To: Gouge, Vickie; Nobari, Farid
Subject: RE. Legacy Parkway ===> Bridge 23

I talked with Joe about this.

His suggestion was to keep the column reinforcing the same 2.61% and make the footings larger to make this footing work. (Make it bigger on both Bent 2 and 3) Vickie can you look at this The constraint on the footing is that it not be under the railroad tracks. If this doesn't work we will go with your option of having different column reinforcing.

Thanks,

JD

-----Original Message-----
From: Gouge, Vickie
Sent: Friday, January 18, 2002 7:02 PM
To: Nobari, Farid; Deschamps, J.D.
Subject: Legacy Parkway ===> Bridge 23

Farid and JD,

I have completed my analysis of the columns and the pile groups. I reduced the reduction factor R= 5 to a lower value. Original calculations had longitudinal steel of 50 -#36 bars. For the worst cases (bent2, bottom of column 1 and bent3, bottom of column 1) the reduction factor was R=5 and the % steel = 1.81. By increasing the longitudinal steel to 72-#36 bar, the reduction factor was reduce to R=4.0 and the % steel was increased to 2.61. The plastic moments and shears from these two recol files were input into group to determine if the pile capacity was adequate for the increased moments and shears at bent 2 and bent 3.

Below is a summary of the results:

	Reduction factor	% steel	D/C	Pile stress Kn/m^2	Allowable stress Kn/m^2	
Bent 2 Column 1	5.0	1.81	1.02	4.16E5	6.72E5	
Bent 2 Column 1	4.0	2.61	1.01	5.78E5	6.72E5	
Bent 3 Column 1	4.0	1.81	1.24	5.63E5	6.72E5	
Bent 3 column 1	3.0	2.61	1.34	8.90e5	6.72E5	===> No. Good!

As you can see from the above results a % steel of 2.61 does not work for bent 3. There are two reasons for this.

1.) The columns at bent 3 are shorter than at bent 2 by about 14 feet. This causes the plastic shear to be greater in the columns of bent 3.

2.) The top soil layer at bent 3 is a sand with a stiffness of 13050kPa/m compared to a top soil layer of clay with a stiffness of 63665kPa/m at bent 2.

Based on the above results, would it be okay to use 72-#36 bars (% steel =2.61) for the columns at

bent 2 and 50-#36 (% steel =1.81) at bent 3?
This will keep the reduction modification factor of R=4 for the columns at both bents.

Vickie Gouge
Parsons Brinckerhoff,
Sacramento Office
PH: (916) 567-2552
FAX: (916) 925-3517
E-MAIL: gouge@pbworld.com

Bridge 23: Factored Pile Load Data

Pier	DL (kip)	LL (kip)	Seismic Compression (kip)	Seismic Tension (kip)	Number of Piles
A1	-	-	-	-	20
2	116	37	407	-139	32
3	116	45	359	-131	32
A4	-	-	-	-	20

Note: Load values presented in the table above are representative of the maximum values for a single pile in a pile group. This does not represent the value of every pile in the foundation. Each pile may have a different tension or compression value in the footing.

PARSONS BRINCKERHOFF
COMPUTATION SHEET

Subject: Legacy Parkway - Bridge S23
Bent Pile Loads

Page
Made by VLG
Date 1/22/02
Checked by -2
Date

Maximum Pile Loads Bent 2

Load Type	FAD Model	Controlling Load Group	Load Case	Service Pile Loads kips	Factored Pile Load kips
DL only	Bent2r4a.out	II		76	116
DL + LL	Bent2r4a.out	IH	3	106	153
LL only	Bent2r4a.out			30	37
DL + Seismic (compression)	Bent2r4a.out	VII	1		407
DL + Seismic (tension)	Bent2r4a.out	VII	1		-139

Maximum Pile Loads Bent 3

Load Type	FAD Model	Controlling Load Group	Load Case	Service Pile Loads kips	Factored Pile Load kips
DL only	Bent3r5a out	II		76	116
DL + LL	Bent3r5a.out	IH	3	110	161
LL only	Bent3r5a.out			34	45
DL + Seismic (compression)	Bent3r5a.out	VII	1		359
DL + Seismic (tension)	Bent3r5b.out	PB2	1		-131

PARSONS BRINCKERHOFF COMPUTATION SHEET

Subject: Legacy Parkway - Bridge S23
Bent Pile Loads

Page
Made by VLG
Date 12/20/01
Checked by
Date

Maximum Pile Loads Bent 2

Load Type	FAD Model	Controlling Load Group	Load Case	Service Pile Loads kips	Factored Pile Load kips
DL only	Bent2r2.out	II		89	138
DL + LL	Bent2r2.out	IH	3	129	187
LL only	Bent2r2.out			40	49
DL + Seismic (compression)	Bent2r2.out	PB1	1		449
DL + Seismic (tension)	Bent2r2.out	PB2	1		-194

Maximum Pile Loads Bent 3

Load Type	FAD Model	Controlling Load Group	Load Case	Service Pile Loads kips	Factored Pile Load kips
DL only	Bent3r4.out	II		64	97
DL + LL	Bent3r4.out	IH	3	99	150
LL only	Bent3r4.out			35	53
DL + Seismic (compression)	Bent3r4 out	VII	1		504
DL + Seismic (tension)	Bent3r4.out	VII	2		-233

859

Bridge 23: Factored Pile Load Data

Pier	DL (kip)	LL (kip)	Seismic Compression (kip)	Seismic Tension (kip)	Number of Piles
A1	-	-	-	-	20
2	138	49	449	-194	25
3	97	53	504	-233	25
A4	-	-	-	-	20

Note: Load values presented in the table above are representative of the maximum values for a single pile in a pile group. This does not represent the value of every pile in the foundation. Each pile may have a different tension or compression value in the footing.

PARSONS BRINCKERHOFF COMPUTATION SHEET

Page _____ of _____ 861

Made by _____

Date _____

Subject _____

Checked by _____

Date _____

L Pile Analysis

PARSONS BRINCKERHOFF COMPUTATION SHEET

Page _____ of _____

Made by VLG

Date December 12, 2001

Checked by _____

Date _____

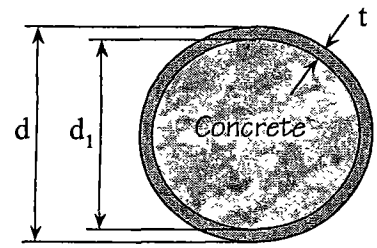
Subject *Legacy Parkway-Foundation Seismic Design*

BRIDGE 23: Section Properties

BRIDGE 23: Section Properties

➔ Steel Pipe Piles Filled with Concrete

➔ Input Parameters



Outside Pipe Diameter, d = 16.0 in = 406 mm

Pipe Thickness, t = 3/8 in = 10 mm

Inside Pipe Diameter, d_1 = 15.25 in = 387 mm

Concrete f'_c = 4,000 psi

Steel f_y = 45.0 ksi

E_s = 29,000.0 ksi

Modulus of Elasticity, E_c = $57{,}000\sqrt{f'_c}$ psi = $57{,}000\sqrt{4{,}000}$ = 3,604,997 psi

for normal weight concrete (w = 145 pcf)

➔ Calculations

Since outer shell and filler material are of different materials, i.e. steel and concrete

Transform concrete area based on

$$n = \frac{E_s}{E_c} = \frac{29{,}000}{3{,}605} = 8.0$$

The total area of concrete,

$$A_s = \frac{\pi d_1^2}{4} = \frac{3.1416\,(15.25)^2}{4} = 182.7 \text{ in}^2$$

will be transformed into an equivalent area of steel with the same neutral axis

$$A' = \frac{A_s}{n} = \frac{182.7}{8.0} = 22.7 \text{ in}^2$$

Transformed area diameter

$$A' = \frac{\pi d_1^2}{4}$$

$$\Longrightarrow \quad d_1 = \sqrt{\frac{4A'}{\pi}} = \sqrt{\frac{4\,(22.7)}{3.1416}} = 5.38 \text{ in}$$

LEGACY PARKWAY
BRIDGE 23
PILE CAPACITY SUMMARY - PP 406x9 53 (16" x 3/8")
YIELD STRENGTH = 448 MPa

	Initials	Date
Completed By		
Reviewed By		

A-1 Target Geotechnical Capacity per Pile (2 25xService Load) 3,503 kN
(Target Service Load Provided by Structural Engineer)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Location	Finished Grade Elevation (m)	Bottom of Pile Cap Elevation (m)	Est Embankm. Height (m)	Target Pile Tip Elevation (m)	Minimum Pile Tip Elevation (m)	Service Uplift Load Resistance (kN)	Required Seismic Compression Resistance (kN)	Required Seismic Uplift Resistance (kN)	Service Load (DL + LL) (kN)	Required Driving Resistance (kN)	Est Pile Length w/ fill (m)	Estimated Maximum Structural Load in Pile (kN) (Service Load + Drag Load)	Est Elevation of Neutral Plane (m)	Estimated Pile Tip Settlement (mm)
Bridge 23, Abutment 1	1310.7	1305 1	15 6	1281 7	1281 7	934	N/A	N/A	1,557	3,503	23	3,138	1285.2	4

Location	Borings Used for Soil Profile
Bridge 23, Abutment 1	RB-365

Description of Information Presented in Each Column:

A **Finished Grade Elevation** - Top of approach slab elevation at abutment locations and adjacent ground elevation at bent locations as shown on the structure Plan and Profile drawing provided

B **Bottom of Pile Cap Elevation** - Elevation at the bottom of the pile cap as scaled from the structure Plan and Profile drawing provided

C **Estimated Embankment Height** - Elevation difference between the top of the approach slab and the native ground surface at the abutment as scaled from the structure Plan and Profile drawing provided

D **Target Pile Tip Elevation** - Estimated elevation to which the bottom of the pile will need to be driven to develop the required capacity and meet the settlement criteria (Additional depth may be required to reach required resistance during driving)

E **Minimum Pile Tip Elevation** - Estimated minimum elevation to which the bottom of the pile will need to be driven to meet settlement, minimum length, or minimum depth criteria should the required driving resistance be obtained above the Target Pile Tip Eleva

F **Service Uplift Load Resistance** = (Ultimate Friction Resistance)/(FS=2 25) Per comment resolution meeting with UDOT (8/15/01)

G **Seismic Compression Resistance** = Ultimate Friction and End Bearing Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate resistance values to resist seismic loads)

H **Seismic Uplift Resistance** = Ultimate Friction Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate friction resistance value to resist seismic uplift loads)

I **Service Load (DL + LL)** - The maximum load that can be applied at the top of the pile by the structure provided the pile is driven to the assumed capacity

J **Required Driving Resistance** - The minimum load (service load x 2 25 or required seismic resistance plus estimated loss during liquefaction, whichever is greater) that must be verified in the field by PDA

K **Estimated Pile Length w/ Fill** - The estimated length of pile required Calculated as (Bottom Of Pile Cap - Estimated Tip Elevation) rounded up to the nearest meter (Actual lengths may vary depending on driving conditions encountered at each pile location)

L **Estimated Structural Load in the Pile** - The largest load that will develop in the pile due to structural service dead loads and drag loads This load occurs at the neutral plane where equilibrium exists between the sum of the downward acting permanent load (service load) applied at the top of the pile and drag load due to negative skin friction and the sum of upward acting positive shaft resistance and mobilized toe resistance

M **Estimated Elevation of Neutral Plane** - The level in the pile where relative movement between the pile and soil is zero

N **Estimated Pile Tip Settlement** - The magnitude of pile tip settlement required to mobilize estimated pile tip loads This does not include elastic compression of the pile

Gouge, Vickie

From: Nobari, Farid
Sent: Friday, December 14, 2001 1.34 PM
o: Gouge, Vickie
c: Cooper, Tom
Subject: FW: Bridge 23 Pile Summary Deliverable (12-14-01) xls

Bridge 23 Pile Summary Deliver

There you are. Please show the red marks on check print, and revise the plans, and print for stamp. Thanks.

-----Original Message-----
From: Nigel Miller [mailto:nmiller@kleinfelder.com]
Sent: Friday, December 14, 2001 1:42 PM
To: Nobari, Farid
Cc: Cooper, Tom
Subject: Bridge 23 Pile Summary Deliverable (12-14-01).xls

This has been checked and all calcs turned in to Guna today.

Nigel Miller, P.E.
Project Geotechnical Engineer

Kleinfelder, Inc.
2677 East Parley's Way
Salt Lake City, UT 84109

PHONE 1.801.466.6769
FAX 1.801.466.6788
nmiller@kleinfelder.com

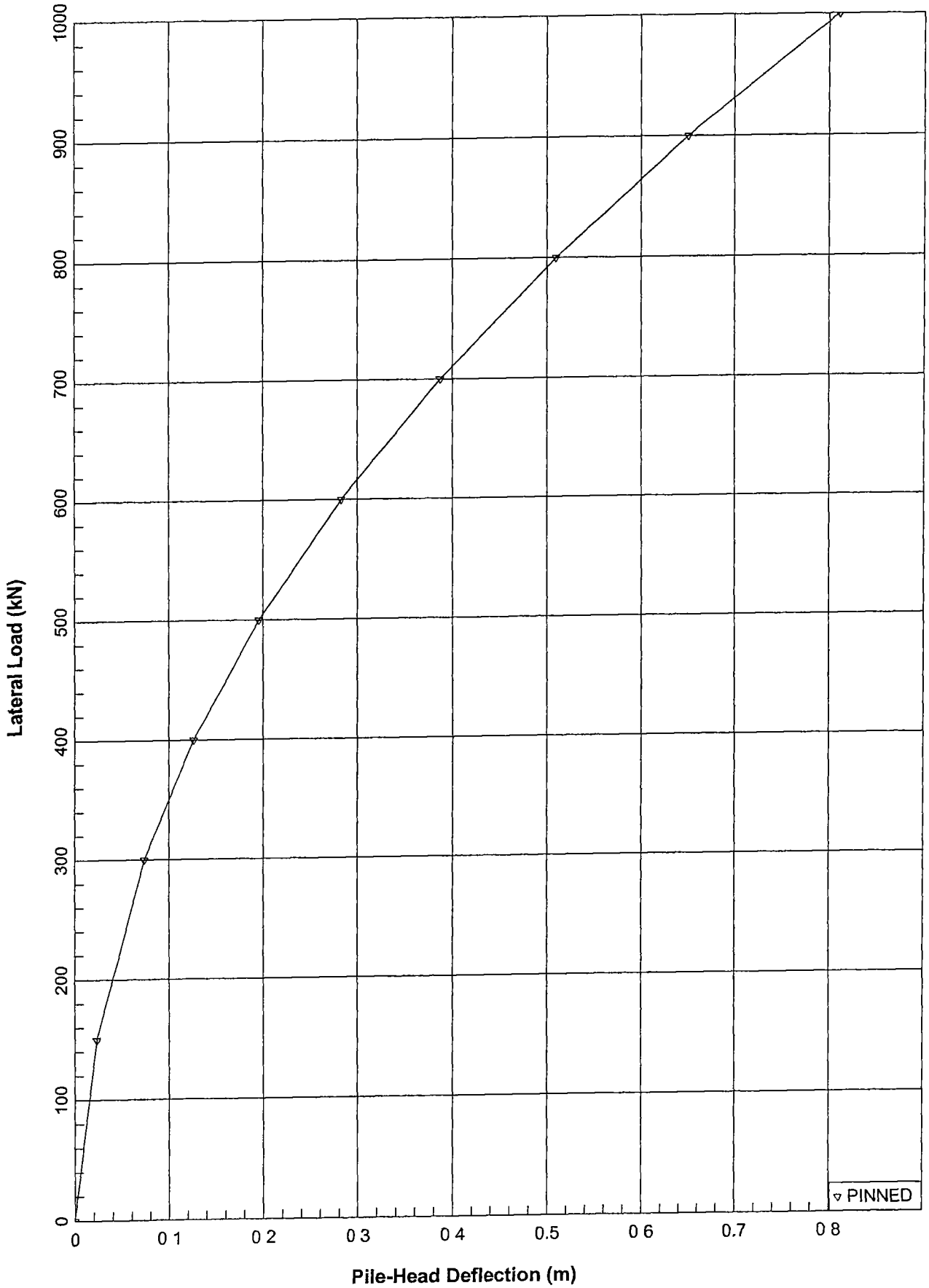
Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	23
Support(s)	1,2
Water Depth (m)	1 5
Finished Grade Elevation (m)	1295 4
Soil Borings Used for Profile	RB-365, SC-23-290A

	Initials	Date
Completed By		
Checked By		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Soft Clay	0 0	1 5	18 7	60	0 020	63,665	-	0	6	0	220
2	Soft Clay	1 5	3 0	8 9	60	0 020	63,665	-	6	9	250	360
3	Sand	3 0	8 7	10 1	-	-	17,070	35	19	46	4,020	9,610
4	Soft Clay	8 7	10 1	9 9	27	0 020	14,165	-	24	28	1,200	1,370
5	Sand	10 1	15 0	10 5	-	-	22,750	38	58	84	13,120	19,100

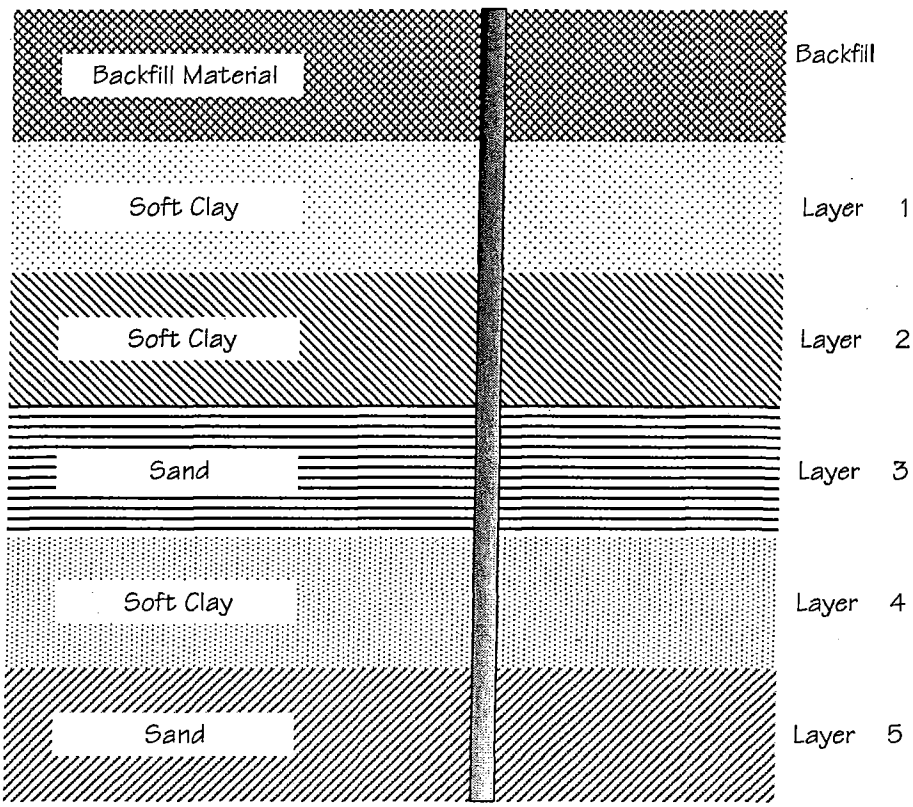
BENT 2 867


Lateral Load (kN)
0
100
200
300
400
500
600
700
800
900
1000
0
0 1
0 2
0 3
0 4
0.5
0 6
0.7
0 8
Pile-Head Deflection (m)
PINNED

➔ BRIDGE 23: Layer Properties - Abut 1

Existing ground elevation = 1,295.5 m
Top of pile = 1,304.5 m (Scaled from plans)
Assume a pile length = -24.0 m

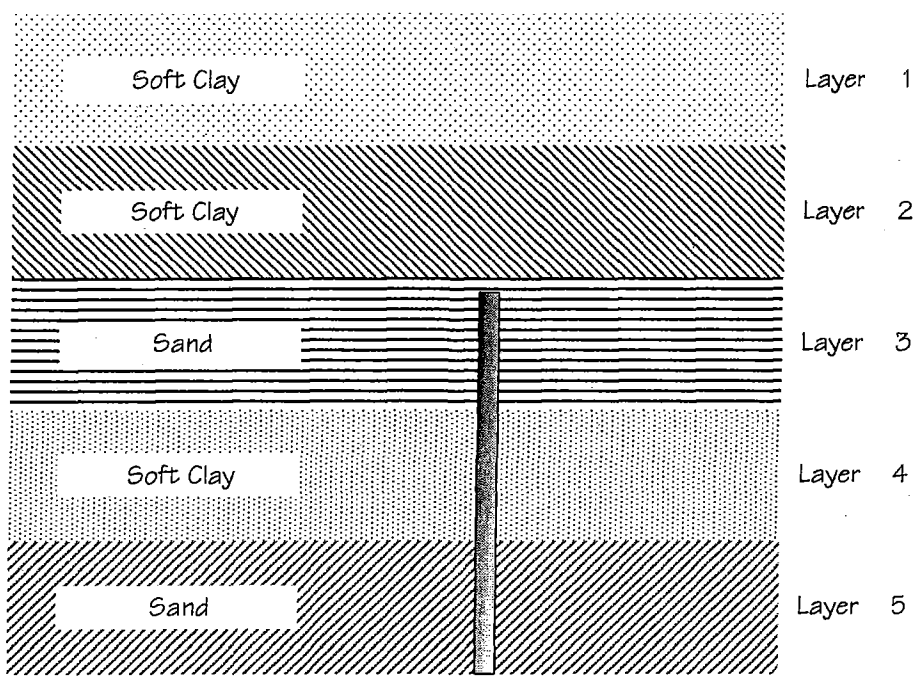
Description	Depth Geothech	Depth L-PILE
Top of Pile	9.0	0.0
Original Ground	0.0	-9.0
	-1.5	-10.5
	-3.0	-12.0
	-8.7	-17.7
	-10.1	-19.1
	-15.0	-24.0



➔ BRIDGE 23: Layer Properties - Bent 2

Existing ground elevation = 1,295.5 m
Top of pile = 1,292.3 m (Scaled from plans)
Assume a pile length = -11.8 m

Description	Depth Geothech	Depth L-PILE
Top of Pile	-3.3	0.0
Original Ground	0.0	3.3
	-1.5	1.8
	-3.0	0.3
	-8.7	-5.5
	-10.1	-6.9
	-15.0	-11.8



Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	23
Support(s)	3,4
Water Depth (m)	2.1
Finished Grade Elevation (m)	1297.9
Soil Borings Used for Profile	SB-23-290C; SC-23-291

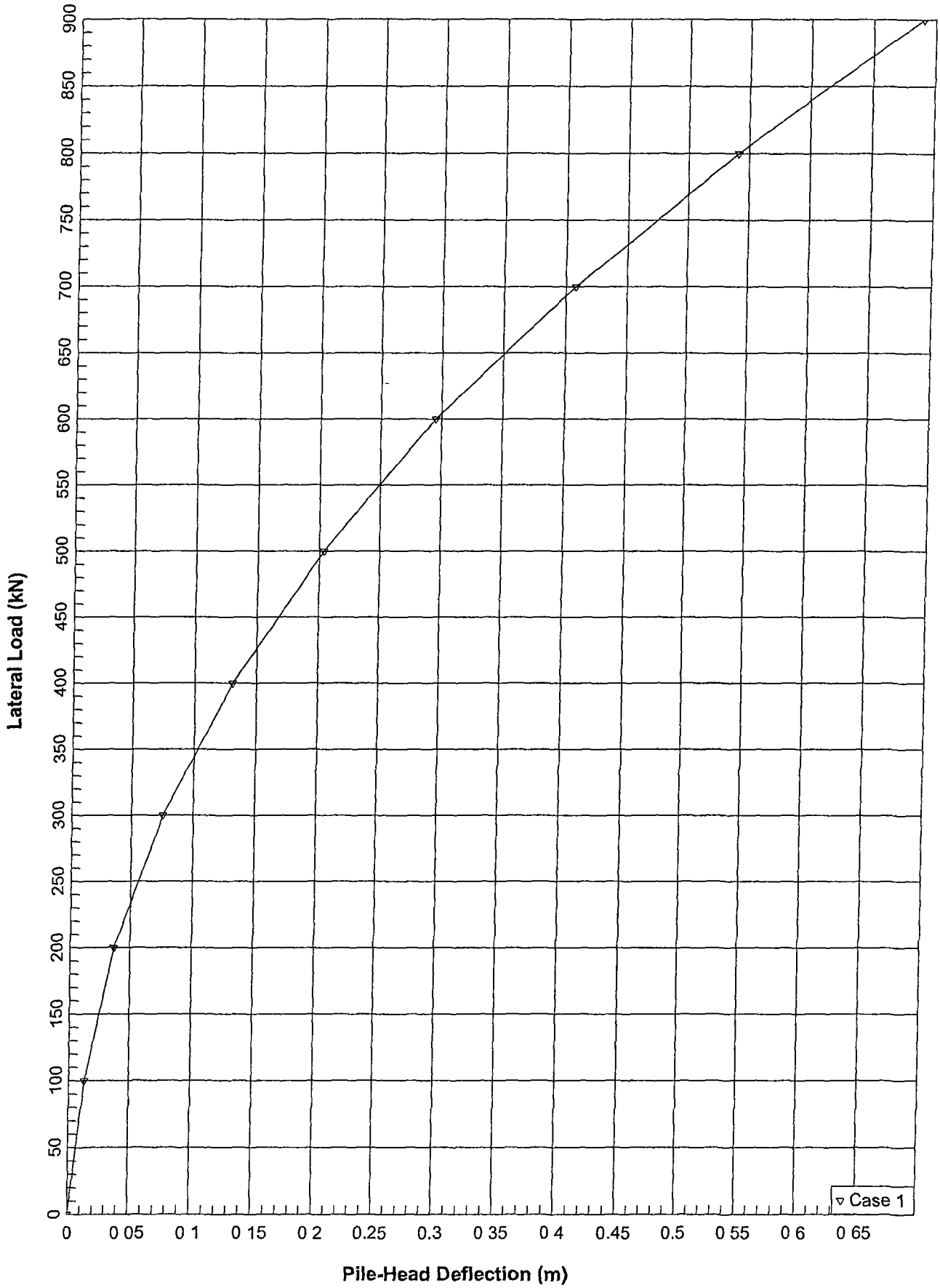
	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	2.1	19.9	-	-	13,050	32	0	16	0	2,950
2	Soft Clay	2.1	5.0	9.7	60	0.020	63,665	-	11	18	640	1,080
3	Silt	5.0	9.8	10.0	40	0.020	33,665	31	21	35	1,700	2,870
4	Soft Clay	9.8	12.6	10.8	24	0.020	9,665	-	25	31	600	760
5	Sand	12.6	15.0	10.9	-	-	32,690	41	88	104	22,220	26,140

Press the "Copy" button to copy this tab to a new spreadsheet. The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies. Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers.

Part 3
Abut 4

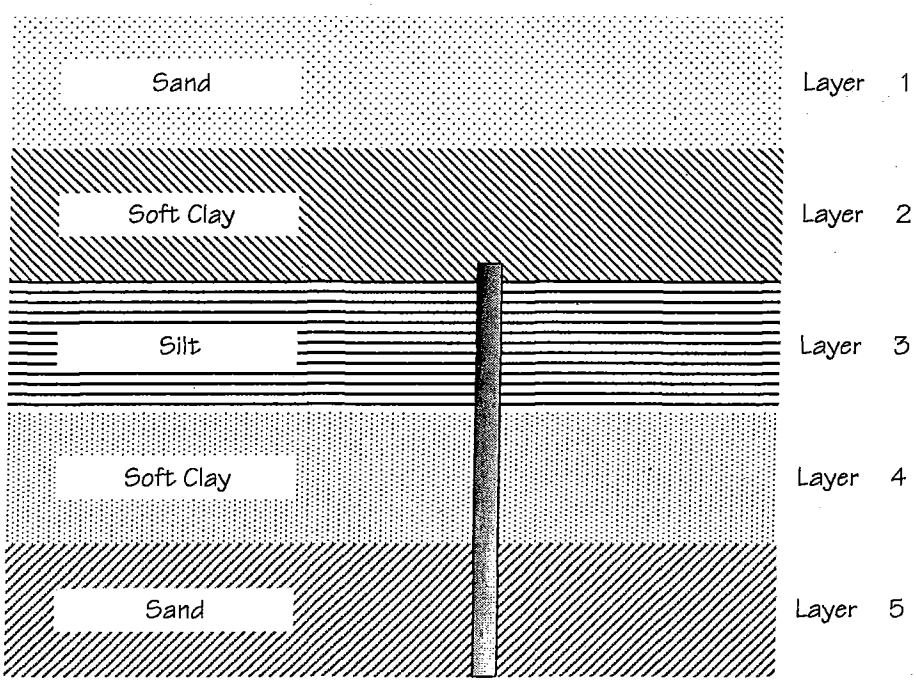
907



➔ BRIDGE 23: Layer Properties - Bent 3

Existing ground elevation = 1,297.5 m
Top of pile = 1,295.0 m (Scaled from plans)
Assume a pile length = -12.5 m

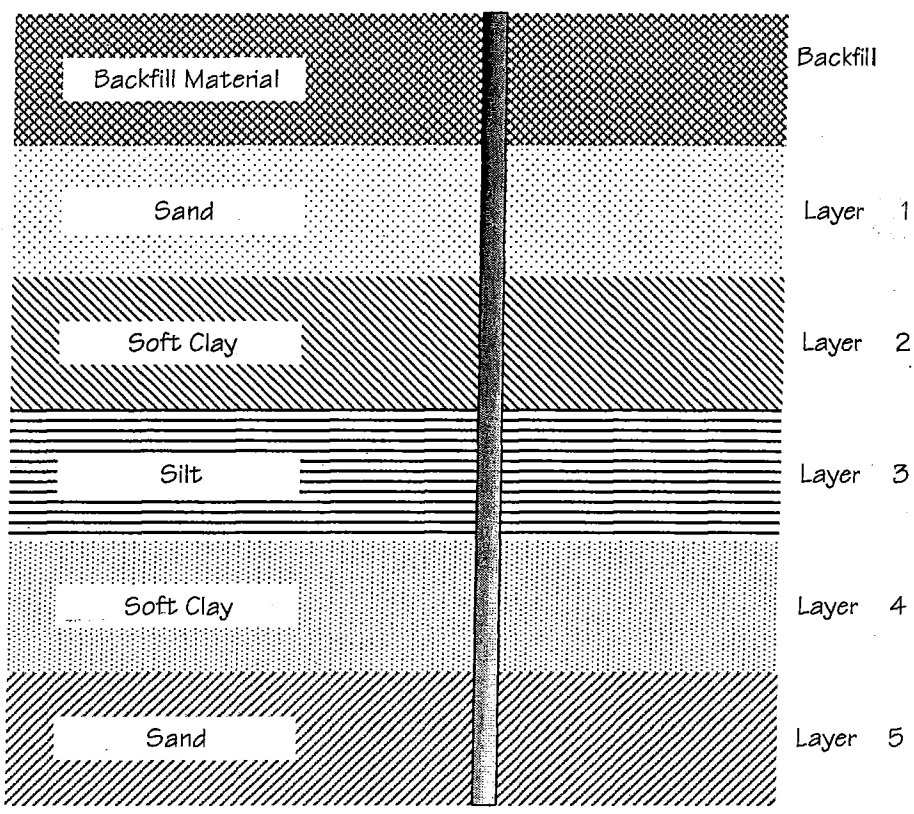
Description	Depth Geothech	Depth L-PILE
Top of Pile	-2.5	0.0
Original Ground	0.0	2.5
	-1.5	1.0
	-3.0	-0.5
	-8.7	-6.2
	-10.1	-7.6
	-15.0	-12.5



➔ BRIDGE 23: Layer Properties - Abut 4

Existing ground elevation = 1,297.5 m
Top of pile = 1,302.0 m (Scaled from plans)
Assume a pile length = -19.5 m

Description	Depth Geothech	Depth L-PILE
Top of Pile	4.5	0.0
Original Ground	0.0	-4.5
	-1.5	-6.0
	-3.0	-7.5
	-8.7	-13.2
	-10.1	-14.6
	-15.0	-19.5



PARSONS BRINCKERHOFF COMPUTATION SHEET

Page _____ of _____ 938

Made by _____

Date _____

Checked by _____

Date _____

Subject _____

GROUP ANALYSIS

PARSONS BRINCKERHOFF
COMPUTATION SHEET

Page	
Made by	VLG
Date	12/21/01
Checked by	
Date	

Subject: Legacy Parkway - Bridge S23
GROUP Analysis

GROUP Analysis
Determine Demand @ Top of Piles

BENT 2

footing depth = 6.56 ft = 2.00 m

	Axial		Shear		Moment	
	kips	kN	kips	kN	k-ft	kN-m
Demand @ Bottom of Column	4340	19304	1303	5796	21442	29070
+ Footing Weight	394	1753	-	-	-	-
+ Soil Weight	89	396	-	-	-	-
- Soil Passive Resistance	-	-	171	761	-	-
+ Moment due to Shear x (Ftg depth)	-	-	-	-	7428	10070
= Demand @ Top of Piles	**4823**	**21453**	**1132**	**5035**	**28870**	**39140**

note:
Bottom of Column Demands are due to Column Plastic Hinging .

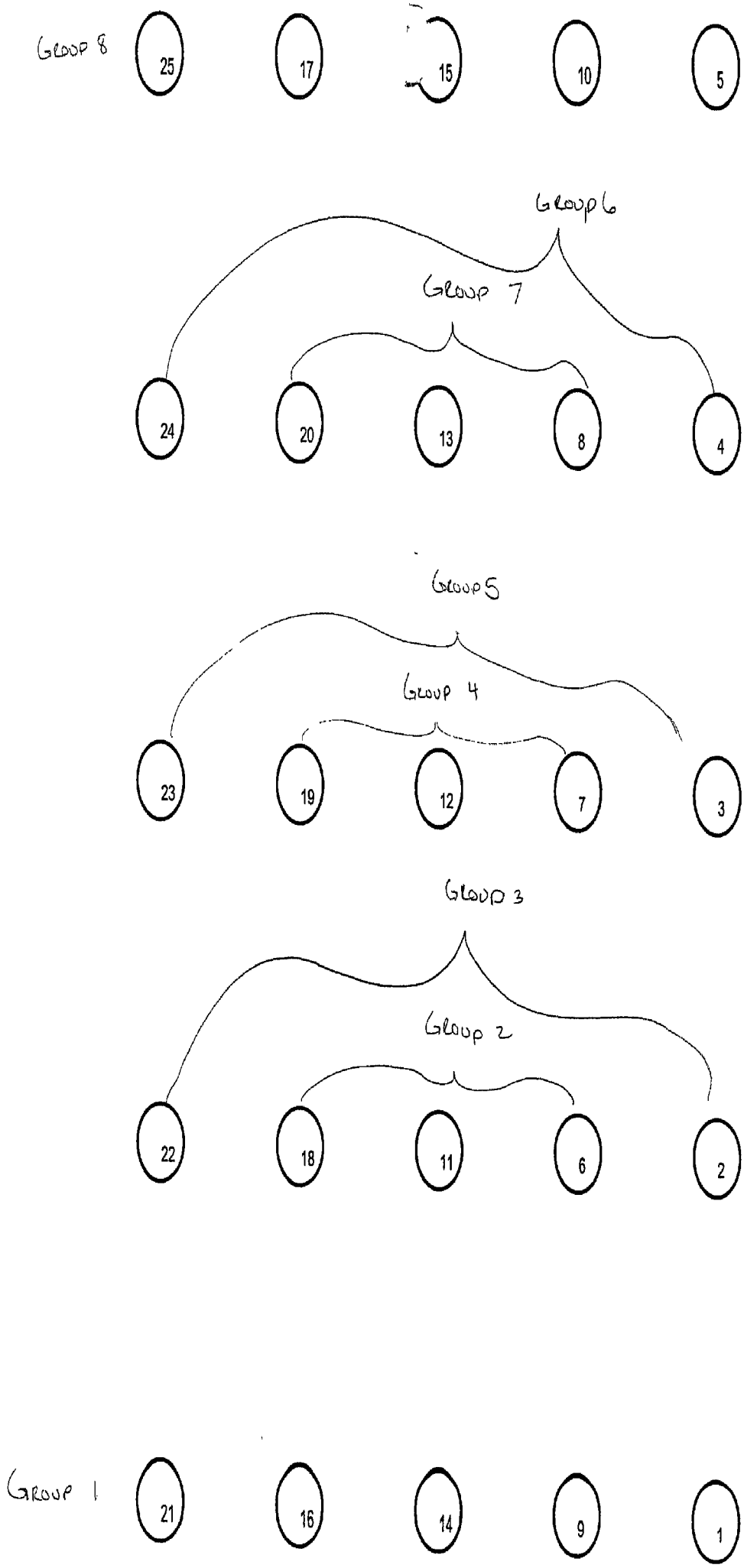
GROUP Analysis
Determine Demand @ Top of Piles

BENT 3

footing depth = 6.56 ft = 2.00 m

	Axial		Shear		Moment	
	kips	kN	kips	kN	k-ft	kN-m
Demand @ Bottom of Column	3039	13517	1549	6890	19117	25918
+ Footing Weight	394	1753	-	-	-	-
+ Soil Weight	89	396	-	-	-	-
- Soil Passive Resistance	-	-	171	761	-	-
+ Moment due to Shear x (Ftg depth)	-	-	-	-	9042	12259
= Demand @ Top of Piles	**3522**	**15666**	**1378**	**6129**	**28159**	**38177**

note:
Bottom of Column Demands are due to Column Plastic Hinging .


Group 8
25
17
15
10
5
Group 6
Group 7
24
20
13
8
4
Group 5
Group 4
23
19
12
7
3
Group 3
Group 2
22
18
11
6
2
Group 1
21
16
14
9
1

BRIDGE 23: Bearing Forces and Shear Key

(per bearing)

DESIGN BEARING RESTRAINT:

Bearing Lateral Forces, Earthquake only: Unit:kn

Bent	Bearing Forces (From analysis)			Bearing Lat. Forces (from column force)		Plastic Shear (From Column strength)	
	L	T	V	L	T	L	T
2	575	1375	204	680	1413	1104	2068
3	886	1987	428	1197	1758	1047	2388

Bent 2 results are based on a 2-column bent, with 1.8 m columns and 2.76% Steel

Bent 3 results are based on a 3-column bent, with 1.8 m columns, and 1.45% steel

(Note: All earthquake loads are +/-)

Abut	Bearing Lat. Forces		1/2 Bnt Brg Force (From adjacent bent, for 1/2 span)		Control Bear. Force	
	L	T	L	T	L	T
1	N/A	1312	N/A	688	N/A	1312
4	N/A	675	N/A	994	N/A	994

(Note: Combination of shear key+sliding force less than Pile capacity)

Note:

L: Longitudinal direction (Free means sliding force 40% vertical only)

T: Transverse direction

Design Bearing Restraint at Bents (Shear Key): **Plastic shear value to be used**

Bent 2	**L=**	1,104 kn	Seismic Gap =	508	mm
	T=	2,068 kn	Seismic Gap =	508	mm
	V=	204 kn			
Bent 3	**L =**	1,047 kn	Seismic Gap =	508	mm
	T =	2,388 kn	Seismic Gap =	508	mm
	V =	428 kn			

Seismic Strategy – Super Structure Bearing-to-Substructure Connectivity

ALL Values are Per Girder and/or Per Bearing.

UNITS: Force: KN, Movement: mm

		TYPE			Behavior						Design Values							
					Longitudinal			Transverse			Longitudinal				Transverse			
		elastometric	Pot-bearing	integral	Fused, Sliding, with no restraint	Fused, Sliding, with a seismic gap	Completly restrained	Fused, Sliding, with no restraint	Fused, Sliding, with a seismic gap	Completly restrained	Restrained Design Force for shear key design	Restraint in both +/- direction (Yes/No)	Seismic relative movement (engagement gap)	Movement in +/- direction (Yes/No)	Restrained Design Force for shear keu design	Restraint in both +/- direction (Yes/No)	Seismic relative movement (engagement gap)	Movement in +/- direction (Yes/No)
Support No.	Notes	1	2		3	4	5	3	4	5	9	9	6, 7, 8, 9, 10	10			6, 7	
Abutment	1		X			X			X		N/A	No	102	No	1138	Yes	610	Yes
Bent	2		X			X			X		1104	Yes	508	Yes	2068	Yes	508	Yes
Bent	3		X			X			X		1047	Yes	508	Yes	2388	Yes	508	Yes
Abutment	4		X			X			X		N/A	No	102	No	1138	Yes	610	Yes

NOTES		
1	Elastomeric bearings subject to higher displacement than service limits are assumed to slide with 40% friction at the base.	
2	Pot Bearings will be designed to be connected to the base masonry plate by a weld connection designed to fail below 40% vertical bearing dead load.	
3	"No seismic restraint" means seismic strategy does not depend on restrained behavior. Fail-Safe restraints beyond seismic movements may /will be provided.	
4	Sliding with a seismic gaps means the strategy restrains the sliding of the bearings at specific seismic design gap, after which motion is restrained.	
5	"No lateral movement of bearing (beyond service requirements)" means that the seismic gap is zero for bearing types.	
6	Seismic movement = seismic gap if bearing behavior is "Fused, Sliding with a seismic gap."	
7	For fail-safe restraints in the case of "Fused, Sliding with no restraints". Place the restraints beyond range of "Seismic relative movement."	
8	Longitudinal gap between girders and backwall, at abutments to be confirmed by service designer, and expansion joint opening.	Make the gap the same as expansion joint opening
9	Longitudinally, girder impact against backwall/backfill will produce 2000 KN resistance per girder. No restraint when girders move away from the abutment walls.	
10	Free longitudinal girder movements are:102mm towards abutment wall to engage the wall, 565 mm when moving away from the wall.	USE for abutment backwall key location and seatwidth design

kPa = 1000 Pa MPa = 1000 kPa kips = lbf 1000

kN = 1000 newton MN = 1000 kN ksi = 1000 psi

CALTRANS: SEISMIC DESIGN CRITERIA DECEMBER 2001 VERSION 1.2

SUPERSTRUCTURE (BENT CAP) JOINT SHEAR (SECTION 7.4)

INPUT

MATERIAL PROPERTIES

Concrete:

$f'_c = 31$ MPa

Reinforcing Steel:

$f_y := 414$ MPa

STRUCTURE GEOMETRY / DETAILS

Column:

$D_c = 1.83 \cdot m$ — Diameter or cross-sectional dimension of column in the direction of bending

$l_{ac} = 2.0$ m — Length of column reinforcement embedded into the bent cap

$A_{st} = 38\ 1006\ mm^2$ — Total area of column reinforcement anchored in the joint (38 - # 36)

Bent Cap·

$D_s = 2.25$ m — Bent Cap Depth

$B_{cap} = 2.0$ m — Bent Cap Width

$A_{top} := 22\ 2\ 1006\ mm^2$ — Area of Flexural Reinforcement at top of cap (22 - # 36 bundles)

$A_{bot} := 14\ 2\ 1006\ mm^2$ — Area of Flexural Reinforcement at bottom of cap (14 - # 36 bundles)

STRUCTURE FORCES

$P_c = 13468$ kN — The column axial force including the effects of overturning

$P_b := 0 \cdot kN$ — The effective axial force at the center of the joint including prestressing

$T_c := 11698$ kN — Tensile force associated with M_o^{col} (see XSECTION results· Br23col out)

CALCULATIONS

Define A_{jh}: effective horizontal joint area

$$A_{jh} = (D_c + D_s)\, B_{cap} \qquad A_{jh} = 8.160\,\mathrm{m}^2 \qquad (7.16)$$

Define A_{jv}: effective vertical joint area

$$A_{jv} = l_{ac}\, B_{cap} \qquad A_{jv} = 4.00\,\mathrm{m}^2 \qquad (7\ 14)$$

Find f_v: average normal stress in the vertical direction within a moment resiting joint

$$f_v = \frac{P_c}{A_{jh}} \qquad f_v = 1.650\,\mathrm{MPa} \qquad (7.15)$$

Find f_h average normal stress in the horizontal direction within a moment resiting joint

$$f_h = \frac{P_b}{B_{cap}\, D_s} \qquad f_h = 0.000\,\mathrm{MPa} \qquad (7.17)$$

Note Unless the prestressing is specifically designed to provide horizontal joint compression, f_h can typically be ignored without significantly effecting the principal stress calculation.

Find v_{jv}: nominal vertical shear stress in a moment resisting joint

$$v_{jv} = \frac{T_c}{A_{jv}} \qquad v_{jv} = 2.925\,\mathrm{MPa} \qquad (7.13)$$

CALCULATIONS - continued

Principal Compression and Tension Stresses

compression stress: $p_c := \frac{f_h + f_v}{2} + \sqrt{\left(\frac{f_h - f_v}{2}\right)^2 + v_{jv}^2}$ $p_c = 3.864\,\text{MPa}$ (7.12)

allowable compression stress: $0.25 \cdot f'_c = 7.750\,\text{MPa}$ (7.8)

check: $\text{check_1} := \text{if}\left(p_c \le 0.25 \cdot f'_c, \text{"OK"}, \text{"NG"}\right)$ $\text{check_1} = \text{"OK"}$

tension stress: $p_t := \frac{f_h + f_v}{2} - \sqrt{\left(\frac{f_h - f_v}{2}\right)^2 + v_{jv}^2}$ $p_t = -2.213\,\text{MPa}$ (7.11)

Note: A negative value for p_t signifies that the joint has nominal pricipal tensile stresses.

allowable tension stress: $1.0\sqrt{f'_c} \cdot \sqrt{\text{MPa}} = 5.568\,\text{MPa}$ (7.9)

check: $\text{check_2} := \text{if}\left(p_t \le 1.0\sqrt{f'_c} \cdot \sqrt{\text{MPa}}, \text{"OK"}, \text{"NG"}\right)$ $\text{check_2} = \text{"OK"}$

Minimum Joint Shear Reinforcement: Caltrans SDC 7.4.4.2

The volumetric ratio of transverse column reinforcement ρ_s continued into the cap shall not be less than the value specified by the following:

$\rho_{s_min} := \frac{0.29 \cdot \sqrt{f'_c}}{f_y} \cdot \sqrt{\text{MPa}}$ $\rho_{s_min} = 3.900 \times 10^{-3}$ (7.18)

If the principal tension stress, p_t is less than or equal to the following, no additional reinforcement is required.
If the principal tension stress, p_t is greater than the following, the joint reinforcement specified in 7.4.4.3 is required.

