Appendix G - MHP Global Strength Design - Example Calculations

Service Load Assumptions

Design Calculations

SERVICE LOAD ASSUMPTIONS

Service load is estimated for typical berthing scenarios for phased maintenance activities according to document MIL-HDBK-1025/1. The derivation of the loads can be found in the following pages and are summarized here:

1. Planned Restricted Availability (PRA):

Laydown Area	6,690 sf at 193 psf
Crane	170,000 lbs

2. Selected Restricted Availability (SRA):

Laydown Area	10,940 sf at 205 psf
Crane	170,000 lbs

3. Regular Overhaul (ROH):

Laydown Area	12,730 sf at 213 psf
Crane	170,000 lbs

The following additional service loads were considered:

4.	Additional Crane	170,000 lbs
5.	Additional Laydown Area	250 sf at 1,200 psf equaling 300,000 lbs

All possible load combinations from the above five service loads were considered for the design.

Plus:

- Wind and current
- Mooring loads
- Earthquake

Project: MHP PH II
Date: 6/18/2001
File: O:\2001\A01047\ENGR\Design Criteria\[LLcriteria.xls]Laydown Area

ESTIMATE the unit Load for Laydown Area: [Ref: MIL-HDBK-1025/1 pg 15]

OPERATING AREA

	Unit Load [est.] **	PRA *		SRA *		ROH *	
	psf	sf	lbs	sf	lbs	sf	lbs
Demineralizer	300	-	-	1,500	450,000	1,500	450,000
Bilge water/stripping tank	300	-	-	400	120,000	400	120,000
Dumpsters	100	1,150	115,000	1,440	144,000	1,730	173,000
Portable Solid-sttate Generators	200	-	-	240	48,000	240	48,000
Air compressors	50	290	14,500	290	14,500	290	14,500
Welding	50	1,500	75,000	1,500	75,000	1,500	75,000
Flammable Storage	50	150	7,500	600	30,000	600	30,000
Transporation Laydown	300	600	180,000	900	270,000	1,500	450,000
Offload area (oils, fuels, etc)	300	3,000	900,000	3,600	1,080,000	4,500	1,350,000
Portable heads	30	-	-	70	2,100	70	2,100
Additional brow	10	-	-	400	4,000	400	4,000
		6,690	1,292,000	10,940	2,237,600	12,730	2,716,600
		w (psf) =	193	w (psf) =	205	w (psf) =	213

Note:
* Areas for PRA, SRA, and ROH were taken from Table 3 Estimated Space Requirements for PMA [MIL-HDBK-1025/1]
** Unit Loads were estimated by MHZ
Crane Work Area was taken out from the list, since we will provided the area separately.

Table 3
Estimated Space Requirements for PMA

Activity	LOAD ASSUMED	PRA	SRA	ROH
COMMAND AREA				
Mobile administration buildings			2,800	5,600
Parking area		250	250	500
Bicycle racks		70	140	200
Subtotal		320	3,190	6,300
OPERATING AREA				
Demineralizer	300 psf	-	1,500	1,500
Bilge water/stripping tank	300 psf	-	400	400
Dumpsters	100 psf	1,150	1,440	1,730
Portable solid-state generators	200 psf	-	240	240
Air compressors	50 psf	290	290	290
Welding	50 psf	1,500	1,500	1,500
Flammable storage	50 psf	150	600	600
Transportation laydown	300 psf	600	900	1,500
Crane work	50 psf	3,850	3,850	5,250
Offload area (oils, fuels, etc.)	300 psf	3,000	3,600	4,500
Portable heads	30 psf	-	70	70
Additional brow	10 psf	-	400	400
		10,540	14,790	17,980
Total		10,860	17,980	24,280

2.2.3.2 Mobile Crane Operation. Piers and wharves are subject to frequent usage by truck-mounted mobile cranes forklifts, and straddle carriers for servicing the ships. This weight-handling equipment requires maneuvering and turnaround space on the deck for effective operation. If possible the deck space should be planned to allow mobile cranes to be backed up perpendicular to the bullrail. This permits the maximum load/reach combination.

2.2.3.3 Crane Tracks. Rail-mounted cranes are often needed for ship fleet loadout in outfitting/refit and repair facilities. Width requirements depend on equipment selected. A rail gage of 40 ft is standard for new cranes, except at container terminals or where it is necessary to conform to gages of existing tracks. When cranes are furnished, the distance from the waterside cranerail to the edge of the pier or wharf should be adequate to provide clearance for bollards, cleats, capstans, pits housing outlets for ship services, crane power conductors, and other equipment. Where aircraft carriers or other ship types with large deck overhangs are anticipated to be berthed, the cranerail should be located so that all parts of the crane will clear the deck overhang. For discussion of crane power conductors, see Naval Facilities Engineering Command NAVFAC DM-38.01, Weight Handling Equipment.

2.2.3.4 Railroad Tracks. For supply and ammunition piers and wharves, railroad service should be considered. Except where local conditions require otherwise, standard gage should be used for trackage. For standard gage and spacing between adjacent tracks, see Naval Facilities Engineering Command NAVFAC DM-5.06, Civil Engineering - Trackage. Width of piers and wharves should be adequate to allow passing of trains and forklift trucks (or other material-handling equipment). Allowances should also be made for stored cargo and other obstructions.

2.2.3.5 Trucks and Other Vehicles. A variety of service trucks and vehicles can be expected to use piers and wharves for moving personnel, cargo, containers, and supplies to and from the ships. The width provided must take into account operation and maneuvering of such vehicles. Turnaround areas should be provided.

2.2.3.6 Sheds and Buildings. Pier and wharf deck is usually too expensive an area for storage sheds, which should therefore be located on land to be cost-effective. However, small buildings to provide for berthing support and storage of equipment may sometimes need to be accommodated on deck.

2.2.3.7 Movable Containers and Trailers. During active berthing of ships, various containers of different sizes are temporarily or permanently located on pier deck to support the operations. These include shipyard tool boxes, garbage dumpsters, training trailers, and supply trucks. Adequate deck space should be available for locating and accessing these containers and trailers.

2.2.3.8 Fire Lane. For piers, provide a 15-foot-wide unobstructed fire lane independent of net operating width requirements. Locate and mark the lane near the longitudinal pier centerline. For wharves, provide a 15-foot-wide unobstructed fire lane immediately adjacent to the operating area. These requirements should not be applied to small craft or yard craft piers.

2.2.3.9 Fuel-Handling Equipment. At specified berths, stationary fuel-handling equipment consisting of self-adjusting loading arms are often furnished to offload fuel products from tankers to onshore storage facilities. Pier or wharf width requirements depend on equipment selected and facilities furnished.

2.2.3.10 Phased Maintenance Activities (PMA). At some naval stations, PMA performed at berthing piers will be of significant magnitude. Requirements for space and pier dimensions due to PMA should be considered for these piers. For additional information, see Naval Civil Engineering Laboratory NCEL TM-5, Advanced Pier Concepts, Users Data Package. The four levels of PMA and their estimated space requirements are as follows and as detailed in Table 3.

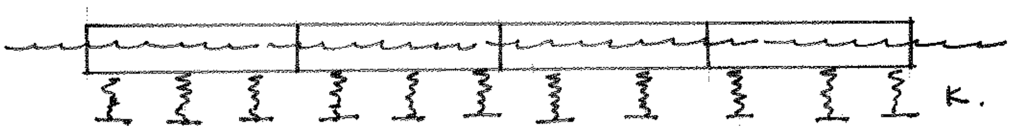
a) Intermediate Maintenance Availability (IMA). IMA consists of removal and repair of shipboard equipment performed by Shore Intermediate Maintenance Activity (SIMA) personnel or tender forces, with a duration of approximately 30 days. Gross deck requirements range from 2000 to 3000 ft^2 with work area dimensions varying from 30 x 65 ft to 30 x 100 ft.

b) Planned Restricted Availability (PRA). PRA consists of limited repairs of shipboard equipment and systems by contract forces under Supervisor of Shipbuilding and Repairs (SUPSHIP) control, with a duration of 30 to 60 days. Gross deck area requirements are about 10,800 ft^2 (35 **x** 310 ft) of command and storage area could be on the lower level.

c) Selected Restricted Availability (SRA). SRA consists of expanded repairs and/or minor ship alterations to shipboard equipment and systems by SUPSHIP contract forces, with a duration of approximately 60 days. Gross deck area requirements are about 18,000 ft^2 (35 x 515 ft). On a double-deck pier with adequate clearance, about 5000 ft^2 of command and operational area could be on the lower level.

d) Regular Overhaul (ROH). ROH consists of major repairs and ship alterations to shipboard equipment and systems by SUPSHIP contract forces, with a duration of six to eight months. Gross deck area requirements are about 23,000 ft^2 (35 x 660 ft). In addition, there would be a requirement for turnaround areas on deck and warehousing off the pier or wharf. On a double-deck pier, up to 8000 ft^2 of command and operational area could be on the lower level.

