APPENDIX B

ANALYSIS OF DAMAGED STABILITY EFFECTS

This appendix contains the analysis of damaged stability effects.

The draft due to the two-compartment damaged condition has two components: displacement in the longitudinal plane and displacement due to the MHP rolling. Because of the length of the floating pier (total 1,300 feet), the pier cannot be analyzed as a rigid member anymore. Therefore, combined structural and hydrostatic displacement in the longitudinal plane was determined based on the beam on elastic foundation theory (reference: *Beam on Elastic Foundation* by M. Hetenyi, 1976). MHP rolling effects were determined assuming the MHP is torsionally rigid.

(Note: MHP rolling was recalculated using the calculated torsional stiffness (by MW), it turns out that MHP is not as torsionally rigid as we assumed for the damaged stability analysis. As a result, the draft due to the rolling is more than the result of the entire analysis. The updated total draft is shown in [ ].

Summary of Analysis

Four-pontoon system:
Total draft = 1.55 feet [2.5 feet]

Two-pontoon system:
Total draft = 2.17 feet [2.8 feet]

DAMAGED STABILITY

Since length of MHP floating pier (after 4-modules are connected) is relatively long (Total of 1300 ft), we cannot assume that it will behave as a "Ridig Member". It will behave like a beam on elastic foundation. In fact, water is the perfect elastic foundation.

(REF: BEAM ON ELASTIC FOUNDATION by M. HETENYI, 1976)

In Transversely, the width of Pier is 88 feet (short). Therefore, we will use "RIDIG MEMBER" analysis to obtain the rolling behavior of the pier. (We assumed that MHP is torsionally very stiff.)

MODEL using RISA-3D

Material Property

Assume

f'c =	7000	psi (@ 56 days)		
γ =	128	pcf (Not including steel)		
E =	33 γ^15 f'c^0.5 =		3,998,000	psi

Member Property

- use Refined Sect Property (Approximate)

For Damaged Δ, Use Average Section (50% Open Section and 50% solid section)

A =	339.5	ft^2 =	48,888	in^2
Ix =	39929	ft^4 =	827,967,744	in^4
Iy =	268288	ft^4 =	5,563,219,968	in^4

Spring Property

Determine Spring for Seawater

k = 88 ft x 64 lb/cf = 5,760 lb/sf = 5.76 kip/sf

Determine Characteristic of System (Page 4 of REFERENCE)

λ : Characteristics of System

E = Assume 4000 ksi = 576,000 kip/sf

I = Ix avg = 39929 ft^4 ~= 40,000 ft^4

$$\lambda = \sqrt[4]{\frac{k}{4EI}} = \sqrt[4]{\frac{5.76 \text{ kip/sf}}{(4)(576000 \text{ kip/sf})(40{,}000 \text{ ft}^4)}}$$

$$= 0.0028$$

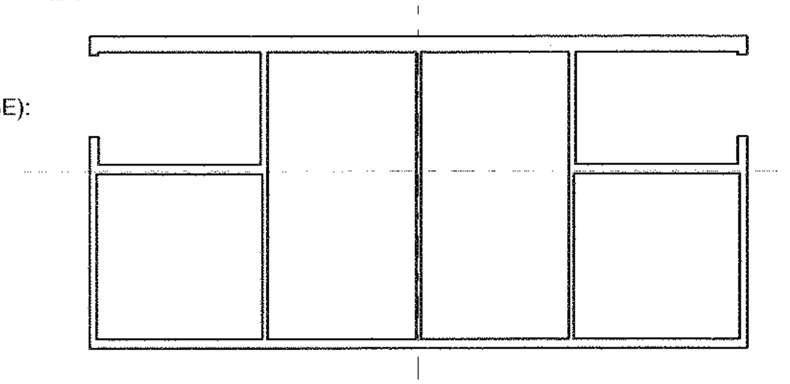
$(1/\lambda = 355.6 \text{ ft})$

Determine the k_end and k_middle for the model

k_end y =	(5.75 kip/sf) (54.16ft) (1/2) =	157 kip/ft =	**13 kip/in**
k_mid y =	(5.76 kip/sf) (54.16ft) =	312 kip/ft =	**26 kip/in**