$0.29 \cdot \sqrt{f'_c} \cdot \sqrt{\text{MPa}} = 1.615\,\text{MPa}$

$\text{check_3} := \text{if}\left(p_t > 0, \text{"Jt. Shear Reinf. Not Req'd"}, \text{if}\left(p_t \le 0.29 \cdot \sqrt{f'_c} \cdot \sqrt{\text{MPa}}, \text{"Jt. Shear Reinf. Not Req'd"}, \text{"Jt. Shear Reinf. Req'd"}\right)\right)$

$\text{check_3} = \text{"Jt. Shear Reinf. Req'd"}$

CALCULATIONS - continued

Joint Shear Reinforcement: Caltrans SDC 7.4.4.3

A) Vertical Stirrups:

$A_{s_jv} := 0.2 \cdot A_{st}$ $\quad A_{s_jv} = 7646\,mm^2$ (7.19)

Vertical stirrups or ties shall be placed transversely within a distance D_c extending from either side of the column centerline. The vertical stirrup area, A_{jv} is required on each side of the column or pier wall.

B) Horizontal Stirrups:

$A_{s_jh} := 0.1 \cdot A_{st}$ $\quad A_{s_jh} = 3823\,mm^2$ (7.20)

Horizontal stirrups or ties shall be placed transversely around the vertical stirrups or ties in two or more intermediate layers spaced vertically at not more than 18 inches (450 mm). This horizontal reinforcement shall be placed within a distance D_c extending from either side of the column centerline.

C) Horizontal Side Reinforcement:

$A_{s_sf} := \max(0.1 \cdot A_{top}, 0.1 A_{bot})$ $\quad A_{s_sf} = 4426\,mm^2$ (7.21)

Longitudinal side face reinforcement in the bent cap shall be at least equal to the greater of the areas specified above.

D) J-Dowels:

$A_{s_jbar} := 0.08 \cdot A_{st}$ $\quad A_{s_jbar} = 3058\,mm^2$ (7.22)

For bents skewed greater thatn 20°, J-dowels hooked around the longitudinal top deck steel extending alternatively 24 inches (600 mm) and 30 inches (750 mm) into the bent cap are required.

E) Transverse Reinforcement:

$\rho_s := 0.4 \cdot \frac{A_{st}}{l_{ac}^2}$ $\quad \rho_s = 3.823 \times 10^{-3}$ (7.23)

Transverse reinforcement in the joint region shall consist of hoops.

F) Main Column Reinforcemnt:

The main column reinforcement shall extend into the cap as deep as possible to fully develop the compression strut mechanism in the joint.

kPa = 1000 Pa MPa = 1000 kPa kips = lbf 1000

kN = 1000 newton MN = 1000 kN ksi = 1000 psi

CALTRANS: SEISMIC DESIGN CRITERIA DECEMBER 2001 VERSION 1.2

SUPERSTRUCTURE (BENT CAP) JOINT SHEAR (SECTION 7.4)

INPUT

MATERIAL PROPERTIES

Concrete:

$f'_c = 31$ MPa

Reinforcing Steel:

$f_y = 414$ MPa

STRUCTURE GEOMETRY / DETAILS

Column

$D_c = 1.83$ m — Diameter or cross-sectional dimension of column in the direction of bending

$l_{ac} = 2.0$ m — Length of column reinforcement embedded into the bent cap

$A_{st} = 28\ 1006\ \text{mm}^2$ — Total area of column reinforcement anchored in the joint (28 - # 36)

Bent Cap:

$D_s = 2.25$ m — Bent Cap Depth

$B_{cap} = 2.0$ m — Bent Cap Width

$A_{top} := 22\ 2\ 1006\ \text{mm}^2$ — Area of Flexural Reinforcement at top of cap (22 - # 36 bundles)

$A_{bot} = 14\ 2\ 1006\ \text{mm}^2$ — Area of Flexural Reinforcement at bottom of cap (14 - # 36 bundles)

STRUCTURE FORCES

$P_c = 13468$ kN — The column axial force including the effects of overturning

$P_b = 0$ kN — The effective axial force at the center of the joint including prestressing

$T_c = 11698$ kN — Tensile force associated with M_o^{col} (see XSECTION results: Br23col.out)

CALCULATIONS

Define A_{jh}: effective horizontal joint area

$$A_{jh} := (D_c + D_s) \cdot B_{cap} \qquad A_{jh} = 8.160\,\mathrm{m}^2 \qquad (7\ 16)$$

Define A_{jv} effective vertical joint area

$$A_{jv} := l_{ac}\, B_{cap} \qquad A_{jv} = 4.00\,\mathrm{m}^2 \qquad (7.14)$$

Find f_v: average normal stress in the vertical direction within a moment resiting joint

$$f_v = \frac{P_c}{A_{jh}} \qquad f_v = 1.650\,\mathrm{MPa} \qquad (7.15)$$

Find f_h: average normal stress in the horizontal direction within a moment resiting joint

$$f_h := \frac{P_b}{B_{cap}\, D_s} \qquad f_h = 0.000\,\mathrm{MPa} \qquad (7.17)$$

Note: Unless the prestressing is specifically designed to provide horizontal joint compression, f_h can typically be ignored without significantly effecting the principal stress calculation.

Find v_{jv} nominal vertical shear stress in a moment resisting joint

$$v_{jv} = \frac{T_c}{A_{jv}} \qquad v_{jv} = 2\ 925\,\mathrm{MPa} \qquad (7.13)$$

CALCULATIONS - continued

Principal Compression and Tension Stresses

compression stress: $p_c := \frac{f_h + f_v}{2} + \sqrt{\left(\frac{f_h - f_v}{2}\right)^2 + v_{jv}^2}$ $p_c = 3.864\,\text{MPa}$ (7.12)

allowable compression stress: $0.25 \cdot f'_c = 7.750\,\text{MPa}$ (7.8)

check: $\text{check_1} := \text{if}\left(p_c \le 0.25 \cdot f'_c, \text{"OK"}, \text{"NG"}\right)$ $\text{check_1} = \text{"OK"}$

tension stress: $p_t := \frac{f_h + f_v}{2} - \sqrt{\left(\frac{f_h - f_v}{2}\right)^2 + v_{jv}^2}$ $p_t = -2.213\,\text{MPa}$ (7.11)

Note: A negative value for p_t signifies that the joint has nominal pricipal tensile stresses.

allowable tension stress: $1.0\sqrt{f'_c} \cdot \sqrt{\text{MPa}} = 5.568\,\text{MPa}$ (7.9)

check: $\text{check_2} := \text{if}\left(p_t \le 1.0\sqrt{f'_c} \cdot \sqrt{\text{MPa}}, \text{"OK"}, \text{"NG"}\right)$ $\text{check_2} = \text{"OK"}$

Minimum Joint Shear Reinforcement: Caltrans SDC 7.4.4.2

The volumetric ratio of transverse column reinforcement ρ_s continued into the cap shall not be less than the value specified by the following:

$\rho_{s_min} := \frac{0.29 \cdot \sqrt{f'_c}}{f_y} \cdot \sqrt{\text{MPa}}$ $\rho_{s_min} = 3.900 \times 10^{-3}$ (7.18)

If the principal tension stress, p_t is less than or equal to the following, no additional reinforcement is required.
If the principal tension stress, p_t is greater than the following, the joint reinforcement specified in 7.4.4.3 is required.

$0.29 \cdot \sqrt{f'_c} \cdot \sqrt{\text{MPa}} = 1.615\,\text{MPa}$

$\text{check_3} := \text{if}\left(p_t > 0, \text{"Jt. Shear Reinf. Not Req'd"}, \text{if}\left(p_t \le 0.29 \cdot \sqrt{f'_c} \cdot \sqrt{\text{MPa}}, \text{"Jt. Shear Reinf. Not Req'd"}, \text{"Jt. Shear Reinf. Req'd"}\right)\right)$

$\text{check_3} = \text{"Jt. Shear Reinf. Req'd"}$

CALCULATIONS - continued

Joint Shear Reinforcement: Caltrans SDC 7.4.4.3

A) Vertical Stirrups:

$A_{s_jv} := 0.2 \cdot A_{st}$ $\quad A_{s_jv} = 5634\,mm^2$ (7.19)

Vertical stirrups or ties shall be placed transversely within a distance D_c extending from either side of the column centerline. The vertical stirrup area, A_{jv} is required on each side of the column or pier wall.

B) Horizontal Stirrups:

$A_{s_jh} := 0.1 \cdot A_{st}$ $\quad A_{s_jh} = 2817\,mm^2$ (7.20)

Horizontal stirrups or ties shall be placed transversely around the vertical stirrups or ties in two or more intermediate layers spaced vertically at not more than 18 inches (450 mm). This horizontal reinforcement shall be placed within a distance D_c extending from either side of the column centerline.

C) Horizontal Side Reinforcement:

$A_{s_sf} := \max(0.1 \cdot A_{top}, 0.1 A_{bot})$ $\quad A_{s_sf} = 4426\,mm^2$ (7.21)

Longitudinal side face reinforcement in the bent cap shall be at least equal to the greater of the areas specified above.

D) J-Dowels:

$A_{s_jbar} := 0.08 \cdot A_{st}$ $\quad A_{s_jbar} = 2253\,mm^2$ (7.22)

For bents skewed greater thatn 20°, J-dowels hooked around the longitudinal top deck steel extending alternatively 24 inches (600 mm) and 30 inches (750 mm) into the bent cap are required.

E) Transverse Reinforcement:

$\rho_s := 0.4 \cdot \frac{A_{st}}{l_{ac}^2}$ $\quad \rho_s = 2.817 \times 10^{-3}$ (7.23)

Transverse reinforcement in the joint region shall consist of hoops.

F) Main Column Reinforcemnt:

The main column reinforcement shall extend into the cap as deep as possible to fully develop the compression strut mechanism in the joint.

Ind Chk

PARSONS BRINCKERHOFF COMPUTATION SHEET

Page ____ of ____ 45

Made by SAW

Date 12/17/01

Checked by

Date

Subject LEGACY PARKWAY – BRIDGE 23
ABUTMENT 1

REACTION @ ABUTMENT 1 FROM COMPUTER PROGRAM BSDI

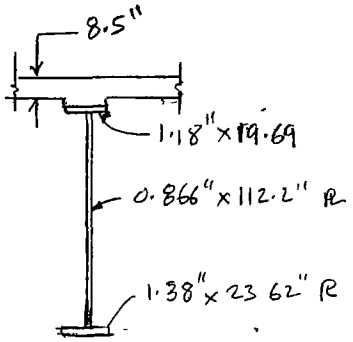
W/O IMPACT = 50/(188+125) = 0.17

GIRDER NO.	LL+I (tension)	LL	DL
1	106k (35k)	91k	33 + 71 + 35 = 139k
2	92k (20)	79k	36 + 76 + 30 = 142k
3	86k (15)	74k	37 + 79 + 18 = 134k
4	92k (15)	79k	38 + 81 + 32 = 151k
8	104k (25)	89k	37 + 81 + 40 = 158k
	480k (110k)	412k	724k

INDEPENDENT CHECK OF DL REACTION

Roadway Width @ Abut 1 = 54.42' (16586 mm)

Assume for Span 1 all five girders have same properties as middle girder 'G3' (Member 109 to Member 121), Span = 55 870 mm = 183.3



Area of Steel Sections near Abut. 1

$A = .866 \times 112.2 + 1.18 \times 19.69 + 1.38 \times 23.62 = 153.0 \text{ in}^2$ (97.2, 23.2, 32.6)

$Wt = 490 \frac{lb}{ft^3} \left(\frac{153.0 \text{ in}^2}{144 \text{ in}^2/ft^2}\right) = 521 \text{ lb/ft}$ per girder

10% for Connections = 52

573 lb/ft

CONC. DECK = $.150 \frac{k}{ft^3} (54.42' \times 8.5/12) = 5.8$ k/ft

CONC PAD ON GIRDERS = $5(.150 \frac{k}{ft^3})(\frac{19.69}{12})(0.33) = 0.4$ k/ft

DECK OVERLAY = $.025 \frac{k}{ft^2}(54.42 - 3.24) = 1.3$ k/ft

7.5

SUPERSTRUCTURE:

concrete deck + conc pad on girders = 7.5 k/'

5 Girders = 5 (0.573) = 2.9 k/'

2 Barriers + Fence = 0.63 + 0.63 + 0.05 = 1.3 k/'

11.7 k/'

2" FUTURE SURFACING NOT INCLUDED PER CRITERIA

Reactions: Ref: AISC Moment Shears & Reactions for Cont. Highway Bridges

No. Ratio of Span = $\frac{79800}{55000}$ = 1.45 Between Table 3.4 & 3.5

Reaction = $\left(\frac{.349 + .332}{2}\right) wl = 0.34\, wl = 0.34\,(11.7)\,(183.3) = 729^k$

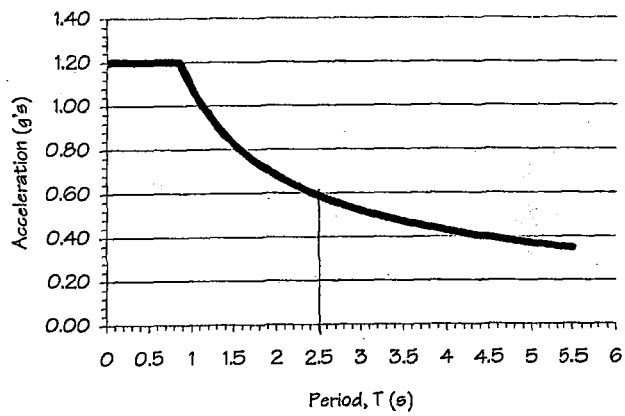
Checks

ACCELERATION RESPONSE SPECTRUM:

A = 0.6
S = 1.5

f (s^{-1})	T (s)	Accel. (g^{ts})	Accel. (Absolute)
100.00	0.01	1.200	11.772
2.00	0.50	1.200	11.772
1.25	0.80	1.200	11.772
1.23	0.81	1.200	11.772
1.22	0.82	1.200	11.772
1.20	0.83	1.200	11.772
1.19	0.84	1.200	11.772
1.18	0.85	1.200	11.772
1.16	0.86	1.194	11.716
1.15	0.87	1.185	11.626
1.14	0.88	1.176	11.537
1.12	0.89	1.167	11.451
1.11	0.90	1.159	11.366
1.00	1.00	1.080	10.595
0.91	1.10	1.014	9.943
0.83	1.20	0.956	9.382
0.77	1.30	0.907	8.895
0.71	1.40	0.863	8.466
0.67	1.50	0.824	8.085
0.63	1.60	0.789	7.745
0.59	1.70	0.758	7.438
0.56	1.80	0.730	7.160
0.53	1.90	0.704	6.906
0.50	2.00	0.680	6.674
0.48	2.10	0.659	6.461
0.45	2.20	0.638	6.263
0.43	2.30	0.620	6.080
0.42	2.40	0.602	5.910
0.40	2.50	0.586	5.752
0.38	2.60	0.571	5.603
0.37	2.70	0.557	5.464
0.36	2.80	0.544	5.333
0.34	2.90	0.531	5.210
0.33	3.00	0.519	5.093
0.31	3.25	0.492	4.829
0.29	3.50	0.468	4.596
0.27	3.75	0.447	4.389
0.25	4.00	0.429	4.204
0.24	4.25	0.412	4.038
0.22	4.50	0.396	3.887
0.21	4.75	0.382	3.749
0.20	5.00	0.369	3.623
0.19	5.25	0.358	3.507
0.18	5.50	0.347	3.400

$$(Acc.)_m = 1.2*A*S/T_m^{2/3}$$



PARSONS BRINCKERHOFF COMPUTATION SHEET

Page ____ of ____ 47

Made by SAW

Date 12/18/01

Checked by

Date

Subject LEGACY PARKWAY – BRIDGE 23
ABUTMENT 1

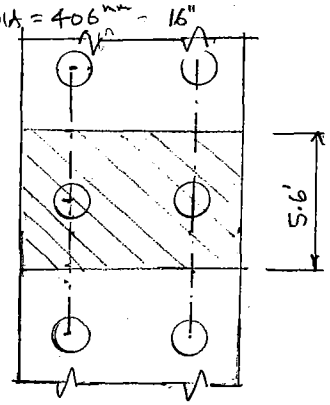
PILE DESIGN :

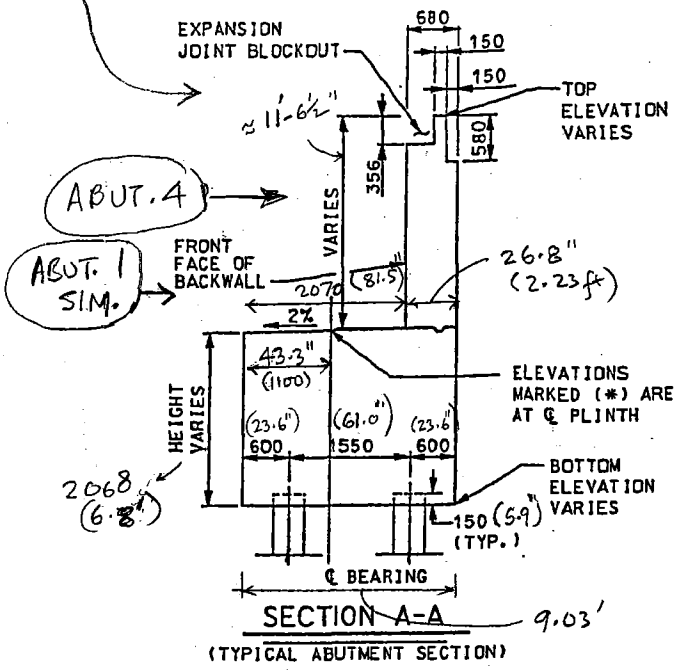
From Bridge 26

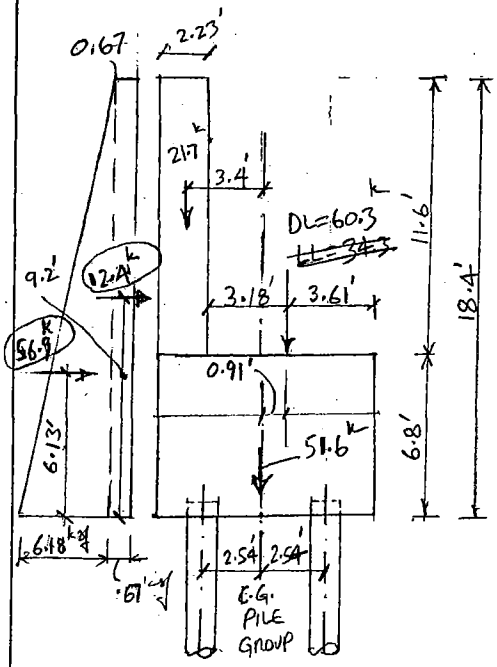
DL, & SOIL LOAD ON 2 PILES

TRLB. LENGTH = 1700 mm = 5.6'

PILE DIA = 406 mm = 16"







Assume :

SOIL EFP = 60 pcf

@ top: $p = (.06)(2)(5.6) = 0.67$

@ bot: $p = (.06)(18.4)(5.6) = 6.18$

WALL STEM

$P = .150(2.23 \times 11.6 \times 5.6) = 21.7^k$

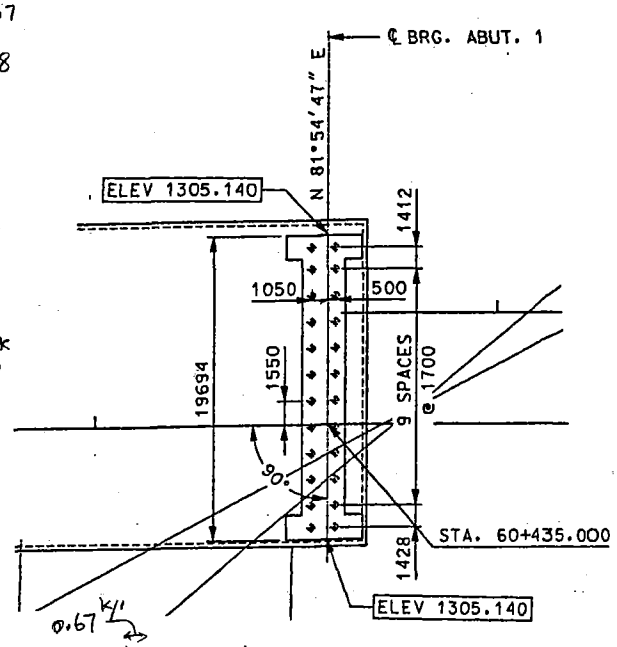
PILE CAP

$P = .150(9.03 \times 6.8 \times 5.6) = 51.6^k$

SUPERSTRUCTURE

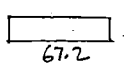
$DL = \frac{724}{24} \times 2 = 60.3^k$

$LL = \frac{412}{24} \times 2 = 34.3^k$

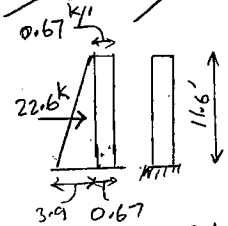


ACTIVE CASE IF $\Delta \geq .005 \times 11.6 \times 12 = 0.70''$.

$I_g = 67.2\frac{(26.7)^3}{12} = 106{,}591$; $I_{eff} = .5 I_g = 53{,}296$



$\Delta = \frac{(.67)(11.6)^4(1728)}{8 \times 3605 \times 53296} + \frac{(22.6)(11.6)^3(1728)}{15 \times 3605 \times 53296} = .04'' << 0.7''$



$P_{bot} = (.06)(11.6)(5.6) = 3.9$

∴ AT REST CASE

Subject LEGACY PARKWAY — BRIDGE 23
ABUTMENT 1

DL+SOIL

$$M_{net} = 12.4^k(9.2') + 56.9^k(6.13) + 60.3(0.91) - 21.7(3.4) = 444^{k\text{-}ft}$$

(114.1, 348.8, 54.9, 73.8)

$$\Sigma V = 60.3 + 51.6 + 21.7 = 134^k$$

$$P = \frac{\Sigma V}{n} + \frac{Md}{\Sigma d^2} \qquad \Sigma d^2 = 2(2.54)^2 = 12.9$$

$$P_{front} = \frac{134}{2} + \frac{444(2.54)}{12.9} = 154^k \text{ (compression) per pile}$$

(67, 87)

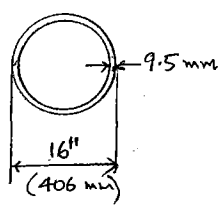
$$P_{back} = 67 - 87 = -20^k \text{ (tension) per pile}$$

L PILE PARAMETERS

Assume: 1) Allowable Lateral Soil Bearing = 6000 psf
2) Pin condition @ top use BC Type 1

DL + SEISMIC CASE

Pile Properties



$$A = \pi \frac{(406^2 - 387^2)}{4} = 11834 \text{ mm}^2 = .01183$$

$$I = \frac{\pi (406^4 - 387^4)}{64 \ (1000)^4} = .000233 \text{ m}^4$$

$$S = \frac{.000233}{.203} = .00115 \text{ m}^3$$

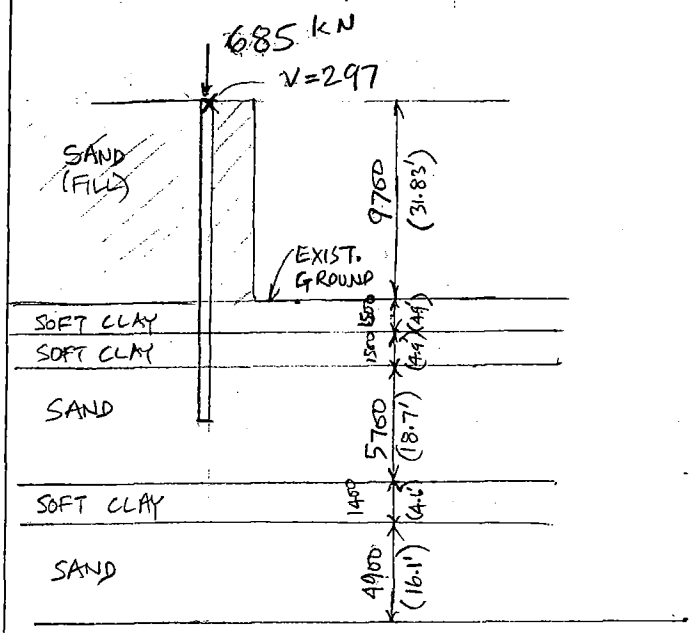
SEISAB : $V_{trans} = 4423$ kN

GTSTRUDL : $V_{trans} = 5700$ kN

$$V_{trans} = \frac{5700}{.8} = 7125 \text{ kN} \qquad R = 0.8 \text{ (AASHTO Table 3.7 DIV IA)}$$

$$V_{trans} \text{ per pile} = \frac{7125}{24} = 297 \text{ kN}$$

DL = 154k = 685 kN



CHECK PILE STRESS (Ref: L Pile Output)

$$\sigma = \frac{685}{.01183} + \frac{530.49 \text{ kN-m}}{.00115 \text{ m}^3}$$

57,904 461,296 M_{max}

$$= 519,200 \ \frac{kN}{m^2}$$

L-Pile : σ = Total Stress = 404,000 $\frac{kN}{m^2}$

F_y = 448,000 $\frac{kN}{m^2}$ (65 ksi)

$1.5F_y$ = 672,000 $\frac{kN}{m^2}$

$$\sigma = 519,200 \frac{kN}{m^2} < 672,000 \frac{kN}{m^2} \ (1.5F_y)$$

∴ OK

Ramirez, Carlos

From: Cooper, Tom
Sent: Thursday, May 10, 2001 3:22 PM
To: Ramirez, Carlos; Subrizi, Cris D.; Wang, Fuxin; Nugent, Victoria
Subject: FW: Legacy Parkway - Bridge 28 Abutment

Latest on abutment fill soil data.

-----Original Message-----
From: Kancheepuram "K" Gunalan [mailto:kgunalan@dot.state.ut.us]
Sent: Thursday, May 10, 2001 12:40 PM
To: Cooper, Tom
Cc: Cchristensen@kleinfelder.com; millern@kleinfelder.com; Nobari, Farid; Showers, Joseph I.
Subject: RE: Legacy Parkway - Bridge 28 Abutment

Tom: Hi! Since the backfill material will be an A-1-a material compacted to 97% in place, I think you could use 50,000KN/m3 for modulus of subgrade reaction value. You will receive directive from Joe on the distance between the wall and center line of pile shortly. You could probabl;y rely on about 50% of soil stiffness when pile moves toward the wall. I will confirm with wall supplier. We have not done anything at the south end yet. Will let you know as soon as we have the LPILE data for Br. 5. Thanks.

$50000 \frac{kN}{m^3} \times \frac{(1m)^3}{(3.281ft)^3} \times \frac{1\ kip}{4.4482\ kN}$

=

Unit!

$22.31 \frac{kN}{m^3} \times \frac{1}{(3.281)^3} \times \frac{1}{4.4482}$

$= .142 \frac{k}{ft^3}$ too high for L-Pile

Max = $21.99 \frac{kN}{m^3}$

$21.99 \frac{kN}{m^3} \times \frac{1}{(3.281)^3} \times \frac{1}{4.4482} = .140 \frac{k}{ft^3}$

Use

within 1.5%

>>> "Cooper, Tom" <Cooper@pbworld.com> 05/09/01 04:44PM >>>
Guna,
Thanks for this information. there is some more information that we need for
the abutment analysis:
Is there a modulus of subgrade reaction value available for this material?
We have assumed 32,000kNm/m3 (sand). Please verify this value or provide
another for us to use in the pile design.
I understand that the distance from the cl of the pile to the LOL of the MSE
wall is 3 meters. How much of the soil stiffness can we count on when the
pile is moving toward the MSE wall?
Is soil information (L-pile data) available yet for Bridge 5?

Joe,
Has it been decided to eliminate the piles on the ends of the wingwalls?

Regards,
Tom

*

-----Original Message-----
From: Kancheepuram "K" Gunalan [mailto:kgunalan@dot.state.ut.us <mailto:kgunalan@dot.state.ut.us>]
Sent: Friday, May 04, 2001 1:25 PM
To: Cooper, Tom
Cc: Showers, Joseph I.
Subject: Re: Legacy Parkway - Bridge 28 Abutment

Tom; I am sorry, I sent the backfill info to Takahiko. Asked him to use a
unti weight of 142 pcf, an angle of internal friction of 32 deg. and an active pressure coefficient of 0.3. With regard to down drag, I was under
the impression that the piles will be sleeved with a 18 inch sleeve to take
care of down drag within the embankment. Hope this is what you were looking
for. Thanks.

>>> "Cooper, Tom" <Cooper@pbworld.com> 05/01/01 02:52PM >>>
Taka,
A few questions on the abutment design:

1. Do you have a general layout for the Type A abutment we are to be using
for Bridge 28? Please forward to us if you do.
We
are currently using the layout from the 30% drawings.

2. The DL and LL information you provided to us was per girder. How many
girders does Bridge 28 have?
What is the total DL and LL for the structure?

Guna, could you please address the following questions?
3. Have any decisions been made on how to handle downdrag from the fills on
the project? Do you know what the assumption will be for downdrag loads on
Bridge 28?

4. Do we have soil parameters to use for the engineered fill at the abutments? we need this information to complete the L-pile analysis and determine system stiffness developed by the passive resistance of the soil.

Regards,

Tom

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

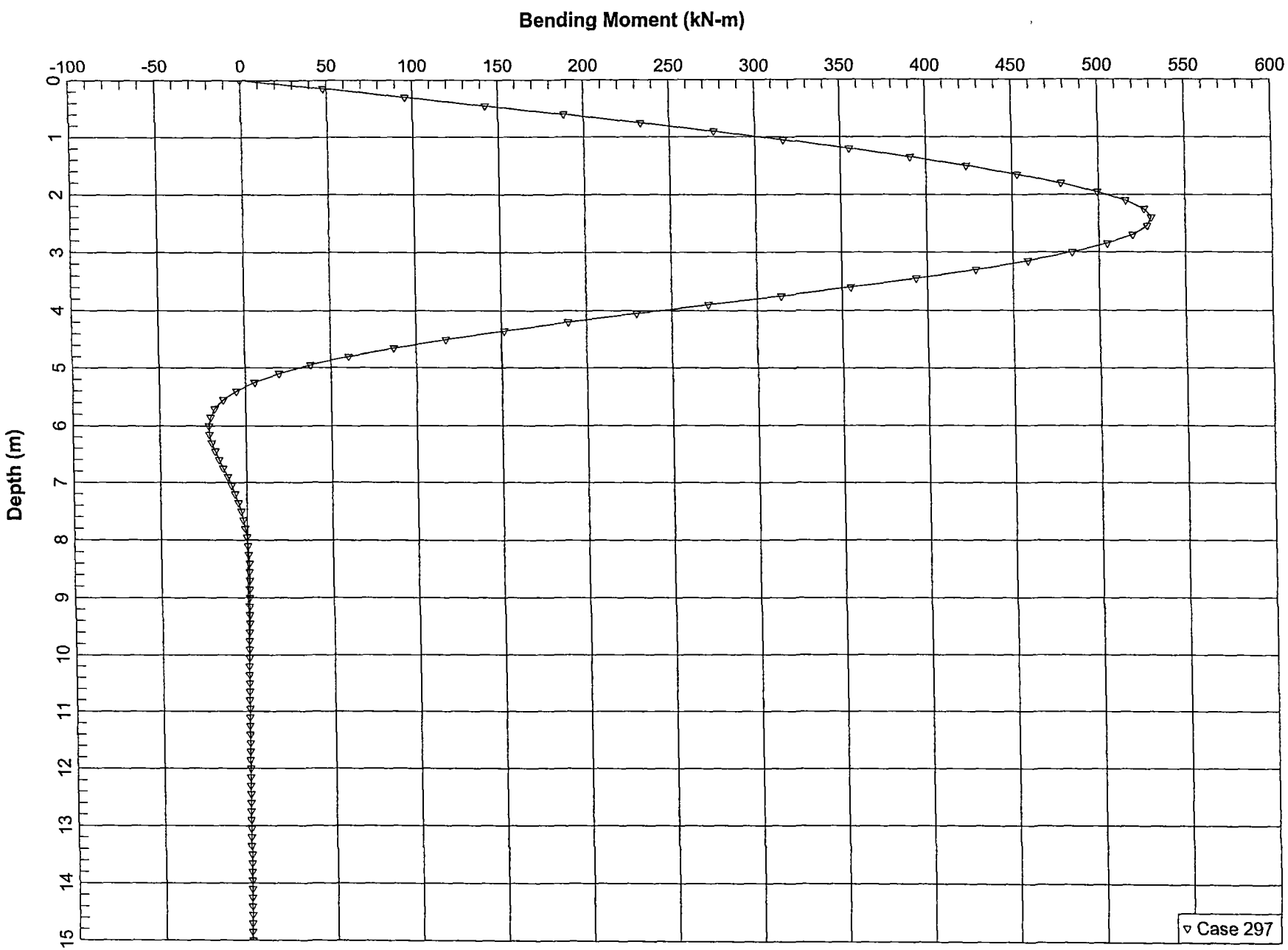
Structure	23
Support(s)	1,2
Water Depth (m)	1.5
Finished Grade Elevation (m)	1295.4
Soil Borings Used for Profile	RB-365; SC-23-290A

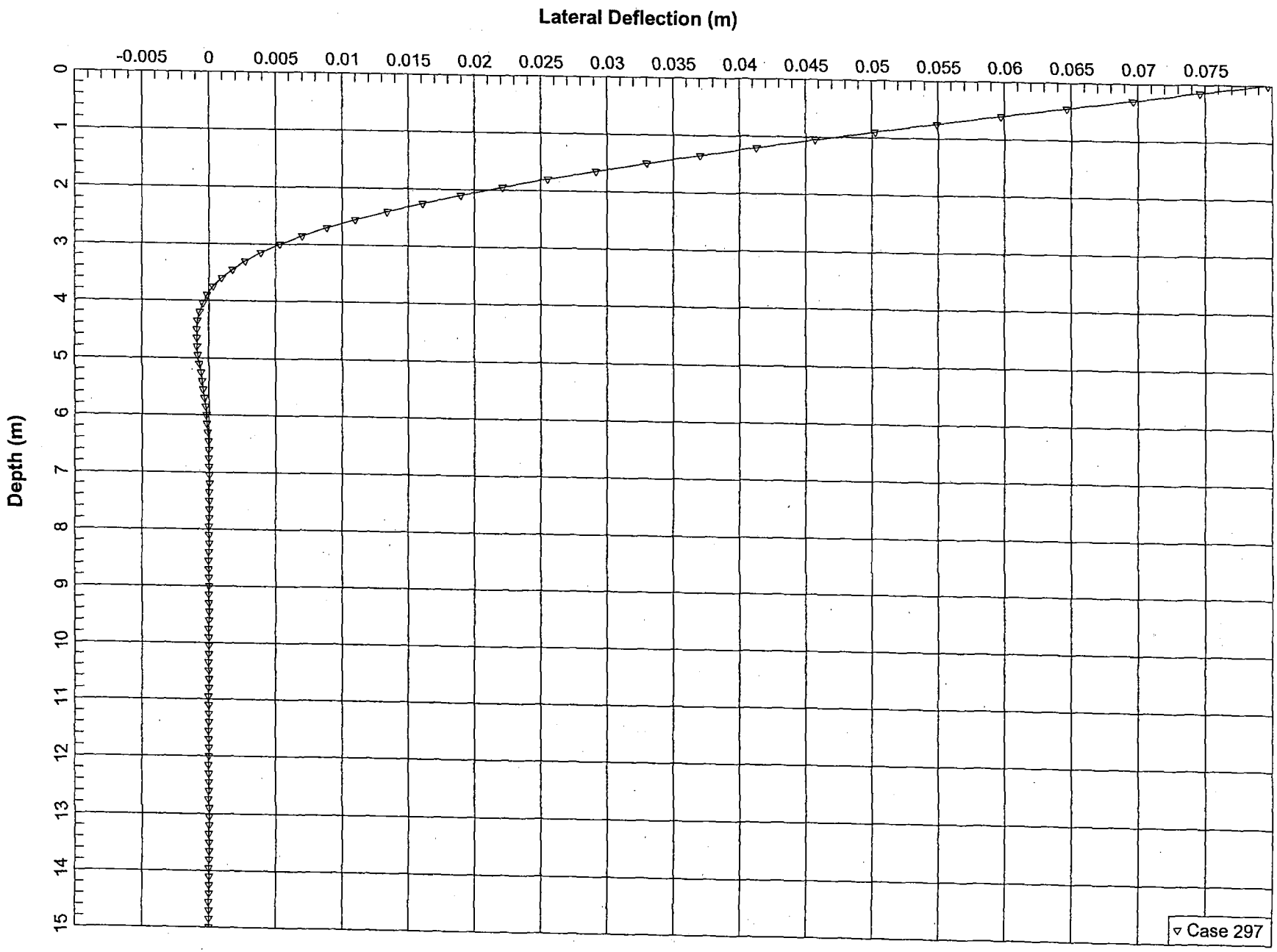
	Initials	Date
Completed By:		
Checked By:		

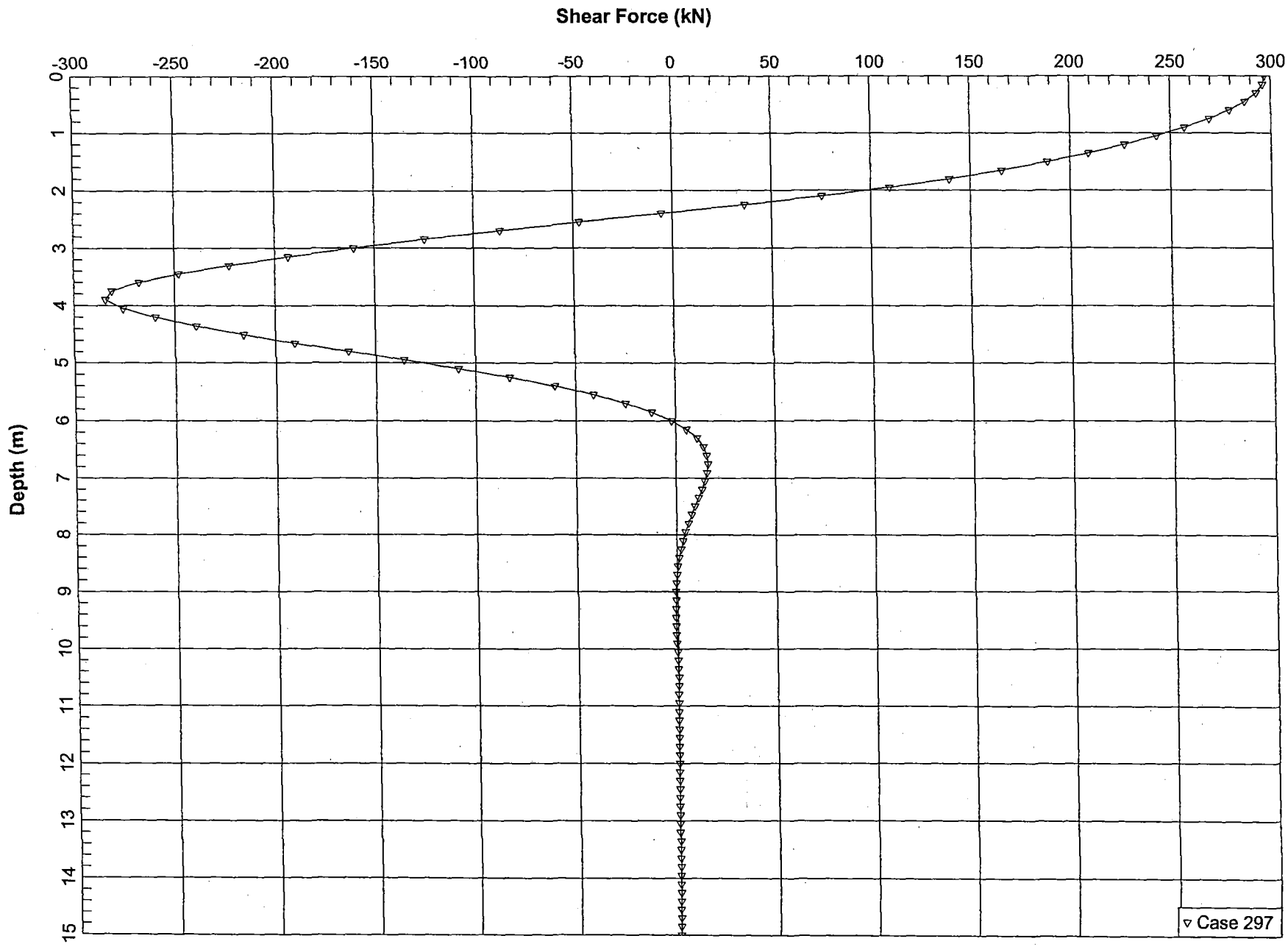
Are these used in input

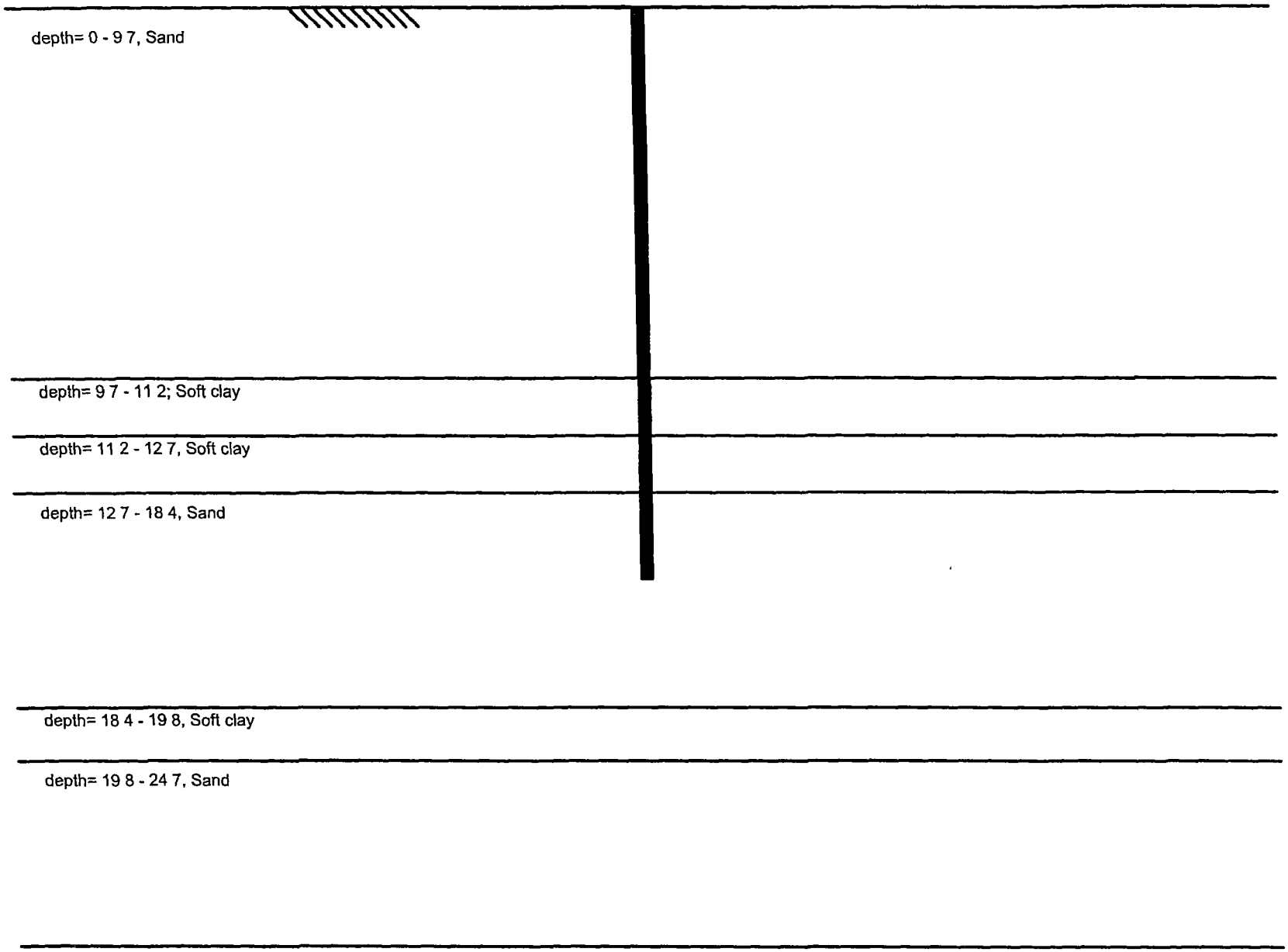
Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
MSE-FILL	Sand			22.31	-	-	50,000	32				
1	Soft Clay	0.0	1.5	18.7	~~80~~ 59	0.020	63,665	-	0	6	0	220
2	Soft Clay	1.5	3.0	8.9	~~80~~ 59	0.020	63,665	-	6	9	250	360
3	Sand	3.0	8.7	10.1	-	-	17,070	35	19	46	4,020	9,610
4	Soft Clay	8.7	10.1	9.9	27	0.020	14,165	-	24	28	1,200	1,370
5	Sand	10.1	15.0	10.5	-	-	22,750	38	58	84	13,120	19,100

LPILE C_{MAX} = 59


Bending Moment (kN-m)
-100
-50
0
50
100
150
200
250
300
350
400
450
500
550
600
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Case 297


Lateral Deflection (m)
-0.005
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
0.04
0.045
0.05
0.055
0.06
0.065
0.07
0.075
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Case 297


Shear Force (kN)
-300
-250
-200
-150
-100
-50
0
50
100
150
200
250
300
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Case 297


depth= 0 - 9 7, Sand
depth= 9 7 - 11 2; Soft clay
depth= 11 2 - 12 7, Soft clay
depth= 12 7 - 18 4, Sand
depth= 18 4 - 19 8, Soft clay
depth= 19 8 - 24 7, Sand

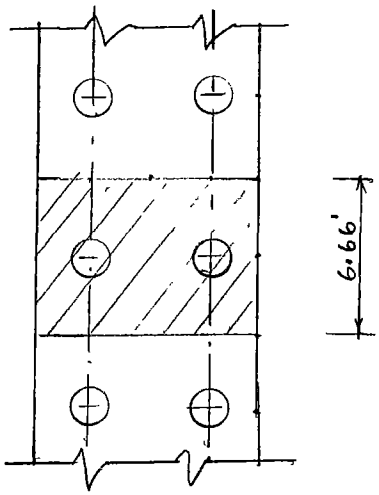
Subject LEGACY PARKWAY - BRIDGE 23
ABUTMENT 4

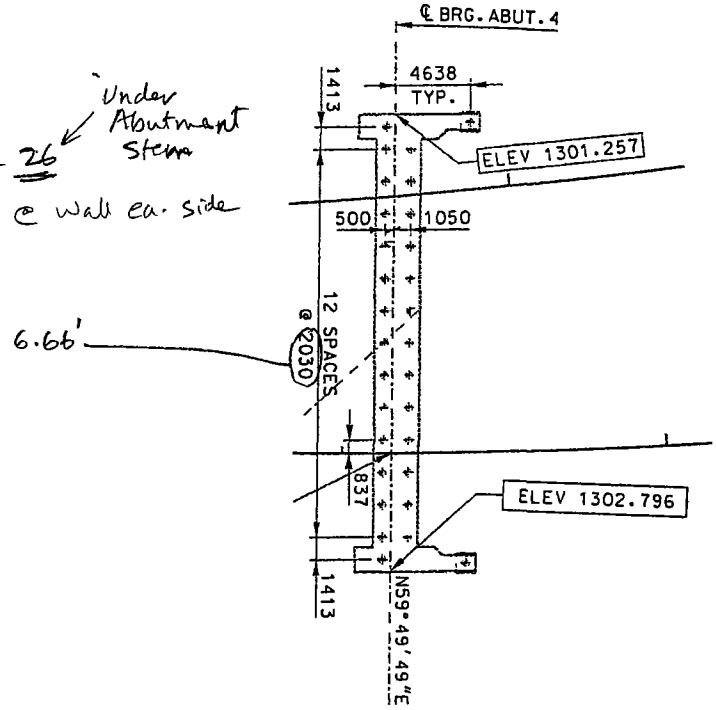
CHECK PILE STRESSES

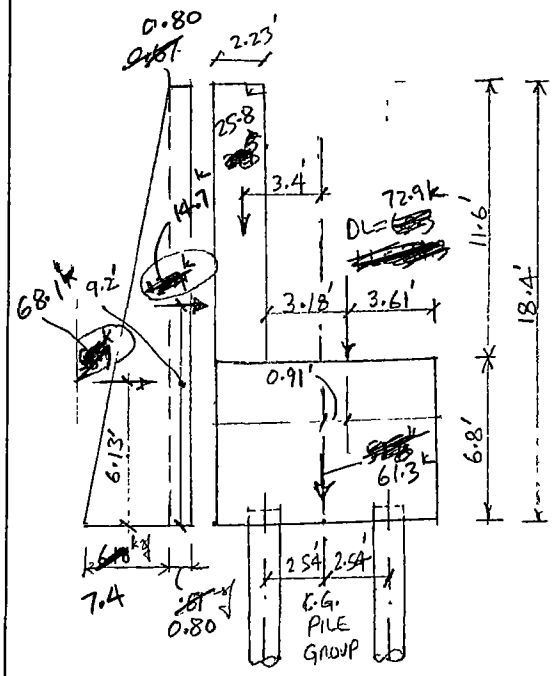
DL + SOIL LOAD ON 2 PILES

TOTAL NUMBER OF PILES = 26 ← Under Abutment Stem

2 @ wall ea. side







DL SUPERSTRUCTURE = 947 kips

DL FOR TRIB = 6.66' = $\frac{947}{26} \times 2 = 72.9^k$

SOIL EFP = 60 PCF ← Assume

@ top: $p = .06 \times 2 \times 6.66 = 0.8$

@ bot: $p = .06 \times 18.4 \times 6.66 = 7.4$

WALL STEM:

$P = .15\,(2.23 \times 11.6 \times 6.66) = 25.8$

PILE CAP

$P = .15\,(9.03 \times 6.8 \times 6.66) = 61.3$

DL + SOIL

$$M_{net} = 14.7\overset{135.2}{(9.2)} + 68.1\overset{417.5}{(6.13)} + 72.9\overset{66.3}{(0.91)} - 25.8\overset{87.7}{(3.4)} = 531.3 \text{ k-ft}$$

$$\Sigma V = 72.9 + 61.3 + 25.8 = \underline{160}^{k}$$

$$P = \Sigma \frac{V}{n} + \frac{M d}{\Sigma d^2} \qquad \Sigma d^2 = 2(2.54)^2 = 12.9$$

$$P = \overset{80}{\frac{160}{2}} + \overset{105}{\frac{531.3(2.54)}{12.9}} = 185^{k} \text{ (compression) per pile or}$$

823 kN

$$P = 80 - 105 = -25^{k} \text{ (tension) per pile}$$

SEISMIC FORCES @ ABUTMENT 4

AASHTO TABLE 3.7
DIVISION IA – SEISMIC DESIGN

SELSAB : $V_{trans} = \underline{4615}^{kN}$, $R = 0.8 \Rightarrow V_{trans} = \frac{4615}{0.8} = 5769^{kN}$

GTSTRUDL : $V_{trans} = \underline{7138}^{kN}$, $R = 0.8 \Rightarrow V_{trans} = \frac{7138}{.8} = 8923^{kN}$

$$V_{trans\ per\ pile} = \frac{8923}{26} = 343^{kN}$$

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	23
Support(s)	3,4
Water Depth (m)	2.1
Finished Grade Elevation (m)	1297.9
Soil Borings Used for Profile	SB-23-290C; SC-23-291

	Initials	Date
Completed By:		
Checked By:		

FOR LPILE 1) C_{MAX} = 59
2)

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
	FILL			21.99			50,000	32				
1	Sand	0.0	2.1	19.9	59	-	13,050	32	0	16	0	2,950
2	Soft Clay	2.1	5.0	9.7	~~60~~	0.020	63,665	-	11	18	640	1,080
3	Silt	5.0	9.8	10.0	40	0.020	33,665	31	21	35	1,700	2,870
4	Soft Clay	9.8	12.6	10.8	24	0.020	9,665	-	25	31	600	760
5	Sand	12.6	15.0	10.9	-	-	32,690	41	88	104	22,220	26,140

Press the "Copy" button to copy this tab to a new spreadsheet. The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies. Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers.