GLOBAL STRUCTURAL BEHAVIOR OF MHP



The pier can be modeled as elastic beam on elastic foundation.

The draft and force calculations were performed according to the following reference:

- Hetényi, M., "Beams on Elastic Foundations," Ann Arbor: The University of Michigan Press, 1974.

CRITICAL DESIGN FORCES

- 2 x ROH berthings at middle of pier
- 2 x ROH berthings at end of pier
- 2 critical pontoon compartments flooded

Design forces are critical for both pontoon and joint design.

MATERIAL PROPERTIES

Maximum allowable concrete stress for service:

in compression	0.4 f'c = 2,800 psi (19 MPa)
in tension	0.0

Prestressing steel	0.6 fu = 162 ksi (1,117 MPa)

DESIGN FORCES

a. For pontoon design:

M_{zmax} = 375,000 kip-ft

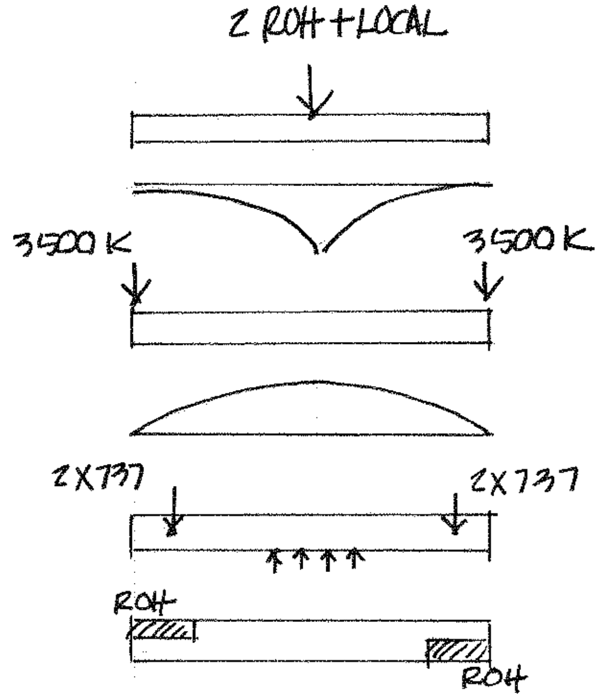
V_{zmax} = 6,000 kip

M_{ymax} = 185,000 kip-ft

V_{ymax} = 1,464 kip

V_{ymax} = 2 x 1,392 kips
for ship at one side

T = 100,000 kip-ft



b. For joint design:

at mid-span: same as for pontoon

at quarter span:

M_{zmax} = 210,000 kip-ft

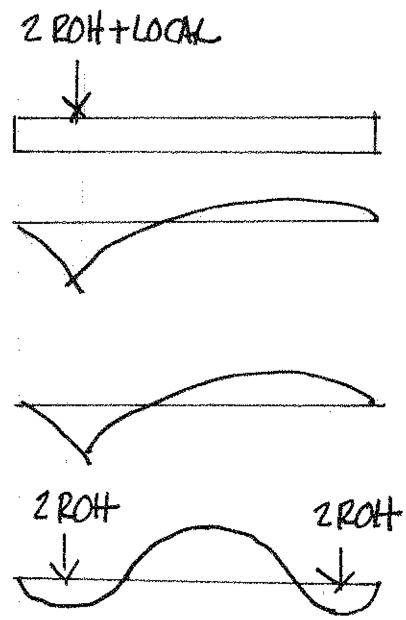
V_{zmax} = 3,000 kip

if with damaged condition:

(M_{zmax} = 80,000 kip-ft)

M_{ymax} = Small

V_{ymax} = 1,464 kip



ELASTIC FOUNDATION PARAMETERS

$$k = 0.064 \, {}^{k}\!/_{cu} \times 88 \; ft = 5.63 \frac{kip}{sf} = 39 \, psi$$

$$E = 4{,}000 \; ksi$$

$$I_z = 827{,}968 \times 10^6 \; in^4, \; I_g = 5.563 \times 10^9 \; in^4$$

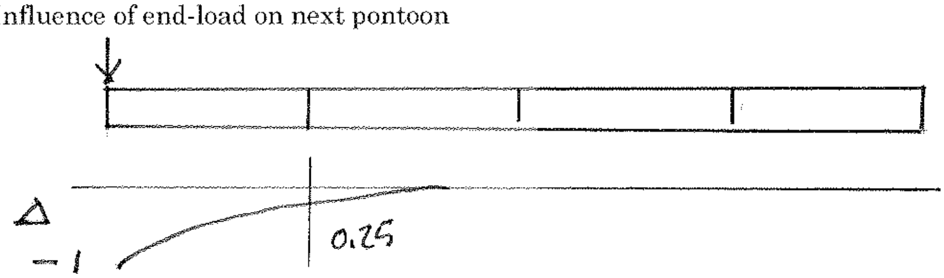
$$\lambda = \sqrt[4]{\frac{k}{4EI}} = 233 \times 10^{-6} \; \frac{1}{in}$$

$$S_{z_{top}} = \frac{I_z}{11.9 \times 17} = 5.792 \times 10^6 \; in^3, \; S_y = \frac{I_y}{44 \times 12} = 10.536 \times 10^6 \; in^3$$

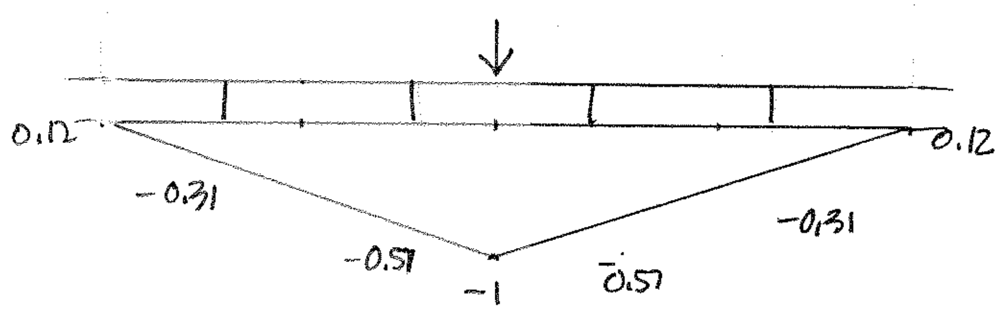
$$S_{z_{bot}} = \frac{I_z}{16.03 \times 12} = 4.288 \times 10^6 \; in^3$$

$$A = 48{,}888 \; in^2$$

Influence of end-load on next pontoon



Influence of mid-load on next pontoon



TORSION STIFFNESS

$$K = \frac{4\,A_{eff}^{\;2}}{\Sigma \dfrac{\ell_i}{t_i}} = 192{,}000\,ft^4$$

$$A_{egg} = 16.88 + 12.44 = 1{,}936\ ft^2$$

$$\Sigma \frac{\ell_i}{t_i} = \frac{88}{8} + \frac{2 \times 28}{10} + \frac{44}{15} = 19.5$$