SECTION PROPERTIES WORKSHEET

PROJECT: NFESC HYBRID FLOATING PIER
FILENAME: O:\2001\A01047\ENGR\Waterfront\Analysis\[section.XLS]
SUBJECT: CROSS SECTION OF PIER
DESIGNER: KAP
DATE: 6/25/2001



SECTION COORDINATES (CLOCKWISE):

X	Y
44.000	0.000
-44.000	0.000
-44.000	19.000
-42.833	19.000
-42.833	16.500
-21.083	16.500
-21.083	26.583
-42.833	26.583
-42.833	26.333
-44.000	26.333
-44.000	28.000
44.000	28.000
44.000	26.333
42.833	26.333
42.833	26.583
21.083	26.583
21.083	16.500
42.833	16.500
42.833	19.000
44.000	19.000
44.000	0.000
end	

SECTION PROPERTIES:

Area:	331.08 ft^2	=	47675.8498	in^2
Xbar:	0 ft	=	0	in
Ybar:	15.921 ft	=	191.056764	in
Ix:	39,521 ft^4	=	8.195E+08	in^4
Iy:	252,158 ft^4	=	5.229E+09	in^4

HOLE COORDINATES (COUNTERCLOCKWISE):

X	Y

CIRCULAR HOLES:

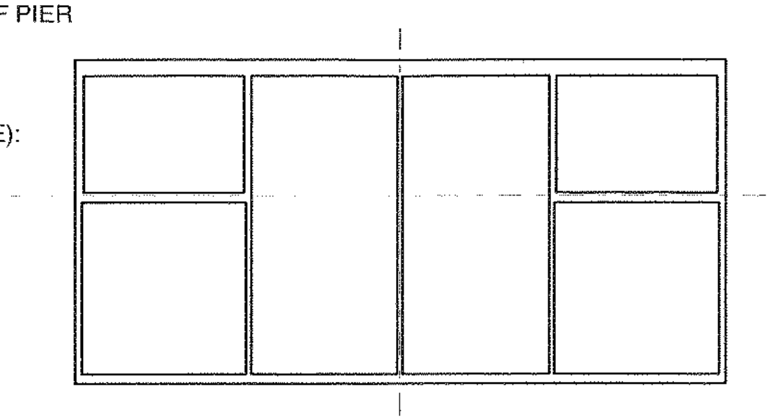
Xo	Yo	D

RECTANGULAR HOLES:

Xo	Yo	B	H
10.208	13.708	19.750	25.750
-10.208	13.708	19.750	25.750
31.958	8.250	22.250	14.833
-31.958	8.250	22.250	14.833

SECTION PROPERTIES WORKSHEET

PROJECT: NFESC HYBRID FLOATING PIER
FILENAME: O:\2001\A01047\ENGR\Waterfront\Analysis\[section.XLS]
SUBJECT: CROSS SECTION OF PIER
DESIGNER: KAP
DATE: 6/25/2001



SECTION COORDINATES (CLOCKWISE):

X	Y
44.000	0.000
-44.000	0.000
-44.000	28.000
44.000	28.000
44.000	0.000
END	

SECTION PROPERTIES:

Area:	348.19	ft^2 =	50139.7884	in^2
Xbar:	0	ft =	0	in
Ybar:	16.253	ft =	195.030813	in
Ix:	40,337	ft^4 =	8.364E+08	in^4
Iy:	284,418	ft^4 =	5.898E+09	in^4

HOLE COORDINATES (COUNTERCLOCKWISE):

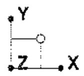
X	Y

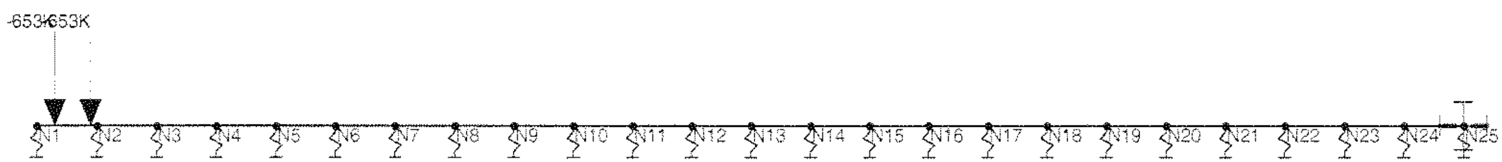
CIRCULAR HOLES:

Xo	Yo	D

RECTANGULAR HOLES:

Xo	Yo	B	H
10.208	13.708	19.750	25.750
-10.208	13.708	19.750	25.750
31.958	8.250	22.250	14.833
-31.958	8.250	22.250	14.833
31.958	21.542	21.750	10.083
-31.958	21.542	21.750	10.083



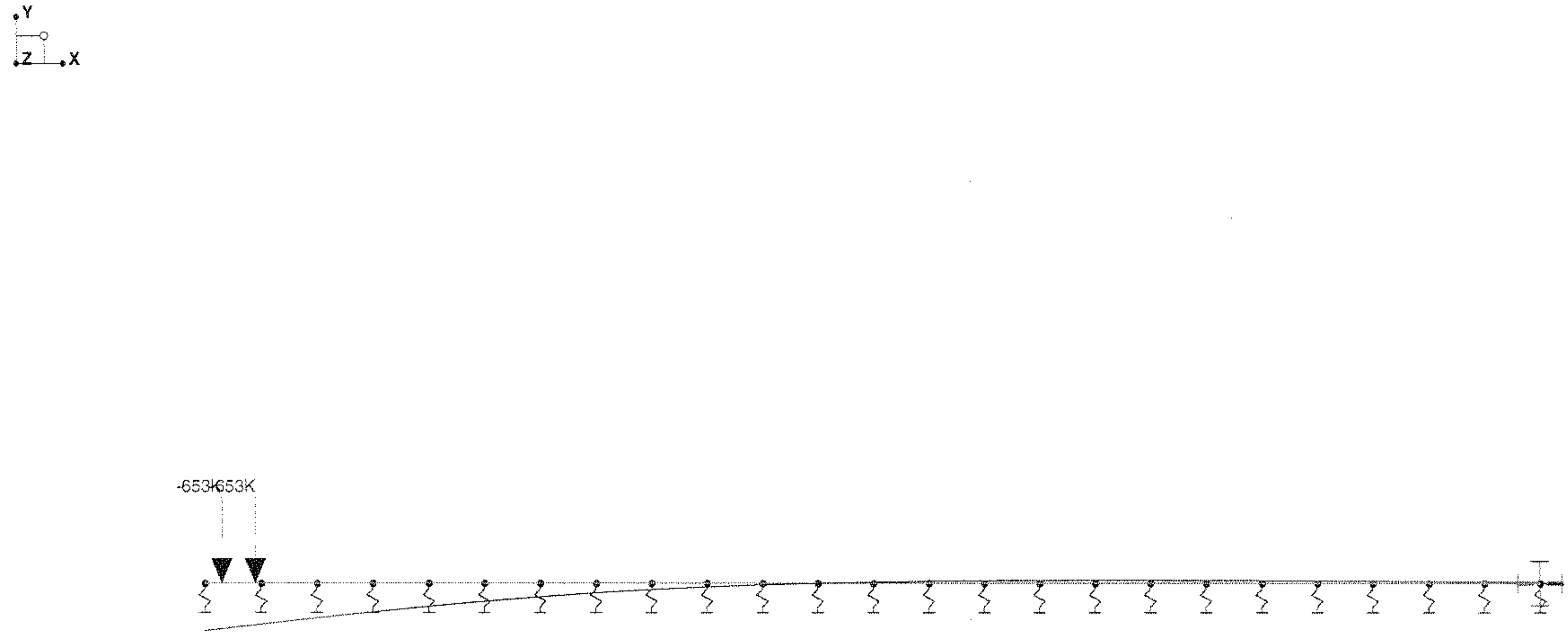


Spacing of spring = 54.16 ft
Total Length = 1300 ft

We Approximate Point of Loading to be: $\dfrac{\text{Long. Dim of Cell}}{2}$

Loads: LC 1, 653 kips @ ends

BERGER/ABAM Inc.	NFSC HYBRID FLOATING PIER	June 25, 2001
Kayoko Price		2:01 PM
A01047	Point of Loading for 2-Compartment Damaged Condition	beamonelastic3.r3d