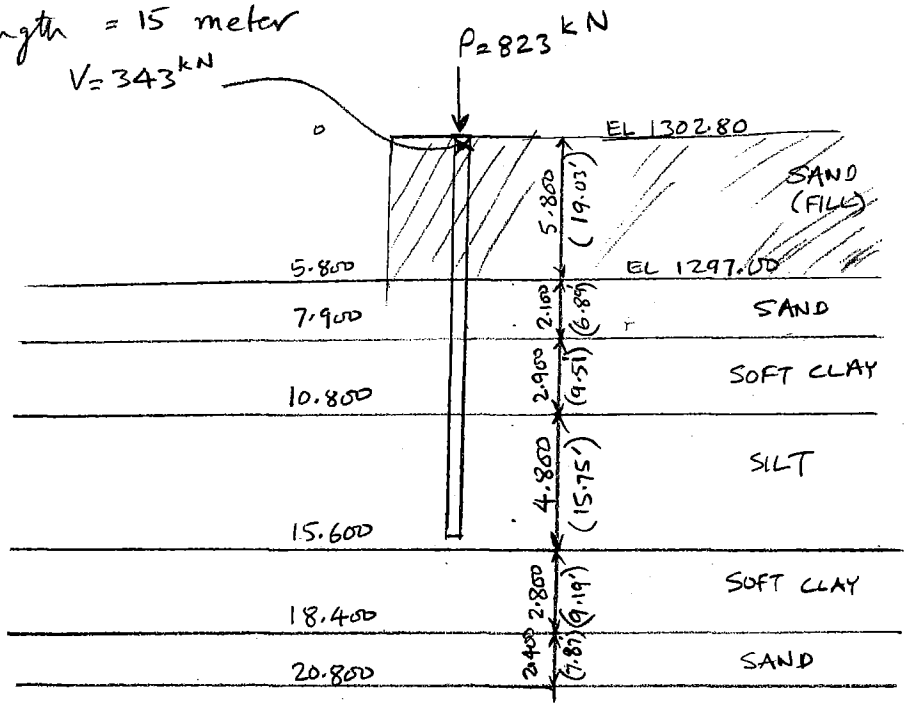
PARSONS BRINCKERHOFF COMPUTATION SHEET

Subject: LEGACY PARKWAY - BRIDGE 23
ABUTMENT 4

Page ____ of ____
Made by: SAW
Date: 1/18/2002
Checked by: ____
Date: ____

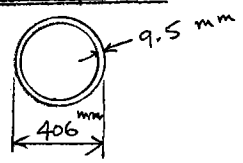
LPILE

Pile Length = 15 meter



Assume: Pin condition @ top use BC Type 1

Pile Properties



$A = 11834 \text{ mm}^2 = .011834 \text{ m}^2$

$I = .000233 \text{ m}^4$

$S = .00115 \text{ m}^3$

$F_y = 448{,}000 \frac{kN}{m^2}$ (65 ksi)

$1.5F_y = 672{,}000 \frac{kN}{m^2}$

LPILE OUTPUT:

$M_{max} = 673 \text{ kN-m}$

$$\sigma = \frac{823}{.01183} + \frac{673 \text{ kN-m}}{.00115} = 654{,}786 \text{ kN/m}^2 < 672{,}000 \frac{kN}{m^2}$$

(823 → 69569; 673 kN-m → 585 217)

∴ OK

Legacy Parkway Bridge 23 - Abutment 4 Independent Check

2	1	0	1	1	0
100	2	0	15	0	
0	0.406	0.000233		0.01183	1.9994815E8
15	0.406	0.000233		0.01183	1.9994815E8
6	12	12	0	0	
4	0	5.8	50000	50000	
4	5.8	7.9	13050	13050	
1	7.9	10.8	0	0	
	10.8	15 6	33665	33665	
:	15.6	18.4	0	0	
4	18.4	20.8	32690	32690	
0	21.99				
5.8	21.99				
5.8	19.9				
7.9	19.9				
7.9	9.7				
10.8	9.7				
10.8	10				
15.6	10				
15.6	10.8				
18.4	10.8				
18.4	10.9				
20.8	10.9				
0	0	32	0	0	
5.8	0	32	0	0	
5.8	0	32	0	0	
7.9	0	32	0	0	
7.9	59	0	0.02	0	
10 8	59	0	0.02	0	
10.8	40	31	0.02	0	
15.6	40	31	0.02	0	
15.6	24	0	0.02	0	
18.4	24	0	0.02	0	
18.4	0	41	0	0	
20.8	0	41	0	0	
0	1	1			
1					
1	343	0	823		
0					
1	1	0			
300	3E-7	3			

LPILE Plus for Windows, Version 4

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

(c) Copyright ENSOFT, Inc., 1985-2000
All Rights Reserved

==========

This program is licensed to:

S. Ali Wahidi
Parsons Brinckerhoff

Name of input data file: C:\Wahidi\sacramento projects\legacy parkway\design\lpile\br23abut4.lpd
Name of output file: C:\Wahidi\sacramento projects\legacy parkway\design\lpile\br23abut4.lpo
Name of plot output file: C:\Wahidi\sacramento projects\legacy parkway\design\lpile\br23abut4.lpp
Name of runtime file: C:\Wahidi\sacramento projects\legacy parkway\design\lpile\br23abut4.lpr

---

Time and Date of Analysis

Date: January 18, 2002 Time: 16:37:13

Problem Title

Legacy Parkway Bridge 23 - Abutment 4 Independent Check

Program Options

Units Used in Computations - SI Units, meters, kilopascals

Basic Program Options:

Analysis Type 1:
- Computation of Lateral Pile Response Using User-specified Constant EI

Computation Options:
- Only internally-generated p-y curves used in analysis
- Analysis does not use p-y multipliers
  (individual pile or shaft action only)
- Analysis assumes no shear resistance at pile tip
- Analysis inludes automatic computation of pile-top deflection vs. pile embedment length
- Analysis includes computation of foundation stiffness matrix elements
- Analysis assumes no soil movements acting on pile
- No additional p-y curves to be computed at user-specified depths

Solution Control Parameters:
- Number of pile increments = 100
- Deflection tolerance for closure = 3.0000E-07 m
- Maximum number of iterations allowed = 300
- Maximum allowable deflection = 3.0000E+00 m

Printing Options:
- Values of pile-head deflection, bending moment, shear force, and
  soil reaction are printed for full length of pile.
- Printing Increment (spacing of output points) = 1

Pile Structural Properties and Geometry

Pile Length = 15.00 m
Depth of ground surface below top of pile = .00 m
Slope angle of ground surface = .00 deg.

Structural properties of pile defined using 2 points

Point	Depth X m	Pile Diameter m	Moment of Inertia m**4	Pile Area Sq. m	Modulus of Elasticity kN/Sq. m
	.000	.406	2.3300E-04	1.1830E-02	1.9995E+08
2	15.000	.406	2.3300E-04	1.1830E-02	1.9995E+08

Soil Layering Information

The soil profile is modelled using 6 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974
Distance from top of pile to top of layer = .000 m
Distance from top of pile to bottom of layer = 5.800 m
p-y subgrade modulus k for top of soil layer = 5.0000E+04 kN/ m**3
p-y subgrade modulus k for bottom of layer = 5.0000E+04 kN/ m**3

Layer 2 is sand, p-y criteria by Reese et al., 1974
Distance from top of pile to top of layer = 5.800 m
Distance from top of pile to bottom of layer = 7.900 m
p-y subgrade modulus k for top of soil layer = 1.3050E+04 kN/ m**3
p-y subgrade modulus k for bottom of layer = 1.3050E+04 kN/ m**3

Layer 3 is soft clay, p-y criteria by Matlock, 1970
Distance from top of pile to top of layer = 7.900 m
Distance from top of pile to bottom of layer = 10.800 m
p-y subgrade modulus k for top of soil layer = 0.0000E+00 kN/ m**3
p-y subgrade modulus k for bottom of layer = 0.0000E+00 kN/ m**3

NOTE: Internal default values for p-y subgrade modulus will be computed for the above soil layer.

Layer 4 is silt with cohesion and friction
Distance from top of pile to top of layer = 10.800 m
Distance from top of pile to bottom of layer = 15.600 m
p-y subgrade modulus k for top of soil layer = 3.3665E+04 kN/ m**3
p-y subgrade modulus k for bottom of layer = 3.3665E+04 kN/ m**3

Layer 5 is soft clay, p-y criteria by Matlock, 1970
Distance from top of pile to top of layer = 15.600 m
Distance from top of pile to bottom of layer = 18.400 m
p-y subgrade modulus k for top of soil layer = 0.0000E+00 kN/ m**3
p-y subgrade modulus k for bottom of layer = 0.0000E+00 kN/ m**3

NOTE: Internal default values for p-y subgrade modulus will be computed for the above soil layer.

Layer 6 is sand, p-y criteria by Reese et al., 1974
Distance from top of pile to top of layer = 18.400 m
Distance from top of pile to bottom of layer = 20.800 m
p-y subgrade modulus k for top of soil layer = 3.2690E+04 kN/ m**3
p-y subgrade modulus k for bottom of layer = 3.2690E+04 kN/ m**3

(Depth of lowest layer extends 5.80 m below pile tip)

Effective Unit Weight of Soil vs. Depth

Distribution of effective unit weight of soil with depth
is defined using 12 points

Point No.	Depth X m	Eff. Unit Weight kN/ m**3
1	.00	21.99000
2	5.80	21.99000
3	5.80	19.90000
4	7.90	19.90000
5	7.90	9.70000
6	10.80	9.70000
7	10.80	10.00000
8	15.60	10.00000
9	15.60	10.80000
10	18.40	10.80000
11	18.40	10.90000
12	20.80	10.90000

Shear Strength of Soils

Distribution of shear strength parameters with depth
defined using 12 points

Point No.	Depth X m	Cohesion c kN/ m**2	Angle of Friction Deg.	E50	RQD %
	.000	.00000	32.00	--	--
2	5.800	.00000	32.00	--	--
3	5.800	.00000	32.00	--	--
4	7.900	.00000	32.00	--	--
5	7.900	59.00000	.00	.02000	.0
6	10.800	59.00000	.00	.02000	.0
7	10.800	40.00000	31.00	.02000	.0

9	19.000	24.00000	.00	.02000	.0
10	18.400	24.00000	.00	.02000	.0
11	18.400	.00000	41.00	--	--
12	20.800	.00000	41.00	--	--

Notes:

(1) Cohesion = uniaxial compressive strength for rock materials.
(2) E50 = k_rm for rock materials.
RQD is input only for rock materials.
Internal default values for E50 will be used if input value = 0.

Static loading criteria was used for computation of p-y curves

---

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load Case Number 1

Pile-head boundary conditions are Shear and Moment (BC Type 1)
Shear force at pile head = 343.000 kN
Bending moment at pile head = .000 m- kN
Axial load at pile head = 823.000 kN

(Zero moment for this load indicates a pinned-head condition)

Computed Values of Load Distribution and Deflection
for Lateral Loading for Load Case Number 1

Pile-head boundary conditions are Shear and Moment (BC Type 1)
Specified shear force at pile head = 343.000 kN
Specified bending moment at pile head = .000 m- kN
Specified axial load at pile head = 823.000 kN

(Zero moment for this load indicates free-head conditions)

Depth m	Deflect. y m	Moment M kN- m	Shear V kN	Slope S Rad.	Total Stress kN/ m**2	Flx. Rig. EI kN- m**2	Soil Res p kN/ m
0.000	.108	-2.01E-10	343.000	-.043787	6.96E+04	4.66E+04	0.000
.150	.102	56.855	342.021	-.043695	1.19E+05	4.66E+04	-13.052
.300	.094987	113.395	338.899	-.043421	1.68E+05	4.66E+04	-28.581
.450	.088502	169.246	333.399	-.042966	2.17E+05	4.66E+04	-44.751
.600	.082098	224.023	325.535	-.042333	2.65E+05	4.66E+04	-60.098
.750	.075802	277.358	315.397	-.041526	3.11E+05	4.66E+04	-75.073
.900	.069640	328.894	303.150	-.040550	3.56E+05	4.66E+04	-88.219
1.050	.063637	378.315	289.065	-.039411	3.99E+05	4.66E+04	-99.583
1.200	.057817	425.345	273.226	-.038117	4.40E+05	4.66E+04	-111.611
1.350	.052202	469.694	255.257	-.036676	4.79E+05	4.66E+04	-127.966
1.500	.046814	510.977	234.818	-.035098	5.15E+05	4.66E+04	-144.556
1.650	.041672	548.805	211.844	-.033392	5.48E+05	4.66E+04	-161.767
1.800	.036796	582.775	185.679	-.031570	5.77E+05	4.66E+04	-187.095
1.950	.032201	612.303	155.599	-.029646	6.03E+05	4.66E+04	-213.977
2.100	.027902	636.774	121.302	-.027635	6.24E+05	4.66E+04	-243.315
2.250	.023911	655.517	82.384	-.025555	6.41E+05	4.66E+04	-275.595
2.400	.020236	667.799	38.475	-.023424	6.51E+05	4.66E+04	-309.861
2.550	.016883	672.843	-10.723	-.021266	6.56E+05	4.66E+04	-346.113
2.700	.013856	669.832	-63.493	-.019105	6.53E+05	4.66E+04	-357.489
2.850	.011152	658.512	-115.527	-.016966	6.43E+05	4.66E+04	-336.293
3.000	.008766	639.363	-164.214	-.014877	6.27E+05	4.66E+04	-312.870
3.150	.006689	612.921	-209.302	-.012861	6.04E+05	4.66E+04	-288.304
3.300	.004908	579.748	-250.457	-.010941	5.75E+05	4.66E+04	-260.420
3.450	.003407	540.485	-286.984	-.009137	5.40E+05	4.66E+04	-226.615
3.600	.002167	495.909	-317.958	-.007469	5.02E+05	4.66E+04	-186.363
3.750	.001166	446.942	-342.288	-.005951	4.59E+05	4.66E+04	-138.043
3.900	3.81E-04	394.692	-358.219	-.004596	4.13E+05	4.66E+04	-74.365
4.050	-2.13E-04	340.611	-360.565	-.003412	3.66E+05	4.66E+04	43.084
4.200	-6.42E-04	287.365	-348.414	-.002401	3.20E+05	4.66E+04	118.921
4.350	-9.33E-04	236.680	-327.535	-.001558	2.76E+05	4.66E+04	159.472
4.500	-.001110	189.489	-301.404	-8.72E-04	2.35E+05	4.66E+04	188.937
4.650	-.001195	146.474	-271.462	-3.31E-04	1.97E+05	4.66E+04	210.292
900	-.001209	108.132	-238.816	7.90E-05	1.64E+05	4.66E+04	224.986
50	-.001171	74.809	-204.394	3.73E-04	1.35E+05	4.66E+04	233.972
.100	-.001097	46.721	-168.995	5.69E-04	1.10E+05	4.66E+04	238.019
5.250	-.001000	23.970	-133.306	6.83E-04	9.05E+04	4.66E+04	237.835
5.400	-8.92E-04	6.561	-97.911	7.32E-04	7.53E+04	4.66E+04	234.107
5.550	-7.81E-04	-5.584	-64.104	7.34E-04	7.44E+04	4.66E+04	216.642
5.700	-6.72E-04	-12.852	-33.492	7.04E-04	8.08E+04	4.66E+04	191.519
5.850	-5.70E-04	-15.805	-15.868	6.58E-04	8.33E+04	4.66E+04	43.477

6.150	-3.88E-04	-18.900	-4.694	5.45E-04	8.60E+04	4.66E+04	31.169
6.300	-3.11E-04	-19.317	-.438	4.83E-04	8.64E+04	4.66E+04	25.587
6.450	-2.43E-04	-19.151	3.018	4.21E-04	8.63E+04	4.66E+04	20.488
6.600	-1.85E-04	-18.516	5.749	3.61E-04	8.57E+04	4.66E+04	15.920
6.750	-1.35E-04	-17.515	7.836	3.03E-04	8.48E+04	4.66E+04	11.911
6.900	-9.41E-05	-16.240	9.364	2.48E-04	8.37E+04	4.66E+04	8.469
7.050	-6.07E-05	-14.767	10.419	1.98E-04	8.24E+04	4.66E+04	5.587
7.200	-3.45E-05	-13.163	11.081	1.53E-04	8.10E+04	4.66E+04	3.245
7.350	-1.47E-05	-11.481	11.430	1.14E-04	7.96E+04	4.66E+04	1.411
500	-4.19E-07	-9.762	11.539	7.95E-05	7.81E+04	4.66E+04	.040981
550	9.16E-06	-8.039	11.474	5.09E-05	7.66E+04	4.66E+04	-.914
..800	1.48E-05	-6.332	11.292	2.78E-05	7.51E+04	4.66E+04	-1.511
7.950	1.75E-05	-4.658	10.409	1.01E-05	7.36E+04	4.66E+04	-10.255
8.100	1.79E-05	-3.212	8.866	-2.61E-06	7.24E+04	4.66E+04	-10.330
8.250	1.67E-05	-1.998	7.333	-1.10E-05	7.13E+04	4.66E+04	-10.100
8.400	1.46E-05	-1.009	5.852	-1.58E-05	7.04E+04	4.66E+04	-9.650
8.550	1.19E-05	-.238	4.451	-1.78E-05	6.98E+04	4.66E+04	-9.033
8.700	9.21E-06	.330	3.152	-1.77E-05	6.99E+04	4.66E+04	-8.283
8.850	6.64E-06	.712	1.974	-1.60E-05	7.02E+04	4.66E+04	-7.426
9.000	4.41E-06	.926	.931	-1.34E-05	7.04E+04	4.66E+04	-6.478
9.150	2.62E-06	.995	.036785	-1.03E-05	7.04E+04	4.66E+04	-5.449
9.300	1.32E-06	.940	-.697	-7.18E-06	7.04E+04	4.66E+04	-4.333
9.450	4.69E-07	.787	-1.252	-4.39E-06	7.03E+04	4.66E+04	-3.070
9.600	4.56E-11	.565	-1.493	-2.22E-06	7.01E+04	4.66E+04	-.143
9.750	-1.96E-07	.340	-1.332	-7.59E-07	6.99E+04	4.66E+04	2.295
9.900	-2.28E-07	.166	-.979	5.64E-08	6.97E+04	4.66E+04	2.412
10.050	-1.79E-07	.046491	-.631	3.99E-07	6.96E+04	4.66E+04	2.227
10.200	-1.08E-07	-.023110	-.323	4.36E-07	6.96E+04	4.66E+04	1.881
10.350	-4.80E-08	-.050371	-.073678	3.18E-07	6.96E+04	4.66E+04	1.436
10.500	-1.25E-08	-.045292	.103	1.64E-07	6.96E+04	4.66E+04	.917
10.650	1.20E-09	-.019567	.140	5.97E-08	6.96E+04	4.66E+04	-.419
10.800	5.43E-09	-.003263	.056645	2.29E-08	6.96E+04	4.66E+04	-.694
10.950	8.08E-09	-.002579	.004351	1.35E-08	6.96E+04	4.66E+04	-.002979
11.100	9.49E-09	-.001961	.003861	6.22E-09	6.96E+04	4.66E+04	-.003545
11.250	9.95E-09	-.001422	.003313	7.74E-10	6.96E+04	4.66E+04	-.003767
11.400	9.72E-09	-9.67E-04	.002750	-3.07E-09	6.96E+04	4.66E+04	-.003730
11.550	9.03E-09	-5.96E-04	.002208	-5.59E-09	6.96E+04	4.66E+04	-.003509
11.700	8.04E-09	-3.04E-04	.001707	-7.04E-09	6.96E+04	4.66E+04	-.003168
11.850	6.91E-09	-8.23E-05	.001262	-7.66E-09	6.96E+04	4.66E+04	-.002758
12.000	5.75E-09	7.70E-05	8.81E-04	-7.67E-09	6.96E+04	4.66E+04	-.002321
12.150	4.61E-09	1.84E-04	5.66E-04	-7.25E-09	6.96E+04	4.66E+04	-.001887
12.300	3.57E-09	2.49E-04	3.13E-04	-6.55E-09	6.96E+04	4.66E+04	-.001479
12.450	2.65E-09	2.80E-04	1.19E-04	-5.70E-09	6.96E+04	4.66E+04	-.001110
12.600	1.86E-09	2.86E-04	-2.34E-05	-4.79E-09	6.96E+04	4.66E+04	-7.90E-04
12.750	1.21E-09	2.74E-04	-1.22E-04	-3.89E-09	6.96E+04	4.66E+04	-5.20E-04
900	6.95E-10	2.50E-04	-1.83E-04	-3.05E-09	6.96E+04	4.66E+04	-3.02E-04
950	2.98E-10	2.20E-04	-2.16E-04	-2.29E-09	6.96E+04	4.66E+04	-1.31E-04
13.200	7.69E-12	1.86E-04	-2.26E-04	-1.64E-09	6.96E+04	4.66E+04	-3.42E-06
13.350	-1.93E-10	1.52E-04	-2.20E-04	-1.09E-09	6.96E+04	4.66E+04	8.67E-05
13.500	-3.20E-10	1.20E-04	-2.02E-04	-6.54E-10	6.96E+04	4.66E+04	1.46E-04
13.650	-3.89E-10	9.17E-05	-1.78E-04	-3.13E-10	6.96E+04	4.66E+04	1.79E-04
13.800	-4.14E-10	6.71E-05	-1.50E-04	-5.72E-11	6.96E+04	4.66E+04	1.92E-04
13.950	-4.06E-10	4.67E-05	-1.21E-04	1.26E-10	6.96E+04	4.66E+04	1.91E-04
14.100	-3.76E-10	3.07E-05	-9.36E-05	2.51E-10	6.96E+04	4.66E+04	1.79E-04
14.250	-3.31E-10	1.86E-05	-6.82E-05	3.30E-10	6.96E+04	4.66E+04	1.59E-04
14.400	-2.77E-10	1.01E-05	-4.62E-05	3.76E-10	6.96E+04	4.66E+04	1.34E-04
14.550	-2.18E-10	4.63E-06	-2.81E-05	4.00E-10	6.96E+04	4.66E+04	1.07E-04
14.700	-1.57E-10	1.56E-06	-1.43E-05	4.10E-10	6.96E+04	4.66E+04	7.79E-05
14.850	-9.55E-11	2.42E-07	-4.85E-06	4.13E-10	6.96E+04	4.66E+04	4.78E-05
15.000	-3.36E-11	0.000	0.000	4.13E-10	6.96E+04	4.66E+04	1.70E-05

Output Verification:

Computed forces and moments are within specified convergence limits.

Output Summary for Load Case No. 1:

Pile-head deflection	=	.1081	m
Computed slope at pile head	=	-4.3787E-02	
Maximum bending moment	=	672.843	kN- m
Maximum shear force	=	-360.565	kN
Depth of maximum bending moment	=	2.550	m
Depth of maximum shear force	=	4.050	m
Number of iterations	=	26	
Number of zero deflection points	=	6	

-- ----------

Summary of Pile-head Response

Definition of symbols for pile-head boundary conditions:

y = pile-head displacment, m

V = pile-head shear force, kN
S = pile-head slope, radians
R = rotational stiffness of pile-head, m- kN/rad

BC Type	Boundary Condition 1	Boundary Condition 2	Axial Load kN	Pile Head Deflection m	Maximum Moment m- kN	Maximum Shear kN
	V= 3.430E+02	M= 0.000E+00	823.000	.108	672.843	-360.565

Computed Pile-head Stiffness Matrix
K22, K23, K32, K33 for superstructure

Lateral Load kN	K22 kN/ m	K23 kN/Rad	Bending Moment m- kN	K32 m- kN/ m	K33 m- kN/Rad
3.43000E+01	5.05902E+04	4.76582E+04	1.00000E+01	4.65566E+04	7.03197E+04
1.03253E+02	2.82285E+04	4.75328E+04	3.01030E+01	3.24747E+04	7.02003E+04
1.63653E+02	2.23594E+04	4.66642E+04	4.77121E+01	2.82623E+04	6.93399E+04
2.06507E+02	2.01342E+04	4.59715E+04	6.02060E+01	2.65435E+04	6.86674E+04
2.39747E+02	1.89643E+04	4.53770E+04	6.98970E+01	2.55966E+04	6.81066E+04
2.66906E+02	1.82340E+04	4.47792E+04	7.78151E+01	2.49852E+04	6.75721E+04
2.89869E+02	1.77129E+04	4.43245E+04	8.45098E+01	2.45491E+04	6.71609E+04
3.09760E+02	1.72616E+04	4.38471E+04	9.03090E+01	2.41879E+04	6.67560E+04
3.27305E+02	1.68642E+04	4.34531E+04	9.54243E+01	2.38726E+04	6.64186E+04
3.43000E+02	1.65102E+04	4.30458E+04	1.00000E+02	2.35920E+04	6.60847E+04

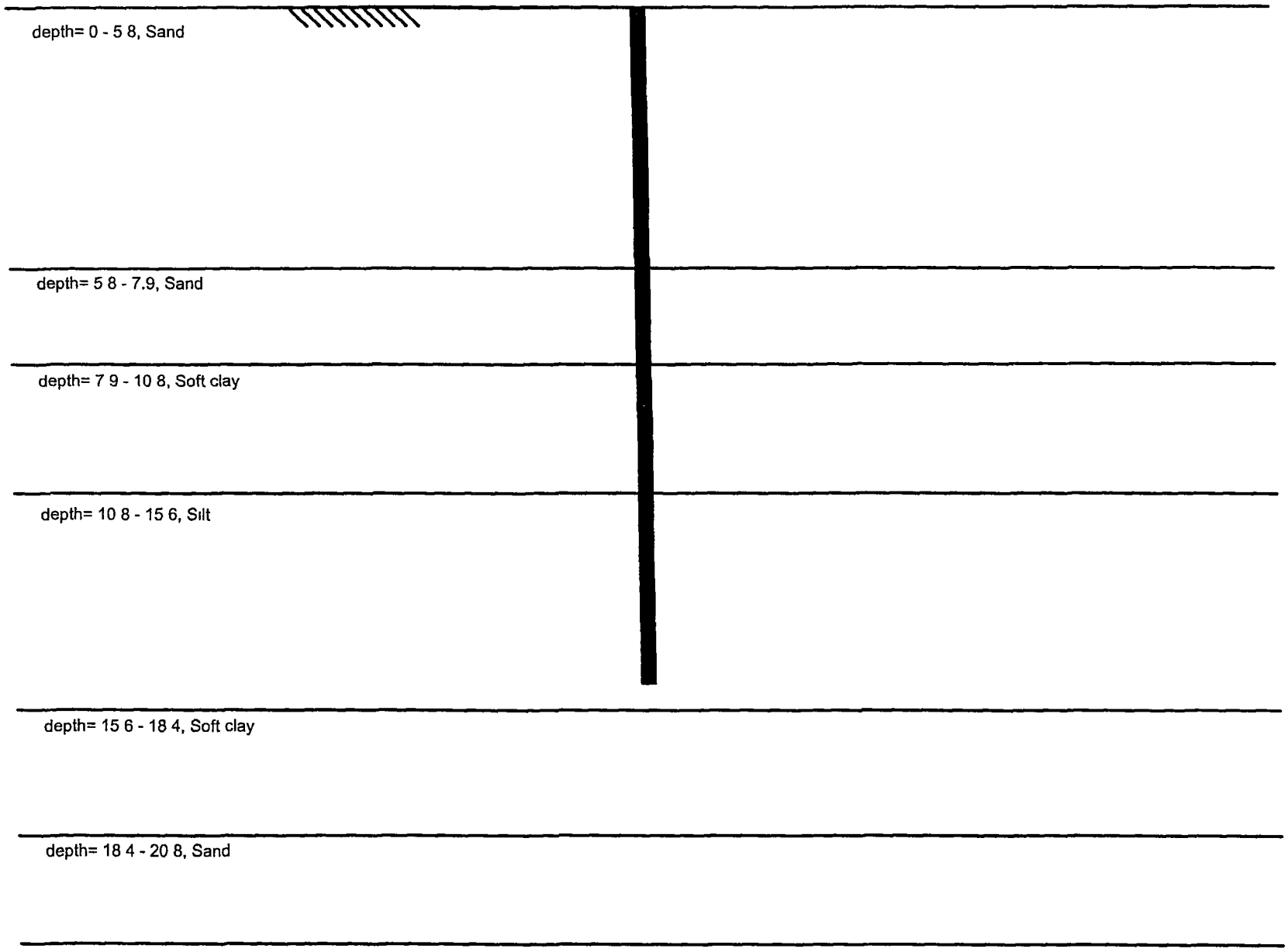
Pile-head Deflection vs. Pile Length

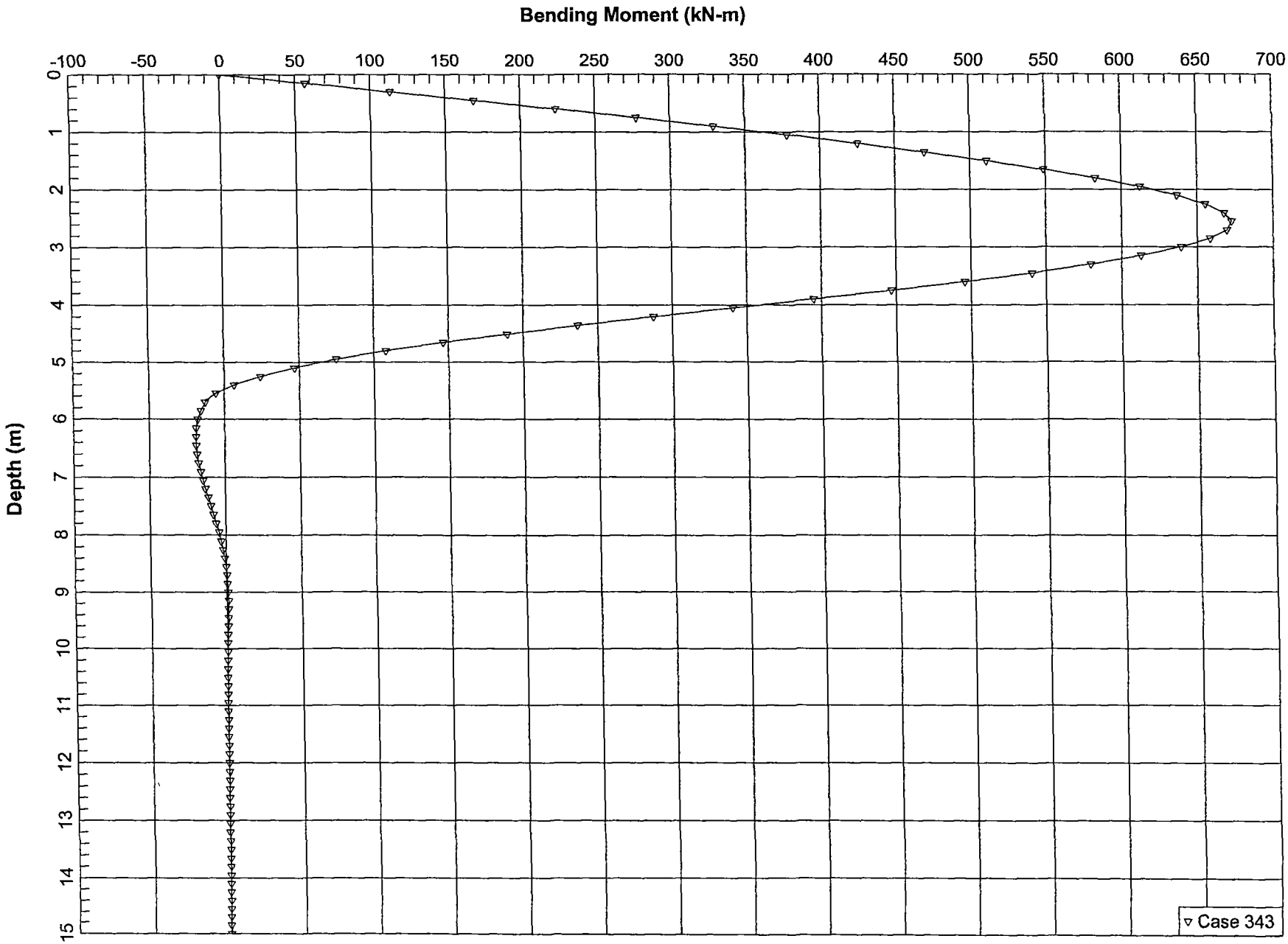
Boundary Condition Type 1, Shear and Moment

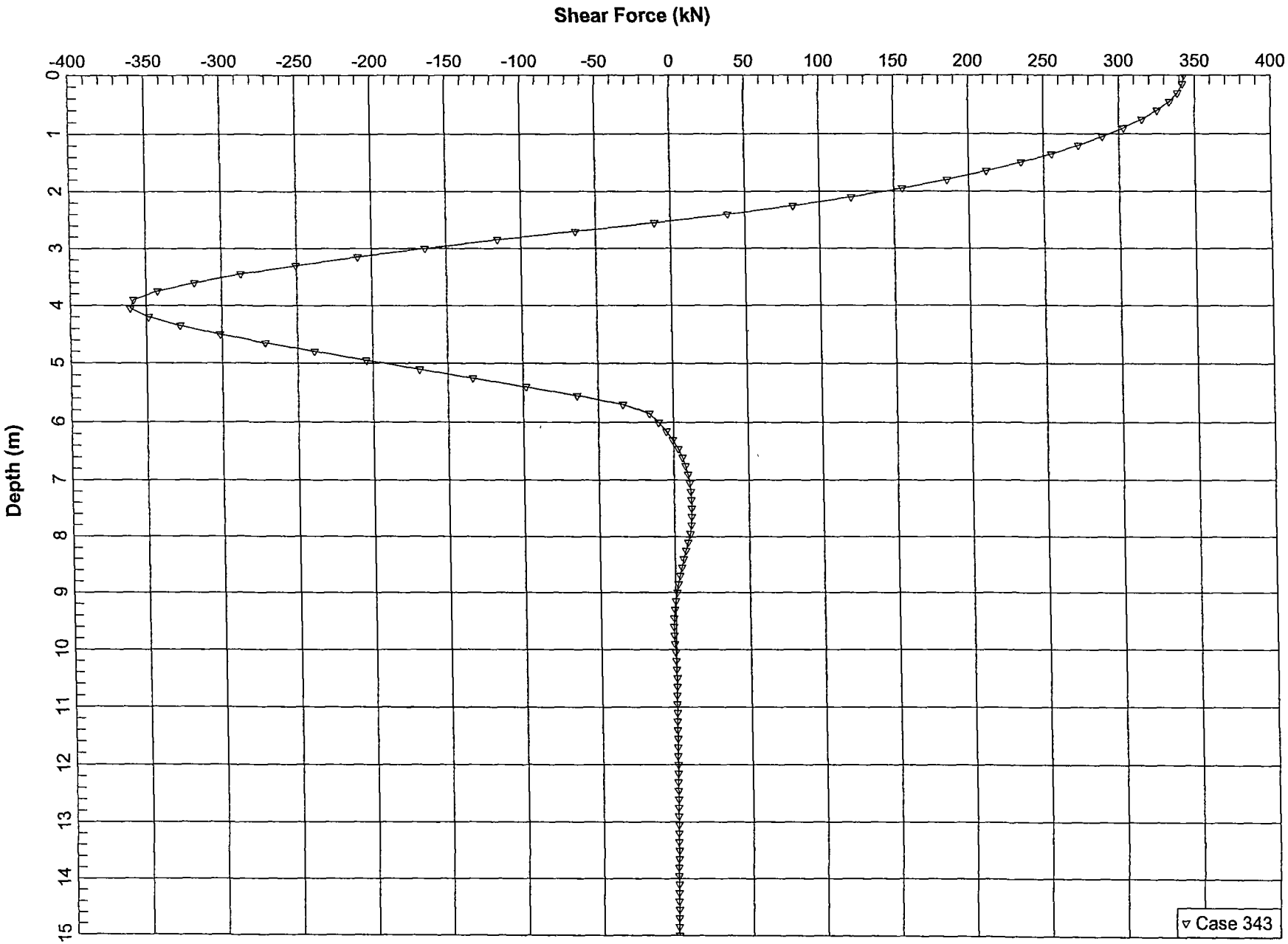
Shear = 343. kN
Moment = 100. m- kN
Axial Load = 823. kN

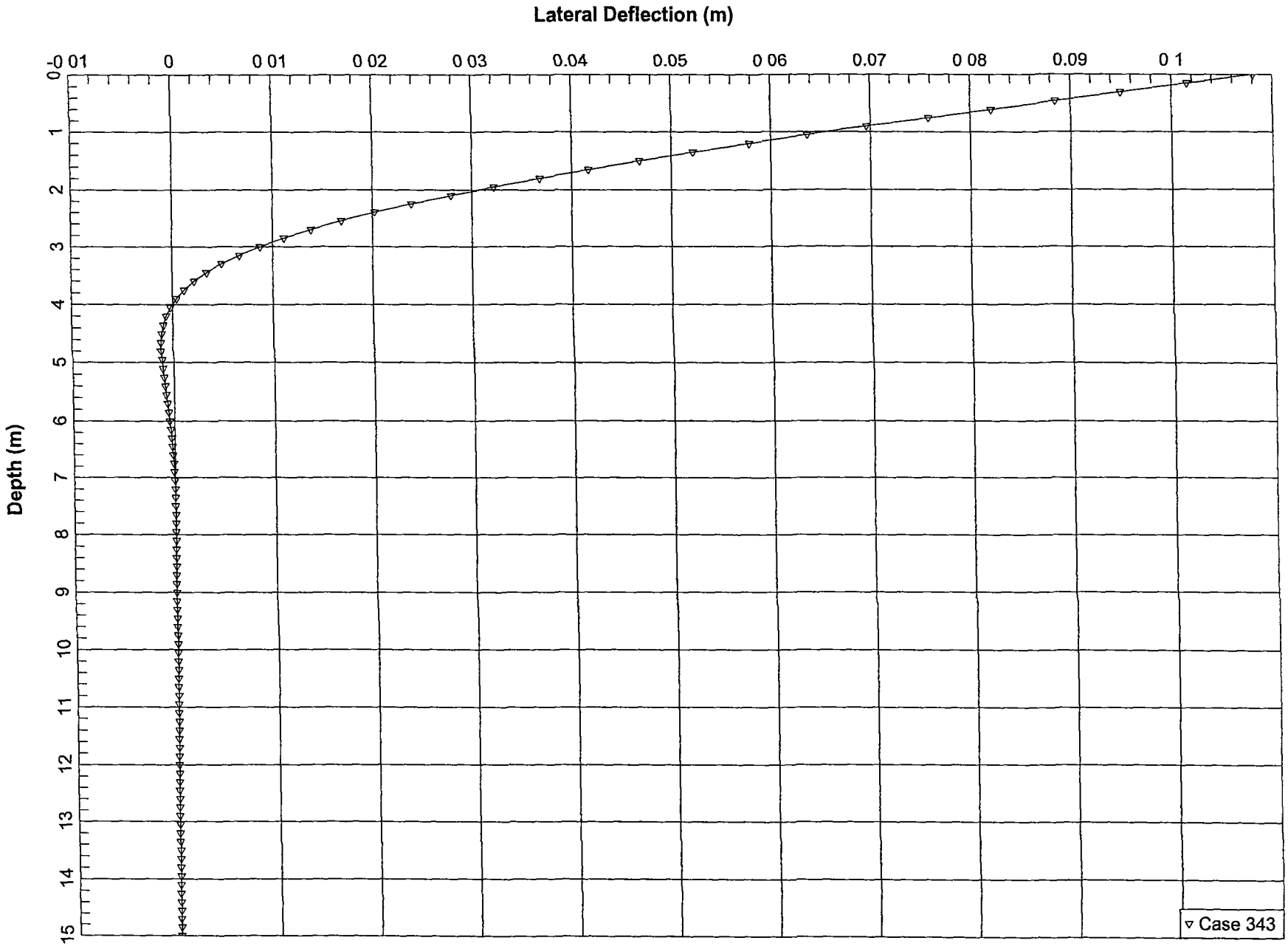
Pile Length	Pile Head Deflection m	Maximum Moment m- kN	Maximum Shear kN
15.000	.131	788.304	-418.106
14.250	.131	788.152	-417.645
13.500	.131	788.318	-418.718
12.750	.131	787.844	-417.807
12.000	.131	787.226	-417.771
11.250	.131	787.852	-419.046
10.500	.131	787.285	-418.057
9.750	.131	787.241	-418.567
9.000	.131	787.415	-419.280
8.250	.131	787.421	-419.415

The analysis ended normally.


depth= 0 - 5 8, Sand
depth= 5 8 - 7.9, Sand
depth= 7 9 - 10 8, Soft clay
depth= 10 8 - 15 6, Silt
depth= 15 6 - 18 4, Soft clay
depth= 18 4 - 20 8, Sand


Bending Moment (kN-m)
-100
-50
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Case 343


Shear Force (kN)
-400
-350
-300
-250
-200
-150
-100
-50
0
50
100
150
200
250
300
350
400
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Case 343


Lateral Deflection (m)
-0 01
0
0 01
0 02
0 03
0.04
0.05
0 06
0.07
0 08
0.09
0 1
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Case 343

Ref: Pile Group Computer Program

BENT 3 COLUMNS W/ 76 #11 @ EACH COL.

Allowable Stress = 1.5 Fy = 1.5 (65) k/in² = 97.5 k/in² = 672,236 kN/m

Pile Group 7:

Max total stress = 917,000 kN/m² > 672,236 kN/m²

N.G.
w/ 76 # 11

BENT 3 COLUMNS W/ 40 #11 @ EACH COL.

