WAVE LOADING

COMPUTATION SHEET

PROJECT CHAMBER MODULE	PAGE 1 OF 18	COMPUTED BY MHG	DATE 6/96
SUBJECT WAVE LOADING		CHECKED BY	DATE

H & H DATA

1. Transport Case 4-6' wave, use $h = 4'$ as large ship passage can be restricted to $h = 3'$ (6' wave), as per para 2 of H&H Memo dated 17 Jun 96
   $d = L_{module} = 440'$
2. Construction Case - Assume a curtain wall is constructed and wave height is negligible.
3. Hurricane Wave - the construction site (Golvez Street Wharf) is far enough from the open lake that the 13' rise will be a gradual rise and not a wave; the max wave ht @ the Construction Site is 7'.

WAVE LOADING AS PER "STRUCTURAL CONSIDERATIONS and CONFIGURATIONS II
JEAN MULLER

From Para 3.2

1) Head on Wave - Long Direction ($\alpha = 0$)

$B = 172'$, $L = 440'$, $h = 3'$

$$M_{o} @ L/2 = \frac{\gamma \cdot B \cdot L^2 \cdot h}{2\pi^2} = \frac{0.063 \cdot 172 \cdot 440^2 \cdot 3}{2 \cdot \pi^2} = 320{,}000 \text{ 'k}$$

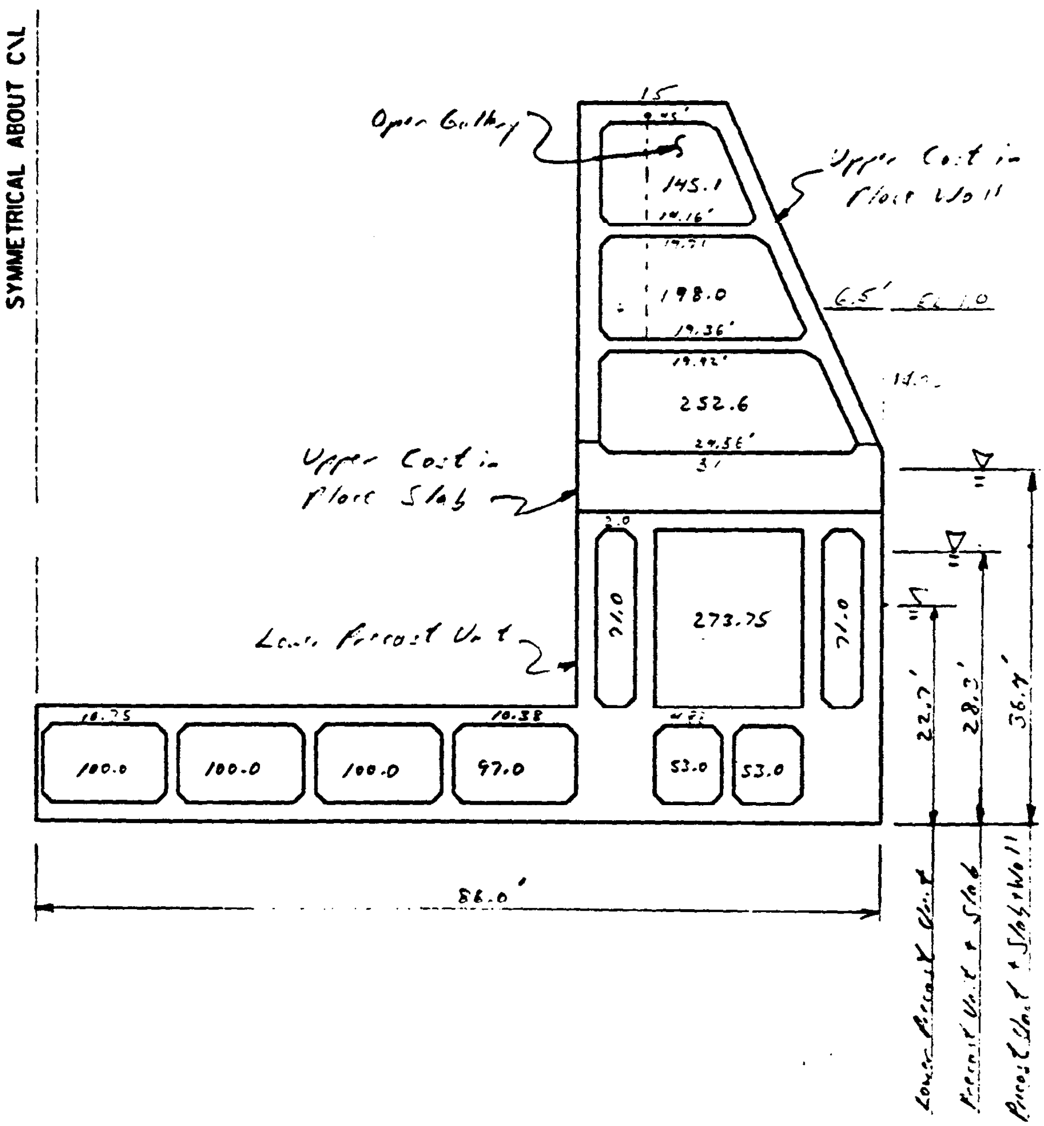
$$V_{o} @ L/2 = \frac{\gamma \cdot B \cdot L \cdot h}{2\pi} = \frac{0.063 \cdot 172 \cdot 440 \cdot 3}{2\pi} = 2{,}280 \text{ K}$$