Δ E = 13.8" ~= 14 " (RISA Analysis)
Δ ROLL = 0.38 ft = 4.64 " (Hand Calc's)
Δ TOTAL = 1.55ft

Loads: LC 1, 653 kips @ ends
Solution: LC 1, 653 kips @ ends

BERGER/ABAM Inc.	NFSC HYBRID FLOATING PIER	June 25, 2001
Kayoko Price		2:33 PM
A01047	Elastic Displacement for 2 Compartment Damaged Condition	beamonelastic3.r3d

[Summary]

After MHP PH II meeting w/ Navy, we decided to increase the number of Transverse Walls in Exterior Cells
The result - The draft due to damage stability has reduced as follows.

(4 Pontoon System)

	Previous	Updated	
Δ elastic	21.4 in	14 in	
Δ roll (cL to side)	0.75 ft	0.387 ft	
TOTAL	2.53 ft	1.55 ft	Less than 3.0 ft

**

Δ elastic was checked by handcalculation. Handcal'cΔ = 14.8 in

(2 Pontoon System)

We also checked the draft for 2 Pontoon System. It turns out that 2 - pontoon system has a larger Damaged Draft.

	Updated	
Δ elastic	16.6 in	
Δ roll (cL to side)	0.775 ft	
TOTAL	2.16 ft	less than 3.0 ft

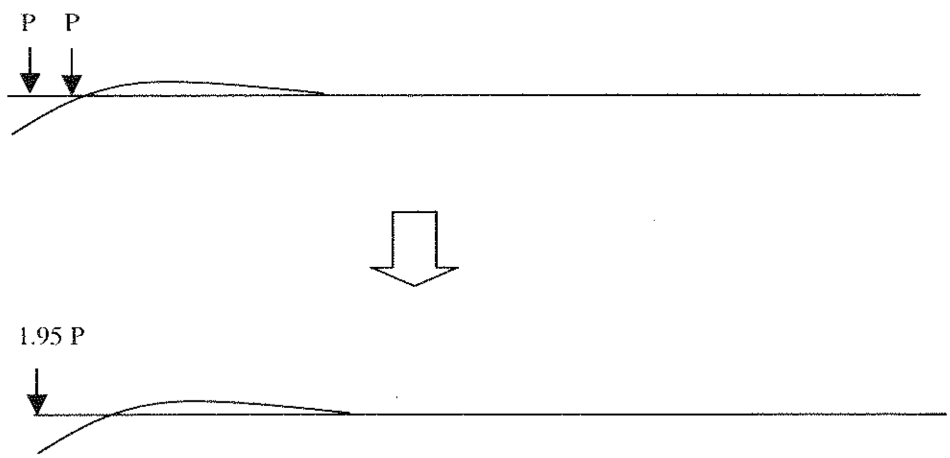
Comments:

Δ roll was calculated assuming that MHP is torionally very rigid. However, according to MW's calculation, it is not as rigid as we were assuming. Therefore, the Draft Displ.

BERGER/ABAM ENGINEERS INC.

Project	MHP PH II	Sheet	of
		Job Number	A01047
Subject	DAMAGED STABILITY	Designer	KAP
		Date	5/9/01 updated

HAND CALCULATION : WHAT KIND OF Δ DO WE EXPECT TO SEE?



SUM Ma = P(1300-48.9) + P(1300-16.4) = xP(1300')

x = $\boxed{1.95}$

Now Use M. HETENYI METHOD - Page 24 of Ref.

$$D = y = \frac{2P\lambda}{k}(D\_kx) \qquad D\_kx = e^{-x}\cos(x)$$

$$= e^{-0}\cos(0) = 1.0$$

$$= \frac{2\,(1.95\text{ kips})\,(0.00281/\text{ft})}{5.76\text{ kip/sf}}\,(-1)$$

$$= 0.0019\,P$$

IF P = 653 KIPS ------- Δ = 1.24 ft = 14.8 in

— HAND CALC —

BEAM ON ELASTIC FOUNDATION by M. HETENYI 1974

Giving such values to P_0 and M_0, we shall obtain for the right side of the beam (Fig. 15a) a situation identical to that shown in Figure 15c.