Max. total stress = 561,000 < 672,236 kN/m²
(Pile group # 8)

OK

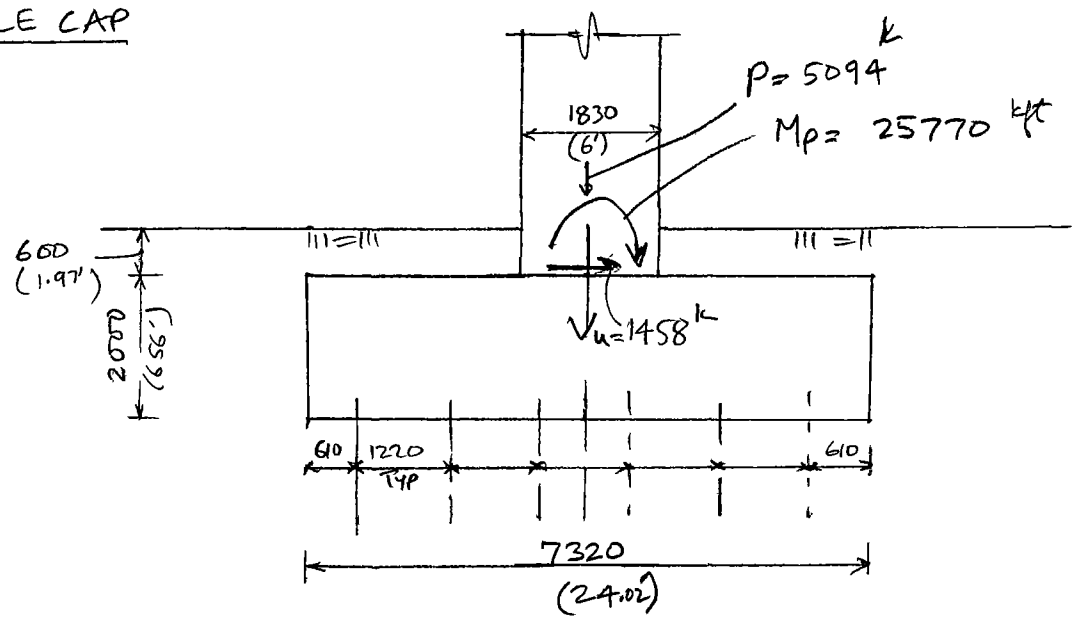
BENT 2 COLUMNS W/ 76 #11 @ EACH COL.

Max total stress = 403,000 < 672,236 kN/m²

Subject LEGACY PARKWAY BRIDGE 23
PILE CAP

BENT 2

PILE CAP



Cap Self Wt = $.150 \frac{k}{ft^3} (24.02 \times 24.02 \times 6.56) = 568^k$

Soil Wt = $.120 \frac{k}{ft^3} (1.97') (24.02 \times 24.02 - 32.96 ft^2) = 128^k$

BENT 2

P(kip)	Vu (kip)	Mp (k-ft)
5094	1458	25770

BENT 3

	w/ 76 #11 Vert. Rebars in Col			w/ 40 #11		
	P(kip)	Vu (kip)	Mp (k-ft)	P(kip)	Vu(kip)	Mp (k-ft)
COL 1 - (a)	2118	2477	23,211	(a): 2118	1660	15586
(b)	5433	2768	25,893	(b): 4433	1980	18550
(c)	2118	1241	23,211	(c): 2118	833	15586
COL 3 - (a)	1334	2005	22,128			
(b)	4223	2296	25,294			
(c)	1334	1006	22,128			

PARSONS BRINCKERHOFF
COMPUTATION SHEET

Page	
Made by	SAW
Date	1/24/02
Checked by	
Date	

Subject: Legacy Parkway - Bridge S23
GROUP Analysis

GROUP Analysis
Determine Demand @ Top of Piles

BENT 2

footing depth = 6.56 ft = 2.00 m

	Axial		Shear		Moment	
	kips	kN	kips	kN	k-ft	kN-m
Demand @ Bottom of Column	5094	22658	1458	6485	25770	34938
+ Footing Weight	568	2526	-	-	-	-
+ Soil Weight	128	569	-	-	-	-
- Soil Passive Resistance	-	-	171	761	-	-
+ Moment due to Shear x (Ftg depth)	-	-	-	-	8445	11449
= Demand @ Top of Piles	**5790**	**25754**	**1287**	**5725**	**34215**	**46387**

note:
Bottom of Column Demands are due to Column Plastic Hinging .

GROUP Analysis
Determine Demand @ Top of Piles

BENT 3

footing depth = 6.56 ft = 2.00 m

	Axial		Shear		Moment	
	kips	kN	kips	kN	k-ft	kN-m
Demand @ Bottom of Column	5433	24166	2768	12312	25893	35104
+ Footing Weight	568	2526	-	-	-	-
+ Soil Weight	128	569	-	-	-	-
- Soil Passive Resistance	-	-	171	761	-	-
+ Moment due to Shear x (Ftg depth)	-	-	-	-	17041	23103
= Demand @ Top of Piles	**6129**	**27262**	**2597**	**11551**	**42934**	**58207**

note:
Bottom of Column Demands are due to Column Plastic Hinging .

PARSONS BRINCKERHOFF
COMPUTATION SHEET

Subject	Legacy Parkway - Bridge S23
	GROUP Analysis
Page	
Made by	SAW
Date	1/28/02
Checked by	
Date	

GROUP Analysis **BENT 3** **40 #11 (#36) rebars**

Determine Demand @ Top of Piles

footing depth = 6.56 ft = 2.00 m

	Axial		Shear		Moment	
	kips	kN	kips	kN	k-ft	kN-m
Demand @ Bottom of Column	4433	19718	1980	8807	18550	25149
+ Footing Weight	568	2526	-	-	-	-
+ Soil Weight	128	569	-	-	-	-
- Soil Passive Resistance	-	-	171	761	-	-
+ Moment due to Shear x (Ftg depth	-	-	-	-	11870	16093
= Demand @ Top of Piles	**5129**	**22814**	**1809**	**8046**	**30420**	**41242**

note:
Bottom of Column Demands are due to Column Plastic Hinging .

304

LEGACY PARKWAY

BRIDGE 24A SEISMIC DESIGN STRATEGY

INTRODUCTION

Seismic Design of the bridges for the Legacy Parkway project is primarily based on AASHTO and amended by project specific design criteria, which, addresses issues not specifically accounted for by the AASHTO code.

GENERAL STRUCTURE DESCRIPTION

The structure is 209.0 m long with four-spans (42.0 m – 65.0 m – 60.0 m – 42.0 m). The substructure consists of short seat type abutments and single column bents with non-integral caps. The abutments are supported by two rows of concrete filled steel pipe (406 mm diameter x 10 mm) piles. Columns range in height from 8 m to 10 m. The columns are octagonal with a diameter of 2.5 m. Each column is supported on individual pile footings, with similar concrete filled steel pipe piles. The superstructure consists of 4 built up steel girders made composite with a concrete deck. Superstructure girders are typically supported on bridge elastomeric bearings.

LEVEL OF PERFORMANCE

This structure is designed as an "Essential Bridge" under the definition provided by AASHTO (Division 1-A). The seismic performance of the structure is "Serviceability", following minor repairs, which may be required, after the event of "Design Level Earthquake"

SEISMICITY

Seismic design load corresponds to a PGA of 0.60g, per UDOT recommendations. AASHTO curves for Type III soil are used to account for soil amplification.

SEISMIC BEHAVIOR

Seismic design strategy for this structure consists of:

- Lateral load transfer to piers, via bearings
- Mobilization of backfill soil behind the abutments.
- Limited plastic hinging in columns

The strategy includes strength design of bearing connections to resist service loads such as wind, and braking forces, as well as, the design level earthquake. The bearing connections are designed to transfer forces to the substructure. The columns were designed using a reduction factor (R) of 3, as permitted by AASHTO for single columns designed for Category D. This design approach results in an estimated maximum top of column deflection of approximately 100 mm.

At the abutments, and primarily in the longitudinal direction, the backfill soil provides additional resistance strength to limit the extent of superstructure movement. Backfill contributions to longitudinal as well as transverse directions (i.e. through interaction with wing-walls, and fin-walls) has been limited to 7.7 KSF passive resistance.

EXPECTED DAMAGE UNDER DESIGN EVENT

Damage to the abutments will be limited to backwall failure. The superstructure is expected to displace longitudinally on the abutment seats. The abutment seats are sized to accommodate the estimated seismic displacements.
The expected inspection and immediate repair which may be required, following a design level earthquake, will be centering the bridge near it's original position, and temporary repairs over bridge joints to allow for traffic. While the bridge can be opened to traffic following the immediate repair tasks, follow-up repairs may be necessary to replace damaged elastomeric bearings. Refer to table below for expected seismic performance of various bridge components.
Note that use of isolation bearing, which could be used for this project, can reduce the extent of bearing damages and/or required repairs, after the event of a design level earthquake.

Table 1. Expected Seismic Performance

Abutments	- Damage to backwall possible - Maximum longitudinal displacement ~ 4 inches - Essentially elastic pile response
Bearings	- Fuse feature at abutment, may require replacement
Columns	- R = 3, cracking and spalling. Repair by epoxy injection.
Foundations	- Piles remain essentially elastic
Joints	- Moderate damage requiring minor repair

Legacy Parkway ,
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	24A
Support(s)	1
Water Depth (m)	1 4
Finished Grade Elevation (m)	1295 2
Soil Borings Used for Profile	LSB-24-498

	Initials	Date
Completed By		
Checked By		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Sand	0 0	0 6	20 7	-	-	57,600	41	0	7	0	1,860
2	Sand	0 6	1 4	19 5	-	-	900	29	4	9	550	1,240
3	Sand	1 4	3 8	9 7	-	-	740	29	9	16	1,170	2,150
4	Silt	3 8	12 6	10 0	44	0 027	38,165	30	14	39	1,160	3,170
5	Sand	12 6	30 0	10 5	-	-	25,590	39	75	173	17,520	40,520

A-11

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	24A
Support(s)	2
Water Depth (m)	1.0
Finished Grade Elevation (m)	1295.0
Soil Borings Used for Profile	RB-372

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Soft Clay	0.0	1.0	19.6	50	0.020	48,665	-	0	4	0	140
2	Soft Clay	1.0	5.0	9.7	50	0.020	48,665	-	4	13	140	420
3	Sand	5.0	7.1	10.1	-	-	14,230	34	25	35	5,120	6,980
4	Soft Clay	7.1	12.2	10.1	28	0.020	15,665	-	17	29	580	960
5	Sand	12.2	18.7	10.1	-	-	17,780	36	62	93	13,060	19,590
6	Soft Clay	18.7	30.0	11.4	100	0.015	123,665	-	58	96	3,990	6,590

A12

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	24A
Support(s)	3,4,5
Water Depth (m)	0.9
Finished Grade Elevation (m)	1295.5
Soil Borings Used for Profile	RB-373; RC-373; RB-367

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	0.9	20.3	-	-	37,350	37	0	9	0	2,080
2	Soft Clay	0.9	4.4	9.7	63	0.020	68,165	-	4	12	150	440
3	Sand	4.4	6.9	10.5	-	-	27,010	39	28	43	6,850	10,280
4	Sand	6.9	8.8	9.7	-	-	4,290	30	28	34	4,240	5,230
5	Soft Clay	8.8	11.6	9.8	36	0.020	27,665	-	22	28	760	970
6	Sand	11.6	12.9	10.1	-	-	8,550	32	49	54	8,510	9,400
7	Sand	12.9	21.0	10.9	-	-	32,690	41	82	135	20,630	33,860
8	Stiff Clay with Free Water	21.0	22.5	9.7	89	0.020	107,165	-	54	58	2,380	2,530
9	Sand	22.5	30.0	10.9	-	-	32,690	41	144	193	36,050	48,300

A13

LEGACY PARKWAY
BRIDGE 24A
PILE CAPACITY SUMMARY - PP 406x9 53 (16" x 3/8")
YIELD STRENGTH = 448 MPa

	Initials	Date
Completed By:	NM	7/16/02
Reviewed By:	[illegible]	7/16/02

Abutment 1 Target Geotechnical Capacity per Pile (2.25xService Load)	*3,503*	*kN*
Bent 2 Target Geotechnical Capacity per Pile (2.25xService Load)	*1,262*	*kN*
Bent 3 Target Geotechnical Capacity per Pile (2.25xService Load)	*1,251*	*kN*
Bent 4 Target Geotechnical Capacity per Pile (2.25xService Load)	*1,161*	*kN*
Abutment 5 Target Geotechnical Capacity per Pile (2 25xService Load)	*3,503*	*kN*

(Target Service Load Provided by Structural Engineer)

Location	A Finished Grade Elevation (m)	B Bottom of Pile Cap Elevation (m)	C Est. Embankm Height (m)	D Estimated Pile Tip Elevation (m)	E Minimum Pile Tip Elevation (m)	F Service Uplift Load Resistance (kN)	G Seismic Compression Resistance (kN)	H Seismic Uplift Resistance (kN)	I Service Load (DL + LL) (kN)	J Required Driving Resistance (kN)	K Est Pile Length w/ fill (m)	L Estimated Maximum Structural Load in Pile (kN) (Service Load + Drag Load)	M Est. Elevation of Neutral Plane (m)	N Estimated Pile Tip Settlement (mm)
S-24A Abutment 1	1304 0	1297 8	9	1280 0	1280 0	565	n/a	n/a	1,557	3,503	17 8	2,828	1280 0	3
S-24A Bent 2	1294 5	1290 9	n/a	1263 5	1265 5	1,028	2,375	1,383	561	2 556	27 4	2 744	1263 5	1
S-24A Bent 3	1298 0	1294 4	n/a	1272 9	1272 9	685	2,366	1,388	556	2,507	21 5	1,968	1272 9	1
S-24A Bent 4	1299 5	1295 9	n/a	1274 7	1274 7	675	2 366	1,388	516	2 708	21 2	2 135	1274 7	1
S-24A Abutment 5	1310 6	1305 8	15 6	1279 6	1279 6	1,064	n/a	n/a	1,557	3 503	26 2	3,607	1281 7	3

Location	Borings Used for Soil Profile
S-24A Abutment 1	LSB-24-498
S-24A Bent 2	RB-372
S-24A Bent 3	RB-367
S-24A Bent 4	RB-373 RC-373
S-24A Abutment 5	RB-373, RC-373

Description of Information Presented in Each Column:

A. **Finished Grade Elevation** - Top of approach slab elevation at abutment locations and adjacent ground elevation at bent locations as shown on the structure Plan and Profile drawing provided

B. **Bottom of Pile Cap Elevation** - Elevation at the bottom of the pile cap as scaled from the structure Plan and Profile drawing provided

C. ***Estimated Embankment Height*** - Elevation difference between the top of the approach slab and the native ground surface at the abutment as scaled from the structure Plan and Profile drawing provided

D **Estimated Pile Tip Elevation** - Estimated elevation to which the bottom of the pile will need to be driven to develop the required capacity and meet the settlement criteria (Additional depth may be required to reach required resistance during driving)

E: **Minimum Pile Tip Elevation** - Estimated minimum elevation to which the bottom of the pile will need to be driven to meet settlement criteria should the required capacity be reached above the Target Pile Tip Elevation

F **Service Uplift Load Resistance** = (Ultimate Friction Resistance)/(FS=2.25)

G **Seismic Compression Resistance** = Ultimate Friction and End Bearing Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate friction resistance value to resist seismic uplift loads)

H **Seismic Uplift Resistance** = Ultimate Friction Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate friction resistance value to resist seismic uplift loads)

I **Service Load (DL + LL)** - The maximum load that can be applied at the top of the pile by the structure provided the pile is driven to the assumed capacity

J. **Required Driving Resistance** - The minimum load (service load x 2 25 or required seismic resistance plus estimated loss during liquefaction, whichever is greater) that must be verified in the field by PDA

K. **Estimated Pile Length w/ Fill** - The estimated length of pile required Calculated as (Bottom Of Pile Cap - Estimated Tip Elevation) rounded up to the nearest meter (Actual lengths may vary depending on driving conditions encountered at each pile location)

L. **Estimated Structural Load in the Pile** - The largest load that will develop in the pile due to structural service dead loads and drag loads This load occurs at the neutral plane where equilibrium exists between the sum of the downward acting permanent load (service load) applied at the top of the pile and drag load due to negative skin friction and the sum of upward acting positive shaft resistance and mobilized toe resistance

M **Estimated Elevation of Neutral Plane** - The level in the pile where relative movement between the pile and soil is zero

N **Estimated Pile Tip Settlement** - The magnitude of pile tip settlement required to mobilize estimated pile tip loads This does not include elastic compression of the pile

Memorandum

LEGACY

Date: 11/09/2001 revised 5/17/02 *File Code:* GDM-STR-007rev1

To: Joe Showers

From: K. N. Gunalan
Curt Christensen

Subject: Geotechnical Recommendations for Bridge 24A

Cc: DocC, Kleinfelder, Tom Cooper

Introduction

This memorandum presents our Geotechnical evaluation and recommendations developed in accordance with UDOT's Geotechnical MOI for Bridge 24A. Included herein is our evaluation of liquefaction and lateral spread concerns at the bridge location. Detailed descriptions of our understanding of the project, geology, soils encountered etc. will be incorporated into the project Geotechnical report and submitted along with other documents as part of final submittal for the project. This information will be maintained in the project files for reference until being incorporated into the final report.

General Geotechnical Conditions

Geotechnical conditions at the site are defined by previous investigations performed for UDOT. Based on the information obtained during those investigations and a subsequent investigation undertaken by FAK, the profile at the north interchange can be defined as consisting of interbedded medium stiff to stiff silts, clay and loose to very dense sand and gravel layers in the upper 10 to 15 meters. Dense to very dense silty sands, poorly graded sands and poorly graded gravel with lenses of silts and clays were encountered below 10 to 15 meters. Ground water was encountered at depths ranging from 1.0 to 1.5 meters.

Liquefaction Potential

Bridge 24A falls within the Farmington Siding landslide complex, which consists of liquefaction induced landslides. The bridge site is located within the older mapped portion of this complex, approximately 0.5 km southeast of the mapped contact with the younger portion of the complex. These slides date back to latest Pleistocene and Holocene time. UGS studies indicate that susceptibility to liquefaction induced land sliding may be less than the earlier times due to lower average lake and associated ground water levels. The study also indicated that above average precipitation could create locally perched conditions which when subject to strong ground

motions could liquefy and slide. Therefore, a study was undertaken to evaluate the potential for liquefaction and lateral spread at Bridge 24A. Information obtained from a total of four exploratory borings located at or near the bridge site were used in this evaluation. Evaluations indicated layers of silts and sands may liquefy under an earthquake of magnitude 7.3 with a peak horizontal ground acceleration of 0.6g.

Additionally, soil profiles from the borings at the bridge site were reviewed for liquefaction induced lateral spread potential. Based on the analysis, liquefaction induced settlement was determined to range from 15 mm in boring RB-367 to 95 mm in boring RB-372. The potential for lateral spread was estimated to be negligible in two of the borings with up to 1.2 m in boring RB-373. The lateral spread magnitude evaluated in boring RB-373 was based on field and laboratory data from Phase I investigations. It is our opinion that further testing would indicate that the layer contributing to the lateral spread is actually made up of thinner layer and therefore the magnitude would be much smaller.

Recommendations

It is our understanding that 406 mm (16 in.) diameter pipe piles are being proposed for the bridge foundations and that the anticipated service load per pile at the abutments 1 and 5 is 1557 kN. Service load per pile at the bents 2 through 4 range from 516 kN to 561 kN. Seismic uplift resistance required at bent 2 through 4 range from 1165 kN to 1388 kN. Recommended pile capacities and Geotechnical parameters required for analysis and design are presented in attached table.

Ind

Legacy Parkway
Bridge 24A

Seismic Design Calculation Check

Pile Foundation Analysis

The pile foundation check analyses included in the Seismic Design Calculation were performed jointly by Partha Sircar and David Williams in order to provide checking function and independent assessment.

The design loads for the foundation design check were based on the plastic hinge capacities of the piers (with overstrength) and deformed shape. They were provided by structural design engineer Stephane Dulor.

Soil properties were provided by Kleinfelder. Sensitivity analyses were undertaken to ensure the design was not sensitive to variation in certain soil properties.

Critical load cases were undertaken for design of the separate pier foundations. Critical load cases were selected based on the design loads applied to the foundation and the soil properties for the foundation. The direction of loading was in either principal axis or the diagonal. The soil properties at Bents 2, 3 and 6 were sufficiently different to warrant separate analysis. The foundation at Bent 4 was considered to fall within the other foundations analysed. The foundation footing at Bent 5 had a non square configuration requiring separate analysis.

The results of the foundation analysis included maximum pile displacements and combined stresses, foundation stiffnesses and determination of the required geotechnical axial capacities of the piles. These are used by Kleinfelder for their determination of pile tip elevations.

By: DW
01/02/02

Bridge 24A

Results Summary

Legacy Parkway – Bridge 24A

Foundation Check Analysis

By: P. Sircar, 12/24/01

Chk'd: D. Williams, 01/02/02

Design Parameters:

1. Footing: 8.53m x 8.53m x 2.6m (28' x 28' x 8.5'),
   Bent 2 - Buoyant wt.: 2600 kN (584 kip)
   Bent 3 &4 - Dry wt: 4440 kN (1000 kip)
2. Soil wt. Overburden (dry wt.): 1380 kN (310 kip)
3. No. of Piles: 32 (406 mm-diameter)
4. Soil Properties: Tables S-24A-2 & S-24A-5 LPILE Parameters from Kleinfelder
5. Loading: Over-strength Plastic Hinge Capacity, M_p = 81,000 kN-m (59,750 kip-ft)
   Longitudinal V_p = 9940 kN (2235 kip)
   Transverse V_p = 7810 kN (1760 Kip)
   P (axial) incl. footing & soil wt: Bent 2: 14,600 kN (3300 kip)
   Bent 3 & 4: 16,500 kN (3700 kip)

Summary of Lateral Load Analysis Results:

	Max Ten (kN)	Max Comp (kN)	Max Defl. (mm)	Max BM (kN-m)	Max Stress (MPa)	K_H (KN/m)	K_t (kNm/rad)
Bent 2							
Transverse	1240	1980	19.4	292	236	3.9E5	N/A
Longitudinal	1340	2040	27.0	394	294	3.6E5	N/A
Bents 3 & 4							
Transverse							
Case 1	1180	2080	4.1	75	120	1.6E6	5.6E7
Longitudinal							
Case 1	1270	2170	5.5	94	134	1.5E6	5.6E7
Case 2	1270	2170	11.2	159	170	8.2E5	5.6E7

Notes:

1. The values for soil skin friction and end bearing have been those recommended by Kleinfelder.
2. For Bent 2, for the soil properties presented, pile capacities calculated by API RP2A, using the recommended limits for skin friction and end bearing yielded values too low for the load demands.
3. For Bents 3 & 4 there is a sand layer. Thus, the capacities will be obtained within 30-meter depth. Nevertheless, the values from the Kleinfelder table were used for axial bahavior, for consistency.
4. For Bent 3, an assumption is required for properties to use for the first layer. The proposed finish grades at the bent locations are 2 to 3 meters higher than the elevation for the supplied boring. A sensitivity analysis was performed for this uncertainty as described below:
   Case 1 – Sand, Phi=37 degrees to bottom of footing. Other properties same as supplied.
   Case 2 – Sand, Phi=30 degrees to bottom of footing. Lower density and Modulus values.
5. The influence of the top layer properties is readily evidenced from the differences in the results.
6. The significant differences in the lateral load behavior for bents 2 and 3 are attributed primarily to the differences in passive resistances offered by the soil around the footing:
   Clay for Bent 2, Sand for Bent 3.

"New bottom of Footing Elev's. Dec 4, 2001 Hm"

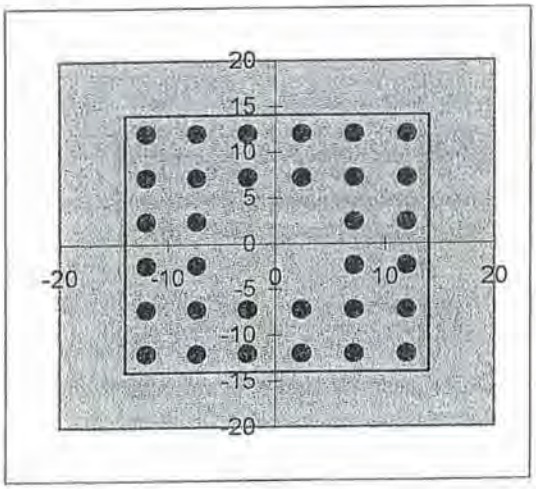
Bridge 24A

Structural Properties and Soil Profiles

1. Pile Layout
2. Pile Structural Properties
3. Footing Elevations
4. Soil Parameters – Bent 2
5. Soil Parameters – Bent 3,4,5

Pile Layout

	Number of entrie	32	
	Bar dia. (mm)	Ypile	Zpile
1		-12	-12
2		-7.2	-12
3		-2.4	-12
4		2.4	-12
5		7.2	-12
6		12	-12
7		-12	-7.2
8		-7.2	-7.2
9		7.2	-7.2
10		12	-7.2
11		-12	-2.4
12		12	-2.4
13		-12	2.4
14		12	2.4
15		-12	7.2
16		-7.2	7.2
17		7.2	7.2
18		12	7.2
19		-12	12
20		-7.2	12
21		-2.4	12
22		2.4	12
23		7.2	12
24		12	12
25		7.2	2.4
26		-7.2	2.4
27		2.4	7.2
28		2.4	-7.2
29		7.2	-2.4
30		-7.2	-2.4
31		-2.4	7.2
32		-2.4	-7.2



Pile Cap. 28' x 28' x 8.5'

DW
02/02/02

PARSONS BRINCKERHOFF COMPUTATION SHEET

Page ____ of ____

Made by DW

Date 7/18/07 / 9/5/07 01/02/0

Checked by

Date

Subject Legacy
Piles - Bridge ~~27~~ 24A
Pile Structural Prop.

Axial Capacity

Structural:

$f_y \approx 360$ MPa (= 52 ksi).
(actual f_y = 65 ksi min)

$$P_{ult} = A_s f_y + A_c f_c'$$
$$= 0.012 \times 360 + 0.12 \times 25$$
$$= 4.32 + 3.00$$
$$= 7.32 \text{ MN}$$
$$= 7320 \text{ kN}$$

$$A_s = \pi d t$$
$$= \pi \times 0.397 \times 0.0095$$
$$= 0.01185 \text{ m}^2$$

$$A_c = \pi d^2/4$$
$$= \pi\, 0.387^2$$
$$= 0.1176 \text{ m}^2$$

$$P_{max} \approx 0.4 P_{ult} \approx 2000 \text{ kN}$$
$$= 675 \text{ k}$$

$$A_{ct} = \frac{A_c}{n} = \frac{0.118}{8} \approx 0.015$$

$$\therefore A_e = A_s + A_{ct}$$
$$= 0.027 \text{ m}^2$$

EI check.

$$I_s = \pi r^3 t$$
$$= \pi \times (0.397/2)^3 \cdot 9.5 \times 10^{-3}$$
$$= 0.000233$$

$$\frac{I_c}{n} = \frac{\pi d^4}{64 \times 8} \quad \text{at } 0.387$$
$$= 0.000137$$

$$\therefore I_{equiv} = 0.00037 \text{ m}^4$$

for $n = 8$

Williams, David (US)

From: Dulor, Stephane
Sent: Tuesday, December 04, 2001 10:24 AM
To: Williams, David (US)
Subject: FW: B24A markups

The abutment elevations should still be fine. Eric Leeker calculated them and I just reconfirmed that the elevations should still be valid to within 500mm.

The bottom of footing elevations have changed slightly. We received a revised final grade topo from Norfolk on 10/12 which changed the bottom of footing elevations slightly. We calculated the elevations by taking the lowest final elevation at each footing and subtracting 1 m for cover and 2.6 m for the footing thickness.

NEW BOTTOM OF FOOTING ELEVATIONS:

	Final Grade		Cover		Footing		Bottom of footing
Bent 2:	1294.5	-	1m	-	2.6m	=	1290.9m
Bent 3:	1298.0	-	1m	-	2.6m	=	1294.4m
Bent 4:	1299.5	-	1m	-	2.6m	=	1295.9m

Taka Kimura, P.E.
Parsons Brinckerhoff
1660 Lincoln St. Suite 2100
Denver, CO 80264
PHONE: (303) 390-5861
FAX: (303) 832-9096

-----Original Message-----
From: Cooper, Tom
Sent: Tuesday, October 16, 2001 11:55 PM
To: Nugent, Victoria; Showers, Joseph I.
Cc: Dulor, Stephane
Subject: RE: B24A markups

Joe,
Please verify that the the mark-ups are correct and that the DATA we are using for footing elevations is correct. I know we discussed this before, but this information is critical to the design of the columns and foundations.

Tom

-----Original Message-----
From: Nugent, Victoria
Sent: Tuesday, October 16, 2001 12:55 PM
To: Showers, Joseph I.
Cc: Cooper, Tom
Subject: B24A markups

Hi Joe,

I was talking with Tom this morning and I realized that I hadn't marked up the first few sheets for 24A to reflect the elevation information that I received from you guys a few weeks back. So, I put some comments on the layout sheets and I am sending them to you to add to the drawings that I sent the other day.

<< File: Layout.zip >>

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	24A
Support(s)	2
Water Depth (m)	1.0
Finished Grade Elevation (m)	1295.0
Soil Borings Used for Profile	RB-372

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Soft Clay	0.0	1.0	19.6	50	0.020	48,665	-	0	4	0	140
2	Soft Clay	1.0	5.0	9.7	50	0.020	48,665	-	4	13	140	420
3	Sand	5.0	7.1	10.1	-	-	14,230	34	25	35	5,120	6,980
4	Soft Clay	7.1	12.2	10.1	28	0.020	15,665	-	17	29	580	960
5	Sand	12.2	18.7	10.1	-	-	17,780	36	62	93	13,060	19,590
6	Soft Clay	18.7	30.0	11.4	100	0.015	123,665	-	58	96	3,990	6,590

$$\frac{19.6 + 4 \times 9.7}{5} =$$

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	24A
Support(s)	3,4,5
Water Depth (m)	0.9
Finished Grade Elevation (m)	1295.5
Soil Borings Used for Profile	RB-373; RC-373; RB-367

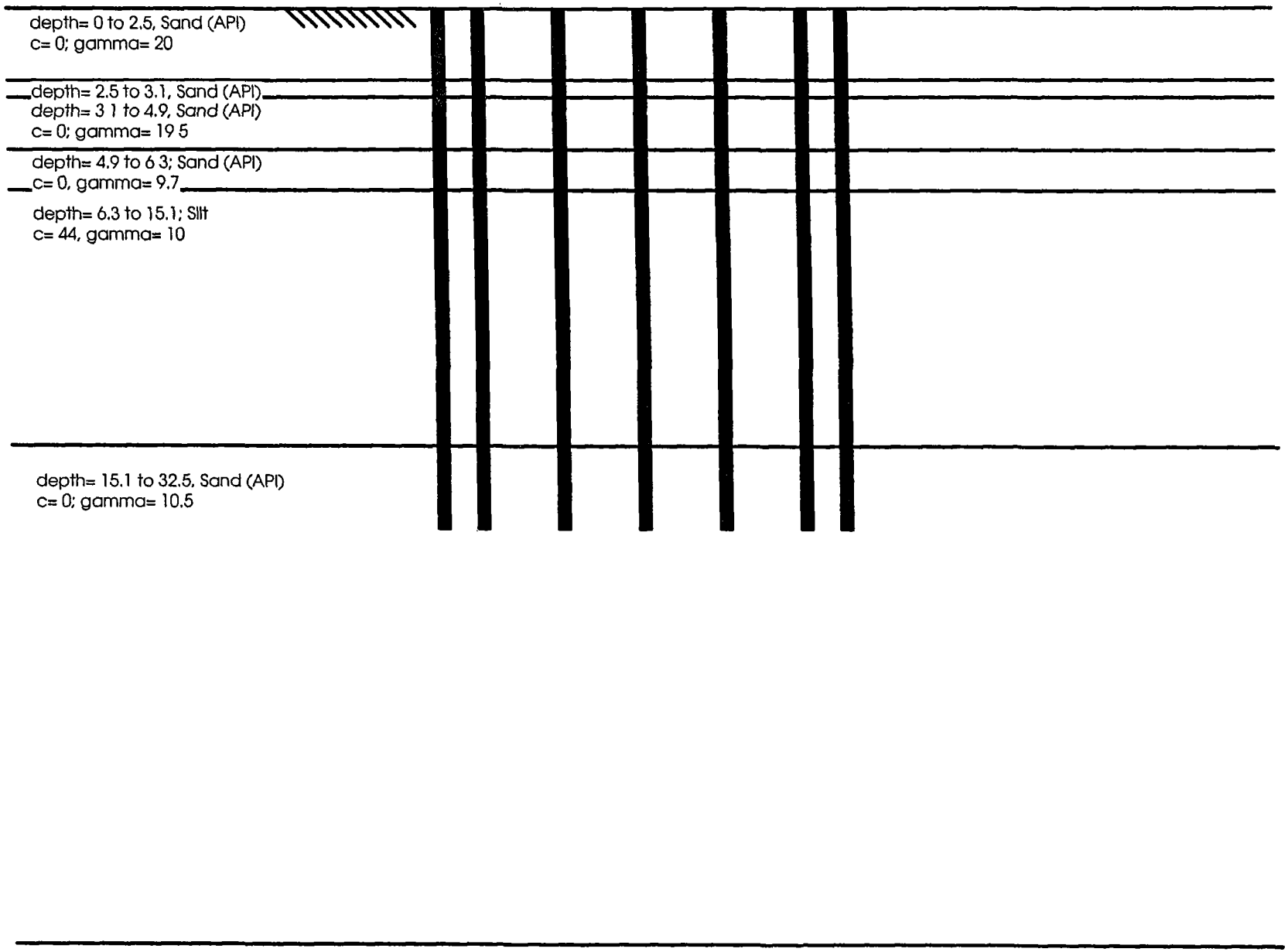
	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	0.9	20.3	-	-	37,350	37	0	9	0	2,080
2	Soft Clay	0.9	4.4	9.7	63	0.020	68,165	-	4	12	150	440
3	Sand	4.4	6.9	10.5	-	-	27,010	39	28	43	6,850	10,280
4	Sand	6.9	8.8	9.7	-	-	4,290	30	28	34	4,240	5,230
5	Soft Clay	8.8	11.6	9.8	36	0.020	27,665	-	22	28	760	970
6	Sand	11.6	12.9	10.1	-	-	8,550	32	49	54	8,510	9,400
7	Sand	12.9	21.0	10.9	-	-	32,690	41	82	135	20,630	33,860
8	Stiff Clay with Free Water	21.0	22.5	9.7	89	0.020	107,165	-	54	58	2,380	2,530
9	Sand	22.5	30.0	10.9	-	-	32,690	41	144	193	36,050	48,300

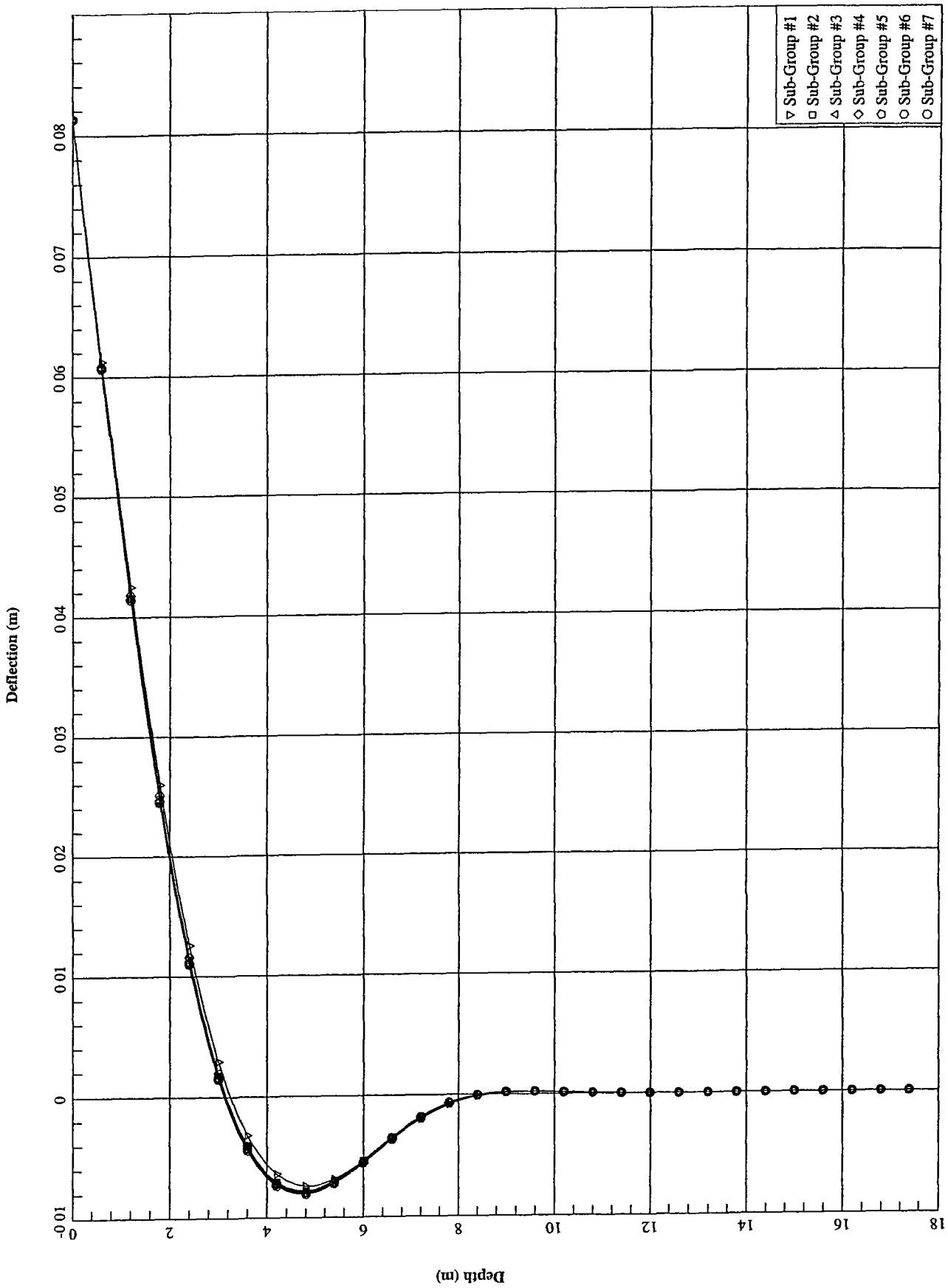
1295.5 +

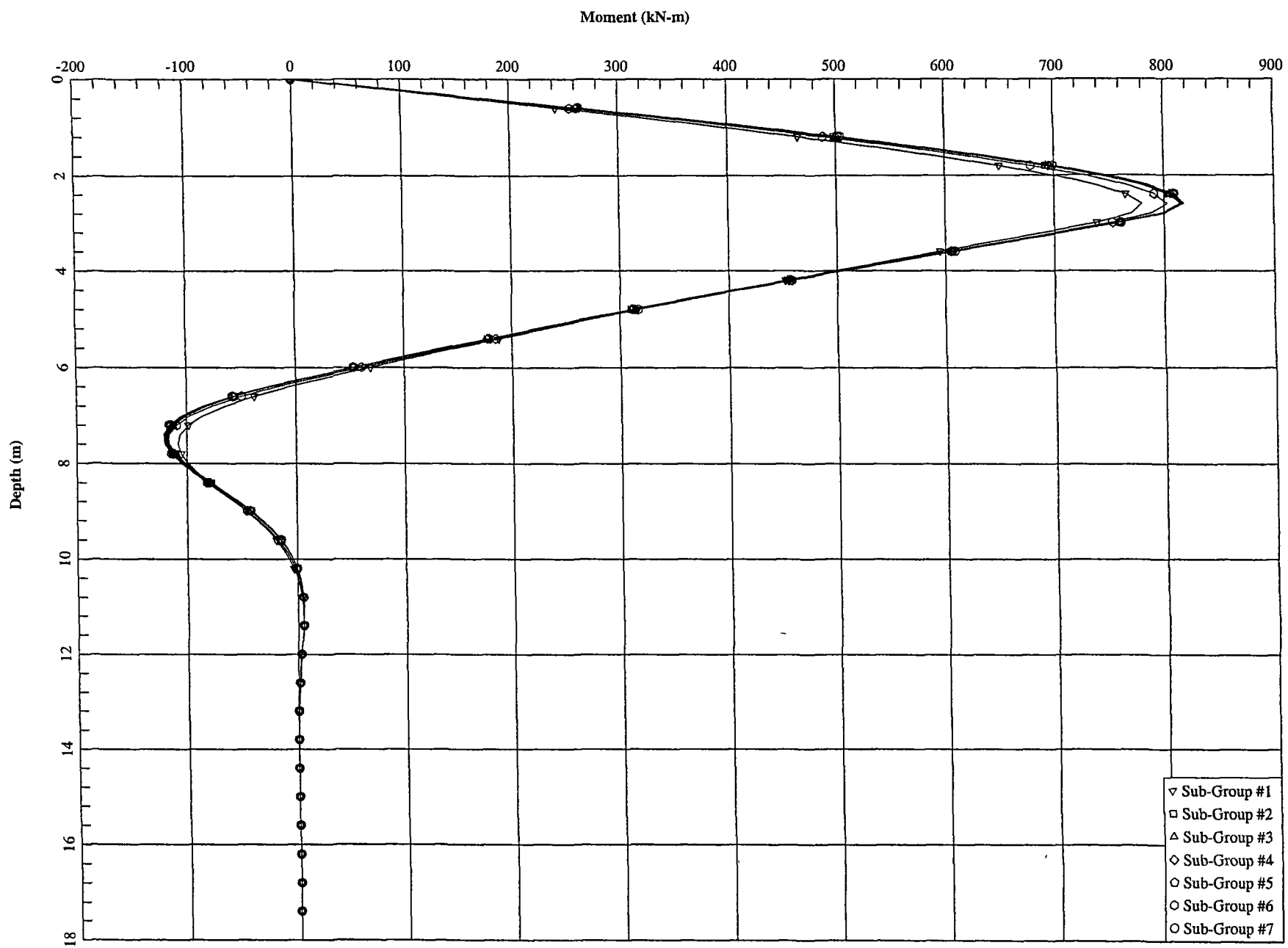
Add 3

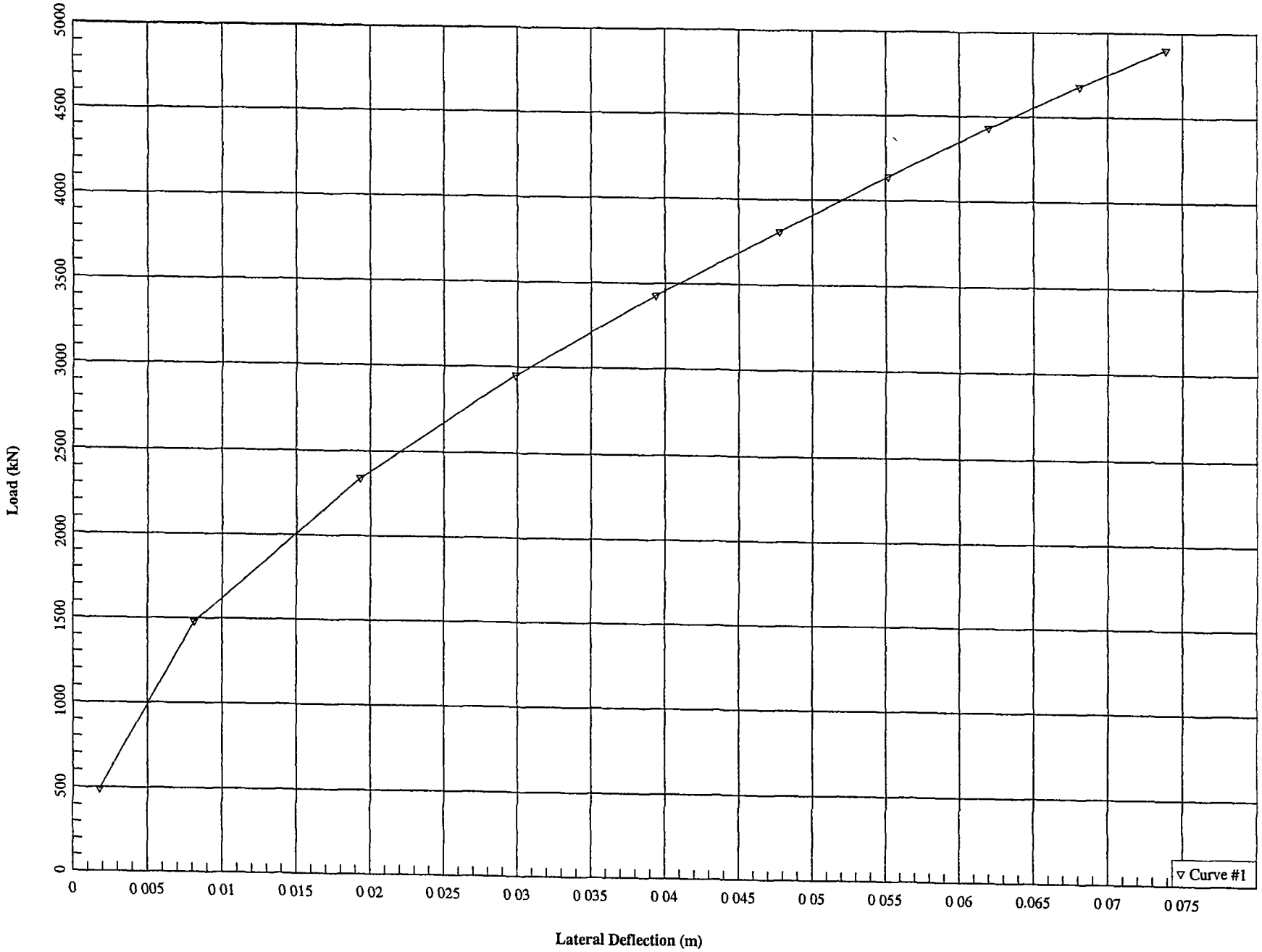
PACKAGE No. 3
Abutment 1 — Transverse Loading

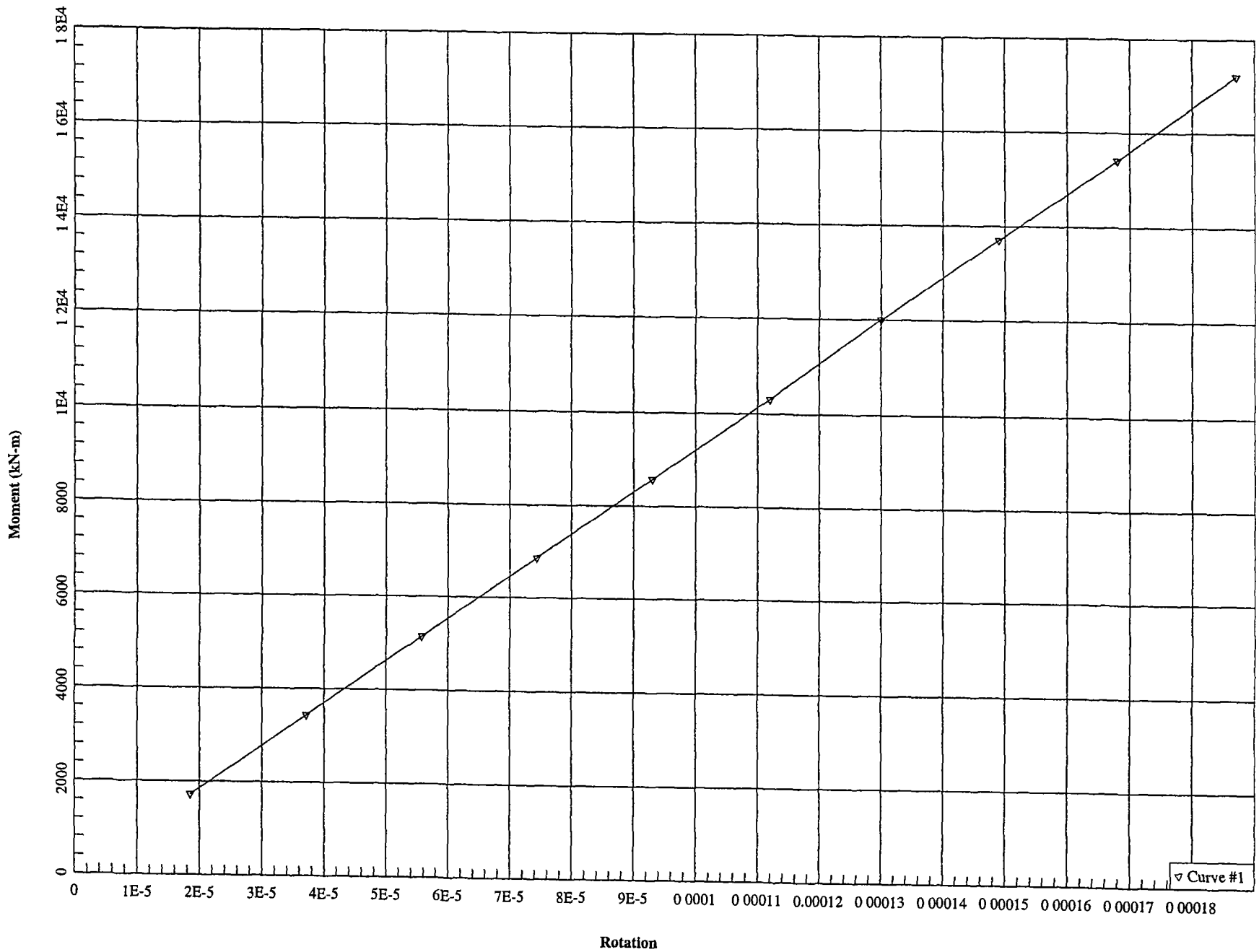


Package B — Run No. 1




Moment (kN-m)
-200
-100
0
100
200
300
400
500
600
700
800
900
Depth (m)
0
2
4
6
8
10
12
14
16
18
Sub-Group #1
Sub-Group #2
Sub-Group #3
Sub-Group #4
Sub-Group #5
Sub-Group #6
Sub-Group #7


Load (kN)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
0
0 005
0 01
0 015
0 02
0 025
0 03
0 035
0 04
0 045
0 05
0 055
0 06
0.065
0 07
0 075
Lateral Deflection (m)
Curve #1


Moment (kN-m)
0
2000
4000
6000
8000
1E4
1 2E4
1 4E4
1 6E4
1 8E4
0
1E-5
2E-5
3E-5
4E-5
5E-5
6E-5
7E-5
8E-5
9E-5
0 0001
0 00011
0.00012
0 00013
0 00014
0 00015
0 00016
0 00017
0 00018
Rotation
Curve #1

LEGACY PARKWAY

BRIDGE 24B SEISMIC DESIGN STRATEGY

FARID S. NOBARI REGISTERED NO. 4971307 STATE OF UTAH PROFESSIONAL ENGINEER

INTRODUCTION

Seismic Design of the bridges for the Legacy Parkway project is primarily based on AASHTO, amended by project specific design criteria, which addresses issues not specifically accounted for by the AASHTO code.