$$K \cong I_p = I_x + I_y = 300{,}000\ ft^3$$

$$K = 270{,}000\ ft^3$$

Plus internal bulk-heads

$$A_{eff} = 28 \times 88 = 2{,}464\ sft$$

$$\Sigma \frac{\ell_i}{t_i} = \frac{88}{8} + \frac{2 \times 28}{10} + \frac{88}{15} = 22.5$$

$$G = \frac{Ec}{2(1+2)} = \frac{4000}{2(1+0.3)} = 1{,}540\ ksi$$

Draft Changes Due to Live Load

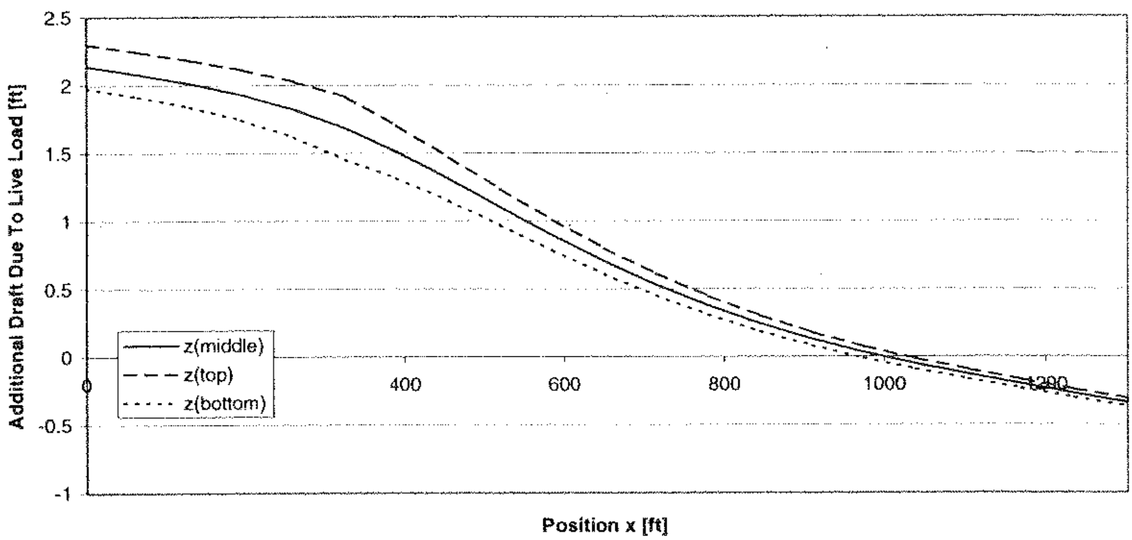
6/25/01

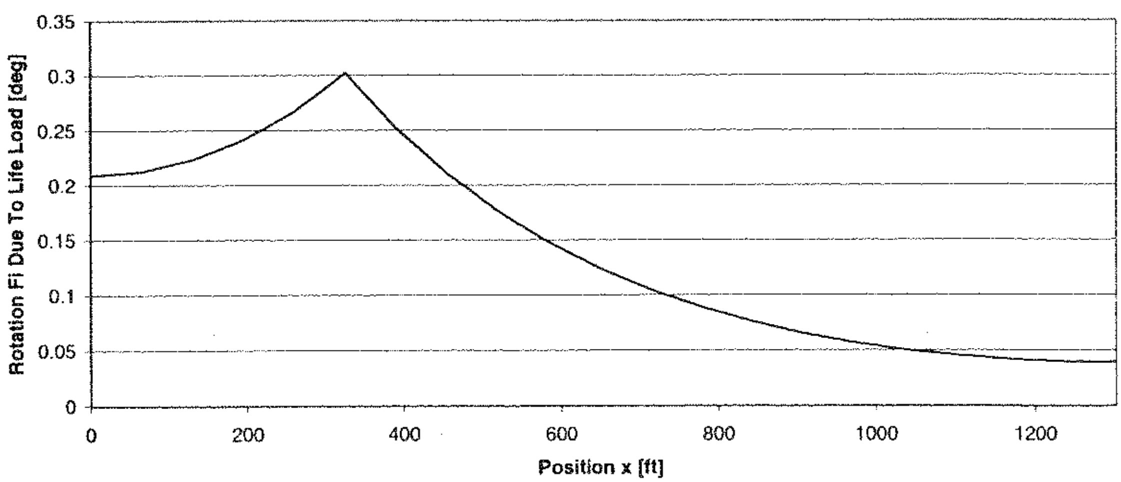
Structural Data:

Total Length:	1300 ft	Section Area:	339.5 sft
Pier Width:	88 ft	Section Vertical Inertia:	39,929 ft4
		Torsional Inertia J:	300,000 ft4
Maximum Additional Draft:	3 ft	Concrete Young's Modulus:	4000 ksi
Maximum Allowable Moment:	375000 kip-ft	Torsional Shear Modulus G:	1538 ksi

Loading on Pier (kip): **ROH on 2 berths plus concentrated load**

y \ x	126.00	232.00	325.00	395.00	650.00	735.00	1068.00	1174.00
40			170					
39			300					
29	678	678	678	678				
-29	678	678	678	678				
39								
-40			170					





Maximum Draft =	2.300 ft
Maximum Rotation =	0.302 degrees
Maximum Pos Moment =	206,197 kip-ft
Maximum Neg Moment =	-113,325 kip-ft
Total Load =	6064 kip