c. Semi-infinite Beam with Fixed End (Fig. 15d)

In order to fulfill the conditions $y = 0$ and $\theta = 0$ for point A, if the loading produced y_A and θ_A at this point of the infinite beam the end-conditioning forces P_0 and M_0 would have to produce $-y_A$ and $-\theta_A$ at the same place. This condition can be written, by use of (5 a–b) and (6 a–b), as

$$y_A + \frac{P_0 \lambda}{2k} = 0 \quad \text{and} \quad \theta_A + \frac{M_0 \lambda^3}{k} = 0, \tag{c}$$

from which we obtain the end-conditioning forces as

$$\left.\begin{aligned} P_0 &= -\frac{2k}{\lambda} y_A , \\ M_0 &= -\frac{k}{\lambda^3} \theta_A . \end{aligned}\right\} \tag{18}$$

If P_0 and M_0 in Figure 15a have these values, the right part of the beam will behave in exactly the same manner as the fixed-end beam shown in Figure 15d.

FIG. 16

9. *Particular Cases of End Loading*

The formulas developed above for the end-conditioning forces can also be used for deriving expressions for a semi-infinite beam subjected to various types of end conditions.

Let us consider first the situation shown in Figure 16. Here the end conditions for point O are $M = 0$ and $Q = -P_1$. Putting $M_A = 0$ and $Q_A = P_1$ into (16), we obtain the corresponding end-conditioning forces $P_0 = 4P_1$ and $M_0 = -(2/\lambda)P_1$. If we apply these P_0 and M_0 on the infinite beam, using (5 a–d) and (6 a–d), we get the solution for $x > 0$. The result will be

$$\left.\begin{aligned} y &= \frac{2P_1 \lambda}{k} D_{\lambda x} , \\ \theta &= -\frac{2P_1 \lambda^2}{k} A_{\lambda x} , \\ M &= -\frac{P_1}{\lambda} B_{\lambda x} , \\ Q &= -P_1 C_{\lambda x} . \end{aligned}\right\} \tag{19a–d}$$

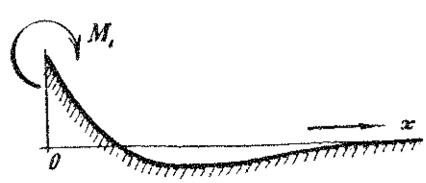


FIG. 17

In order to reach the solution for the situation shown in Figure 17 we have to put $M_A = -M_1$ and $Q_A = 0$ into (16), which then gives $P_0 = -4\lambda M_1$ and $M_0 = 4M_1$. Applying these end-conditioning forces at point O on the infinite beam, we have for values of $x > 0$:

TABLE I

$\sin x$, $\cos x$, $\text{Sinh}\, x$, $\text{Cosh}\, x$, e^{x}, e^{-x},

$A_x = e^{-x}(\cos x + \sin x)$, $B_x = e^{-x} \sin x$,

$C_x = e^{-x}(\cos x - \sin x)$, $D_x = e^{-x} \cos x$.

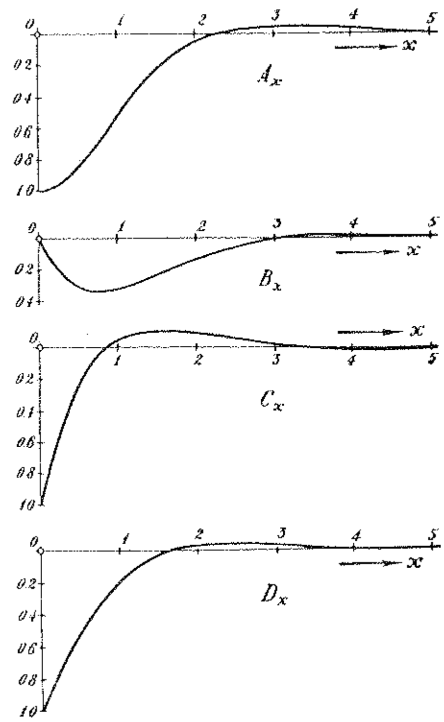


Fig. 162