GENERAL STRUCTURE DESCRIPTION

The structure is 388 m long with six-spans (50, 3 at 73, 74, and 45 meters). Supports are typically normal to the alignments, with some minor skews. The substructure consists of seat type abutments and single and multi-column bents. The abutments are supported by two rows of concrete filled steel pipe (410 mm diameter x 10 mm) piles. The columns are 2.5 meters octagonal. Columns are supported on pile footings, using concrete filled steel pipe piles. The superstructure consists of built up steel girders made composite with a concrete deck. Superstructure girders are typically supported on pot bearings or elastomeric bearings where non-integral cap supports are used.

An important geometric constraint within the structure is at Bent 5, located at the median of I-15. The constraints, require a single column bent, non-skewed, with integral superstructure-bent cap. The overall geometry, number of columns in each bent, column end fixity, and superstructure cap connection are refined to achieve optimum balance between seismic and service load performances for the structure.

LEVEL OF PERFORMANCE

This structure is designed as an "Essential Bridge" under the definition provided by AASHTO (Division 1-A). The seismic performance of the structure is "Serviceability", following minor repairs, which may be required, after the event of "Design Level Earthquake"

SEISMICITY

The structure is designed for PGA = 0.6g. AASHTO curves for Type III soil are used to account for soil amplification.

SEISMIC BEHAVIOR

The seismic design strategy for this structure consists of:

- Restrained superstructure bearings at non-integral caps, with specified seismic gaps.
- Strength design of superstructure and bent caps at integral caps to meet column plastic demands.

- Longitudinal freedom of movement at abutments, upon connection failure of bearings
- Transverse restrains of bearings at abutments, with specified seismic gaps.

At the abutments, and primarily in the longitudinal direction, the bearings are allowed to be fused (fail base connection), to allow the girders slide over the footing Bearings are assumed (conservatively) to slide with 40% coefficient of friction. Upon closure of thermal expansion joints at the abutments, additional resistance will be provided by backfill, however, the design conservatively ignores this resistance. In the transverse direction, at the abutments, the bearings are allowed to be fused and slide over the pile cap, with restraints at specific design seismic gap values The objective of the strategy at the abutments is to limit load transfer to the substructure piles and prohibit their damage

EXPECTED DAMAGE UNDER DESIGN EVENT

Due to the expected fused bearing behavior at the abutments the majority of damage will be localized to the bearing elements and restraints. Damage to the abutments will be limited to backwall failure

The expected inspection and immediate repair which may be required, following a design level earthquake, will be centering the bridge near it's original position, and temporary repairs over bridge joints to allow for traffic While the bridge can be opened to traffic following the immediate repair tasks, follow-up repairs can be performed to replace damaged bearings and connections

Table 1. Expected Seismic Performance

Abutments	• Bearing sliding upon connection failure, and repairable damage to back-wall • Essentially elastic pile response
Bearings	• Fuse at 40% vertical dead load, with shear keys/restraints at specific seismic gaps Bearings will require repair and/or replacement • Fuse feature at abutment, may require bearing replacement or repositioning
Columns	• Column plastic action will be limited, requiring repair of flexure cracks
Expansion Joints	• Moderate damage requiring minor repair to allow immediate use of traffic, and follow-up permanent repair

This section was to be revised to discuss the excessive amount of est. liq-induced settlement at the abutments.
(Level 3, comment # 1-B)
JBH 10-13-14

LEGACY PARKWAY

BRIDGE 24B SEISMIC DESIGN STRATEGY

ADAVANCED RELEASE FOR

ABUTMENT 1 PILING– ADVANCED RELEASE FOR CONSTRUCTON

INTRODUCTION

Seismic Design of the bridges for the Legacy Parkway project is primarily based on AASHTO, amended by project specific design criteria, which addresses issues not specifically accounted for by the AASHTO code.

GENERAL STRUCTURE DESCRIPTION

The structure is 388 m long with six-spans (50, 3 at 73, 74, and 45 meters). Supports are typically normal to the alignments, with some minor skews. The substructure consists of seat type abutments and single and multi-column bents. The abutments are supported by two rows of concrete filled steel pipe (410 mm diameter x 10 mm) piles. The columns are octagonal with a long dimension of 1.8 and 2.5 meters. Each column is supported on individual pile footings, using concrete filled steel pipe piles. The superstructure consists of built up steel girders made composite with a concrete deck. Superstructure girders are typically supported on pot bearings or elastomeric bearings where non-integral cap supports are used.

An important geometric constraint within the structure is at Bent 5, located at the median of I-15. The constraints, require a single column bent, non-skewed, with integral superstructure-bent cap. The overall geometry, number of columns in each bent, column end fixity, and superstructure cap connection are refined to achieve optimum balance between seismic and service load performances for the structure.

LEVEL OF PERFORMANCE

This structure is designed as an "Essential Bridge" under the definition provided by AASHTO (Division 1-A). The seismic performance of the structure is "Serviceability", following minor repairs, which may be required, after the event of "Design Level Earthquake"

SEISMICITY

The structure is designed for PGA = 0.6g. AASHTO curves for Type III soil are used to account for soil amplification.

SEISMIC BEHAVIOR

The seismic design strategy for this structure consists of:

- Restrained superstructure bearings at non-integral caps, with specified seismic gaps.
- Strength design of superstructure and bent caps at integral caps to meet column plastic demands.
- Longitudinal freedom of movement at abutments, upon connection failure of bearings
- Transverse restrains of bearings at abutments, with specified seismic gaps.

At the abutments, and primarily in the longitudinal direction, the bearings are allowed to be fused (fail base connection), to allow the girders slide over the footing. Bearings are assumed (conservatively) to slide with 40% coefficient of friction. Upon closure of thermal expansion joints at the abutments, additional resistance will be provided by backfill; however, the design conservatively ignores this resistance. In the transverse direction, at the abutments, the bearings are allowed to be fused and slide over the pile cap, with restraints at specific design seismic gap values. The objective of the strategy at the abutments is to limit load transfer to the substructure piles and prohibit their damage.

EXPECTED DAMAGE UNDER DESIGN EVENT

Due to the expected fused bearing behavior at the abutments the majority of damage will be localized to the bearing elements and restraints. Damage to the abutments will be limited to backwall failure. The entire superstructure is expected to displace on the supporting pile cap footing, however adequate seat will be provided..

The expected inspection and immediate repair which may be required, following a design level earthquake, will be centering the bridge near it's original position, and temporary repairs over bridge joints to allow for traffic. While the bridge can be opened to traffic following the immediate repair tasks, follow-up repairs can be performed to replace damaged bearings and connections.

Table 1. Expected Seismic Performance

Abutments	• Bearing sliding upon connection failure, and repairable damage to back-wall • Essentially elastic pile response
Bearings	• Fuse at 40% vertical dead load, with shear keys/restraints at specific seismic gaps • Fuse feature at abutment, may require bearing replacement or repositioning
Expansion Joints	• Moderate damage requiring minor repair to allow immediate use of traffic, and follow-up permanent repair

Memorandum

LEGACY

Date: 04/21/2004

File Code: GDM-STR-008rev1

To: J. Deschamp

From: K. N. Gunalan

LICENSED PROFESSIONAL ENGINEER No. 270604 KANCHEEPURAM N. GUNALAN STATE OF UTAH

Subject: Geotechnical Recommendations for Bridge 24 B

Cc: DocC, Kleinfelder, Farid Nobari

Introduction

This memorandum presents our Geotechnical evaluation and recommendations developed in accordance with UDOT's Geotechnical MOI for Bridge 24B (includes recommendations for Abutment 1 dated 12/27/01). Detailed descriptions of our understanding of the project, geology, soils encountered etc. will be incorporated into the project Geotechnical report and submitted along with other documents as part of final submittal for the project. This information will be maintained in the project files for reference until being incorporated into the final report.

General Geotechnical Conditions

Geotechnical conditions at the site are defined by previous investigations performed for UDOT and based on the information obtained during subsequent investigation undertaken by FAK. The profile at the north interchange can be defined as consisting of interbedded soft to stiff silts, clay and loose to medium dense sand and gravel layers in the upper 10 to 15 meters. Dense to very dense silty sands, poorly graded sands and poorly graded gravel with lenses of stiff silts and clays were encountered below 10 to 15 meters. Ground water was encountered at depths ranging from 1 0 to 1.5 meters. Based on the site specific information, we recommend that AASHTO Soil Type III be used for design.

Liquefaction Potential

Bridge 24B falls within the Farmington Siding landslide complex, which consists of liquefaction induced landslides. The bridge is located within the older mapped portion of this complex, approximately 1 0 km southeast of the mapped contact with the younger portion of the complex. These slides date back to latest Pleistocene and Holocene time. UGS studies indicate that susceptibility to liquefaction induced land sliding may be less than the earlier times due to lower average lake and associated ground water levels. The study also indicated that above average precipitation could create locally perched conditions which when subject to strong ground

motions could liquefy and slide. Therefore, a study was undertaken to evaluate the potential for liquefaction at Bridge 24B. Information obtained from exploratory borings located near the bridge was used in this evaluation. Evaluations indicated layers of silts and sands at approximate elevations of 1295 to 1282 m may liquefy under an earthquake of magnitude 7.3 with a peak horizontal ground acceleration of 0.6g.

Liquefaction induced settlement were estimated to range from 17 to 194 mm. A 2 m thick layer of silty sand at an approximate elevation of 1293 m in boring SB 23-289 was determined to have a potential to liquefy and laterally spread 0.6 m. Based on this isolated potential, no ground modification measures are recommended.

Recommendations

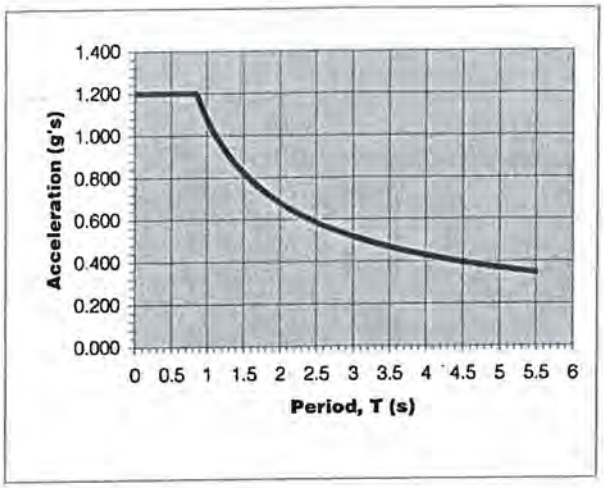
It is our understanding that 406 mm (16 in.) diameter pipe piles are being proposed for the bridge foundation and that the anticipated service load per pile at the abutments is 1557 kN and at the bents it ranges from 356 to 787 kN. Recommended pile capacity and Geotechnical parameters required for analysis and design are presented in attached table.

ACCELERATION RESPONSE SPECTRUM:

A = 0.6
S = 1.5 (Soil Type III)

f (s^{-1})	T (s)	Accel. ($g's$)	Accel. (Absolute - m/s^2)
100.00	0.01	1.200	11.772
2.00	0.50	1.200	11.772
1.25	0.80	1.200	11.772
1.23	0.81	1.200	11.772
1.22	0.82	1.200	11.772
1.20	0.83	1.200	11.772
1.19	0.84	1.200	11.772
1.18	0.85	1.200	11.772
1.16	0.86	1.194	11.716
1.15	0.87	1.185	11.626
1.14	0.88	1.176	11.537
1.12	0.89	1.167	11.451
1.11	0.90	1.159	11.366
1.00	1.00	1.080	10.595
0.91	1.10	1.014	9.943
0.83	1.20	0.956	9.382
0.77	1.30	0.907	8.895
0.71	1.40	0.863	8.466
0.67	1.50	0.824	8.085
0.63	1.60	0.789	7.745
0.59	1.70	0.758	7.438
0.56	1.80	0.730	7.160
0.53	1.90	0.704	6.906
0.50	2.00	0.680	6.674
0.48	2.10	0.659	6.461
0.45	2.20	0.638	6.263
0.43	2.30	0.620	6.080
0.42	2.40	0.602	5.910
0.40	2.50	0.586	5.752
0.38	2.60	0.571	5.603
0.37	2.70	0.557	5.464
0.36	2.80	0.544	5.333
0.34	2.90	0.531	5.210
0.33	3.00	0.519	5.093
0.31	3.25	0.492	4.829
0.29	3.50	0.468	4.596
0.27	3.75	0.447	4.389
0.25	4.00	0.429	4.204
0.24	4.25	0.412	4.038
0.22	4.50	0.396	3.887
0.21	4.75	0.382	3.749
0.20	5.00	0.369	3.623
0.19	5.25	0.358	3.507
0.18	5.50	0.347	3.400

$$(Acc.)_m = 1.2*A*S/T_m^{2/3}$$



Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	24B
Support(s)	3
Water Depth (m)	2.3
Boring Elevation (m)	1297.8

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	2.3	19.5	-	-	900	30	0	15	0	2200
2	Sand	2.3	3.0	10.1	-	-	16,360	35	20	23	4250	4920
3	Soft Clay	3.0	5.0	10.6	39	0.020	32,165	-	11	15	320	450
4	Silt	5.0	7.0	10.0	40	0.020	33,665	29	20	28	1630	2080
5	Sand	7.0	9.0	10.5	-	-	25,590	39	50	61	11720	14360
6	Soft Clay	9.0	12.0	10.2	10	0.020	3,500	-	23	29	460	580
7	Sand	12.0	13.5	9.7	-	-	2,160	30	49	54	6760	7440
8	Sand	13.5	15.0	10.9	-	-	32,690	47	95	105	23860	26310

PARSONS BRINCKERHOFF COMPUTATION SHEET	Page
	Made by BLC
	Date 11/21/01
Subject Legacy Parkway - Bridge 24b	Checked by
GROUP Analysis: Bent 3	Date

Bent 3
Assumptions for GROUP Analysis

Pile Structure Capacity
Maximum Total Pile Stress = 65 ksi = 4.48E+05 kN / m2

Passive Soil Resistance @ Pile Cap.
Soil Passive Pressure = 2 0 ksf

Depth of Top of Pile from Ground Surface = 3 2 m

Increase pile length and lowest depth of input soil properties to assure pile is adequate in compression and tension

Soil Profile Used

Layer	Soil Type	Measured From Ground Surface		Measured From Top of Pile		Unit Weight of Soil	Shear Strength c	Strain ε_{50}	Modulus of Subgrade Reaction, K	Friction Angle ϕ	Maximum Side Friction		Maximum Tip Resistance	
		Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	(kN/m³)	(kN/m²)		(kN/m³)	(degrees)	top (kN/m²)	bottom (kN/m²)	top (kN/m²)	bottom (kN/m²)
2	sand	0 0	3 0	-3 2	0 0	10 1	-	-	16360	35	20	23	4250	4920
3	soft clay	3 0	5 0	0 0	1 8	10 6	39	0 02	32165	-	11	15	320	450
4	silt	5 0	7 0	1 8	3 8	10 0	40	0 02	33665	29	20	26	1630	2080
5	sand	7 0	9 0	3 8	5 8	10 5	-	-	25590	39	50	61	11720	14360
6	soft clay	9 0	12 0	5 8	8 8	10 2	10	0 02	3500	-	23	29	460	580
7	sand	12 0	13 5	8 8	10 3	9 7	-	-	2160	30	49	54	6760	7440
8	sand	13.5	120 0	10 3	120.0	10 9	-	-	32690	47	95	105	23860	26310

PARSONS BRINCKERHOFF COMPUTATION SHEET

Made by BLC
Date 1/7/02
Checked by:
Date

Subject Legacy Parkway, Bridge 24b. Bent 3
Passive Resistance of Soil @ Bent Footings

$kPa = 1000Pa$ $MPa := 1000\ kPa$ $kips = lbf \cdot 1000$ $kN := 1000\ newton$

INPUT

SOIL PROPERTIES

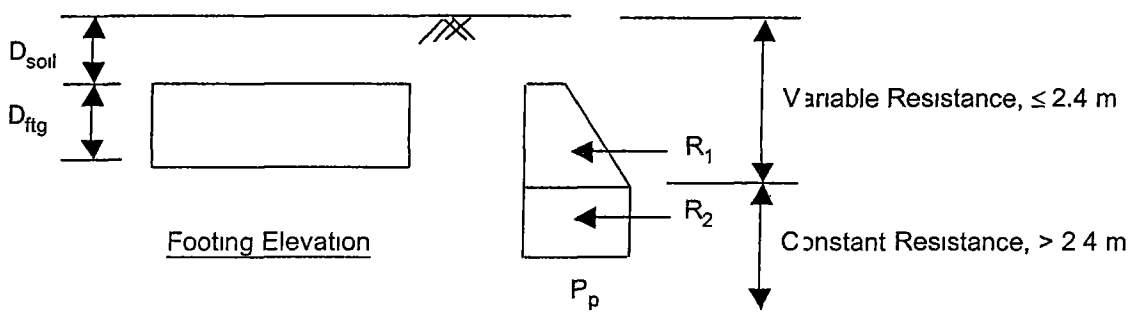
$D_{soil} := 0.6 \cdot m$ Depth of Soil Cover

$P_p := 2.0 \frac{kips}{ft^2}$ Soil Passive Pressure:
Soil Type 1, 2: P_p = 4.8 ksf (above water table), P_p = 4.0 ksf (below water table)
Soil Type 3, 4: P_p = 2.4 ksf (above water table), P_p = 2.0 ksf (below water table)

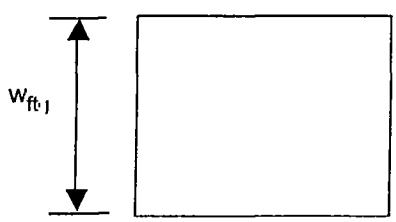
FOOTING GEOMETRY / DETAILS

$D_{ftg} := 2.6\ m$ Footing Depth

$w_{ftg} := 9.76 \cdot m$ Footing Width



Footing Elevation



Footing Plan

PARSONS BRINCKERHOFF COMPUTATION SHEET

Subject: Legacy Parkway, Bridge 24b Bent 3
Passive Resistance of Soil @ Bent Footings

Made by: BLC
Date: 11/21/01
Checked by.
Date

CALCULATIONS

Soil Restistance

$$P_p = 95.761 \frac{kN}{m^2}$$

Variable Resistance, for Depth ≤ 2 4 m

$$P_{p_top} := \frac{D_{soil}}{2.4 \cdot m} \cdot P_p \qquad P_{p_top} = 23.940 \frac{kN}{m^2}$$

$$P_{p_bot} := \text{if}\left(D_{soil} + D_{ftg} \le 2.4 \cdot m, P_p \cdot \frac{D_{soil} + D_{ftg}}{2.4 \cdot m}, P_p\right) \qquad P_{p_bot} = 95.761 \frac{kN}{m^2}$$

$$R_1 := \frac{1}{2}\left(P_{p_top} + P_{p_bot}\right) \cdot w_{ftg} \cdot \left(2.4 \cdot m - D_{soil}\right) \qquad R_1 = 1.051 \times 10^3\, kN$$

Constant Resistance, for Depth > 2.4 m

$$R_2 := \text{if}\left[D_{ftg} + D_{soil} > 2\,4\ m, P_p \cdot w_{ftg} \cdot \left(D_{ftg} + D_{soil} - 2\,4 \cdot m\right), 0 \cdot kN\right] \qquad R_2 = 747.698\, kN$$

Total Soil Resistance

$$R_T := R_1 + R_2 \qquad R_T = 1799\, kN$$

PARSONS BRINCKERHOFF COMPUTATION SHEET		
Subject	Legacy Parkway - Bridge 24b	Page
	GROUP Analysis, Bent 3	Made by BLC
		Date 1/2/02
		Checked by
		Date

BENT 3

GROUP Analysis - Longitudinal
Determine Demand @ Top of Piles

footing depth = 8.53 ft = 2.60 m

	Axial		Shear		Moment	
	kips	kN	kips	kN	k-ft	kN-m
Demand @ Bottom of Column	2930	13033	3661	16285	87514	118647
+ Footing Weight	1306	5809	-	-	-	-
+ Soil Weight	232	1032	-	-	-	-
- Soil Passive Resistance	-	-	404	1799	-	-
+ Moment due to Shear x (Ftg depth)	-	-	-	-	13890	18831
= Demand @ Top of Piles	**4468**	**19874**	**3257**	**14486**	**101404**	**137478**

← LONGITUDINAL CONTROLS

note:
Bottom of Column Demands are due to Column Plastic Hinging .

GROUP Analysis - Transverse
Determine Demand @ Top of Piles

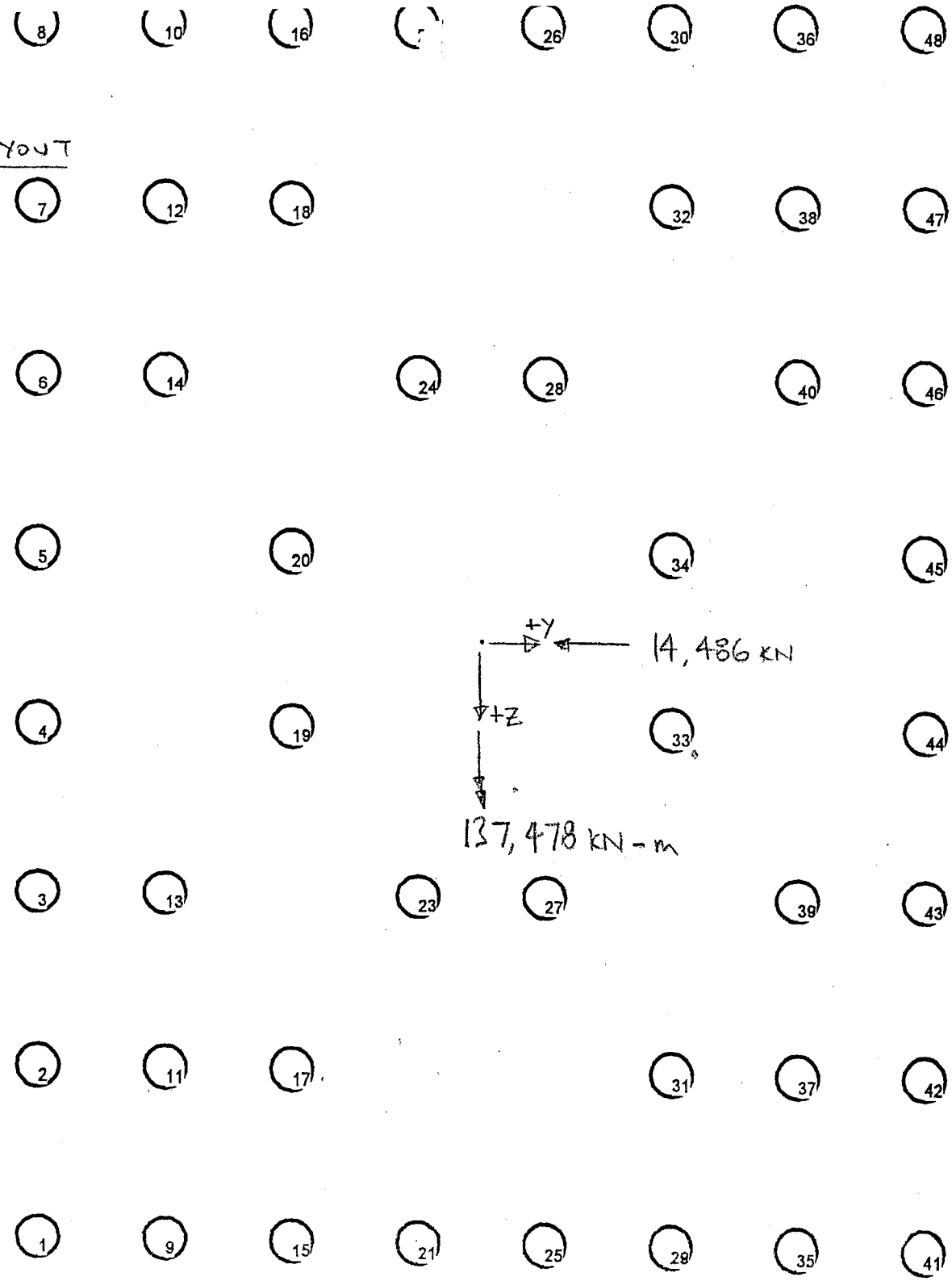
footing depth = 8.53 ft = 2.60 m

	Axial		Shear		Moment	
	kips	kN	kips	kN	k-ft	kN-m
Demand @ Bottom of Column	2930	13033	3019	13429	87514	118647
+ Footing Weight	1306	5809	-	-	-	-
+ Soil Weight	232	1032	-	-	-	-
- Soil Passive Resistance	-	-	404	1799	-	-
+ Moment due to Shear x (Ftg depth)	-	-	-	-	11152	15119
= Demand @ Top of Piles	**4468**	**19874**	**2615**	**11630**	**98666**	**133766**

note:
Bottom of Column Demands are due to Column Plastic Hinging .

BENT 3 PILE LAYOUT

BENT3.gpd



PILE GROUP ANALYSIS PROGRAM-GROUP
PC VERSION 5.0 (C) COPYRIGHT ENSOFT,INC. 2000

THE PROGRAM WAS COMPILED USING MICROSOFT FORTRAN
POWERSTATION 4.0 (C) COPYRIGHT MICROSOFT CORPORATION, 1996.

Bridge 24B Bent 3

***** INPUT INFORMATION *****

BRIDGE 24B
BENT 3 FOOTING
GROUP OUTPUT
BLC 1/22/02

* TABLE C * LOAD AND CONTROL PARAMETERS

UNITS--□□□□

V LOAD, KN	H LOAD, KN	MOMENT, KN- M
.1987E+05	-.1449E+05	.1375E+06

* THE LOADING IS STATIC *

KPYOP = 0 (CODE TO GENERATE P-Y CURVES)

(KPYOP = 1 IF P-Y YES; = 0 IF P-Y NO; = -1 IF P-Y ONLY)

* CONTROL PARAMETERS *

TOLERANCE ON CONVERGENCE OF FOUNDATION REACTION = .254E-06 M
TOLERANCE ON DETERMINATION OF DEFLECTIONS = .254E-06 M
MAX NO OF ITERATIONS ALLOWED FOR FOUNDATION ANALYSIS = 100
MAXIMUM NO. OF ITERATIONS ALLOWED FOR PILE ANALYSIS = 100

* TABLE D * ARRANGEMENT OF PILE GROUPS

GROUP	CONNECT	NO OF PILE	PILE NO	L-S CURVE	P-Y CURVE
1	PIN	8	1	1	0
2	PIN	2	1	1	0
3	PIN	2	1	1	0
4	PIN	2	1	1	0
5	PIN	2	1	1	0
6	PIN	2	1	1	0
7	PIN	2	1	1	0
8	PIN	2	1	1	0
9	PIN	2	1	1	0
10	PIN	2	1	1	0
11	PIN	2	1	1	0
12	PIN	2	1	1	0
13	PIN	2	1	1	0
14	PIN	2	1	1	0
15	PIN	2	1	1	0
16	PIN	2	1	1	0
17	PIN	2	1	1	0
18	PIN	8	1	1	0

GROUP	VERT, M	HOR, M	SLOPE, M/ M	GROUND, M	SPRING, KN- M
1	.0000E+00	-.4270E+01	.0000E+00	- 3200E+01	.0000E+00
2	.0000E+00	-.3050E+01	.0000E+00	-.3200E+01	.0000E+00
3	.0000E+00	-.3050E+01	.0000E+00	-.3200E+01	.0000E+00
4	.0000E+00	- 3050E+01	.0000E+00	-.3200E+01	.0000E+00

THE GLOBAL STRUCTURE COORDINATE SYSTEM

XDISPL, M	YDISPL, M	SLOPE	AXIAL, KN	LAT, KN	BM, KN- M	STRESS, KN/ M**2
-.401E-02	-.338E-01	-.159E-01	-.1083E+04	-.4423E+03	.000E+00	.401E+05

THE LOCAL MEMBER COORDINATE SYSTEM

XDISPL, M	YDISPL, M	SLOPE	AXIAL, KN	LAT, KN	BM, KN- M	STRESS, KN/ M**2
-.401E-02	-.338E-01	-.159E-01	-.108E+04	-.442E+03	.000E+00	.401E+05

LATERALLY LOADED PILE

$\left(\frac{V}{PILE}\right)_{MAX}$

X M	DEFLECTION M	MOMENT KN- M	SHEAR KN	SOIL REACTION KN/ M	TOTAL STRESS KN/ M**2	FLEXURAL RIGIDITY KN- M**2
*****	**********	**********	**********	**********	**********	**********
.00	-.338E-01	.000E+00	-.442E+03	-.296E+03	.401E+05	.744E+05
1.00	-.179E-01	-.277E+03	-.295E+03	-.652E+02	.192E+06	.744E+05
2.00	-.574E-02	-.493E+03	-.229E+03	-.395E+03	.310E+06	.744E+05
3.00	-.222E-03	-.322E+03	.166E+03	-.469E+02	.216E+06	.744E+05
4.00	.975E-03	-.108E+03	.213E+03	.108E+03	.991E+05	.744E+05
5.00	.720E-03	-.326E+01	.105E+03	.971E+02	.419E+05	.744E+05
6.00	.421E-03	.432E+01	.791E+01	.479E+01	.425E+05	.744E+05
7.00	.181E-03	.718E+01	.311E+01	.362E+01	.440E+05	.744E+05
8.00	.370E-04	.652E+01	-.505E+00	.214E+01	.437E+05	.744E+05
9.00	-.193E-04	.381E+01	-.265E+01	-.296E+00	.422E+05	.744E+05
10.00	-.244E-04	.146E+01	-.235E+01	-.425E+00	.409E+05	.744E+05
11.00	-.991E-05	-.451E+00	-.192E+01	-.189E+01	.404E+05	.744E+05
12.00	-.149E-05	-.471E+00	-.291E-01	-.332E+00	.404E+05	.744E+05
13.00	.589E-06	-.166E+00	.303E+00	.149E+00	.402E+05	.744E+05
14.00	.438E-06	-.129E-01	.153E+00	.125E+00	.401E+05	.744E+05
15.00	.114E-06	.154E-01	.287E-01	.360E-01	.401E+05	.744E+05
16.00	-.251E-08	.792E-02	-.739E-02	-.871E-03	.401E+05	.744E+05
17.00	-.127E-07	.138E-02	-.652E-02	-.481E-02	.401E+05	.744E+05
18.00	-.434E-08	-.323E-03	-.171E-02	-.178E-02	.401E+05	.744E+05
19.00	-.307E-09	-.256E-03	.629E-04	-.135E-03	.401E+05	.744E+05
20.00	.289E-09	-.569E-04	.198E-03	.136E-03	.401E+05	.744E+05
21.00	.119E-09	.472E-05	.618E-04	.599E-04	.401E+05	.744E+05
22.00	.128E-10	.653E-05	.193E-05	.683E-05	.401E+05	.744E+05
23.00	-.573E-11	.161E-05	-.490E-05	-.324E-05	.401E+05	.744E+05
24.00	-.264E-11	-.558E-07	-.167E-05	-.158E-05	.401E+05	.744E+05
25.00	-.312E-12	-.142E-06	-.891E-07	-.196E-06	.401E+05	.744E+05
26.00	.107E-12	-.353E-07	.107E-06	.703E-07	.401E+05	.744E+05
27.00	.499E-13	.912E-09	.363E-07	.344E-07	.401E+05	.744E+05
28.00	.536E-14	.277E-08	.191E-08	.405E-08	.401E+05	.744E+05
29.00	-.189E-14	.622E-09	-.214E-08	-.149E-08	.401E+05	.744E+05
30.00	-.774E-15	-.299E-10	-.653E-09	-.636E-09	.401E+05	.744E+05
31.00	-.631E-16	-.459E-10	-.167E-10	-.539E-10	.401E+05	.744E+05
32.00	.313E-16	-.858E-11	.372E-10	.278E-10	.401E+05	.744E+05
33.00	.104E-16	.817E-12	.942E-11	.956E-11	.401E+05	.744E+05
34.00	.460E-18	.670E-12	-.136E-12	.438E-12	.401E+05	.744E+05
35.00	-.469E-18	.951E-13	-.574E-12	-.462E-12	.401E+05	.744E+05
36.00	-.119E-18	-.171E-13	-.113E-12	-.121E-12	.401E+05	.744E+05
37.00	.728E-21	-.850E-14	.848E-14	.764E-15	.401E+05	.744E+05
38.00	.614E-20	-.776E-15	.772E-14	.665E-14	.401E+05	.744E+05
39.00	.112E-20	.283E-15	.106E-14	.125E-14	.401E+05	.744E+05
40.00	-.884E-22	.917E-16	-.190E-15	-.101E-15	.401E+05	.744E+05
41.00	-.691E-22	.310E-17	-.886E-16	-.816E-16	.401E+05	.744E+05

Ind Check

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	24B
Support(s)	1,2
Water Depth (m)	1.5
Existing Ground Elevation (m)	1295.2

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Silt	0.0	1.5	19.6	63	0.020	68,165	30	0	8	0	700
2	Silt	1.5	5.0	9.6	43	0.010	38,165	29	8	17	650	1400
3	Sand	5.0	8.5	9.7	-	-	2,870	30	21	33	3090	4760
4	Stiff Clay with Free Water	8.5	10.0	9.7	63	0.020	68,165	-	22	25	810	930
5	Sand	10.0	12.0	10.1	-	-	7,840	32	43	51	7350	8680
6	Sand	12.0	15.0	10.9	-	-	32,690	43	78	98	19740	24640

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	24B
Support(s)	3
Water Depth (m)	2.3
Boring Elevation (m)	1297.8

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	2.3	19.5	-	-	900	30	0	15	0	2200
2	Sand	2.3	3.0	10.1	-	-	16,360	35	20	23	4250	4920
3	Soft Clay	3.0	5.0	10.6	39	0.020	32,165	-	11	15	320	450
4	Silt	5.0	7.0	10.0	40	0.020	33,665	29	20	26	1630	2080
5	Sand	7.0	9.0	10.5	-	-	25,590	39	50	61	11720	14360
6	Soft Clay	9.0	12.0	10.2	10	0.020	3,500	-	23	29	460	580
7	Sand	12.0	13.5	9.7	-	-	2,160	30	49	54	6760	7440
8	Sand	13.5	15.0	10.9	-	-	32,690	47	95	105	23860	26310

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	24B
Support(s)	4
Water Depth (m)	1.5
Boring Elevation (m)	1296.7

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Silt	0.0	1.5	19.8	31	0.020	18,665	29	0	8	0	650
2	Soft Clay	1.5	9.0	8.2	17	0.020	3,500	-	6	19	130	420
3	Stiff Clay with Free Water	9.0	11.0	9.7	54	0.010	54,665	-	20	25	710	860
4	Sand	11.0	12.0	10.1	-	-	5,000	31	40	44	6230	6800
5	Sand	12.0	15.0	10.5	-	-	21,330	37	60	76	13450	16960

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	24B
Support(s)	5
Water Depth (m)	1.5
Boring Elevation (m)	1297.6

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	1.5	20.7	-	-	57,600	42	0	18	0	4650
2	Soft Clay	1.5	4.2	10.1	11	0.020	3,500	-	6	12	120	230
3	Sand	4.2	5.5	10.1	-	-	9,970	33	23	29	4260	5220
4	Soft Clay	5.5	11.5	9.8	39	0.020	32,165	-	15	28	480	880
5	Sand	11.5	15.0	10.1	-	-	12,100	33	55	70	10460	13300

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	24B
Support(s)	6
Water Depth (m)	1.5
Boring Elevation (m)	1297.2

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Silt	0.0	1.5	19.8	31	0.020	18,665	29	0	8	0	650
2	Soft Clay	1.5	6.5	9.8	39	0.020	32,165	-	6	16	150	400
3	Sand	6.5	8.0	10.1	-	-	9,970	33	32	38	5750	6860
4	Soft Clay	8.0	11.0	10.0	31	0.020	18,665	-	20	26	530	700
5	Sand	11.0	13.0	10.1	-	-	5,000	31	45	52	6970	8110
6	Sand	13.0	15.0	10.9	-	-	32,690	41	86	99	21580	24840

LEGACY PARKWAY

BRIDGE 25 SEISMIC DESIGN STRATEGY

INTRODUCTION

Seismic Design of the bridges for the Legacy Parkway project is primarily based on AASHTO and amended by project specific design criteria, which, addresses issues not specifically accounted for by the AASHTO code.

GENERAL STRUCTURE DESCRIPTION

The structure is 374 m long with six-spans (43.0 m, 64.5 m, 64.5 m, 62.0 m, 72.0 m, 64.5 m). The substructure consists of short seat type abutments and single column bents with non-integral caps. The abutments are supported by two rows of concrete filled steel pipe piles (typical: 406 mm diameter x 10 mm). Columns range in height from 7.5 m to 9.5 m. The columns are octagonal with a diameter of 2.5 m. Each column is supported on individual pile group foundation, with typical concrete filled steel pipe piles. The superstructure consists of 4 built up steel girders made composite with a concrete deck. Superstructure girders are supported on pot bearings, which are welded to the base plate, on top of the bent caps. At the abutments, the elastomeric bearings are allowed to be fused to slide over the seat, and interact with back-fill soil.

LEVEL OF PERFORMANCE

This structure is designed as an "Essential Bridge" under the definition provided by AASHTO (Division 1-A). The seismic performance of the structure is "Serviceability", following minor repairs, which may be required, after the event of "Design Level Earthquake"

SEISMICITY

The structure is designed for PGA = 0.6g. AASHTO curves for Type III soil are used to account for soil amplification.

SEISMIC BEHAVIOR

Seismic design strategy for this structure consists of:

- Lateral load transfer to piers, via bearings and shear keys
- Mobilization of backfill soil behind the abutments.
- Limited plastic hinging in columns

The strategy includes strength design of bearing connections to resist service loads such as wind, and braking forces, as well as, the design level earthquake. The bearing connections are designed to transfer forces to the substructure. The columns were designed using a reduction factor (R) of 3, as permitted by AASHTO for single columns designed for Category D. This

design approach results in an estimated maximum top of column deflection of approximately 105 mm.
At the abutments, and primarily in the longitudinal direction, the backfill soil provides additional resistance strength to limit the extent of superstructure movement. Backfill contributions has been limited to 7.7 KSF passive resistance.

EXPECTED DAMAGE UNDER DESIGN EVENT

Damage to the abutments will be limited to backwall failure. The superstructure is expected to displace longitudinally on the abutment seats. The abutment seats are sized to accommodate the estimated seismic displacements.
The expected inspection and immediate repair which may be required, following a design level earthquake, will be centering the bridge near it's original position, and temporary repairs over bridge joints to allow for traffic. While the bridge can be opened to traffic following the immediate repair tasks, follow-up repairs may be necessary to replace damaged bearings. Refer to table below for expected seismic performance of various bridge components.

Table 1. Expected Seismic Performance

Abutments	• Damage to backwall possible • Maximum longitudinal displacement ~ 60 mm • Essentially elastic pile response
Bearings	• Fuse feature at abutment, may require bearing replacement or repositioning
Columns	• R = 3, cracking and spalling. Repair by epoxy injection.
Foundations	• Piles remain essentially elastic
Joints	• Moderate damage requiring minor repair such as epoxy injection of cracks

Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	25
Support(s)	1,2
Water Depth (m)	1.5
Boring Elevation (m)	1295.5

	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	1.0	20.3	-	-	54,900	41	0	11	0	2940
2	Soft Clay	1.0	1.5	19.8	31	0.027	18,665	-	4	6	110	170
3	Soft Clay	1.5	3.6	10.0	31	0.027	18,665	-	6	10	170	290
4	Sand	3.6	6.2	10.1	-	-	8,550	32	20	30	3490	5290
5	Soft Clay	6.2	11.5	9.8	36	0.030	27,665	-	17	28	560	940
6	Sand	11.5	15.0	10.5	-	-	25,590	39	69	89	16280	20910

Press the "Copy" button to copy this tab to a new spreadsheet. The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies. Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers.