V = 30004'0

Draft Changes Due to Live Load

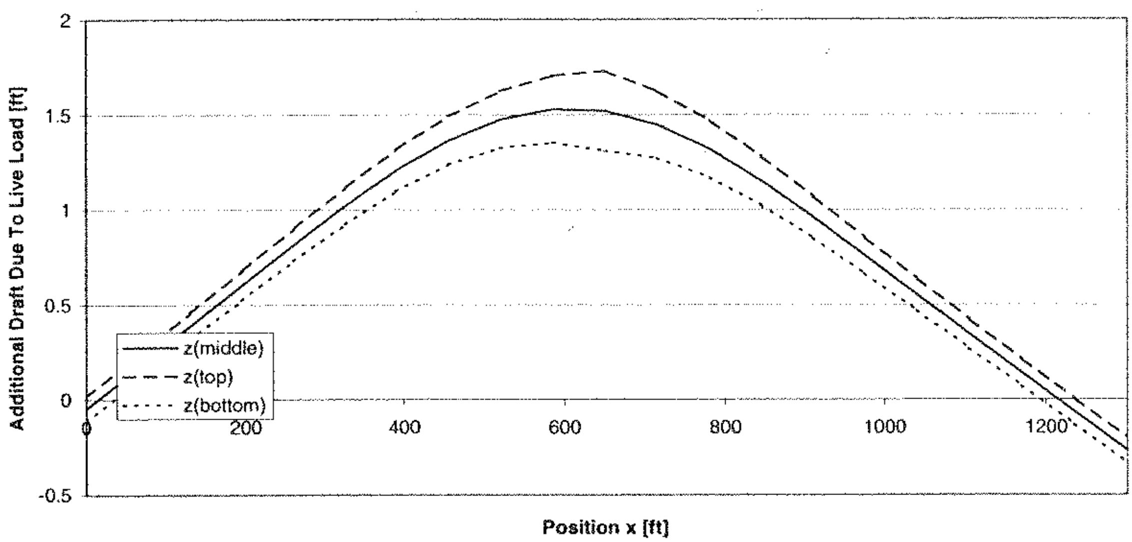
6/25/01

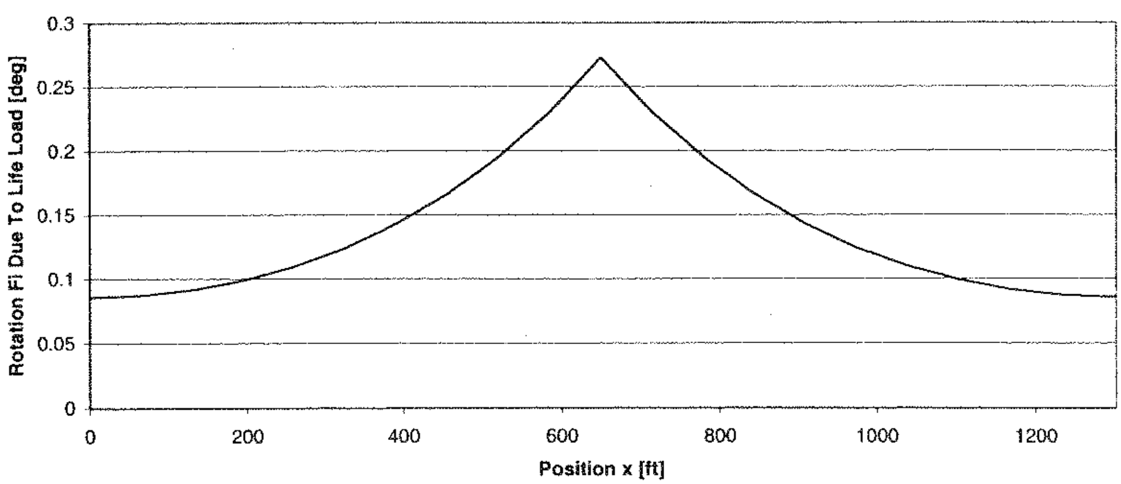
Structural Data:

Total Length:	1300 ft	Section Area:	339.5 sft
Pier Width:	88 ft	Section Vertical Inertia:	39,929 ft4
		Torsional Inertia J:	300,000 ft4
Maximum Additional Draft:	3 ft	Concrete Young's Modulus:	4000 ksi
Maximum Allowable Moment:	375000 kip-ft	Torsional Shear Modulus G:	1538 ksi

Loading on Pier (kip): **ROH on 2 berths, balanced plus concentrated load**

y \ x	100.00	200.00	451.00	557.00	650.00	735.00	1068.00	1174.00
40					170			
39					300			
29			678	678	678	678		
-29			678	678	678	678		
39								
-40					170			





Maximum Draft =	1.730 ft
Maximum Rotation =	0.273 degrees
Maximum Pos Moment =	370,850 kip-ft
Maximum Neg Moment =	-6,857 kip-ft
Total Load =	6064 kip

V ≈ 5600 kip

GLOBAL POST-TENSIONING

$$\text{ftopcorner} = \frac{P}{A} + \frac{M_z}{S_{z_{top}}} + \frac{M_y}{S_y}$$

$$\text{fbotcorner} = \frac{P}{A} + \frac{M_z}{S_{z_{bot}}} + \frac{M_y}{S_y} = \frac{P}{A} + \frac{375{,}000 \times 12}{4.288 \times 10^6} + \frac{185{,}000 \times 12}{10.536 \times 10^6}$$

$$\frac{P}{A} = 1.050 + 0.211 = 1.261\ ksi$$

$$P = 1.261 \times 48{,}888 = 61{,}625\ kip$$

Tendons: $\Phi\ 0.6"\ @\ 60\%,\ F_u = 59\ kip \Rightarrow \frac{61{,}625}{0.6 \times 59} = 1{,}741\ strands\ or\ 145\ cables\ @\ 12x0.6"$

Tendon distribution:

Say $8 \times x = 12.4,\ \ x + y = 145$ $\qquad x = \frac{145}{\left(1 + \frac{2}{3}\right)} = 87$

$x = \frac{3}{2}y$ $\qquad y = 145 - x = 58$

x = tendons in compartment walls

y = tendons in deck slab $\qquad x = \frac{3}{24}$

Tendon spacing:

in deck slabs = $s = \frac{88 - 1}{58 - 1} = 1.526\ ft \cong 1\ ft\ 6\ in$

in compartment walls $s = \frac{2(88 - 1) + 5(16 - 1)}{(87 - 1)} = 2.893\ ft \cong 2\ ft\ 10\ in$

Redistribute internal service deck cables = $\frac{40\ ft}{2.9\ ft}$ = 14 cables

Top slab: $\frac{14 \times 16}{28}$ = 8 cables

Bottom slab: $\frac{12 \times 16}{28}$ = 6 cables

Deck slab: $s = \frac{88-1}{58+8-1} = 1.338\ ft\ 1\ ft\ 4\ in : 66\ tendons$

Bottom slab: $s = \frac{89-1}{(88-1)/2.893'+6} = 2.412\ ft = 2\ ft\ 5\ in : 36\ tendons$

Bulk walls: s = 2.893 = 2 ft 10 in : 5 x 5 tendons

Utility deck: s = 2.44 ft = 2 ft 5 in : 2 x 9 tendons

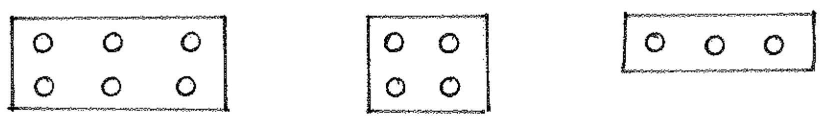
Total: 145 tendons

JOINING BARS

The joining bars are ø 1-3/8 inch Dywidag Bars with a three-step corrosion protection. The system was successfully used in marine environment. The rods will be either galvanized or epoxy-coated and grouted into polyethylene tubes. The rods will be delivered to site in this form. The sheathed rods are sleeved into the prestress ducts. After post-tensioning, all voids are filled with grease. The bars can be inspected and replaced if needed.

The bars show a capacity of 237 kips, which is one-third of the tendon capacity. Since the service force requirements are the same for the joint as for the pontoons, three bars for every tendon is needed.

Arrange bars in bundles:



The Pier's response to the typical loading scenarios are summarized in the following table and graphs.

Figure	Loading Conditions	Trim and Live Load Draft	Trim
1	2 compartments damaged and flooded	1.2'	1.7°
2	PRA at 4 berths	0.8'	0.0°
3	PRA at 2 berths on one side of MHP	1.4'	1.2°
4	SRA at 4 berths	1.4'	0.0°
5	SRA at 2 berths on one side of MHP	2.2'	1.9°
6	ROH at 4 berths	1.7'	0.0°
7	ROH at 2 berths on one side of MHP	2.6'	2.3°

Draft Changes Due to Live Load

5/16/01

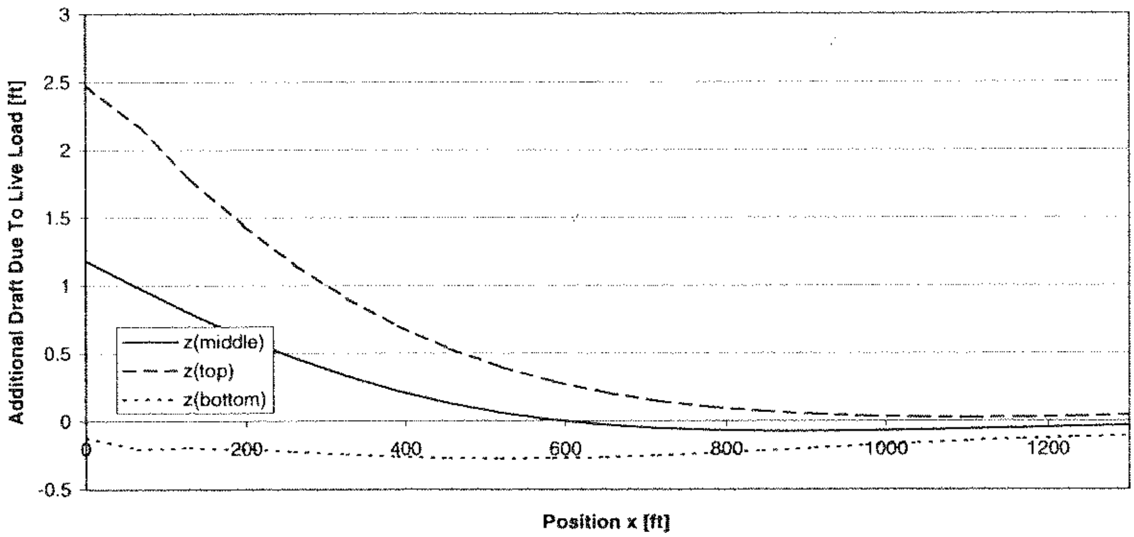
(1)