A17

LEGACY PARKWAY

BRIDGE 25

PILE CAPACITY SUMMARY PP 406x9 53 (16" x 3/8")

YIELD STRENGTH = 448 MPa

	Initials	Date
Completed By	NM	9/17/01
Reviewed By	cc	9/17/01

A 1 Target Geotechnical Capacity per Pile (2.25xService Load)	3,195	kN
B 2 Target Geotechnical Capacity per Pile (2 25xService Load).	1 854	kN
B 3 Target Geotechnical Capacity per Pile (2 25xService Load).	2 032	kN
B 4 Target Geotechnical Capacity per Pile (2 25xService Load).	1 942	kN
B 5 Target Geotechnical Capacity per Pile (2.25xService Load).	1,271	kN
B 6 Target Geotechnical Capacity per Pile (2 25xService Load).	2 178	kN
A 7 Target Geotechnical Capacity per Pile (2 25xService Load)	3 771	kN

(Target Service Load Provided by Structural Engineer)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Location	Finished Grade Elevation (m)	Bottom of Pile Cap Elevation (m)	Est. Embankm. Height (m)	Target Pile Tip Elevation (m)	Minimum Pile Tip Elevation (m)	Service Uplift Load Resistance (kN)	Required Seismic Compression Resistance (kN)	Required Seismic Uplift Resistance (kN)	Service Load (DL + LL) (kN)	Required Driving Resistance (kN)	Est. Pile Length w/ fill (m)	Estimated Maximum Structural Load in Pile (kN) (Service Load + Drag Load)	Est. Elevation of Neutral Plane (m)	Estimated Pile Tip Settlement (mm)
Bridge 25 Abutment 1	1306 3	1300 5	10 3	1283 3	1283.3	588	N/A	29	1,420	3,195	18	2,378	1285 8	[illegible]
Bridge 25, Bent 2	1297 0	1292 0	-	1269 5	1269 5	982	3,135	1,870	824	3,567	23	2,257	1273 5	4
Bridge 25, Bent 3	1297 0	1292 0	-	1272 0	1272 0	947	3,135	1,870	903	3,475	20	2,210	1275 9	4
Bridge 25 Bent 4	1297 5	1293 0	-	1273 0	1273 0	930	3,135	1,870	883	3,583	20	2,243	1276 5	4
Bridge 25, Bent 5	1298 0	1294 4	-	1269.4	1269.4	1,199	3,160	2,135	565	4,135	25	2,487	1273 3	4
Bridge 25, Bent 6	1297 5	1294 4	-	1271 3	1271.3	955	3 135	1,870	968	3 350	24	2,159	1276 6	3
Bridge 25 Abutment 7	1310 1	1304 3	12 1	1286 1	1286 1	676	N/A	N/A	1,676	3,771	19	2,985	1287 4	22

Location	Borings Used for Soil Profile
Bridge 22 Abutment 1	RB 385 SC 27 341 LSB 22-435
Bridge 22 Bent 2	RB-385 SC 27 341 LSB 22-436
Bridge 22 Bent 3	LSB 25-453 SC-27-342
Bridge 22 Bent 4	LSB 22-437
Bridge 22 Bent 5	LSB 25-454 SC 27 344
Bridge 22 Bent 6	LSB 25-455
Bridge 22 Abutment 7	LSB 22-490

Description of Information Presented in Each Column

A Finished Grade Elevation - Top of approach slab elevation at abutment locations and adjacent ground elevation at bent locations as shown on the structure Plan and Profile drawing provided

B Bottom of Pile Cap Elevation Elevation at the bottom of the pile cap as scaled from the structure Plan and Profile drawing provided

C Estimated Embankment Height - Elevation difference between the top of the approach slab and the native ground surface at the abutment as scaled from the structure Plan and Profile drawing provided

D Target Pile Tip Elevation - Estimated elevation to which the bottom of the pile will need to be driven to develop the required capacity and meet the settlement criteria (Additional depth may be required to reach required resistance during driving)

E Minimum Pile Tip Elevation - Estimated minimum elevation to which the bottom of the pile will need to be driven to meet settlement minimum length, or minimum depth criteria should the required driving resistance be obtained above the Target Pile Tip Elevation

F Service Uplift Load Resistance = (Ultimate Friction Resistance)/(FS=2 25) Per comment resolution meeting with UDOT (8/15/01)

G Seismic Compression Resistance = Ultimate Friction and End Bearing Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate resistance values to resist seismic loads)

H Seismic Uplift Resistance = Ultimate Friction Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate friction resistance value to resist seismic uplift loads)

I Service Load (DL + LL) The maximum load that can be applied at the top of the pile by the structure provided the pile is driven to the assumed capacity

J Required Driving Resistance - The minimum load (service load x 2 25 or required seismic resistance plus estimated loss during liquefaction whichever is greater) that must be verified in the field by PDA

K Estimated Pile Length w/ Fill - The estimated length of pile required Calculated as (Bottom Of Pile Cap Estimated Tip Elevation) rounded up to the nearest meter (Actual lengths may vary depending on driving conditions encountered at each pile location)

L Estimated Structural Load in the Pile - The largest load that will develop in the pile due to structural service dead loads and drag loads This load occurs at the neutral plane where equilibrium exists between the sum of the downward acting permanent load (service load) applied at the top of the pile and drag load due to negative skin friction and the sum of upward acting positive shaft resistance and mobilized toe resistance

M Estimated Elevation of Neutral Plane - The level in the pile where relative movement between the pile and soil is zero

N Estimated Pile Tip Settlement - The magnitude of pile tip settlement required to mobilize estimated pile tip loads This does not include elastic compression of the pile

418

A19

Memorandum

LEGACY

Date: 11/01/2001 *File Code:* GDM-STR-006 Rev 2.

To: Joe Showers

From: K. N. Gunalan KNGunalan
Curt Christensen

Subject: Geotechnical Recommendations for Bridge 25

Cc: DocC, Kleinfelder, Tom Cooper

Introduction

This memorandum presents our Geotechnical evaluation and recommendations developed in accordance with UDOT's Geotechnical MOI for Bridge 25. Included herein is our evaluation of liquefaction and lateral spread concerns at the bridge location. Detailed descriptions of our understanding of the project, geology, soils encountered etc. will be incorporated into the project Geotechnical report and submitted along with other documents as part of final submittal for the project. This information will be maintained in the project files for reference until being incorporated into the final report.

General Geotechnical Conditions

Geotechnical conditions at the site are defined by previous investigations performed for UDOT. Based on the information obtained during those investigations and a subsequent investigation undertaken by FAK, the profile at the north interchange can be defined as consisting of interbedded medium stiff to stiff silts, clay and loose to medium dense sand and gravel layers in the upper 10 to 15 meters. Dense to very dense silty sands, poorly graded sands and poorly graded gravel with lenses of silts and clays were encountered below 10 to 15 meters. Ground water was encountered at depths ranging from 1.0 to 1.5 meters.

Liquefaction Potential

Bridge 25 falls within the Farmington Siding landslide complex, which consists of liquefaction induced landslides. The bridge site is located within the older mapped portion of this complex, approximately 0.5 km southeast of the mapped contact with the younger portion of the complex. These slides date back to latest Pleistocene and Holocene time. UGS studies indicate that susceptibility to liquefaction induced land sliding may be less than the earlier times due to lower average lake and associated ground water levels. The study also indicated that above average precipitation could create locally perched conditions which when subject to strong ground

motions could liquefy and slide. Therefore, a study was undertaken to evaluate the potential for liquefaction and lateral spread at Bridge 25. Information obtained from a total of nine exploratory borings and four CPT soundings located at or near the bridge site were used in this evaluation. Evaluations indicated layers of silts and sands may liquefy under an earthquake of magnitude 7.3 with a peak horizontal ground acceleration of 0.6g.

Additionally, soil profiles from the borings at the bridge site were reviewed for liquefaction induced lateral spread potential. Based on the analysis, liquefaction induced settlement was determined to range from 73 mm in boring SB-27-345 to 210 mm in boring SB-27-340. The potential for lateral spread was estimated to be negligible in one of the borings with upto 2.8 m in boring SB-27-340. The lateral spread magnitude evaluated in boring SB-27-340 was based on field and laboratory data from Phase I investigations. It is our opinion that further testing would indicate that the layer contributing to the lateral spread is actually made up of thinner layers and therefore the magnitude would be much smaller.

In general, the layers indicating lateral spread potential along the alignment of this structure are less than 1 m in thickness. The database used for the development of the empirical lateral spread equations presently includes limited data for layers less than 1 meter in thickness. For these thinner layers small displacements were observed. Since the database contains only a few points with layers less than 1 m in thickness and observed displacements were small, the estimated displacement for the layers described above is probably greater than the actual displacement potential and the accuracy of these estimates is questionable. In addition, thinner layers should only be considered a candidate for lateral spread if they appear to be continuous. It is our opinion that such a continuous layer does not appear to be present along the alignment of this structure.

Recommendations

It is our understanding that 406 mm (16 in.) diameter pipe piles are being proposed for the bridge foundations and that the anticipated service load per pile at the abutments 1 and 7 range from 1420 kN to 1676 kN. Service load per pile at the bents 2 through 6 range from 565 kN to 968 kN. Seismic uplift resistance required at bent 2 through 6 range from 1870 kN to 2135 kN. Recommended pile capacities and Geotechnical parameters required for analysis and design are presented in attached table.

Cooper, Tom

From: Showers, Joseph I.
Sent: Tuesday, September 04, 2001 1:20 PM
To: 'nmiller@kleinfelder.com'; Kimura, Takahiko; Cooper, Tom; Nobari, Farid
Cc: Gunalan, K. N.; Deschamps, J.D.
Subject: RE: BR-25

Botom of bent footing elevations for Bridge 25 are as follows:

Bent 2 -	1292.0
Bent 3 -	1292.0
Bent 4 -	1293.0
Bent 5 -	1294.4
Bent 6 -	1294.4

We are stil working on the abutment footing elevations.

-----Original Message-----
From: Nigel Miller [mailto:nmiller@kleinfelder.com]
Sent: Tuesday, September 04, 2001 3:18 PM
To: 'kimura@pbworld.com'; 'cooper@pbworld.com'; 'nobari@pbworld.com'
Cc: 'gunalan@pbworld.com'; 'cchristensen@kleinfelder.com';
'showers@pbworld.com'
Subject: BR-25

We are looking for loads and elevations (bottom of pile cap for bents and abutments, lowest deck elevation for abutments) for Bridge 25. Please let us know when we can expect this information.

Nigel Miller
Staff Geotechnical Engineer

Kleinfelder, Inc.
2677 East Parley's Way
Salt Lake City, UT 84109

PHONE 1.801.466.6769
FAX 1.801.466.6788

Cooper, Tom

From: Williams, David (US)
Sent: Wednesday, August 15, 2001 3:35 PM
To: Wang, Fuxin
Cc: Cooper, Tom
Subject: Legacy, Bridge 22 - Foundation Analyses

Frank,

Summary of results for Bents 5 and 6.

As before for Bents 2 and 3, the results for the unimproved soil are acceptable for all configurations and thus we did not investigate soil improvement for these foundations. Again note the high axial capacity requirements (required to resist the high overturning moment). This may determine the requirement for number of piles, and soil improvement will have negligible effect on the axial load condition. Again, I believe the pile length will be based on axial tension capacity for seismic-induced plastic moment. Assuming this can be met (and I think this will be a challenge), then the 24-pile arrangement is satisfactory for the 28' square footings and the 36-pile arrangement is satisactory for the 18' x 36' footing at Bent 5.

(Natural Soil Profiles)

	Bent 6		Bent 5 (36-pile)	
	32-pile	24-pile	Trans	Long
The pile head displacement (mm)	50	70	20	10
The max moment in pile (kN-m)	180	240	180	190
The max stress in pile (MPa)	170	220	200	170
Max pile axial loads (kN)	-1350	-1500	-1800	-1000
	+1900	+2200	+2550	+1700

Any questions, please let me know.

Regarding GROUP output, we have several runs for most bents. Do you want output for all cases?

David

-----Original Message-----
From: Wang, Fuxin
Sent: Wednesday, August 15, 2001 2:08 PM
To: Williams, David (US)
Subject: group

David, could you email me the output file for the 24 and 32 pile group analysis you did for bridge 22

Frank

Fuxin Wang, PE
Parsons Brinckerhoff

Phone: (916) 567 - 2556
Fax: (916) 925 - 3517

There are no shortcuts to any place worth going

Ramirez, Carlos

From: Wang, Fuxin
Sent: Thursday, September 06, 2001 9:23 AM
To: Ramirez, Carlos
Subject: FW: Legacy, Bridge 22, Foundation Springs

carlos, here are springs David offered for bridge 22.

Frank

Fuxin Wang, PE
Parsons Brinckerhoff

Phone: (916) 567 - 2556
Fax: (916) 925 - 3517

There are no shortcut to any place worth going

-----Original Message-----
From: Williams, David (US)
Sent: Wednesday, August 08, 2001 6:14 PM
To: Wang, Fuxin
Cc: Cooper, Tom
Subject: Legacy, Bridge 22, Foundation Springs

These are reasonable spring values to use for the foundation.

Horizontal: 300,000 kN/m = 20556 k/ft
Rotation: 7×10^7 kN-m/rad = 5.16×10^7 k-ft/rad
Axial: 10^7 kN/m = 6.85×10^8 k/ft

Any questions, please call

David

415-243-4653

From: Williams, David (US)
Sent: Thursday, August 16, 2001 4:18 PM
To: Kimura, Takahiko
Cc: Cooper, Tom; Ramirez, Carlos; Showers, Joseph I.; Deschamps, J.D.; Sircar, Partha; Dulor, Stephane
Subject: RE: Bridge 25 foundations

Taka,

As discussed with you and Carlos, this memo confirms the summary of our foundation design/analysis for Bridge 25.

Bridge 25 foundation design was based primarily on the detailed analyses we performed for the preliminary foundation designs of the different bents for Bridge 22, as provided by Frank Wang. The design loads are very similar, except that for Bridge 25 the plastic shears are generally higher (shorter columns, especially Bent 2 at 25.3 ft) and the axial load (DL+seismic) at Bent 6 is higher. The soils for each bent at Bridges 22 and 25 are based on the same boring logs. Therefore we assumed the substantiated foundation design for Bridge 22 would suffice and performed confirmatory analyses for Bent 2 with the higher shear load and Bent 6 (poorest soil) with the higher axial load.
[Aside: As with Bridge 22, we assumed the soil overburden on each footing was 2 ft. Stephane has since pointed out the footing may be embedded much deeper. This should be beneficial except for the possibility of increased compression load on the piles.]

Resulting responses were consistent with Bridge 22. Lateral displacements were acceptable (maximum of 80 to 90 mm). Maximum stresses in the piles were well below yield.

Thus with the proviso that the required pile capacities (in both compression and tension) can be achieved (and this is to be provided by geotech), the bent foundation designs for Bridge 22 (refer for pile layout) are appropriate for Bridge 25. These are:

Bent	Footing	Number of Piles
2, 3, 4 and 6	28 ft x 28 ft x 8 5 ft	24
5	18 ft x 36 ft x 8.5 ft	36

If you have any questions or comments, or need more details, please let me know.

David,
Tel: 1-415-243-4653

-----Original Message-----
From: Kimura, Takahiko
Sent: Thursday, August 16, 2001 2:56 PM
To: Williams, David (US)
Cc: Cooper, Tom; Ramirez, Carlos; Showers, Joseph I.; Deschamps, J.D.
Subject: Bridge 25 foundations

David-

Per your request, I've sent you the situation plans for Bridge 25. Please use them to verify the bridge geometry you assumed in your analysis.

Once you have done this, please email the Bridge 25 footing dimensions and pile layouts to us. We need the information in writing so we can document the design for quality control purposes. As we agreed on the phone, you do not have to draw the footings and piles. A written description would be enough.

Also, please send these results to Carlos Ramirez so that he can continue the design of the Bridge 25 bents.

Thanks.

Taka Kimura, P.E.
Parsons Brinckerhoff
1660 Lincoln St. Suite 2100

Ramirez, Carlos

From: Gill, Brendan
Sent: Thursday, July 26, 2001 3:47 PM
To: Ramirez, Carlos
Subject: Footing Elevations - Bridge 25

I have reviewed the top of footing elevations for Bridge 25 that you forwarded to Taka, and they match with the information that we have with one exception. As of this afternoon, Bent 7 has been removed. Spans 6 and 7 have increased in lenght. Ground elevation will be set .6 m from top of footing.

Brendan Gill
Parsons Brinckerhoff
1660 Lincoln St.
Suite 2100
Denver, CO 80264
Phone: (303) 390-5884
Fax: (303) 832-9096

Ramirez, Carlos

From: Cooper, Tom
Sent: Tuesday, July 17, 2001 7:38 PM
Nugent, Victoria; Nobari, Farid; Wang, Fuxin; Consolacion, Benjamin; Gouge, Vickie; Ramirez, Carlos; Dulor, Stephane
Cc: Seyedmadani, Ali; Murillo, Juan A.
Subject: Legacy Foundations Design Assignments.xls

Legacy Foundations Design Assi...

Please see the attached schedule of foundation design and checking assignments for the Legacy Parkway project.
A more detailed schedule is available. The due date shown is the date we need to submit checked plans for pile (LEVEL 2) to the Independent Quality Firm (IQF) prior to submitting them to UDOT. Checked calcs should be available at this date.
Pile loads should be submitted to the geotechs (through me) at least one week prior to the Level 2 submittal so that we can have pile data available to put on the plans for the Level 2 submittal.

As most of you know, the contractor is driving piles and intends to continue doing so. That means that these dates are very real. We've done a good job so far at providing designs to get the project started on time. The next 2 to 3 months will be critical in making this project a success. We have to hit these dates, we have to be responsive, we have to be complete.
We are very close to having a template in place that is productive.
The fun is just begining.

Tom

Ramirez, Carlos

From: Cooper, Tom
Sent: Thursday, September 13, 2001 3:15 PM
To: Wang, Fuxin; Ramirez, Carlos
Subject: FW: Bridge 22/25 Foundation Design, Pier 5

For you design notes.

-----Original Message-----
From: Williams, David (US)
Sent: Wednesday, September 12, 2001 6:12 PM
To: Cooper, Tom
Subject: RE: Bridge 22/25 Foundation Design, Pier 5

Tom,

Analysis of Pier 5 foundation for the applied plastic moment of 71,000 kip-ft and corresponding shear of 2100 kip. The footing has 36 piles and lateral response is satisfactory. The critical response is axial pile load caused by the overturning moment in the narrow direction (18 ft wide). The pile loads are 490 kip in tension and 710 kip in compression. Note that all 9 piles in the perimeter row reach this load so load redisribution is not effective.

By removing the moment contribution from the passive earth pressure on the pile cap the tension load reduces to 470 kip, but this is questionable because lateral displacements may not be sufficient to mobilize the full passive earth resistance on the pile cap.

David

Ramirez, Carlos

From: Wang, Fuxin
Sent: Tuesday, September 04, 2001 4:09 PM
To: Ramirez, Carlos
Subject: FW: Rectangular footings on BR 22 & 25

Frank

Fuxin Wang, PE
Parsons Brinckerhoff

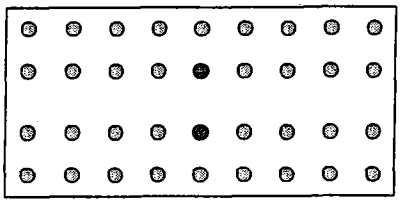
Phone: (916) 567 - 2556
Fax: (916) 925 - 3517

There are no shortcuts to any place worth going

-----Original Message-----
From: Kimura, Takahiko
Sent: Tuesday, September 04, 2001 2:06 PM
To: Wang, Fuxin
Cc: Cooper, Tom; Nobari, Farid; Showers, Joseph I.; Miyamoto, Michael (Denver); Deschamps, J.D.
Subject: Rectangular footings on BR 22 & 25

Frank-

Thank you for sending the plan view of the rectangular footings on Bridges 22 & 25. As we discussed over the phone, I'd like to see if we could get rid of the 2 piles shown below (shown in red). The reason behind this is that the column rebar coming down into the footing will interfere with the pile rebar.



Taka Kimura, P.E.
Parsons Brinckerhoff
1660 Lincoln St. Suite 2100
Denver, CO 80264
PHONE: (303) 390-5861
FAX: (303) 832-9096

From: Nobari, Farid
Sent: Tuesday, September 04, 2001 4.13 PM
To: Showers, Joseph I.
Cc: Cooper, Tom, Wang, Fuxin; Ramirez, Carlos; Kimura, Takahiko
Subject: RE: bar space conflict

Joe,
Our evaluations show that the 16 bars can be cut within one meter below the cap In summary

Half of the bars (total of 50, or 25 bundles of 2) continue into the cap per original design.
The remaining half shall be cut-off at the bottom of cap, with allowance to burn 16 of these bars (i.e 8 bundles of 2) somewhere within the top 1 meter (from bottom of the cap)

We will be able to back this up with necessary calculations.

Please let us know if there are other issues related to this topic

Thanks

Farid

-----Original Message-----
From: Showers, Joseph I.
Sent: Tuesday, September 04, 2001 3:17 PM
To: Nobari, Farid
Cc: Cooper, Tom; Wang, Fuxin; Ramirez, Carlos; Kimura, Takahiko
Subject: RE: bar space conflict

You are going to loose 4 bars (2 bundles) per sleeve, so my guess is 16 total. Assume uniformly spaced removals. The contractor is going to burn these anyway, so it would be better if we approved it in advance. If you guys are OK with it, we will place a note on the drawings stating this Otherwise, the QC police are going to write up the contractor every time the cutting torch comes out.

-----Original Message-----
From: Nobari, Farid
Sent: Tuesday, September 04, 2001 3:51 PM
To: Showers, Joseph I.
Cc: Cooper, Tom; Wang, Fuxin; Ramirez, Carlos; Kimura, Takahiko; Nobari, Farid
Subject: RE: bar space conflict

Joe,
Upon our discussions this morning, we further refined our demand and capacity envelop calculations to see if we can eliminate the need to develop the shorter set of bundled bars in the bent cap (previously noted as 250 mm preference)

WE CONCLUDE THAT HALF OF THE BUNDLED SETS (EVERY OTHER ONE) CAN BE CUT-OFF DIRECTLY AT COLUMN-CAP INTERFACE, FOR BRIDGES 22 & 25.
(this is based on the governing column length, etc as we spoke this morning)

As far as the 2 5" sleeves within the top 1 meter, **how many** of these rods/bolts are involved. If there are a few (say one per side of the columns) we can **cut only those bars** that have conflict with the sleeves, at one meter below cap Would that work for you/contractor?

Farid

-----Original Message-----

From: Showers, Joseph I.
Sent: Tuesday, September 04, 2001 9:26 AM
To: Nobari, Farid; Kimura, Takahiko
Cc: Cooper, Tom; Wang, Fuxin, Ramirez, Carlos, Kimura, Takahiko
Subject: RE: bar space conflict

Another follow up. I talked to Ken this morning about the rebar cutoffs. He has form brackets that support the single column cap forms. These brackets are attached to the column with 2 inch diameter bolts in 2 1/2 inch sleeves. The bars and sleeves need to pass through the forest of vertical steel in the column The brackets and bolt sleeves are located less than a meter from the top of the column. IF we could place the cutoff point at 1 meter below the bottom of cap, we would give the contractor a lot more room to place his sleeves. Do you think that 1 meter would work?

-----Original Message-----
From: Showers, Joseph I.
Sent: Tuesday, September 04, 2001 10 01 AM
To: Nobari, Farid
Cc: Cooper, Tom, Wang, Fuxin; Ramirez, Carlos; Kimura, Takahiko
Subject: RE: bar space conflict

OK, I agree with your column heights of 8 to 9 meters. One of these days, I'll figure out that you don't do calcs the day after a vacaction day.

-----Original Message-----
From: Showers, Joseph I.
Sent: Tuesday, September 04, 2001 8:48 AM
To: Nobari, Farid
Cc: Cooper, Tom, Wang, Fuxin; Ramirez, Carlos, Kimura, Takahiko
Subject: RE· bar space conflict

You are right, it is surprising We figured the height of the columns (top of footing to bottom of cap) is on the order of 13 to 15 meters. The bottom of the cap is about 85% of the distance between the top of footing and top of cap. We assumed that since the columns are "flagpoles", the location where we could develop and drop off half the vertical steel would be a lot lower than the top of column location But these are the numbers, so we will go with it.

Now, from a detailing perspective, all of that vertical steel is creating a major problem by interfering with the cap steel. The footing was a pain to deal with, but we did have a lot of room down there to shift steel around. We don't have any room in the cap. You say you prefer to extend this rebar, but is it absolutely necessary? Will the column break in half if we don't do it? If we can't build the caps, we can't build the bridge.

Please respond regarding the necessity to continue all of the vertical column steel into the cap

-----Original Message-----
From: Nobari, Farid
Sent: Friday, August 31, 2001 6:10 PM
To: Showers, Joseph I.
Cc: Cooper, Tom; Wang, Fuxin; Ramirez, Carlos
Subject: FW: bar space conflict

Joe,
In response to your inquiry of cutting half of the bundled bars below the cap for bridges 22 and 25, Frank and Carlos looked into the possibility
We worked with the shortest column (about 7 5 m) so we can come up with ONE answer for you It might be surprising to you, but since the columns are fairly short and fat, when considering the depth of the flared bent caps, and the c g of the superstructure mass. Cutting the bars at about the bottom of the cap is marginally acceptable. In fact as Frank notes below, the numbers require 250 mm embedment into the cap, with 100 mm confinement spacing in the upper 2 5 length of the columns (if possible).

Hope this helps. Call me if you have any questions

Have a good weekend

Farid

-----Original Message-----

From: Wang, Fuxin
Sent: Friday, August 31, 2001 4:35 PM
To: Nobari, Farid
Cc: Ramirez, Carlos
Subject: bar space conflict

Farid,
Based on our evaluations, we conclude that half of the bundled column bars (bridges 22 and 25) can be cut-off at about the bottom of the bent cap. It is preferred (if possible) to continue these shorter bars in to the bent cap for at least 250 mm.

Also please note the above location is based on extending the shorter bundled bars sufficiently to develop the strength of the bar, where the demands require them. To reduce this development length (cut the bars at about bottom of the cap) for these epoxy-coated bars, we had to depend on confinement steel spacing of 100 mm for the upper 2.5 m of the column (directly below the cap). This in effect will allow us to reduce the required development length by 25% (which we needed), see AASHTO 8.25.3.3).

The above evaluation considers all columns within the two structures.

Please let me know if there are other issues you need me to check on this subject.

Frank

Fuxin Wang, PE
Parsons Brinckerhoff

Phone: (916) 567 - 2556
Fax: (916) 925 - 3517

There are no shortcut to any place worth going

Williams, David (US)

To: Kimura, Takahiko
Cooper, Tom; Ramirez, Carlos; Showers, Joseph I.; Deschamps, J.D ; Sircar, Partha; Dulor, Stephane
Subject: RE. Bridge 25 foundations

Taka,

As discussed with you and Carlos, this memo confirms the summary of our foundation design/analysis for Bridge 25.

Bridge 25 foundation design was based primarily on the detailed analyses we performed for the preliminary foundation designs of the different bents for Bridge 22, as provided by Frank Wang. The design loads are very similar, except that for Bridge 25 the plastic shears are generally higher (shorter columns, especially Bent 2 at 25.3 ft) and the axial load (DL+ seismic) at Bent 6 is higher. The soils for each bent at Bridges 22 and 25 are based on the same boring logs. Therefore we assumed the substantiated foundation design for Bridge 22 would suffice and performed confirmatory analyses for Bent 2 with the higher shear load and Bent 6 (poorest soil) with the higher axial load.
[Aside: As with Bridge 22, we assumed the soil overburden on each footing was 2 ft. Stephane has since pointed out the footing may be embedded much deeper. This should be beneficial except for the possibility of increased compression load on the piles.]

Resulting responses were consistent with Bridge 22. Lateral displacements were acceptable (maximum of 80 to 90 mm). Maximum stresses in the piles were well below yield.

Thus with the proviso that the required pile capacities (in both compression and tension) can be achieved (and this is to be provided by geotech), the bent foundation designs for Bridge 22 (refer for pile layout) are appropriate for Bridge 25. These are:

Bent	Footing	Number of Piles
2, 3, 4 and 6	28 ft x 28 ft x 8.5 ft	24
5	18 ft x 36 ft x 8.5 ft	36

If you have any questions or comments, or need more details, please let me know.

David.
Tel: 1-415-243-4653

-----Original Message-----
From: Kimura, Takahiko
Sent: Thursday, August 16, 2001 2:56 PM
To: Williams, David (US)
Cc: Cooper, Tom; Ramirez, Carlos; Showers, Joseph I.; Deschamps, J.D.
Subject: Bridge 25 foundations

David-

Per your request, I've sent you the situation plans for Bridge 25. Please use them to verify the bridge geometry you assumed in your analysis.

Once you have done this, please email the Bridge 25 footing dimensions and pile layouts to us. We need the information in writing so we can document the design for quality control purposes. As we agreed on the phone, you do not have to draw the footings and piles. A written description would be enough.

Also, please send these results to Carlos Ramirez so that he can continue the design of the Bridge 25 bents.

Thanks.

Taka Kimura, P.E.
Parsons Brinckerhoff
1660 Lincoln St. Suite 2100
Denver, CO 80264
(303) 390-5861

Williams, David (US)

From: Ramirez, Carlos
ent: Tuesday, August 14, 2001 3:42 PM
o: Williams, David (US)
Subject: Bridge 25 Information

Hi David,
Use the following inforamtion for Bridge 25 substructure design:

**Max Plastic Shear = 2307 kips = 10262 kN*

** Plastic Moment = 58370 k-ft = 79150 kN-m*

** Axial Loads at bottom of column due to DL & EQ* (mainly DL - single column)

top of pile cap ✓

Bent	Axial Load	H(ft)	V_p (kip)	V_p (kN)	Total Axial Load (col. wt (incl.) + pile cap wt + soil wt.)
2	2,487	25.3	2307	10,260	2487+237+1000+188 = ~~3912~~ 3675 K = ~~17,408~~ 16,300 kN
3	2,804	30.6	1908	8490	2804+237+1000+188 = ~~4229~~ 4000 K = 18,819 kN 17,800
4	2,645	27.5	2123	9440	2645+237+1000+188 = ~~4070~~ 3830 K = 18,112 kN
5	2,670	29.0	2013	8950	2670+237+1000+188 = ~~4095~~ 3860 K = ~~18,223~~ 17,200 kN
6	3,293	28.6	2041	9080	3293+237+1000+188 = ~~4718~~ 4480 K = ~~20,995~~ 19,900 kN

** Soil Parameters at all bents (see attached files)*

If you have any questions please let me know.
Carlos

S-25-1 LPILE August.pdf
S-25-2 LPILE August.pdf
S-25-3 LPILE August.pdf
S-25-4 LPILE August.pdf
S-25-5 LPILE August.pdf
S-25-6 LPILE August.pdf

depth= -0.6 to 2.6; Sand (API)
c= 0; gamma= 18

$\phi = 25°$

$\Delta = 50$ mm

depth= 2.6 to 3.9; Soft clay
c= 18; gamma= 6.7

$T = -1470$

$G = 2300$ kN

depth= 3.9 to 6.8; Sand (API)
c= 0; gamma= 10.1

$\phi = 31°$

$f_{max} = 330$ MPa

depth= 6.8 to 10.9; Stiff clay w/free water
c= 50; gamma= 9.7

depth= 10.9 to 20.5; Sand (API)
c= 0; gamma= 10.5

$\phi = 37°$

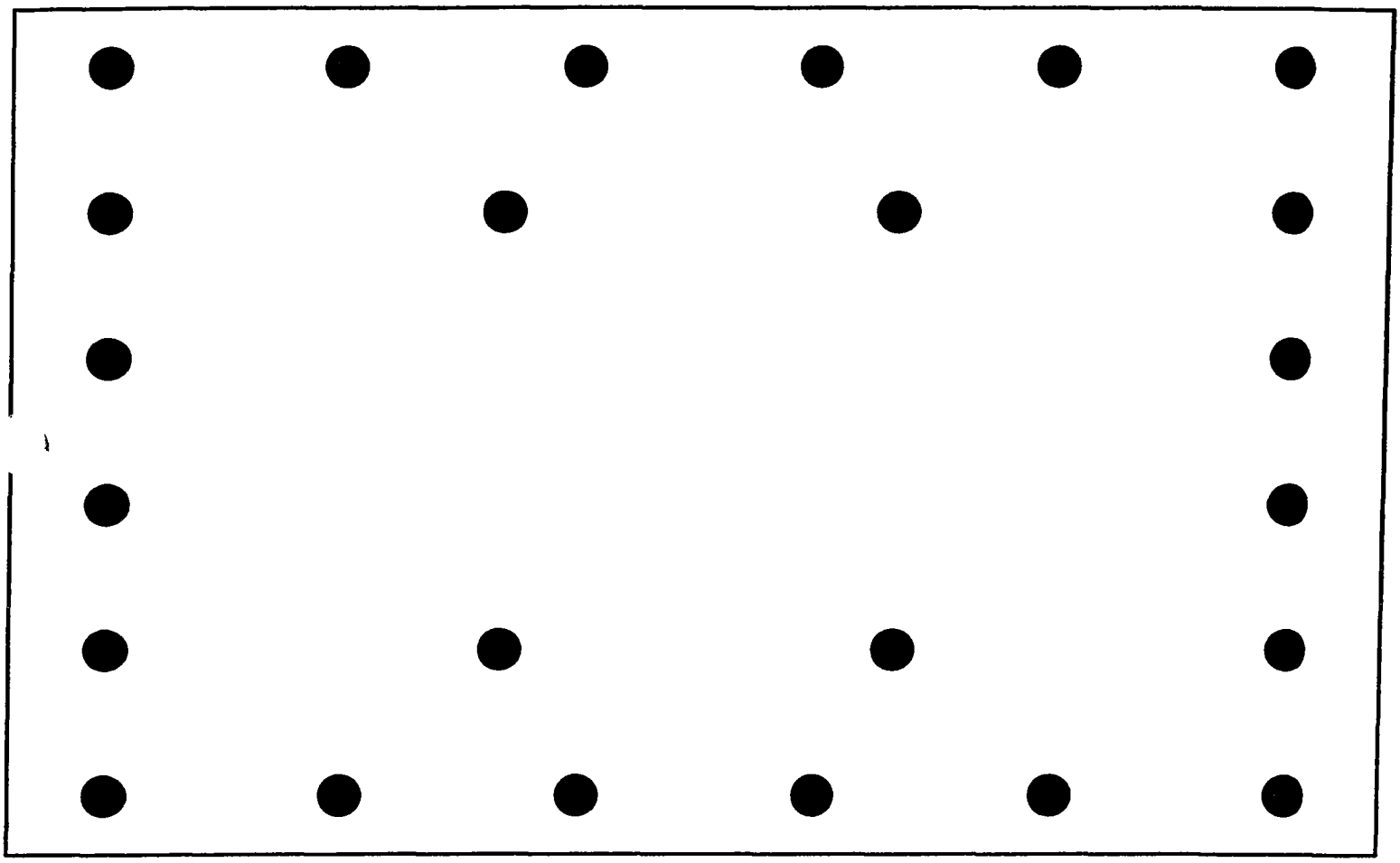
depth= 20.5 to 23.9; Stiff clay w/free water
c= 66.5; gamma= 9.7

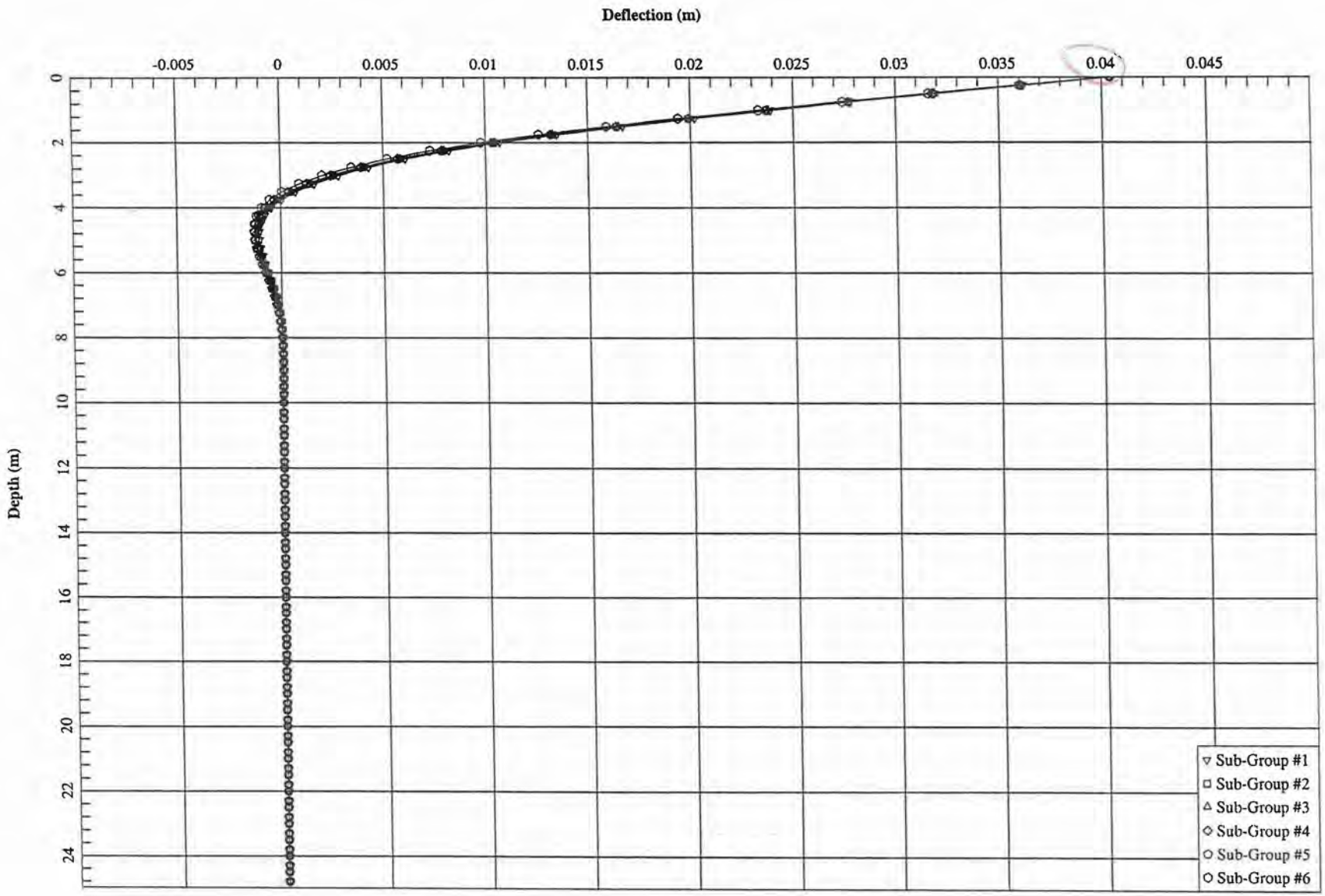
depth= 23.9 to 26.9; Sand (API)
c= 0; gamma= 10.5

$\phi = 40°$

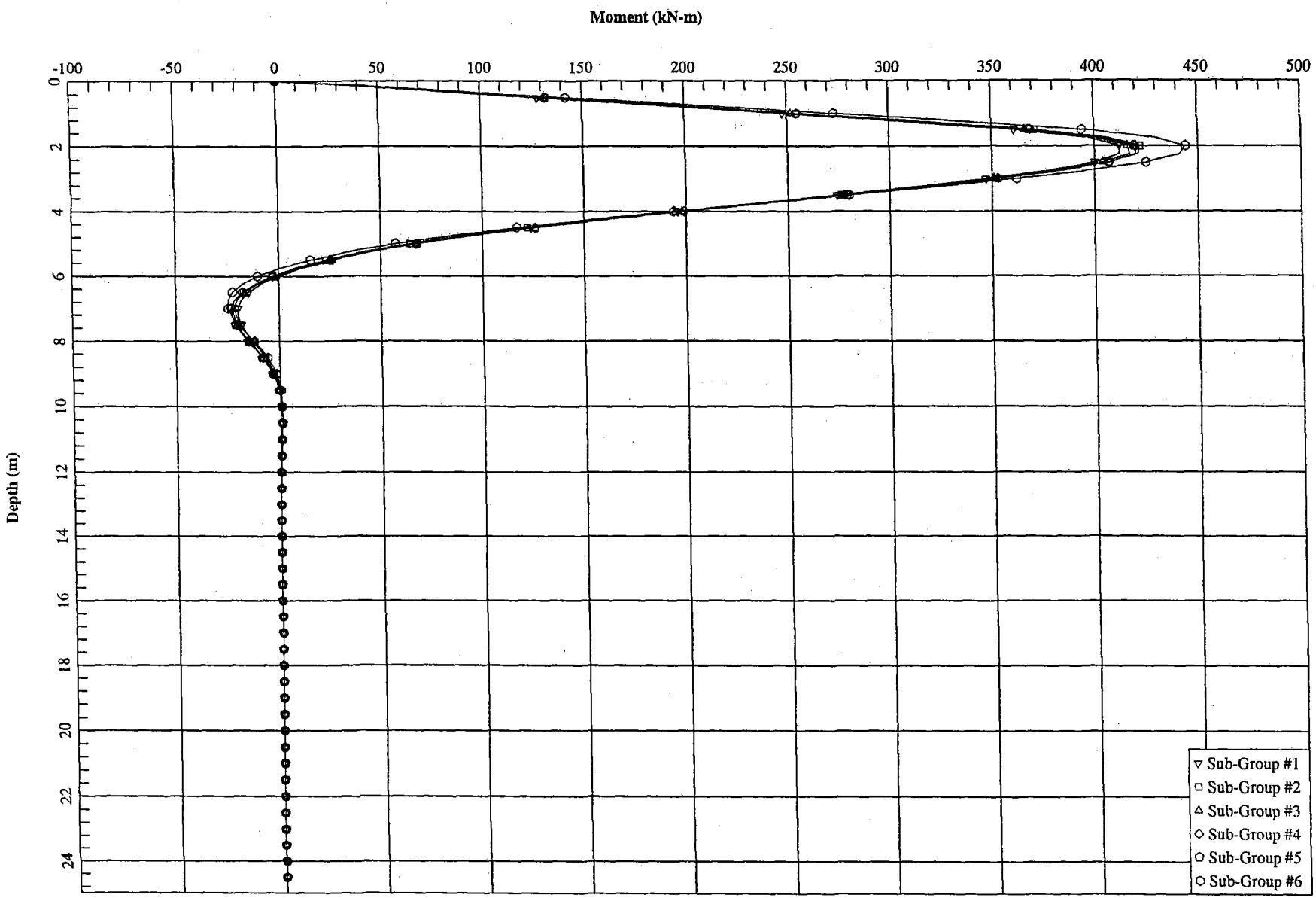
depth= 26.9 to 30; Stiff clay w/free water
c= 154; gamma= 11.4

Legacy Bridge No 2, Bent 2
29 Piles
197





Legacy - Bridge No 25 - Bent 2 - 24 Piles



Legacy - Bridge No 25 - Bent 2 - 24 Piles

depth= -0.6 to 2.9; Sand (API)
c= 0; gamma= 18

$\phi = 20°$

depth= 2.9 to 9, Soft clay
c= 18; gamma= 6 7

depth= 9 to 13.5, Sand (API)
c= 0, gamma= 9.7

$\phi = 30°$

depth= 13.5 to 14 7, Stiff clay w/free water
c= 83; gamma= 9 7

depth= 14 7 to 21.1, Sand (API)
c= 0, gamma= 10 1

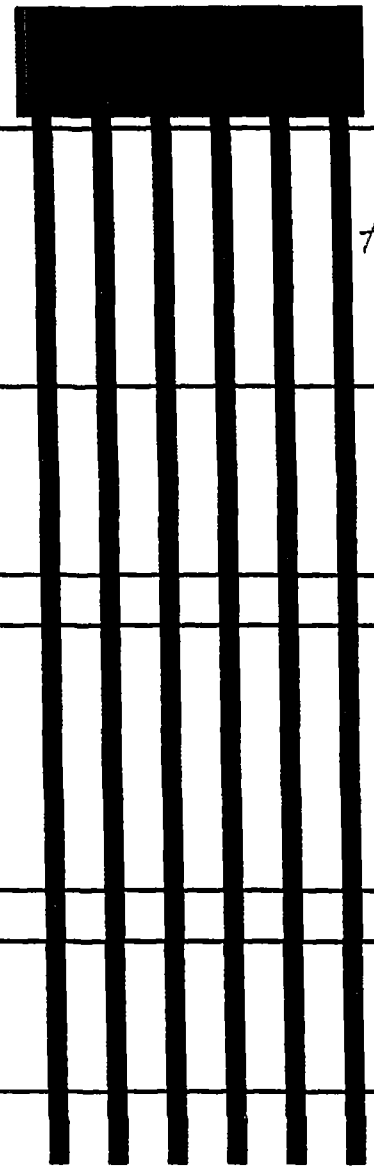
$\phi = 33.5°$

depth= 21 1 to 22.3, Stiff clay w/free water
c= 109; gamma= 11 4

depth= 22 3 to 25 9, Sand (API)
c= 0, gamma= 10 5

$\phi = 40°$

depth= 25 9 to 29; Stiff clay w/free water
c= 128, gamma= 11.4



$\Delta = 80$ mm

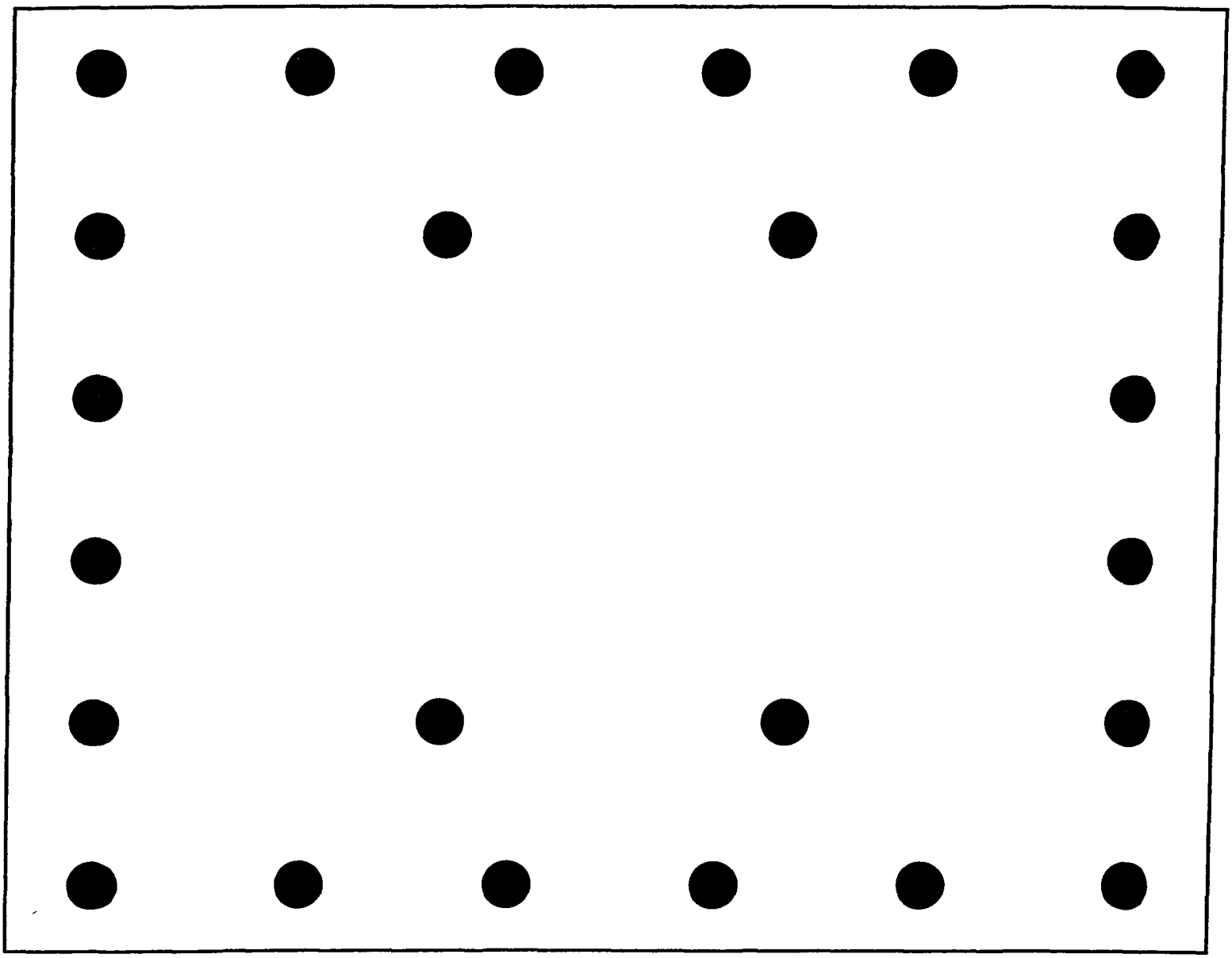
$T = 1530$

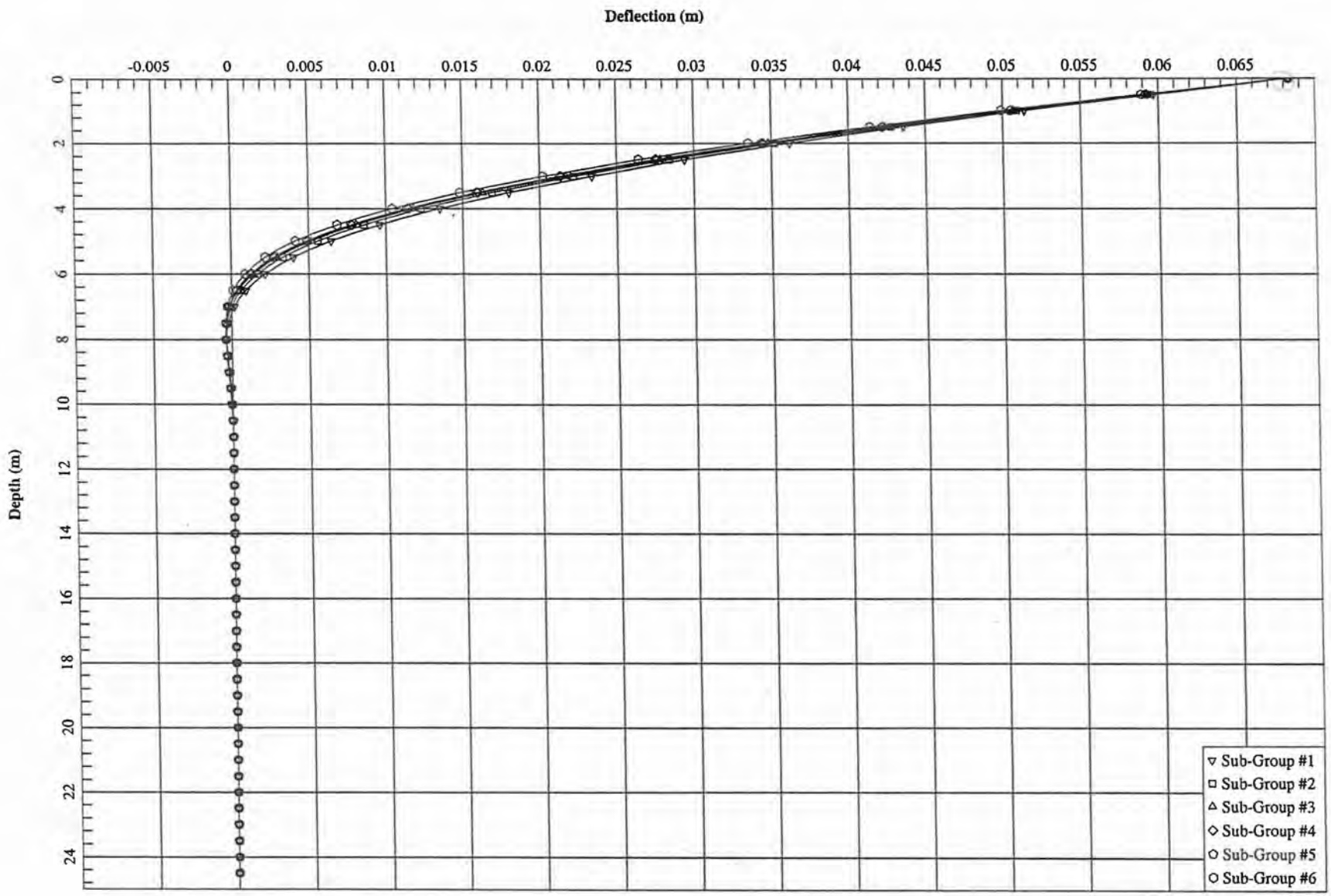
$C = 2250$

$f_{max} = 233$ MPa

Legacy Bridge No 21
Bent No. 6
24 [illegible]

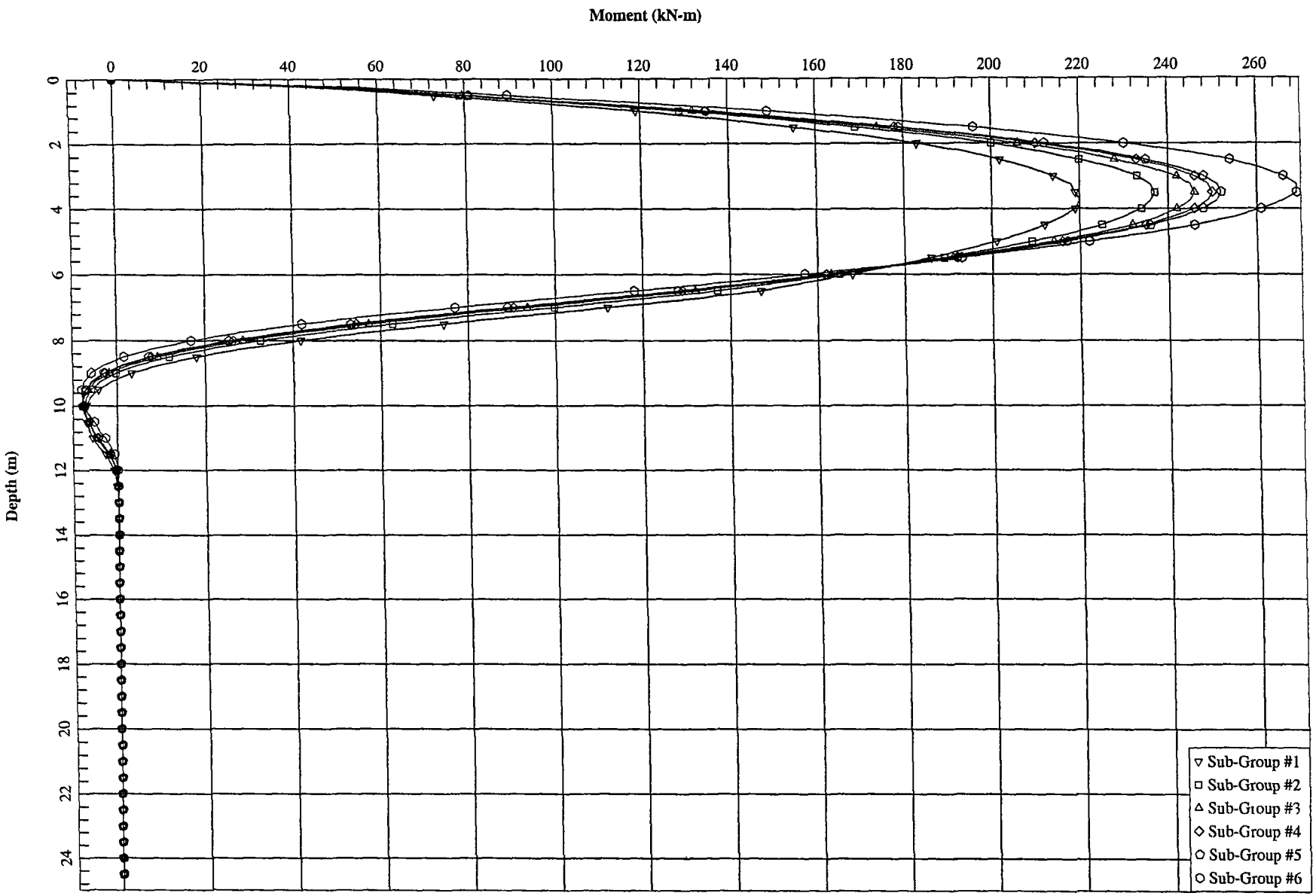
$\phi = 20°$ at top





Legacy - Bridge No 25 - Bent 6 - 24 Piles - 20 Degree Sand on top

68mm



Legacy - Bridge No 25 - Bent 6 - 24 Piles - 20 Degree Sand on top

227 Pile tip 22.5m below pile top. (e.g. in Sand)

Horiz. Load 25 pct. greater than Lateral

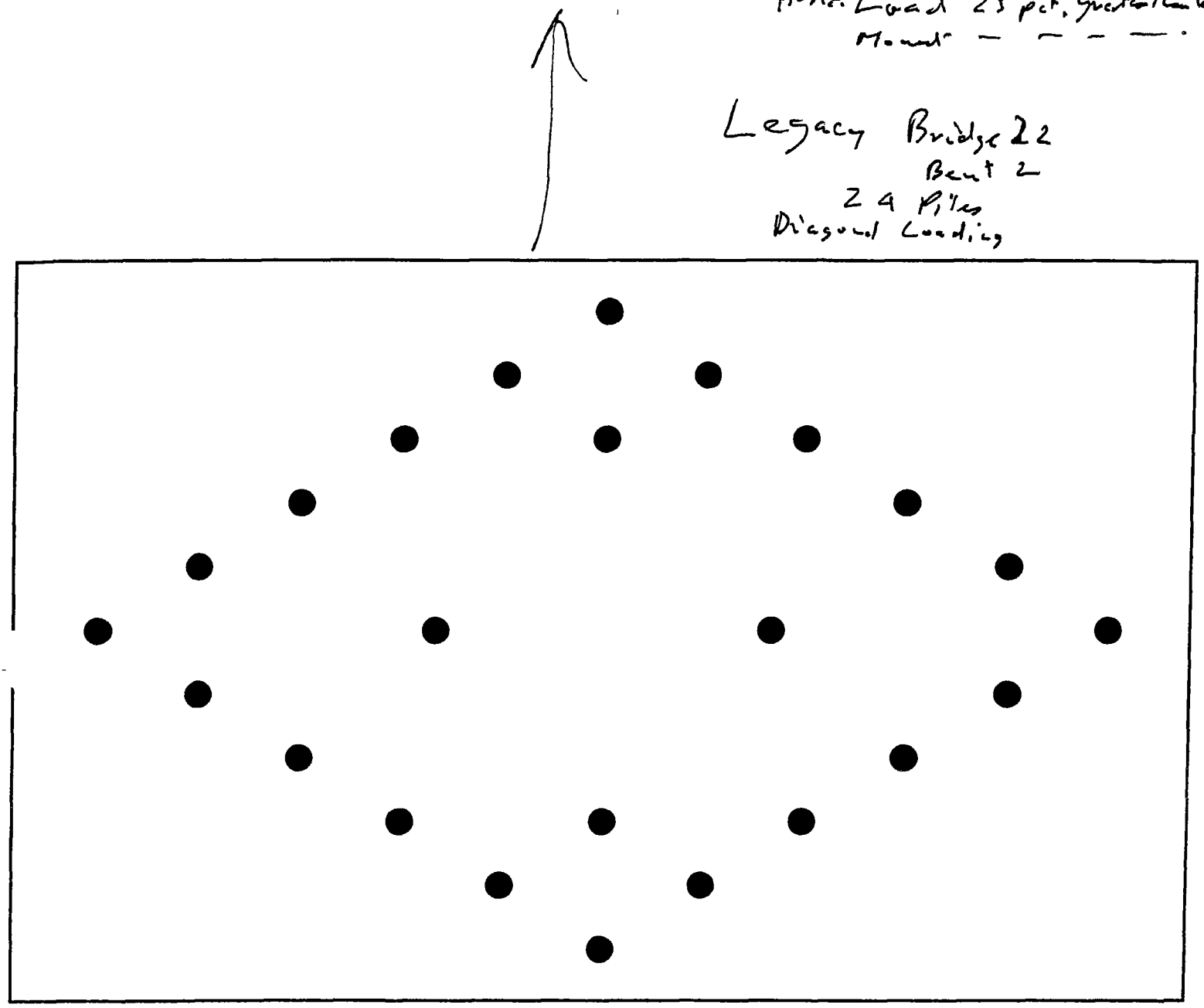
Moment — — — —.

Legacy Bridge 22

Bent 2

24 Piles

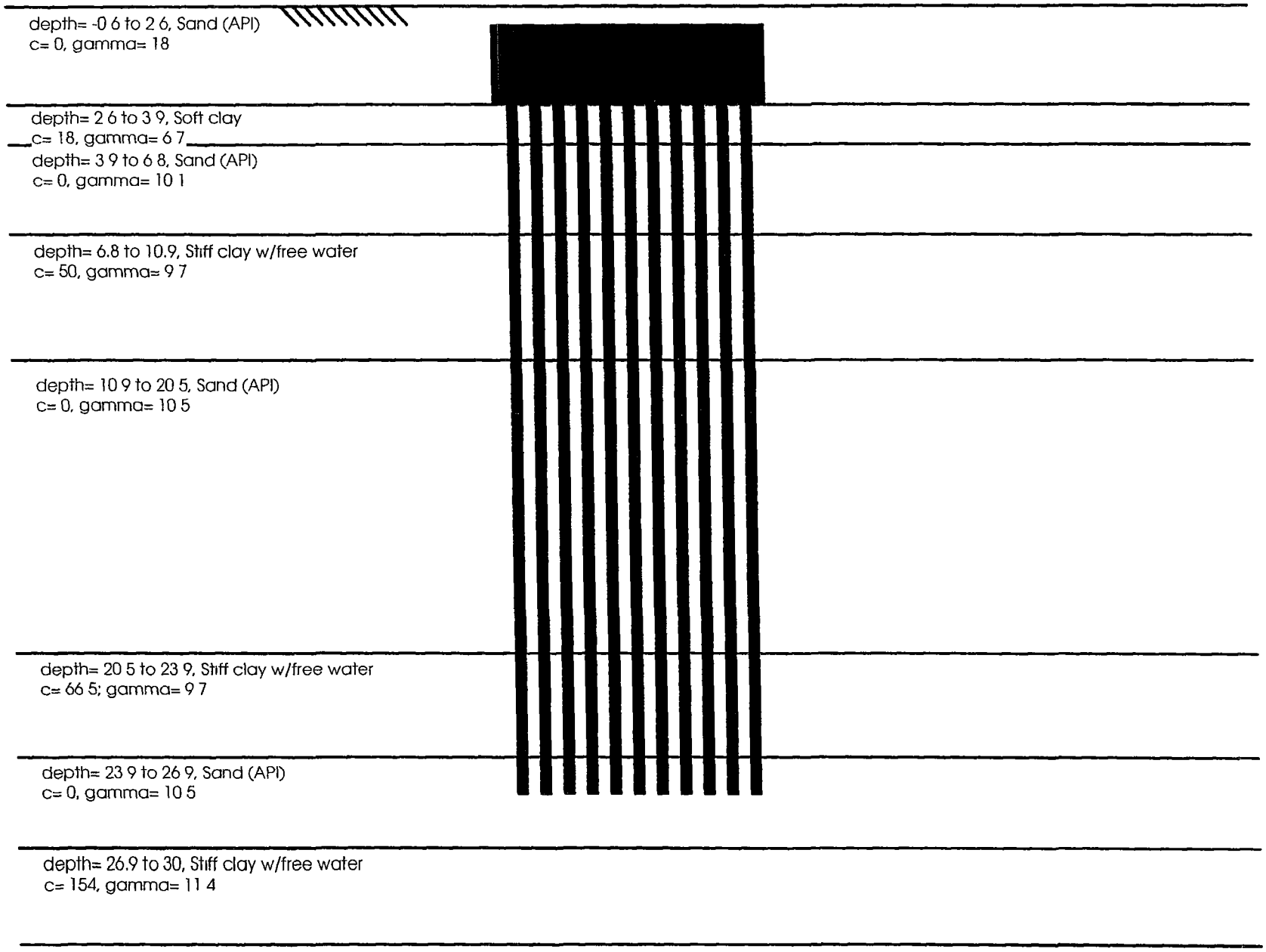
Diagonal Loading

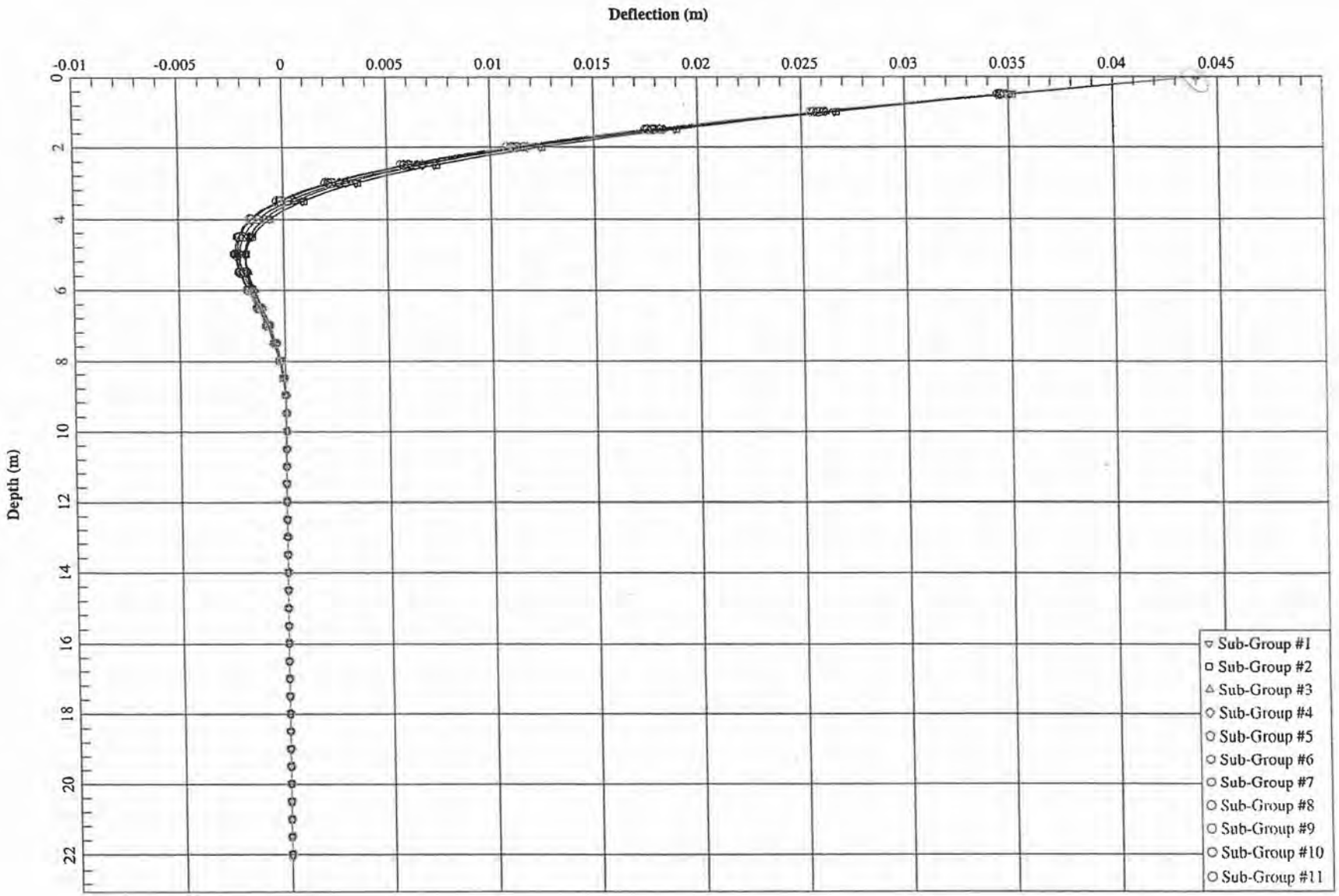


Rotation ≈ 0.01 rad (at pile cap)

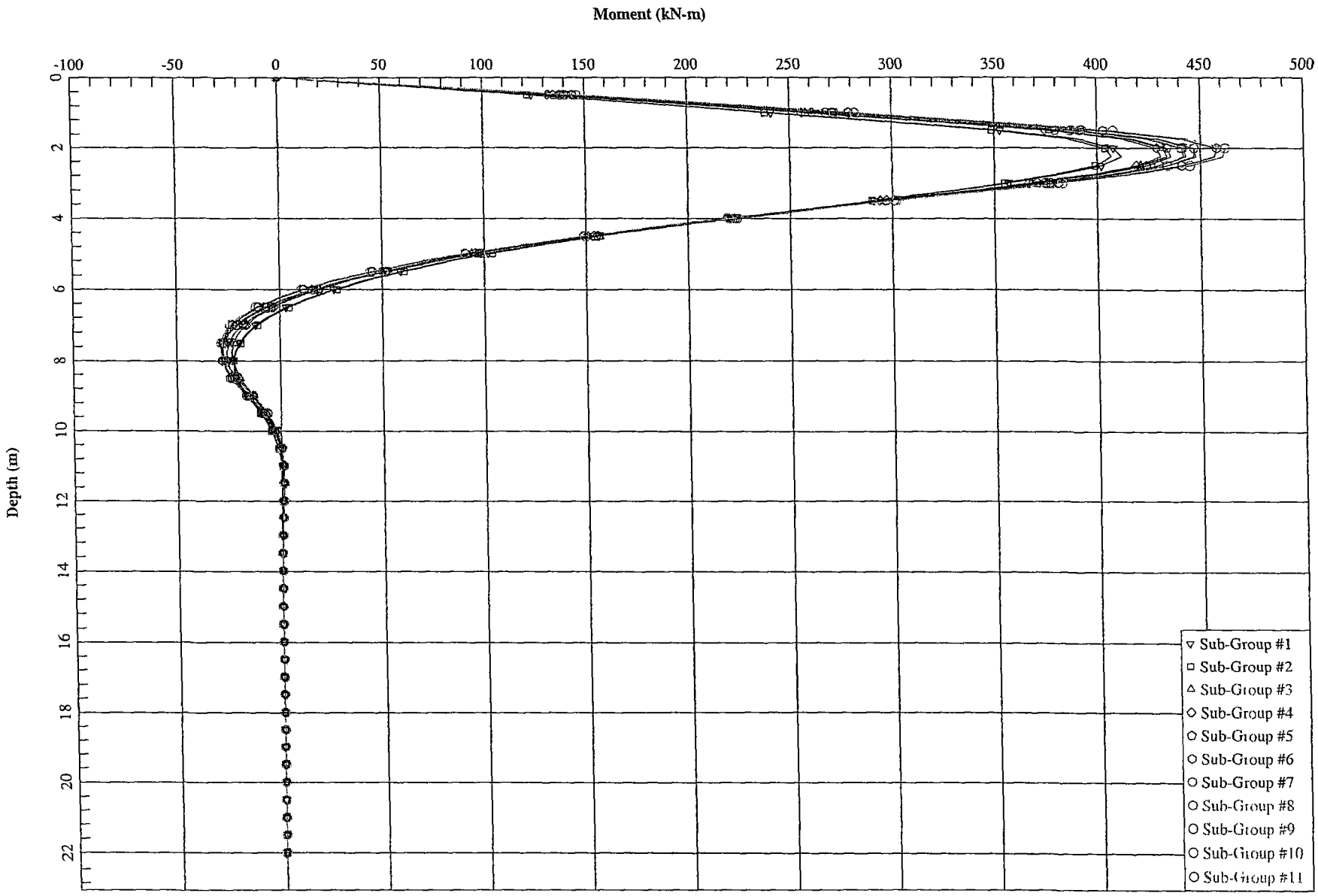
— not acceptable —

Use higher compressive capacity.


depth= -0 6 to 2 6, Sand (API)
c= 0, gamma= 18
depth= 2 6 to 3 9, Soft clay
c= 18, gamma= 6 7
depth= 3 9 to 6 8, Sand (API)
c= 0, gamma= 10 1
depth= 6.8 to 10.9, Stiff clay w/free water
c= 50, gamma= 9 7
depth= 10 9 to 20 5, Sand (API)
c= 0, gamma= 10 5
depth= 20 5 to 23 9, Stiff clay w/free water
c= 66 5; gamma= 9 7
depth= 23 9 to 26 9, Sand (API)
c= 0, gamma= 10 5
depth= 26.9 to 30, Stiff clay w/free water
c= 154, gamma= 11 4



Legacy - Bridge No 22 - Bent 2 - 24 Piles - Diagonal Load - Case 2A



Legacy - Bridge No 22 - Bent 2 - 24 Piles - Diagonal Load - Case 2A

BRIDGE 25: Bearing Forces and Shear Key

➔ DESIGN BEARING RESTRAINT:

Bearing Lateral Forces: Units: kips

Bent	Bearing Lat. Forces		Bearing Lat. Forces (from column force)		1.25 Plastic Shear	
	L	T	L	T	L	T
2	560	564	591	624	590	590
3	359	573	429	658	528	528
4	356	608	428	697	534	534
5	467	609	520	678	587	587
6	509	598	531	652	604	604

Note:

L: Longitudinal direction

T: Transverse direction

Design Bearing Restraint at Bents:

L = 591 kips

T = 697 kips

Design Bearing Restraint at Abutments:

L = free

T = 697 kips

➔ SHEAR KEY

Seismic gap = 0

Shear key gap = service load requirement

➔ INTERIOR DIAPHRAGM DESIGN:

Use maximum bearing transverse load to design the interior diaphragm.

T = 697 kips

Ramirez, Carlos

From: Nobari, Farid
Sent: Monday, October 01, 2001 8:31 AM
To: Showers, Joseph I.; Elwell, John; Baron, Michael J.
Cc: Cooper, Tom; Wang, Fuxin; Ramirez, Carlos
Subject: RE: Bridges 22 & 25 Seismic Design Loads

General Clarification

For bridges 22 and 25, all seismic loads (longitudinal and transverse) have to be transferred to the substructure. This can be called "Pinned Strategy"", as opposed to bearing "Fused Strategy" such as Bridge 26, where after 40%g, bearings will break the welds, and become sliders.
To maintain general pot-bearing type and design details, the same 40% weld connection failure which is used for "Fused Strategy" can be specified for the bearings, HOWEVER, a different load path would then have to be in place to transfer all seismic loads. We have discussed the diaphragm member and connection to be designed for 100% seismic demand.

Essentially the 40% bearing weld connection design, is to protect the bearings from further damage. The restraining bracket (following closure of small nominal gaps) will engage immediately after bearing connection failure, and will be responsible to transfer **all** seismic forces.

For transverse direction, brackets extending below the diaphragm, engaging a raised key from top of the cap is most typical.
For longitudinal direction, brackets extending from bottom of main girders, engaging raised shear keys from top of the cap is typical.

TO SUM IT ALL UP:

1) For steel bridges, we have 2 strategies, so far. Fuse bearing connection so that substructure can be designed for 40%g maximum. ("FUSED STRATEGY")
2) If displacements as a results of fusing are excessive (which in case of 22 & 25 would have been"), the traditional fore method "Pinned Strategy" will have to be used (100% longitudinal and transverse load transfer).

Obviously there are many other options that may work. For now we have been trying to maintain minimum variations between bridges.

-----Original Message-----
From: Showers, Joseph I.
Sent: Saturday, September 29, 2001 10:20 AM
To: Nobari, Farid; Elwell, John; Baron, Michael J.
Cc: Cooper, Tom; Wang, Fuxin; Ramirez, Carlos
Subject: RE: Bridges 22 & 25 Seismic Design Loads

Just to be certain that we are all on the same page,

- **The bearings are going to be designed for shears on the bearing assembly of 40% of dead loads. When the seismic loads exceed this, the welds break (not the bearings). This is the same approach as was used on Bridges 5 and 26 (correct?)**
- Transverse shear forces the exceed the above value of the weld strength will be transferred to the bent caps by way of the "catchers" that project downward from the steel plate diaphragms at the bents.
- It is correct that the bearings are designed to rotate (to a limited extent) and are "pinned" for service live load rotations.
- **AN IMPORTANT CLARIFICATION: Farid - Are we are using "catchers" at the intermediate bents (these are shear blocks extending downward from the bottom flange of the girder) to restrain longitudinal shear forces? The discussion below implies that we are. John - do we have these shown on the information we are sending to Tensor? They used longitudinal catchers on I-15.**
- If the above is correct, then we will need to provide a gap to allow for longitudinal movements used temperature and service loads.

-----Original Message-----
From: Nobari, Farid
Sent: Wednesday, September 26, 2001 2 09 PM
To: Elwell, John; Baron, Michael J.; Showers, Joseph I
Cc: Cooper, Tom; Wang, Fuxin; Ramirez, Carlos
Subject: Bridges 22 & 25 Seismic Design Loads

Per discussions with John/Joe/Tom, the following information & recommendation is provided for **Bridges 22 & 25**

Bearing seismic performance/Restraint engagement gap
Bearings at **all Bents** are **pinned**, requiring the connections to be strong enough to transfer governing lateral loads in Longitudinal and Transverse directions Therefore, seismic strategy requires no sliding gap. Design gaps for service loads/construction tolerance, and keep at a minimum

At **Abutments**, the bearings are **free** to move **longitudinally** (expected to engage back wall), and **restrained transversely.** Therefore transversely there should be no seismic gap (only service load/construction requirements), and longitudinally there should be freedom for seismic movement and engagement of back wall

Bearing Restraint Seismic Design Forces (Forces per bearing)
Bridge **22** Maximum **Longitudinal** Restraint Force at each **Bent= +/- 650 Kips**
Maximum **Transverse** Restraint Force at each **Bent and/or Abutment = +/- 660 Kips**

Bridge **25**: Maximum **Longitudinal** Restraint Force at each **Bent= +/- 650 Kips**
Maximum **Transverse** Restraint Force at each **Bent and/or Abutment = +/- 700 Kips**

Recommendation : Design typical longitudinal bearing restraints for all bents, and transverse restraintaints for bents and abutments, for both bridges 22 and 25, at +/- 700 Kips

Note: +/- strength means, the restraint should be strong enough to resist forward and backward (for longitudinal), and right and left (for transverse) applied loads

Details/Required steel area for reinforced concrete shear key
We have not received to-date details of bent cap/bearing/shear keys to provide any detailed suggestion/recommendation. If the restraint strength is through reinforced concrete shear keys extending above top of the bent cap, then the amount of reinforced steel dowels (acting in shear friction) can be estimated from the design forces above For example for 700 Kips strength, using 60 KSI rebar, Area of required shear key dowels (say reversed u bars) is 700/60=12 square inches.

I Hope the above is helpful for your needs We will compile the supportive material for this information as part of the design calculations

Please call for any questions/clarifications

Sincerely,

Farid S. Nobari, P.E.
Senior Supervising Engineer
Parsons Brinckerhoff, Sacramento
Ph: (916) 567-2531 Fax: (916) 925-3517

-----Original Message-----
From: Elwell, John
Sent: Wednesday, September 26, 2001 6:49 AM
To: Nobari, Farid
Cc: Baron, Michael J ; Showers, Joseph I.
Subject: Bridges 22 & 25 Seismic
Importance: High

Farid,
We are planning to send the Bridge 22 steel info to the detailer on Friday and Br 25 is scheduled to be sent out 10/12. Louisville needs seismic shear forces and shear restrainer gap dimensions for these bridges to design the support diaphragms ASAP (yesterday). Please help.

John Elwell
PARSONS BRINCKERHOFF
510 First Avenue North, Suite 550
Minneapolis, MN 55403
elwell@pbworld.com
ph. 612.677.1266
fax 612.371.4410

Ramirez, Carlos

From: Nobari, Farid
Sent: Wednesday, September 26, 2001 1.38 PM
To: Nobari, Farid; Elwell, John, Baron, Michael J ; Showers, Joseph I.
Cc: Cooper, Tom; Wang, Fuxin, Ramirez, Carlos
Subject: RE Bridges 22 & 25 Seismic Design Loads

In addition to the information I provided below, One other item is addressed here·

Diaphragm Member/Connection Design Forces.
Using the transverse bearing forces at each bent (see below), you can analyze a stand-alone diaphragm system at the bent, with applied load at the deck level, equal and opposite the sum of the bearing transverse loads, to arrive at governing seismic design forces for members and connections
For intermediate diaphragms, you can either conservatively use the same lateral loads for additional 2 panels, or do the following. Realizing that the total applied shear gets accumulated from 2 half spans on either side of each bent, you can interpolate the load intensity at specific intermediate diaphragm locations, apply Factor of Safety and design each system accordingly (i e seismic load on diaphragm at mid-span=0., maximum at ends of the span)

Please call if you have any questions.

Sincerely,

Farid S. Nobari, P.E.
Senior Supervising Engineer
Parsons Brinckerhoff, Sacramento
Ph: (916) 567-2531 Fax: (916) 925-3517

-----Original Message-----
From: Nobari, Farid
Sent: Wednesday, September 26, 2001 1:09 PM
To: Elwell, John; Baron, Michael J., Showers, Joseph I.
Cc: Cooper, Tom; Wang, Fuxin; Ramirez, Carlos
Subject: Bridges 22 & 25 Seismic Design Loads

Per discussions with John/Joe/Tom, the following information & recommendation is provided for **Bridges 22 & 25**

Bearing seismic performance/Restraint engagement gap
Bearings at **all Bents** are **pinned**, requiring the connections to be strong enough to transfer governing lateral loads in Longitudinal and Transverse directions. Therefore, seismic strategy requires no sliding gap Design gaps for service loads/construction tolerance, and keep at a minimum

At **Abutments**, the bearings are **free** to move **longitudinally** (expected to engage back wall), and **restrained transversely.** Therefore transversely there should be no seismic gap (only service load/construction requirements), and longitudinally there should be freedom for seismic movement and engagement of back wall.

Bearing Restraint Seismic Design Forces (Forces per bearing)
Bridge **22** · Maximum **Longitudinal** Restraint Force at each **Bent= +/- 650 Kips**
Maximum **Transverse** Restraint Force at each **Bent and/or Abutment = +/- 660 Kips**

Bridge **25** Maximum **Longitudinal** Restraint Force at each **Bent= +/- 650 Kips**
Maximum **Transverse** Restraint Force at each **Bent and/or Abutment = +/- 700 Kips**

Recommendation : Design typical longitudinal bearing restraints for all bents, and transverse restraintaints for bents and abutments, for both bridges 22 and 25, at +/- 700 Kips.

Note: +/- strength means, the restraint should be strong enough to resist forward and backward (for longitudinal), and right and left (for transverse) applied loads.

Details/Required steel area for reinforced concrete shear key

We have not received to-date details of bent cap/bearing/shear keys to provide any detailed suggestion/recommendation. If the restraint strength is through reinforced concrete shear keys extending above top of the bent cap, then the amount of reinforced steel dowels (acting in shear friction) can be estimated from the design forces above. For example for 700 Kips strength, using 60 KSI rebar, Area of required shear key dowels (say reversed u bars) is 700/60=12 square inches.

I Hope the above is helpful for your needs. We will compile the supportive material for this information as part of the design calculations.

Please call for any questions/clarifications

Sincerely,

Farid S. Nobari, P.E.
Senior Supervising Engineer
Parsons Brinckerhoff, Sacramento
Ph: (916) 567-2531 Fax: (916) 925-3517

-----Original Message-----
From: Elwell, John
Sent: Wednesday, September 26, 2001 6:49 AM
To: Nobari, Farid
Cc: Baron, Michael J.; Showers, Joseph I
Subject: Bridges 22 & 25 Seismic
Importance: High

Farid,
We are planning to send the Bridge 22 steel info to the detailer on Friday and Br 25 is scheduled to be sent out 10/12. Louisville needs seismic shear forces and shear restrainer gap dimensions for these bridges to design the support diaphragms ASAP (yesterday). Please help.

John Elwell
PARSONS BRINCKERHOFF
510 First Avenue North, Suite 550
Minneapolis, MN 55403
elwell@pbworld.com
ph. 612.677 1266
fax 612.371.4410

-----Original Message-----
From: Elwell, John
Sent: Wednesday, September 26, 2001 6:49 AM
To: Nobari, Farid
Cc: Baron, Michael J.; Showers, Joseph I.
Subject: Bridges 22 & 25 Seismic
Importance: High

Farid,
We are planning to send the Bridge 22 steel info to the detailer on Friday and Br 25 is scheduled to be sent out 10/12. Louisville needs seismic shear forces and shear restrainer gap dimensions for these bridges to design the support diaphragms ASAP (yesterday). Please help.

John Elwell
PARSONS BRINCKERHOFF
510 First Avenue North, Suite 550
Minneapolis, MN 55403
elwell@pbworld.com
ph. 612.677.1266
fax 612.371.4410

Ramirez, Carlos

From: Nobari, Farid
Sent: Friday, September 28, 2001 3:57 PM
To: Wang, Fuxin; Ramirez, Carlos
Cc: Cooper, Tom; Nobari, Farid
Subject: Legacy Bridge 22 & 25 - Bearing/diaphragm forces

In recent e-mails, we provided John Elwell bearing forces for Bridges 22 and 25, to be used for diaphragm and bearing connection design. Please remember to add the 2 page tabulation you provided to capture the bearing forces to the design calculations.

Please make an internal cover, title it "calculation amendments dated 9-26-01" and file these calculations and anything we add to our previous submittal under this sub-section, so it is always clear what we have sent them, and what we have amended.

Thanks.

Farid S. Nobari, P.E.
Senior Supervising Engineer
Parsons Brinckerhoff, Sacramento
Ph: (916) 567-2531 Fax: (916) 925-3517

Ramirez, Carlos

From: Nobari, Farid
Sent: Thursday, September 27, 2001 2.50 PM
To: Ramirez, Carlos; Wang, Fuxin
Subject: FW· Bridge 22 and 29 - Seismic Design Calculations

Importance: High

-----Original Message-----
From: Nobari, Farid
Sent: Thursday, September 27, 2001 2:46 PM
To: Williams, David (US); Sircar, Partha
Cc: Kimura, Takahiko; Deschamps, J.D ; Cooper, Tom; Showers, Joseph I.; Dulor, Stephane; Nobari, Farid
Subject: RE: Bridge 22 and 29 - Seismic Design Calculations
Importance: High

David, Partha
As you know last week we have forwarded the compiled design calculations for Bridges 22 and 25 We compiled the structural analysis, design, and check calculations (which were done here in Sacramento), with pile foundation analyses and check (which were done by your office) As a result, maybe a summary memo which could have explained how the pieces go together, is missing to clarify and answer JD's questions
Since I am aware of extensive analysis and check that was done for foundations and lateral soil parameters for bridges 22 and 25, and to assist JD in having audit-ready calculations, I am suggesting/requesting that you prepare a summary memo for bridge 22 and one for 25, and e-mail to all of us, so that JD can print and compile with the calculations. Based on my knowledge of the effort, I suggest the following·

Bridge 22 foundation memo contents
- Analysis by David Williams, Check By Partha
  Several sensitivity analyses were conducted for ranges of soil properties provided by Kleinfelder
  Design of Bents 2, 4, and 6 are all governed by diagonal loading of typical square foundation
- Bent 5 design and analysis was specific for a rectangular foundation, loaded diagonally.
- Abutments 1 and 7 design were governed by Abutment 1

Bridge 25 Foundation memo contents
- Analysis by David Williams, Check by Partha
- Design of Bridge 22 does govern Bridge 25, so minimal analysis was done for Bridge 25 specifically
- Design of Bents 2, 4, and 6 are all governed by diagonal loading of typical square foundation
- Bent 5 design and analysis was specific for a rectangular foundation, loaded diagonally
- Abutments 1 and 7 design were governed by Abutment 1

J.D Agreed that a memo wit the above addressed will be very helpful, however he needs it ASAP. Could David/Partha prepare a single sheet memo for each of the above bridges and forward to all Thanks

Stephanie, It appeared that the question on Bridge 29 was somewhat resolved. You may wish to call JD to see if there is a similar type of single sheet memo that can document pieces went to design of the Bent Cap Carlos (Sacramento) had completed seismic design check of the cap, only

Thanks for you help.

Farid

-----Original Message-----
From: Deschamps, J.D.
Sent: Thursday, September 27, 2001 8.48 AM
To: Nobari, Farid; Cooper, Tom; Showers, Joseph I.
Cc: Kimura, Takahiko
Subject: Bridge 22 and 29 - Seismic Design Calculations

Farid,

I did a quick cursory check of the calculations and I have a few questions.

1.) On Bridge 22 - Pile foundation analysis Volume 2 of 2 there are NO independent calculations. Why? What do I tell the auditor?
2.) In the same binder we have calculations for Bent 2, 3 5 and 6. Where is 4?
3.) There are calculations for Abutment 1 but nothing on abutment 7? Where is this?
4.) Bridge 29 - Pier cap calculations. I have a binder with the Seismic Design check but I can't find calculations with the seismic design calculations. Can you give me binder names and page numbers where everything is located.

Have I missed the text that explains what is going on? Can you get back to me ASAP because the auditor arrives on Monday.

Thanks,

JD

JD Deschamps, PE
Parsons Brinckerhoff
Denver, CO
Tel. 303-832-9091
Direct Dial 303-390-5843
Fax 303-832-9096
deschamps@pbworld.com

BRIDGE 25: ASSUMPTIONS

1 Same backfill as bridge 28 is used in this bridge foundations.
2 Assume the original ground surface is 0.6m higher than footing elevation based on Brendan Gill's email.
3 Soil properties from Kleinfelder is used in this analysis.
4 Assume the pile capacity is 200 ton.
5 Borehole result in support 5 is used in Lpile analysis.
6 Updated footing elevation from Joe Showers on 8/6/01 is used.
7 Modeling the birdge using leffe. for coulumn, use phi (0.5~0.9) and R factor for demeand calculation.
8 Design footing based on plastic overstrength moment Mo=1.3Mn
9 Assume foundations with spring stiffness.
10 Assume Pin connection on top of columns.
11 Assume Shear Key on top of column.
12 Updated footing elevation again based on Joe Showers' email dated on 9/4/01.
13 Assume compression capacity is 3340kN (750kips).
14 Assume Pile Tension Capacity can go as high as 80% of the compression capacity due to pile test.

ABUTMENT 1

LPILE ANALYSIS

LEGACY PARKWAY
BRIDGE 25
PILE CAPACITY SUMMARY - PP 406x9 53 (16" x 3/8")
YIELD STRENGTH = 448 MPa

A-1 Target Geotechnical Capacity per Pile (2.25xService Load)	3,195	kN
B-2 Target Geotechnical Capacity per Pile (2.25xService Load)	1,854	kN
B-3 Target Geotechnical Capacity per Pile (2.25xService Load)	2,032	kN
B-4 Target Geotechnical Capacity per Pile (2 25xService Load)	1,942	kN
B-5 Target Geotechnical Capacity per Pile (2.25xService Load)	1,271	kN
B-6 Target Geotechnical Capacity per Pile (2 25xService Load)	2,178	kN
A-7 Target Geotechnical Capacity per Pile (2 25xService Load)	3,771	kN

(Target Service Load Provided by Structural Engineer)

	Initials	Date
Completed By		
Reviewed By		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Location	Finished Grade Elevation (m)	Bottom of Pile Cap Elevation (m)	Est Embankm. Height (m)	Target Pile Tip Elevation (m)	Minimum Pile Tip Elevation (m)	Service Uplift Load Resistance (kN)	Required Seismic Compression Resistance (kN)	Required Seismic Uplift Resistance (kN)	Service Load (DL + LL) (kN)	Required Driving Resistance (kN)	Est. Pile Length w/ fill (m)	Estimated Maximum Structural Load in Pile (kN) (Service Load + Drag Load)	Est. Elevation of Neutral Plane (m)	Estimated Pile Tip Settlement (mm)
Bridge 25, Abutment 1	1306.3	1300 5	10.3	1283.3	1283.3	588	N/A	29	1,420	3,195	18	2,378	1285 8	6
Bridge 25, Bent 2	1297 0	1292 0	-	1269 5	1269 5	982	3,135	1,870	824	3,567	23	2,257	1273.5	4
Bridge 25, Bent 3	1297 0	1292 0	-	1272 0	1272 0	947	3,135	1,870	903	3,475	20	2,210	1275.9	4
Bridge 25, Bent 4	1297.5	1293 0	-	1273 0	1273.0	930	3,135	1,870	863	3,583	20	2,243	1276 5	4
Bridge 25, Bent 5	1298.0	1294 4	-	1269.4	1269.4	1,199	3,160	2,135	565	4,135	25	2,487	1273 3	4
Bridge 25, Bent 6	1297.5	1294.4	-	1271 3	1271.3	955	3,135	1,870	968	3,350	24	2,159	1276 6	3
Bridge 25, Abutment 7	1310.1	1304 3	12.1	1286 1	1286 1	676	N/A	N/A	1,676	3,771	19	2,985	1287.4	[illegible]

Location	Borings Used for Soil Profile
Bridge 22, Abutment 1	RB-385, SC-27-341, LSB-22-435
Bridge 22, Bent 2	RB-385, SC-27-341, LSB-22-436
Bridge 22, Bent 3	LSB-25-453, SC-27-342
Bridge 22, Bent 4	LSB-22-437
Bridge 22, Bent 5	LSB-25-454, SC-27-344
Bridge 22, Bent 6	LSB-25-455
Bridge 22, Abutment 7	LSB-22-490

Description of Information Presented in Each Column:

A **Finished Grade Elevation** - Top of approach slab elevation at abutment locations and adjacent ground elevation at bent locations as shown on the structure Plan and Profile drawing provided

B **Bottom of Pile Cap Elevation** - Elevation at the bottom of the pile cap as scaled from the structure Plan and Profile drawing provided

C **Estimated Embankment Height** - Elevation difference between the top of the approach slab and the native ground surface at the abutment as scaled from the structure Plan and Profile drawing provided

D **Target Pile Tip Elevation** - Estimated elevation to which the bottom of the pile will need to be driven to develop the required capacity and meet the settlement criteria (Additional depth may be required to reach required resistance during driving)

E **Minimum Pile Tip Elevation** - Estimated minimum elevation to which the bottom of the pile will need to be driven to meet settlement, minimum length, or minimum depth criteria should the required driving resistance be obtained above the Target Pile Tip Elev

F. **Service Uplift Load Resistance** = (Ultimate Friction Resistance)/(FS=2 25) Per comment resolution meeting with UDOT (8/15/01)

G **Seismic Compression Resistance** = Ultimate Friction and End Bearing Resistance neglecting the contribution of potentially liquefiable zones. (AASHTO allows the use of the ultimate resistance values to resist seismic loads)

H **Seismic Uplift Resistance** = Ultimate Friction Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate friction resistance value to resist seismic uplift loads)

I **Service Load (DL + LL)** - The maximum load that can be applied at the top of the pile by the structure provided the pile is driven to the assumed capacity

J **Required Driving Resistance** - The minimum load (service load x 2 25 or required seismic resistance plus estimated loss during liquefaction, whichever is greater) that must be verified in the field by PDA.

K. **Estimated Pile Length w/ Fill** - The estimated length of pile required Calculated as (Bottom Of Pile Cap - Estimated Tip Elevation) rounded up to the nearest meter (Actual lengths may vary depending on driving conditions encountered at each pile location.)