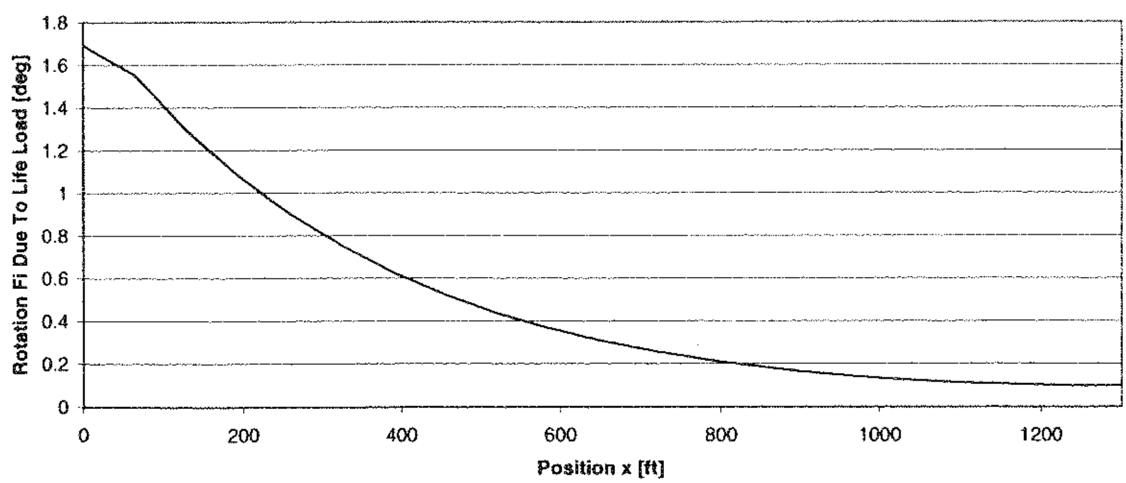
Structural Data:

Total Length:	1300 ft	Section Area:	339.5 sft
Pier Width:	88 ft	Section Vertical Inertia:	39,929 ft4
		Torsional Inertia J:	300,000 ft4
Maximum Additional Draft:	2.5 ft	Concrete Young's Modulus:	4000 ksi
Maximum Allowable Moment:	370000 kip-ft	Torsional Shear Modulus G:	1538 ksi

Loading on Pier (kip): **Damaged Position, 4 Pontoons**

y \ x	16.42	48.90						
32	653	653						
35								
29								
-11								
-29								
-40								





Maximum Draft =	2.479 ft
Maximum Rotation =	1.691 degrees
Maximum Pos Moment =	0 kip-ft
Maximum Neg Moment =	-124,080 kip-ft
Total Load =	1306 kip

2

Draft Changes Due to Live Load

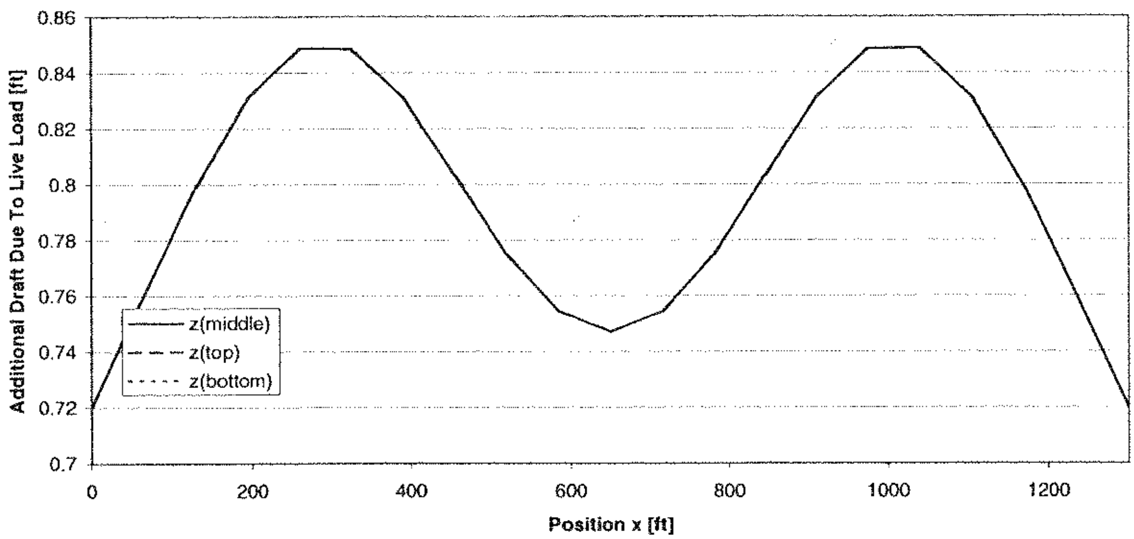
6/25/01

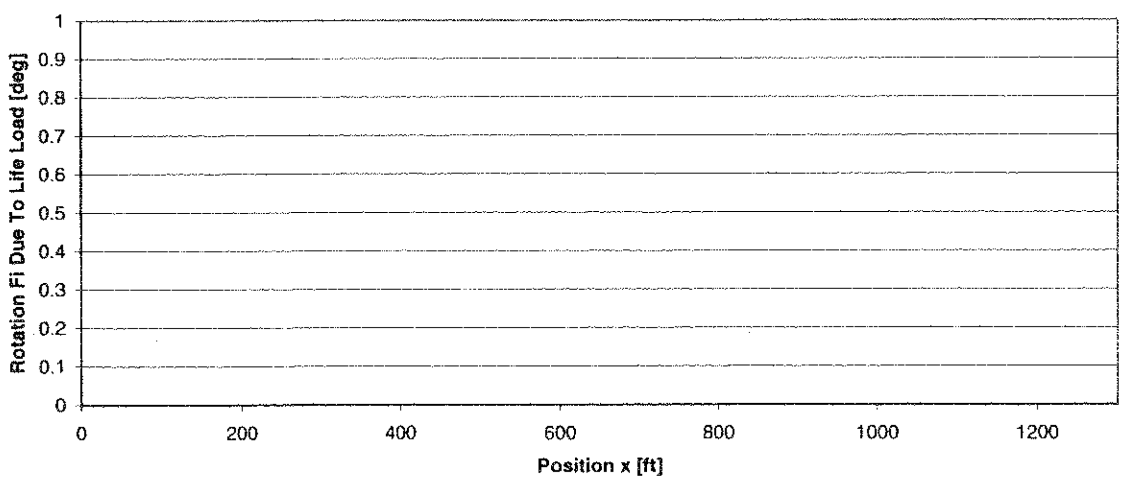
Structural Data:

Total Length:	1300 ft	Section Area:	339.5 sft
Pier Width:	88 ft	Section Vertical Inertia:	39,929 ft4
		Torsional Inertia J:	300,000 ft4
Maximum Additional Draft:	3 ft	Concrete Young's Modulus:	4000 ksi
Maximum Allowable Moment:	375000 kip-ft	Torsional Shear Modulus G:	1538 ksi

Loading on Pier (kip): **PRA on all 4 berths**

y \ x	195.00	255.00	325.00	395.00	905.00	975.00	1045.00	1105.00
40			170			170		
29	323	323	323	323	323	323	323	323
0								
0								
-29	323	323	323	323	323	323	323	323
-40			170			170		





Maximum Draft =	0.849 ft
Maximum Rotation =	0.000 degrees
Maximum Pos Moment =	103,436 kip-ft
Maximum Neg Moment =	-81,078 kip-ft
Total Load =	5848 kip

(3)

Draft Changes Due to Live Load

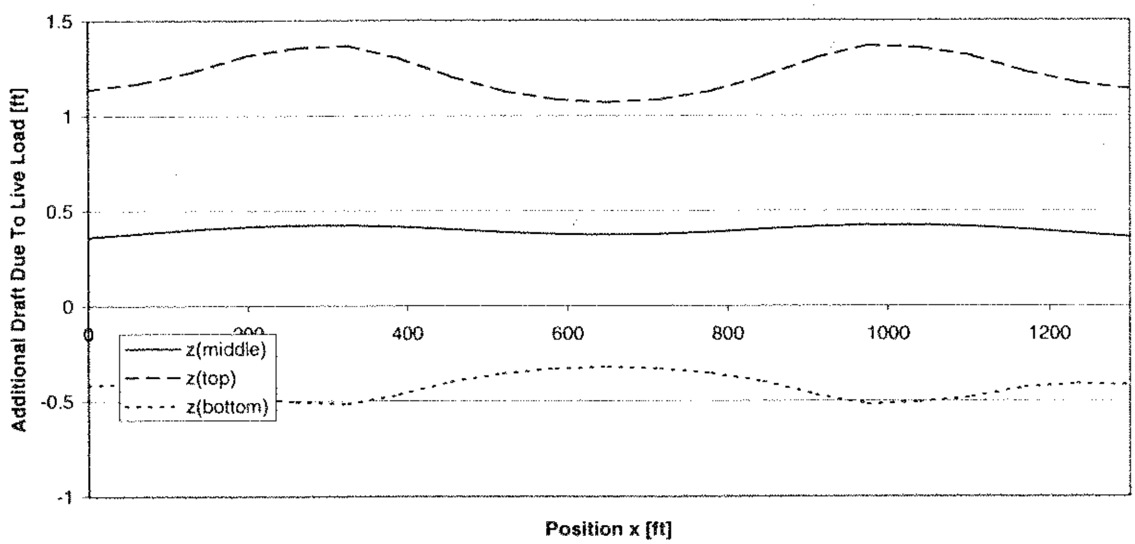
6/25/01

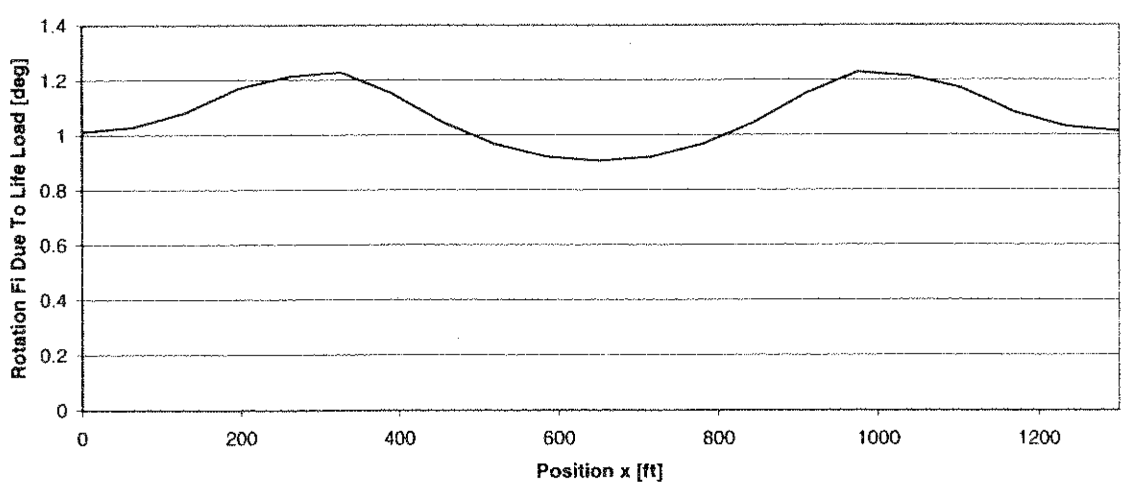
Structural Data:

Total Length:	1300 ft	Section Area:	339.5 sft
Pier Width:	88 ft	Section Vertical Inertia:	39,929 ft4
		Torsional Inertia J:	300,000 ft4
Maximum Additional Draft:	3 ft	Concrete Young's Modulus:	4000 ksi
Maximum Allowable Moment:	375000 kip-ft	Torsional Shear Modulus G:	1538 ksi

Loading on Pier (kip): **PRA on 2 berths, unbalanced**

y \ x	195.00	255.00	325.00	395.00	905.00	975.00	1045.00	1105.00
40			170			170		
29	323	323	323	323	323	323	323	323
0								
0								
-29								
-40								





Maximum Draft =	1.367 ft
Maximum Rotation =	1.227 degrees
Maximum Pos Moment =	51,718 kip-ft
Maximum Neg Moment =	-40,539 kip-ft
Total Load =	2924 kip

(4)

Draft Changes Due to Live Load

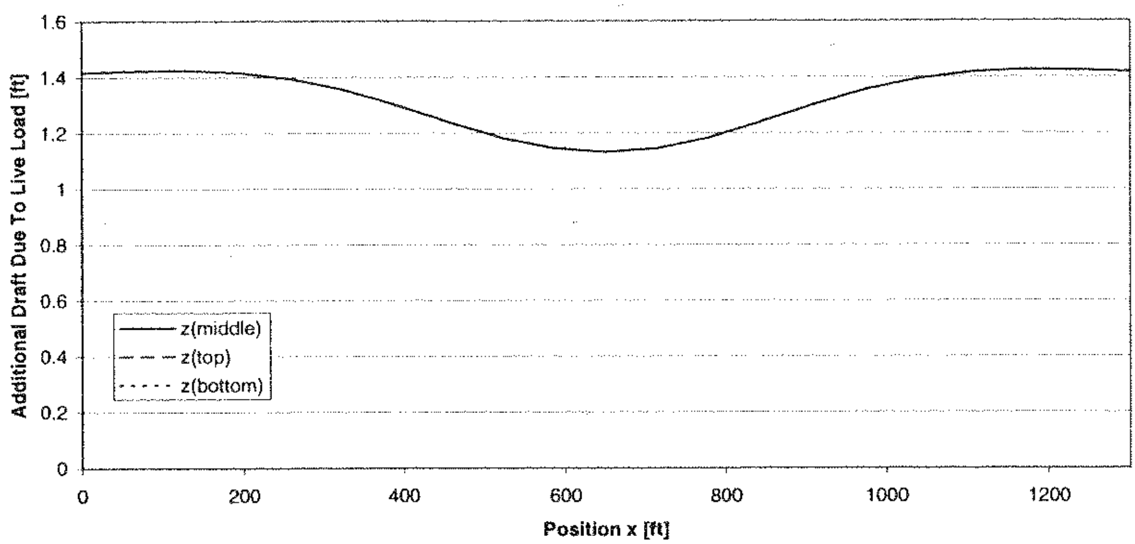
6/25/01

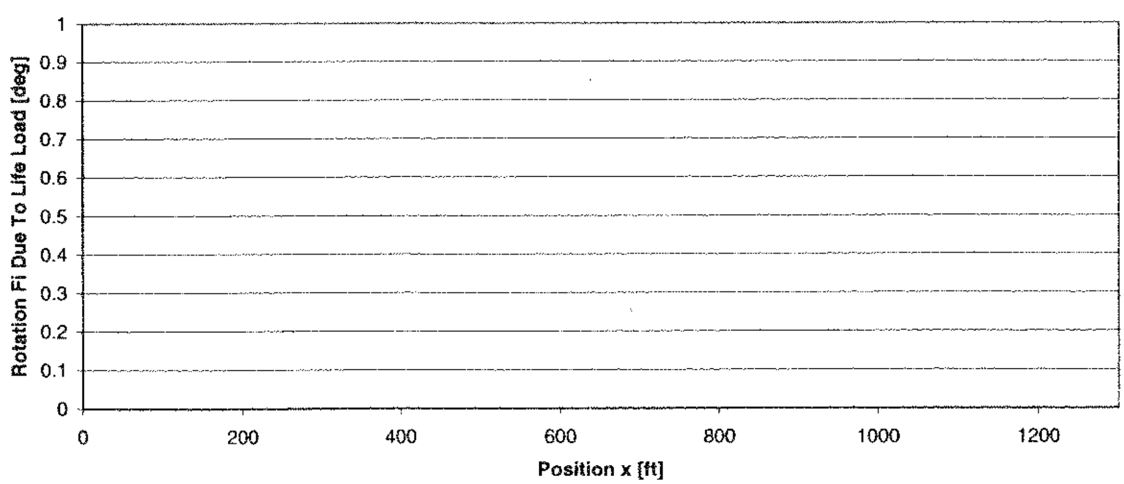
Structural Data:

Total Length:	1300 ft	Section Area:	339.5 sft
Pier Width:	88 ft	Section Vertical Inertia:	39,929 ft4
		Torsional Inertia J:	300,000 ft4
Maximum Additional Draft:	3 ft	Concrete Young's Modulus:	4000 ksi
Maximum Allowable Moment:	375000 kip-ft	Torsional Shear Modulus G:	1538 ksi

Loading on Pier (kip): **SRA on all 4 berths**

y \ x	126.00	232.00	325.00	418.00	882.00	975.00	1068.00	1174.00
40			170			170		
29	559.4	559.4	559.4	559.4	559.4	559.4	559.4	559.4
0								
0								
-29	559.4	559.4	559.4	559.4	559.4	559.4	559.4	559.4
-40			170			170		





Maximum Draft =	1.424 ft
Maximum Rotation =	0.000 degrees
Maximum Pos Moment =	95,190 kip-ft
Maximum Neg Moment =	-151,795 kip-ft
Total Load =	9630.4 kip

(3)

Draft Changes Due to Live Load

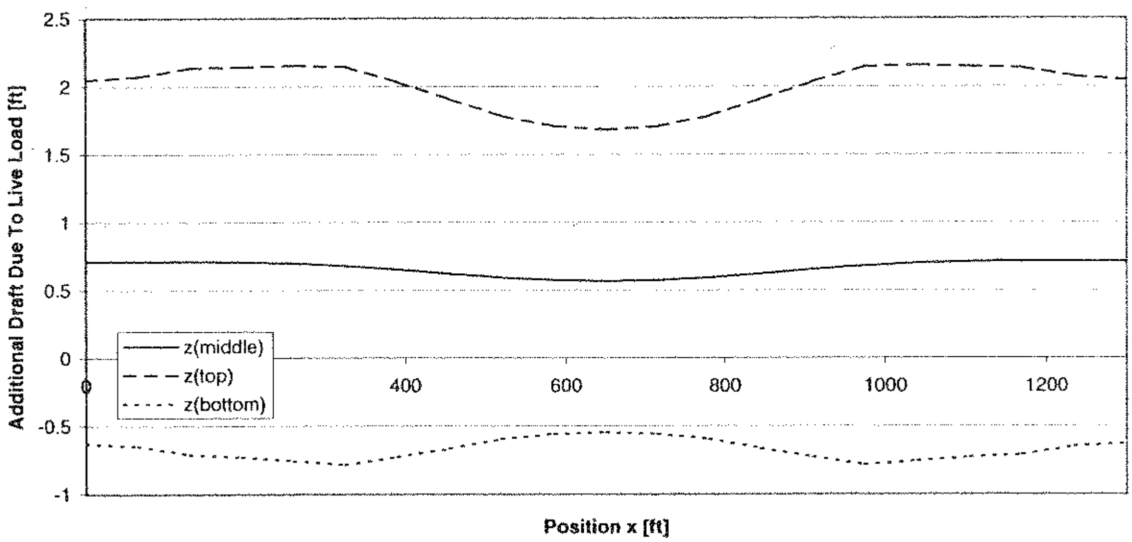
6/25/01

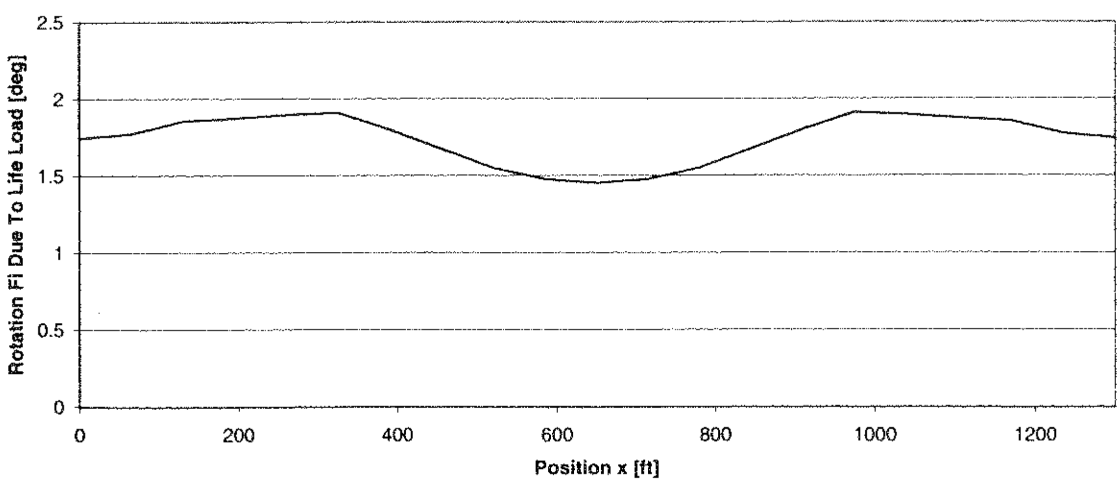
Structural Data:

Total Length:	1300 ft	Section Area:	339.5 sft
Pier Width:	88 ft	Section Vertical Inertia:	39,929 ft4
		Torsional Inertia J:	300,000 ft4
Maximum Additional Draft:	3 ft	Concrete Young's Modulus:	4000 ksi
Maximum Allowable Moment:	375000 kip-ft	Torsional Shear Modulus G:	1538 ksi

Loading on Pier (kip): **SRA on 2 berths, unbalanced**

y \ x	126.00	232.00	325.00	418.00	882.00	975.00	1068.00	1174.00
40			170			170		
29	559.4	559.4	559.4	559.4	559.4	559.4	559.4	559.4
0								
0								
-29								
-40								





Maximum Draft =	2.153 ft
Maximum Rotation =	1.909 degrees
Maximum Pos Moment =	47,595 kip-ft
Maximum Neg Moment =	-75,898 kip-ft
Total Load =	4815.2 kip