L **Estimated Structural Load in the Pile** - The largest load that will develop in the pile due to structural service dead loads and drag loads This load occurs at the neutral plane where equilibrium exists between the sum of the downward acting permanent load (service load) applied at the top of the pile and drag load due to negative skin friction and the sum of upward acting positive shaft resistance and mobilized toe resistance

M **Estimated Elevation of Neutral Plane** - The level in the pile where relative movement between the pile and soil is zero

N **Estimated Pile Tip Settlement** - The magnitude of pile tip settlement required to mobilize estimated pile tip loads This does not include elastic compression of the pile

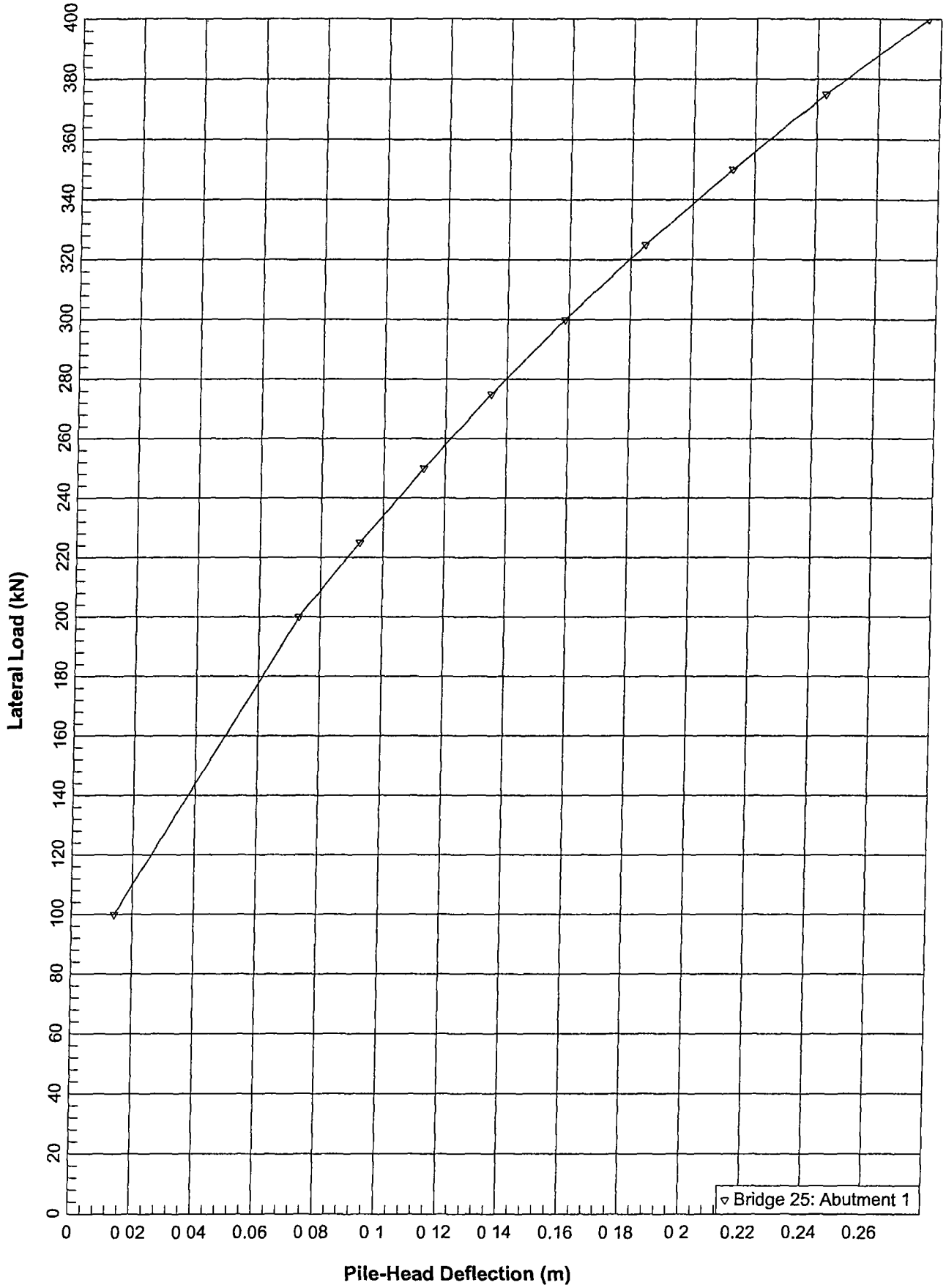
Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	25
Support(s)	1,2
Water Depth (m)	1 5
Boring Elevation (m)	1295 5

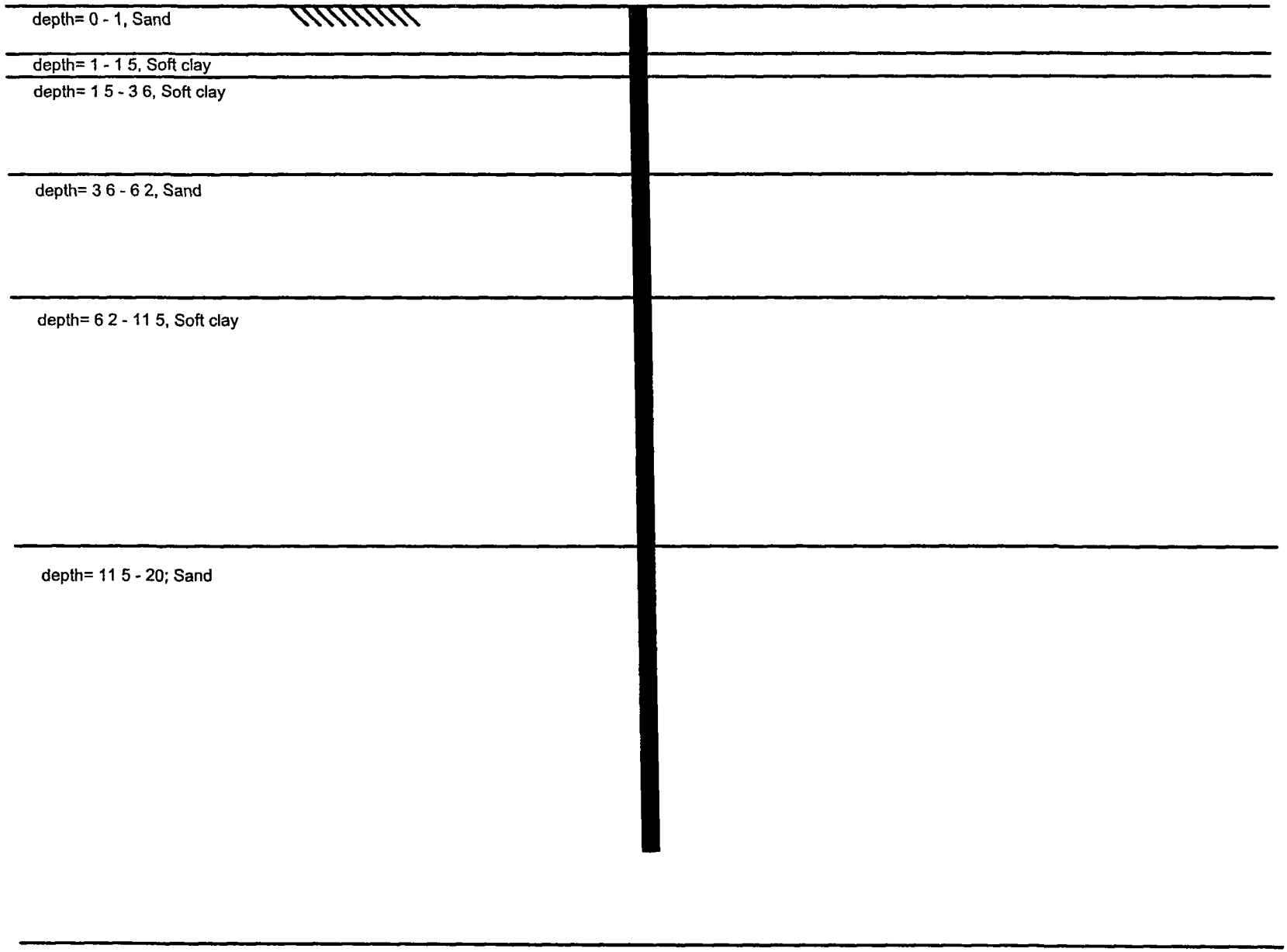
	Initials	Date
Completed By		
Checked By		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Sand	0 0	1 0	20 3	-	-	54,900	41	0	11	0	2940
2	Soft Clay	1 0	1 5	19 8	31	0 027	18,665	-	4	6	110	170
3	Soft Clay	1 5	3 6	10 0	31	0 027	18,665	-	6	10	170	290
4	Sand	3 6	6 2	10 1	-	-	8,550	32	20	30	3490	5290
5	Soft Clay	6 2	11 5	9 8	36	0 030	27,665	-	17	28	560	940
6	Sand	11 5	15 0	10 5	-	-	25,590	39	69	89	16280	20910

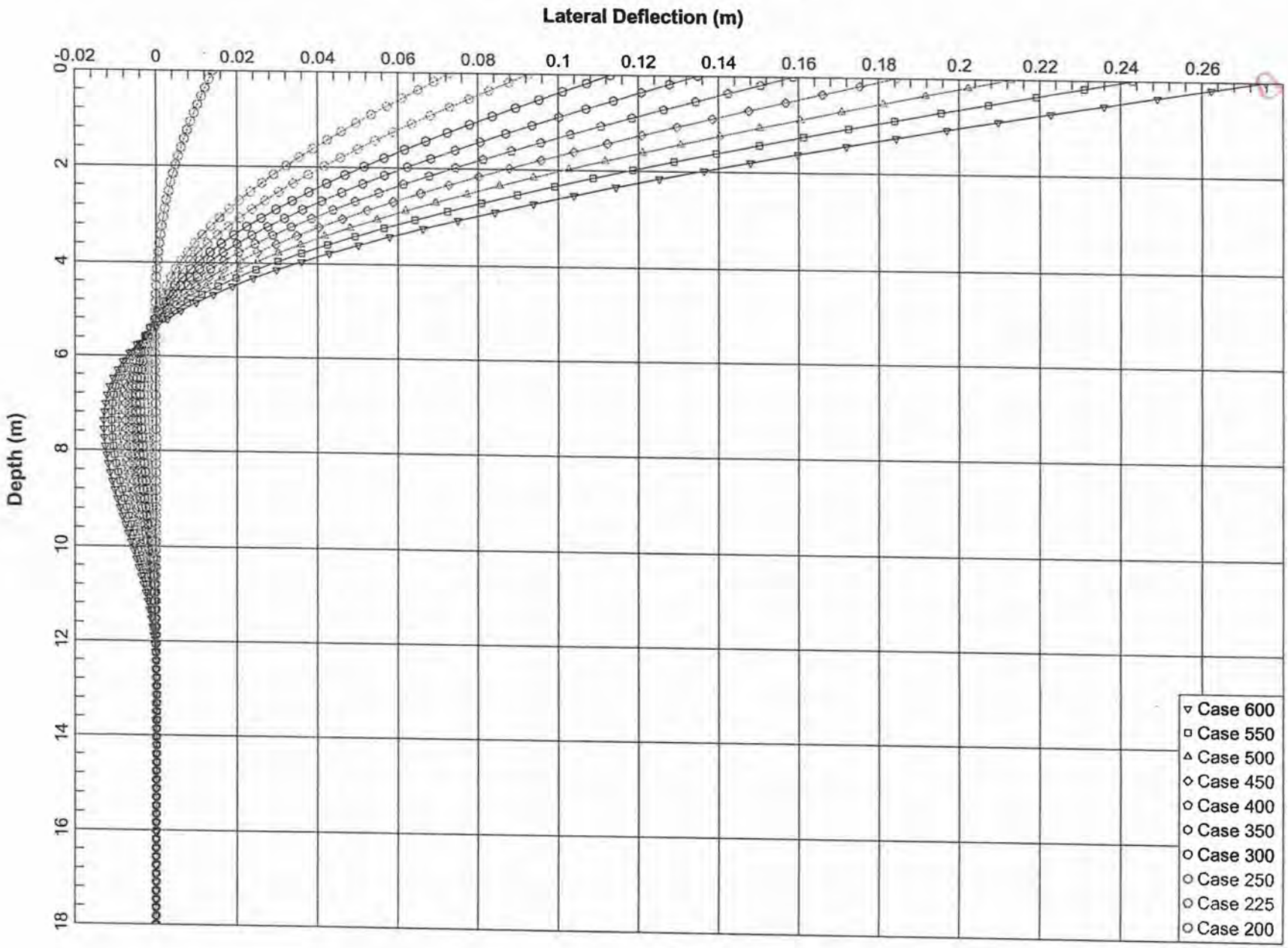
Press the "Copy" button to copy this tab to a new spreadsheet The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers


Lateral Load (kN)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
0
0 02
0 04
0.06
0 08
0 1
0 12
0 14
0.16
0 18
0 2
0.22
0.24
0.26
Pile-Head Deflection (m)
Bridge 25: Abutment 1

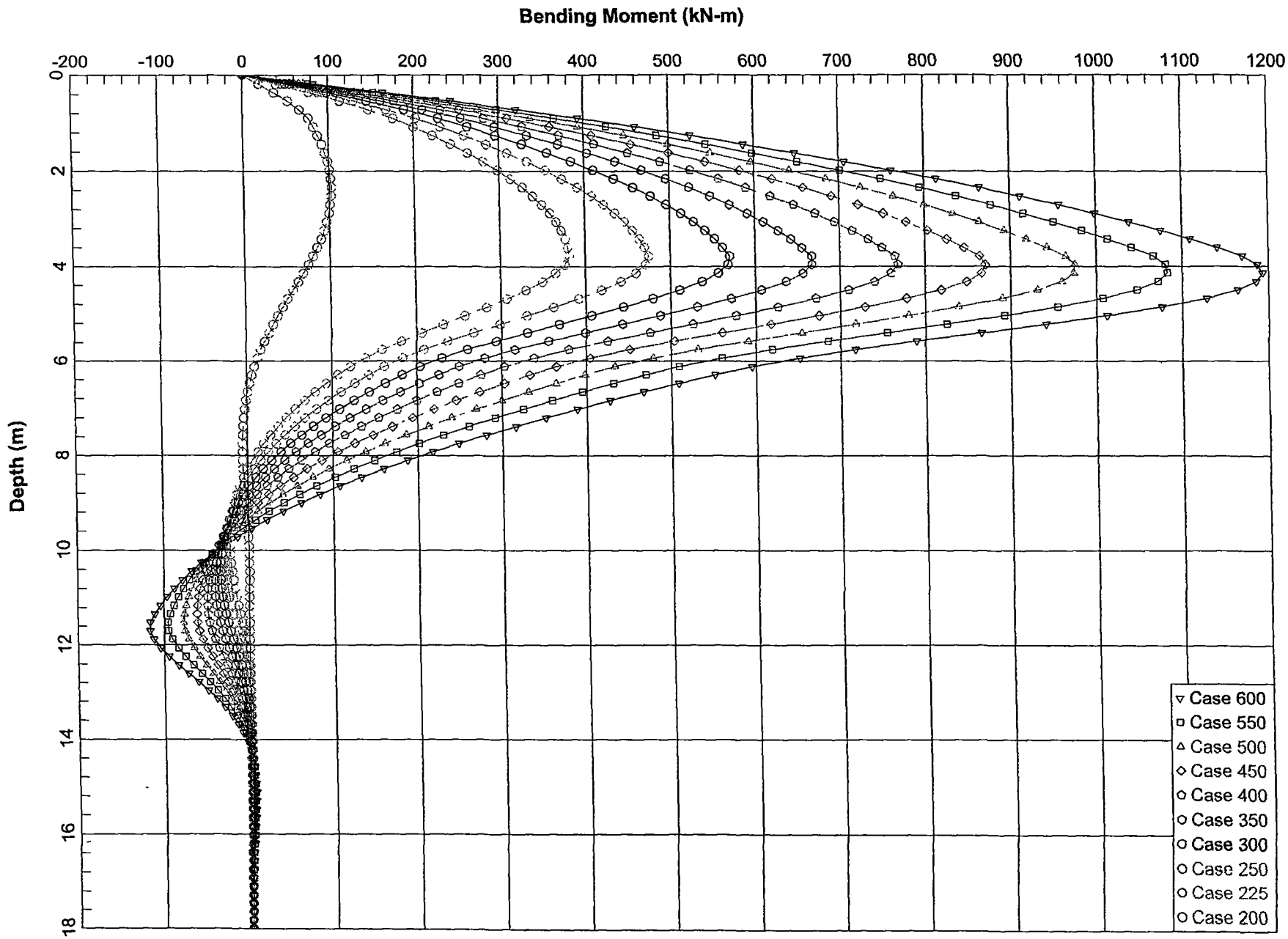
BRIDGE -25: ABUT 1, PROFILE



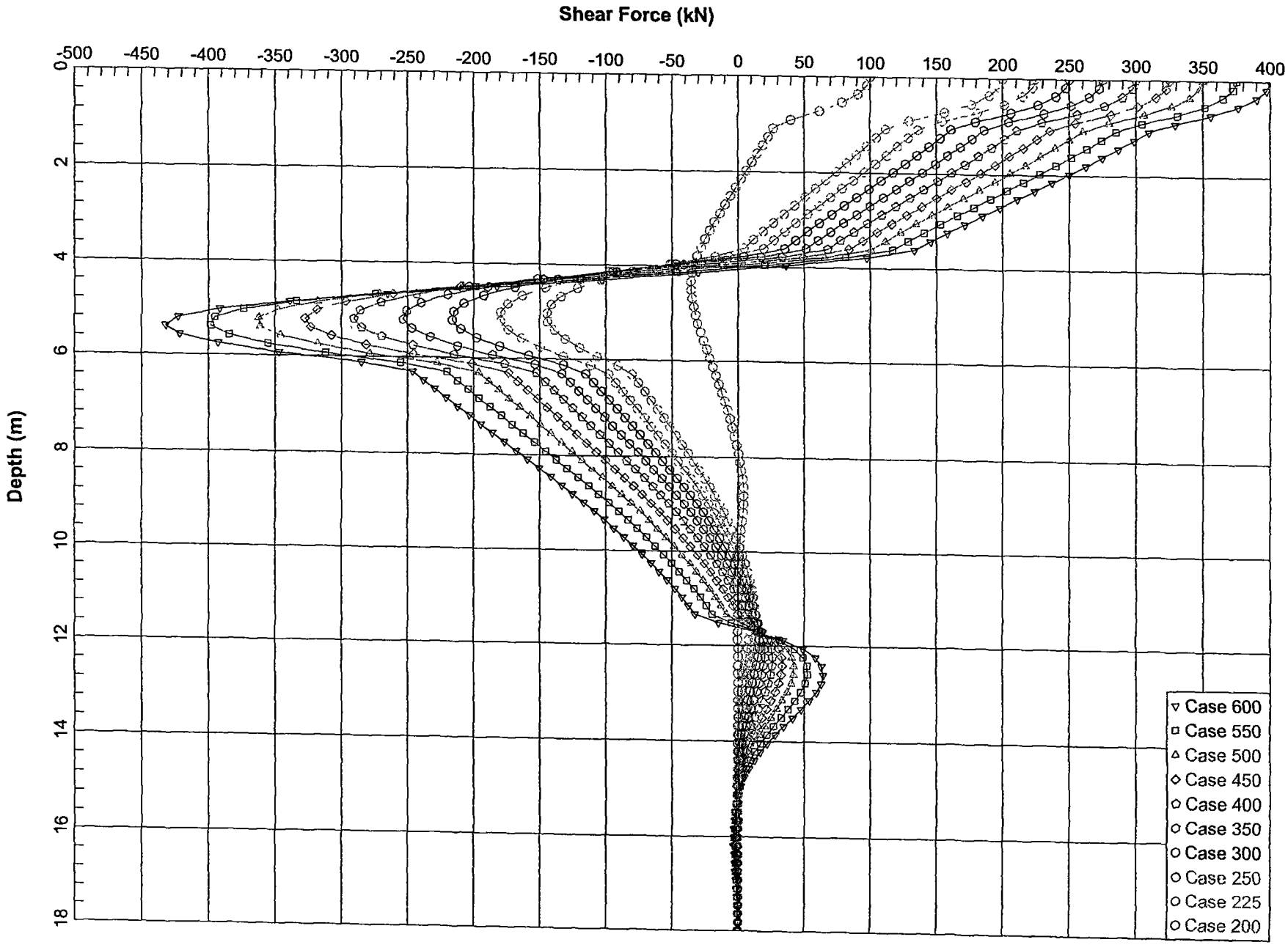
BRIDGE 25: ABUT 1



BRIDGE 25: ABUT 1



BRIDGE 25: ABUT 1



ABUTMENT 7

LPILE ANALYSIS

LEGACY PARKWAY
BRIDGE 25
PILE CAPACITY SUMMARY - PP 406x9 53 (16" x 3/8")
YIELD STRENGTH = 448 MPa

	Initials	Date
Completed By		
Reviewed By		

A-1 Target Geotechnical Capacity per Pile (2.25xService Load)	*3,195*	*kN*
B-2 Target Geotechnical Capacity per Pile (2 25xService Load)	*1,854*	*kN*
B-3 Target Geotechnical Capacity per Pile (2 25xService Load)	*2,032*	*kN*
B-4 Target Geotechnical Capacity per Pile (2.25xService Load)	*1,942*	*kN*
B-5 Target Geotechnical Capacity per Pile (2 25xService Load)	*1,271*	*kN*
B-6 Target Geotechnical Capacity per Pile (2 25xService Load)	*2,178*	*kN*
A-7 Target Geotechnical Capacity per Pile (2 25xService Load)	*3,771*	*kN*

(Target Service Load Provided by Structural Engineer)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Location	Finished Grade Elevation (m)	Bottom of Pile Cap Elevation (m)	Est. Embankm. Height (m)	Target Pile Tip Elevation (m)	Minimum Pile Tip Elevation (m)	Service Uplift Load Resistance (kN)	Required Seismic Compression Resistance (kN)	Required Seismic Uplift Resistance (kN)	Service Load (DL + LL) (kN)	Required Driving Resistance (kN)	Est Pile Length w/ fill (m)	Estimated Maximum Structural Load in Pile (kN) (Service Load + Drag Load)	Est Elevation of Neutral Plane (m)	Estimated Pile Tip Settlement (mm)
Bridge 25, Abutment 1	1306 3	1300 5	10 3	1283 3	1283 3	588	N/A	29	1,420	3,195	18	2,378	1285 8	6
Bridge 25, Bent 2	1297 0	1292 0	-	1269 5	1269 5	982	3,135	1,870	824	3,567	23	2,257	1273 5	4
Bridge 25, Bent 3	1297 0	1292 0	-	1272 0	1272 0	947	3,135	1,870	903	3,475	20	2,210	1275 9	4
Bridge 25, Bent 4	1297 5	1293 0	-	1273 0	1273 0	930	3,135	1,870	863	3,583	20	2,243	1276 5	4
Bridge 25, Bent 5	1298 0	1294 4	-	1269 4	1269.4	1,199	3,160	2,135	565	4,135	25	2,487	1273 3	4
Bridge 25, Bent 6	1297 5	1294.4	-	1271 3	1271 3	955	3,135	1,870	968	3,350	24	2,159	1276 6	3
Bridge 25, Abutment 7	1310 1	1304 3	12 1	1286 1	1286 1	676	N/A	N/A	1,676	3,771	19	2,985	1287.4	22

Location	Borings Used for Soil Profile
Bridge 22, Abutment 1	RB-385, SC-27-341, LSB-22-435
Bridge 22, Bent 2	RB-385, SC-27-341, LSB-22-436
Bridge 22, Bent 3	LSB-25-453, SC-27-342
Bridge 22, Bent 4	LSB-22-437
Bridge 22, Bent 5	LSB-25-454, SC-27-344
Bridge 22, Bent 6	LSB-25-455
Bridge 22, Abutment 7	LSB-22-490

Description of Information Presented in Each Column

A **Finished Grade Elevation** - Top of approach slab elevation at abutment locations and adjacent ground elevation at bent locations as shown on the structure Plan and Profile drawing provided

B **Bottom of Pile Cap Elevation** - Elevation at the bottom of the pile cap as scaled from the structure Plan and Profile drawing provided

C **Estimated Embankment Height** - Elevation difference between the top of the approach slab and the native ground surface at the abutment as scaled from the structure Plan and Profile drawing provided

D **Target Pile Tip Elevation** - Estimated elevation to which the bottom of the pile will need to be driven to develop the required capacity and meet the settlement criteria (Additional depth may be required to reach required resistance during driving)

E **Minimum Pile Tip Elevation** - Estimated minimum elevation to which the bottom of the pile will need to be driven to meet settlement, minimum length, or minimum depth criteria should the required driving resistance be obtained above the Target Pile Tip Eleva

F **Service Uplift Load Resistance** = (Ultimate Friction Resistance)/(FS=2 25) Per comment resolution meeting with UDOT (8/15/01)

G **Seismic Compression Resistance** = Ultimate Friction and End Bearing Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate resistance values to resist seismic loads)

H **Seismic Uplift Resistance** = Ultimate Friction Resistance neglecting the contribution of potentially liquefiable zones (AASHTO allows the use of the ultimate friction resistance value to resist seismic uplift loads)

I **Service Load (DL + LL)** - The maximum load that can be applied at the top of the pile by the structure provided the pile is driven to the assumed capacity

J **Required Driving Resistance** - The minimum load (service load x 2 25 or required seismic resistance plus estimated loss during liquefaction, whichever is greater) that must be verified in the field by PDA

K **Estimated Pile Length w/ Fill** - The estimated length of pile required Calculated as (Bottom Of Pile Cap - Estimated Tip Elevation) rounded up to the nearest meter (Actual lengths may vary depending on driving conditions encountered at each pile location)

L **Estimated Structural Load in the Pile** - The largest load that will develop in the pile due to structural service dead loads and drag loads This load occurs at the neutral plane where equilibrium exists between the sum of the downward acting permanent load (service load) applied at the top of the pile and drag load due to negative skin friction and the sum of upward acting positive shaft resistance and mobilized toe resistance

M **Estimated Elevation of Neutral Plane** - The level in the pile where relative movement between the pile and soil is zero

N. **Estimated Pile Tip Settlement** - The magnitude of pile tip settlement required to mobilize estimated pile tip loads This does not include elastic compression of the pile

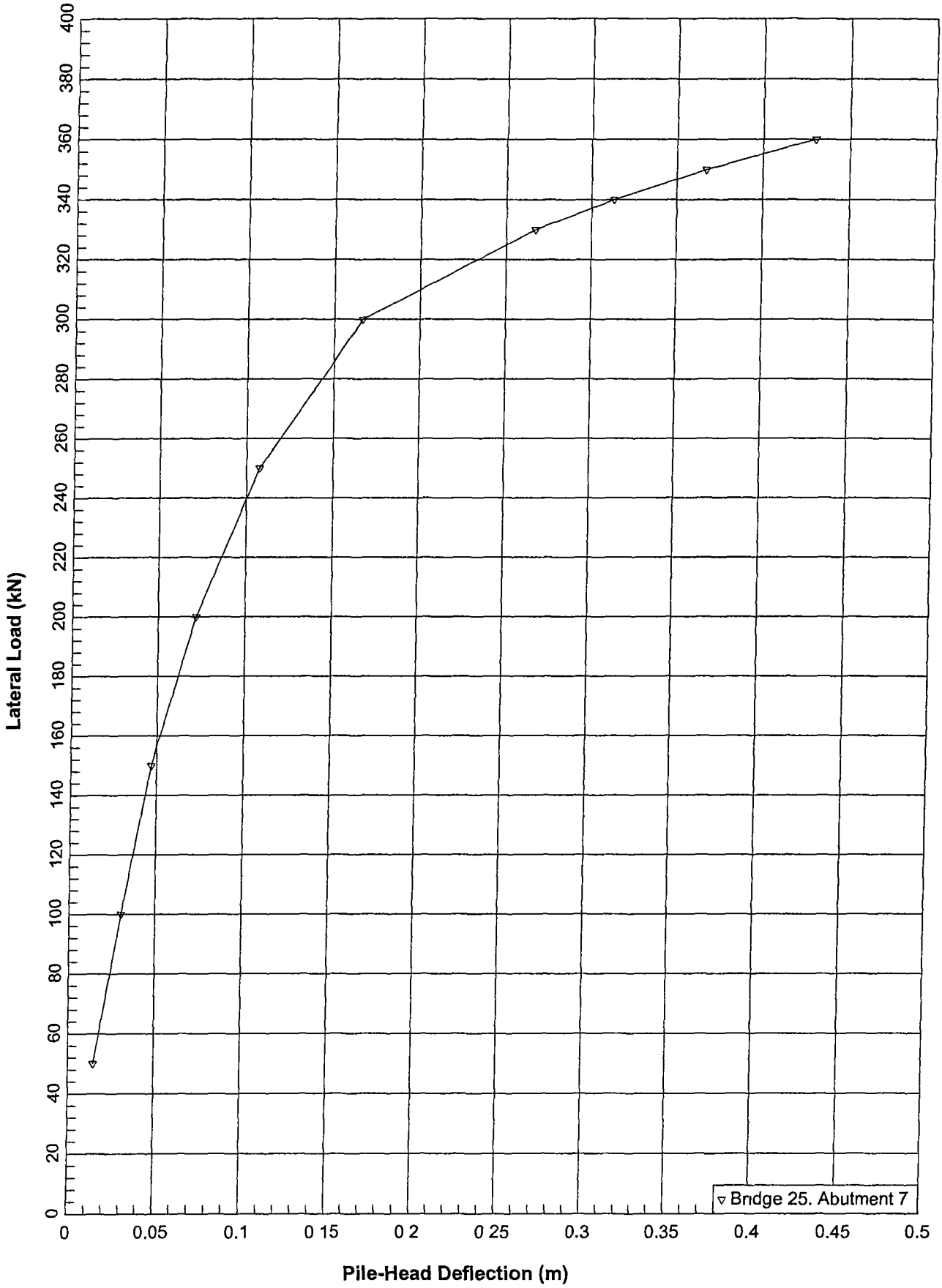
Legacy Parkway
Lateral Pile Analysis
Soil Parameters for LPILE or GROUP

Structure	25
Support(s)	6,7,8
Water Depth (m)	3.0
Existing Ground Elevation (m)	1298.2

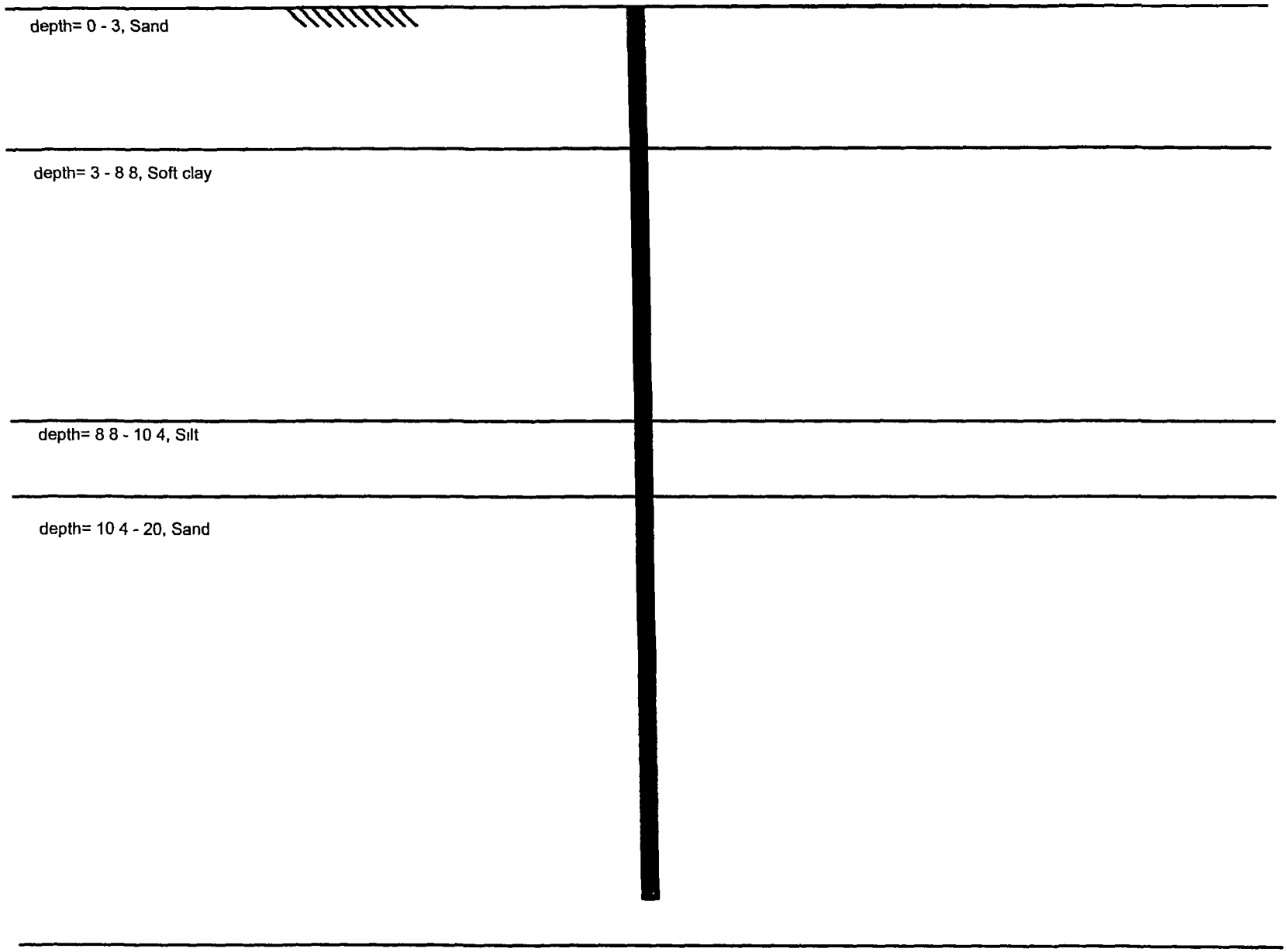
	Initials	Date
Completed By:		
Checked By:		

Layer	Soil Type	Depth to Top of Soil Layer (m)	Depth to Bottom of Soil Layer (m)	Unit Weight of Soil (kN/m^3)	Shear Strength (kN/m^2)	Strain, ε_{50}	Modulus of Subgrade Reaction, k (kPa/m)	Friction Angle, ϕ (degrees)	Maximum Side Friction (kN/m^2)		Maximum Tip Resistance (kN/m^2)	
									Top	Bottom	Top	Bottom
1	Sand	0.0	3.0	19.5	-	-	2,250	30	0	20	0	3010
2	Soft Clay	3.0	8.8	10.3	24	0.020	9,665	-	12	24	270	540
3	Silt	8.8	10.4	9.9	9	0.010	3,500	32	39	44	3120	3530
4	Sand	10.4	15.0	10.1	-	-	12,100	33	57	76	10770	14500

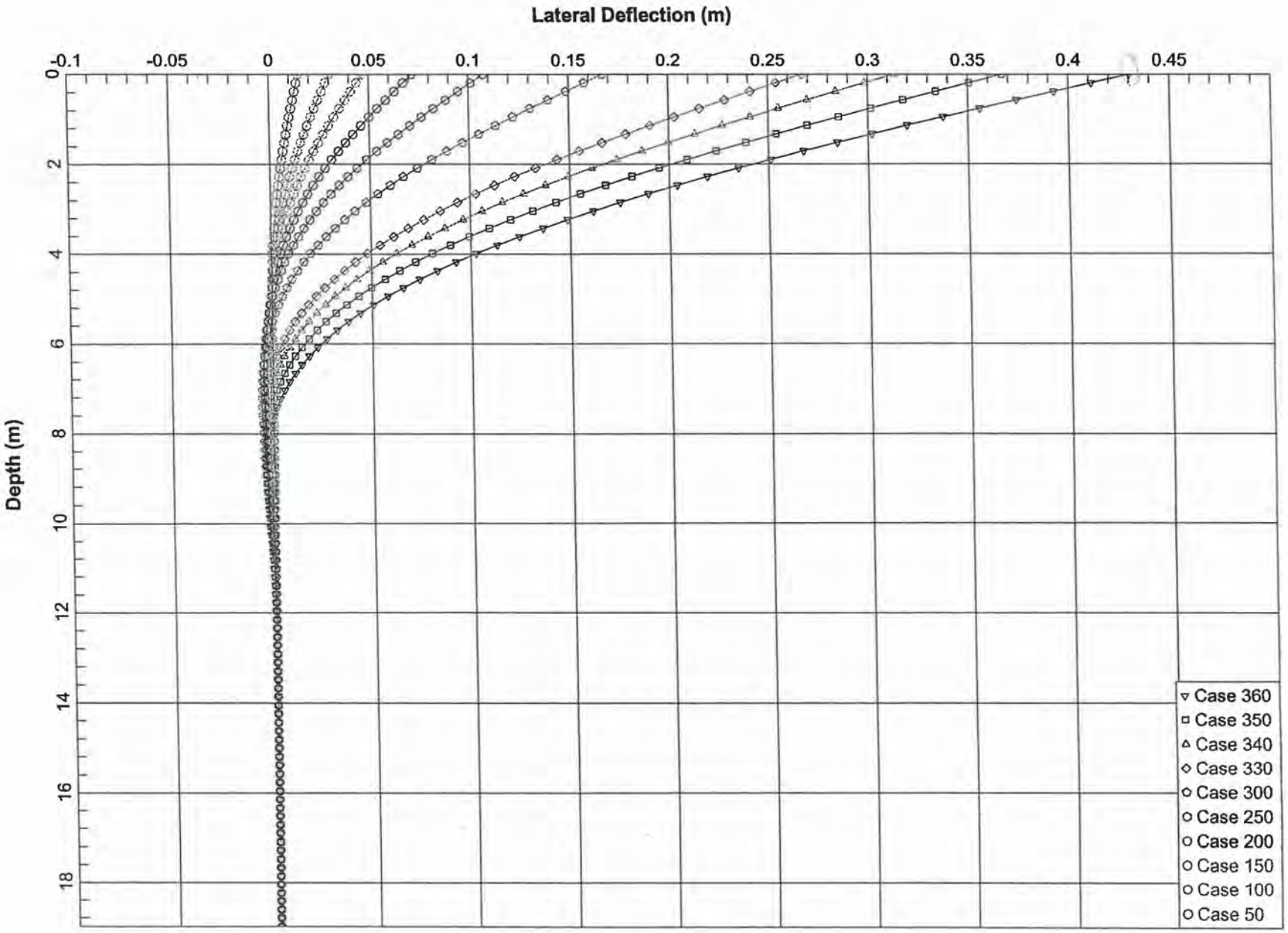
Press the "Copy" button to copy this tab to a new spreadsheet. The new file should be saved in the same directory with the name "S-XX-Y,Y,Y LPILE Parameters" (XX is the structure number and Y is the support numbers for which this file applies. Complete renaming of the spreadsheet immediately after it is copied by adding the structure and support numbers.


Lateral Load (kN)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Pile-Head Deflection (m)
Bridge 25. Abutment 7

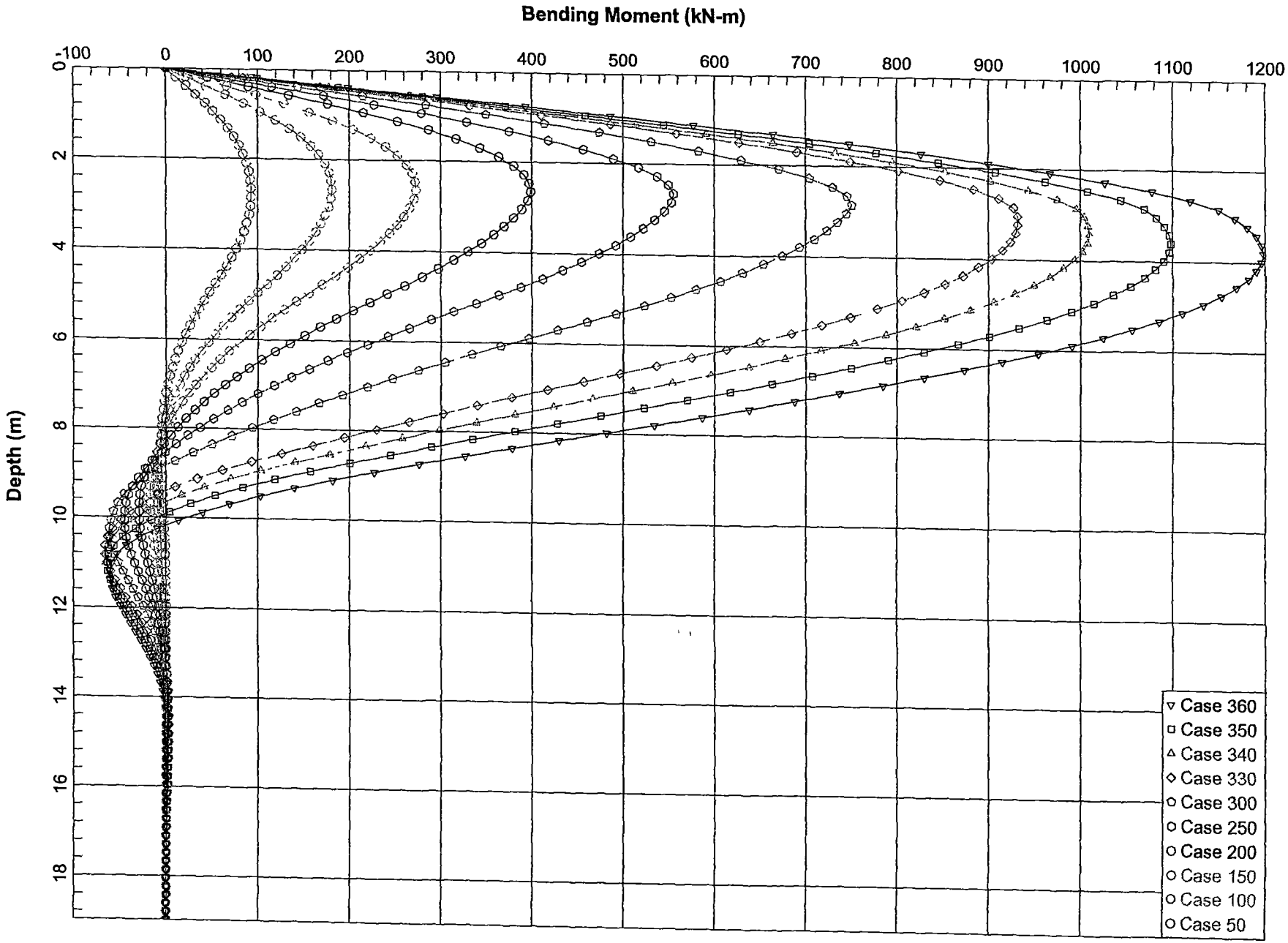
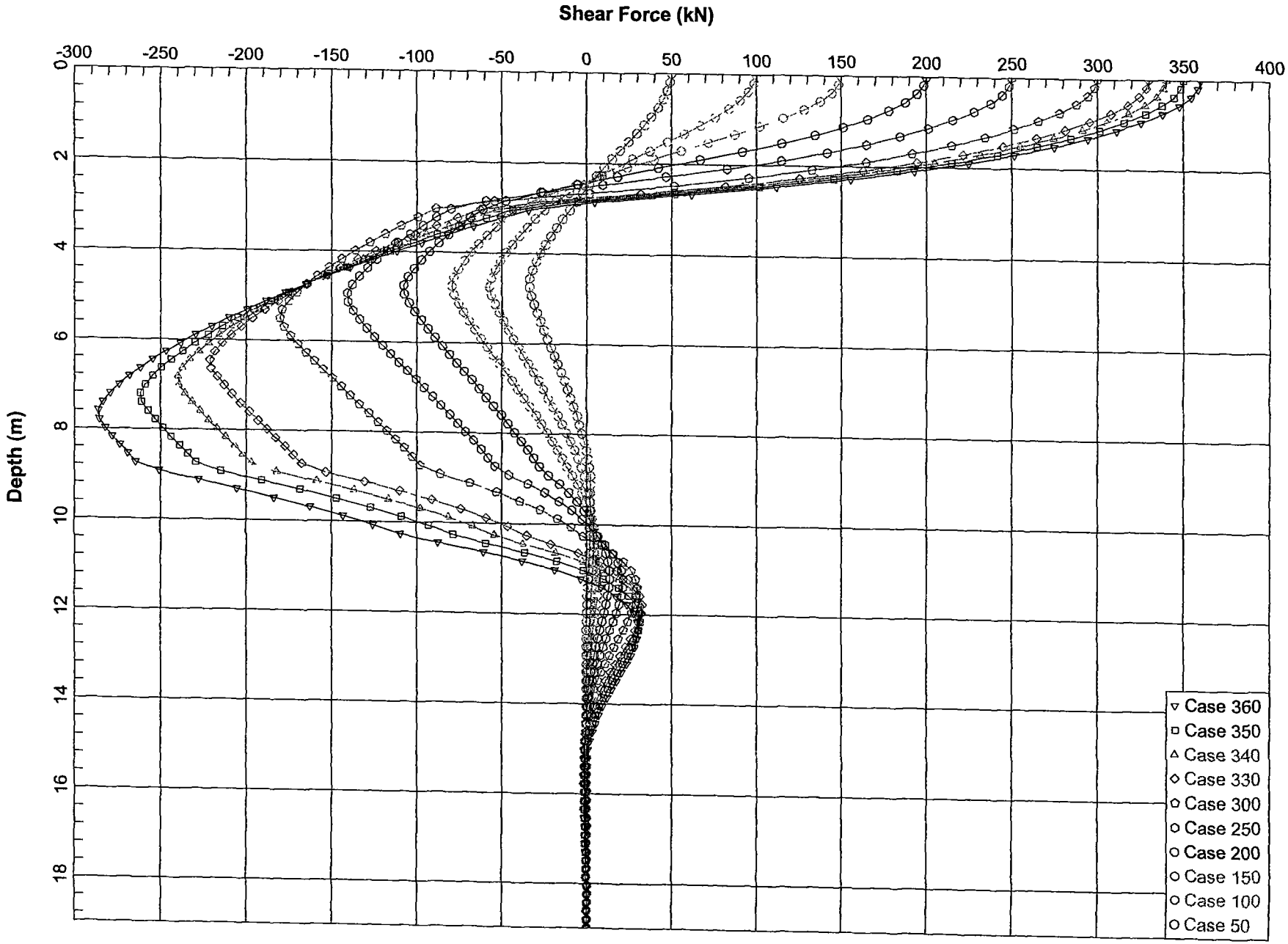
BRIDGE 25. ABUT 7, PROFILE



BRIDGE 25: ABUT 7



BRIDGE 25: ABUT 7



BRIDGE 25: ABUT 7