6

Draft Changes Due to Live Load

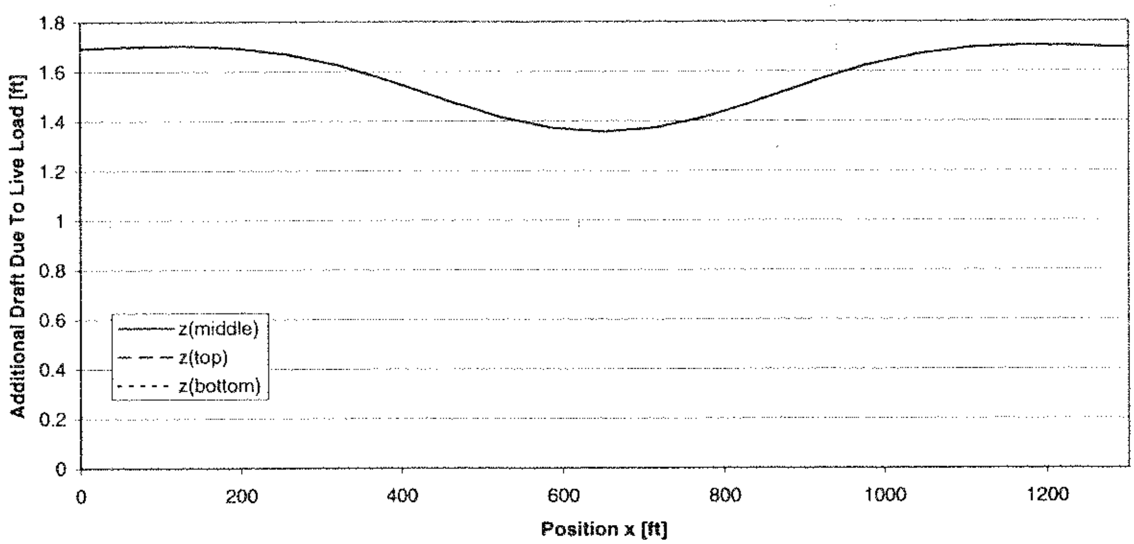
6/25/01

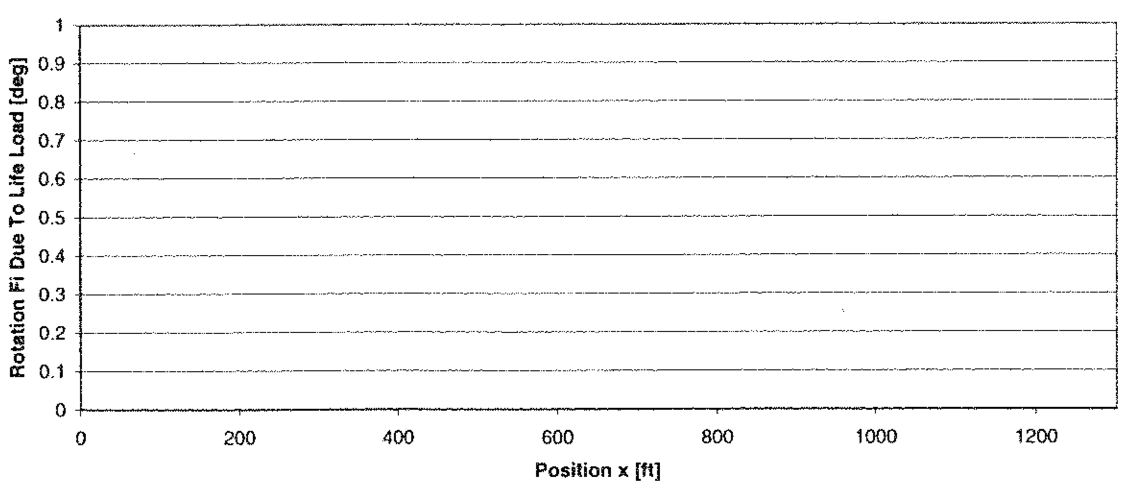
Structural Data:

Total Length:	1300 ft	Section Area:	339.5 sft
Pier Width:	88 ft	Section Vertical Inertia:	39,929 ft4
		Torsional Inertia J:	300,000 ft4
Maximum Additional Draft:	3 ft	Concrete Young's Modulus:	4000 ksi
Maximum Allowable Moment:	375000 kip-ft	Torsional Shear Modulus G:	1538 ksi

Loading on Pier (kip): ROH on all 4 berths

y \ x	127.00	233.00	326.00	419.00	881.00	974.00	1067.00	1173.00
40			170			170		
29	678	678	678	678	678	678	678	678
0								
0								
-29	678	678	678	678	678	678	678	678
-40			170			170		





Maximum Draft =	1.703 ft
Maximum Rotation =	0.000 degrees
Maximum Pos Moment =	111,180 kip-ft
Maximum Neg Moment =	-180,468 kip-ft
Total Load =	11528 kip

7

Draft Changes Due to Live Load

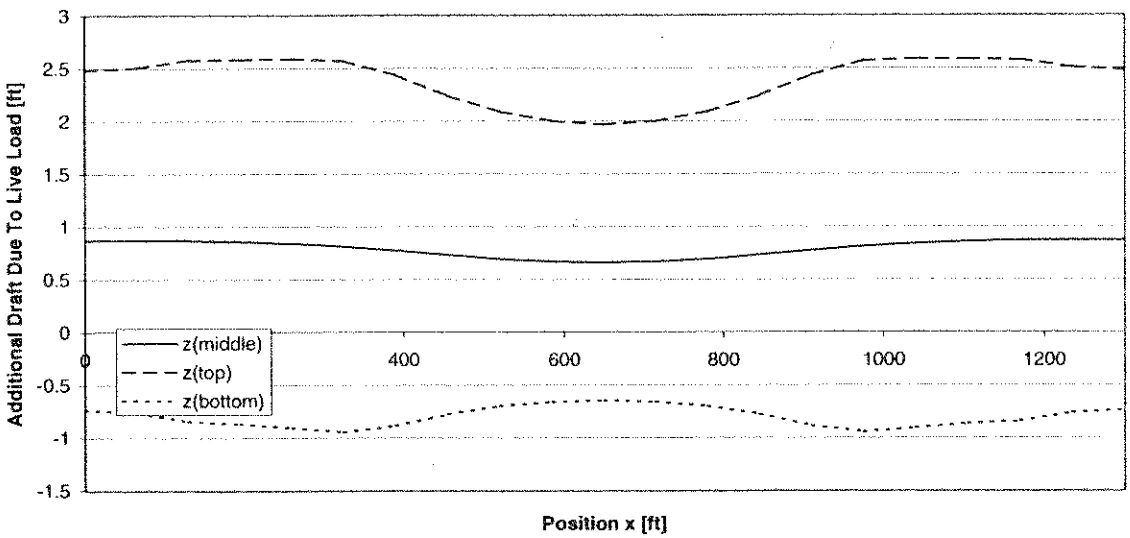
6/25/01

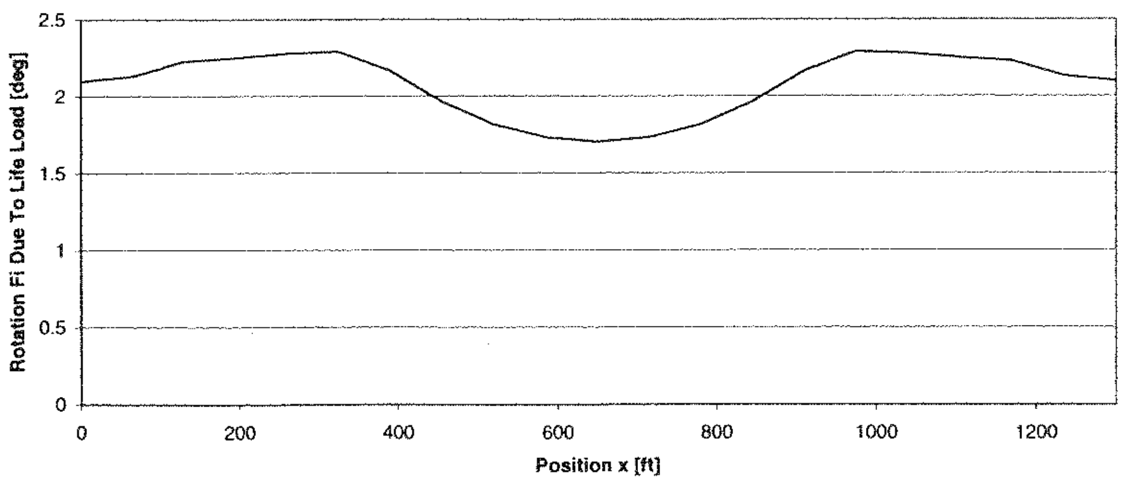
Structural Data:

Total Length:	1300 ft	Section Area:	339.5 sft
Pier Width:	88 ft	Section Vertical Inertia:	39,929 ft4
		Torsional Inertia J:	300,000 ft4
Maximum Additional Draft:	3 ft	Concrete Young's Modulus:	4000 ksi
Maximum Allowable Moment:	375000 kip-ft	Torsional Shear Modulus G:	1538 ksi

Loading on Pier (kip): **ROH on 2 berths, unbalanced**

y \ x	126.00	232.00	325.00	395.00	905.00	975.00	1068.00	1174.00
40			170			170		
29	678	678	678	678	678	678	678	678
0								
0								
-29								
-40								





Maximum Draft =	2.587 ft
Maximum Rotation =	2.290 degrees
Maximum Pos Moment =	59,239 kip-ft
Maximum Neg Moment =	-98,895 kip-ft
Total Load =	5764 kip