LOAD CASE (CONSTRUCTION)

CHAMBER MONOLITH - 14' STRIP

DRAFT COMPUTATIONS

CHAMBER 446 x 172



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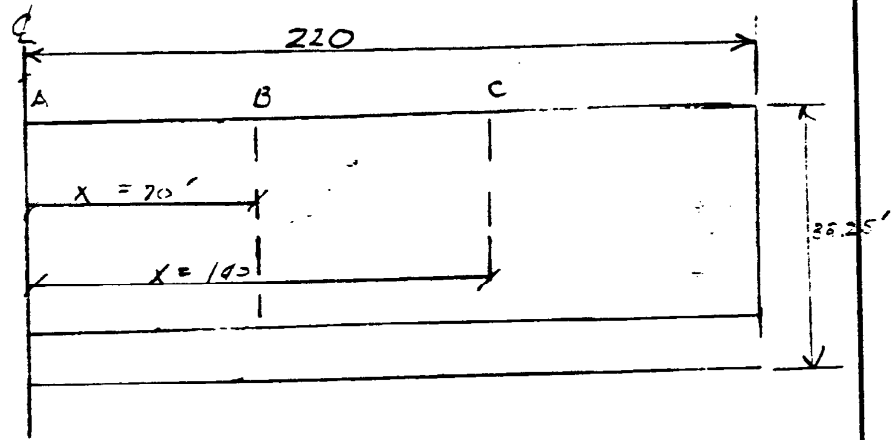
COMPUTATION SHEET

PROJECT	PAGE 2 OF 18	COMPUTED BY MR	DATE 9/96
SUBJECT		CHECKED BY	DATE

2) Determine M & V @ Various Sections along Long. Dir w/ Head On Wave

TRANSPORT SECTION



Moment

$\alpha = 0 \quad \gamma = 0$

$$M_x = M_{℄} \cdot \frac{\pi^2}{2\beta^2}\left(\frac{4x^2 - L^2}{2L^2}\,\beta \cdot \sin\beta + \cos 2\beta\frac{x}{L} - \cos\beta\right)$$

where $\beta = \frac{\pi L}{d}$

select $d = L$ ∴ $\beta = \pi$

$x = 70'$

$$M_{70} = 320{,}000 \cdot \tfrac{1}{2}\left(0 + \cos(2\pi)\frac{70}{440} - \cos\pi\right)$$

$= 320{,}000 \cdot \tfrac{1}{2}(0.541 + 1)$

$= 246{,}600$ 'K

$$M_{140} = 320{,}000 \cdot \tfrac{1}{2}(0 - 0.415 + 1)$$

$= 93{,}600$ 'K

Shear @ $\alpha = 0 \quad \gamma = 0$

$$V_x = \frac{\gamma B h}{2\beta}\left(L \cdot \sin 2\beta\frac{x}{L} - 2x \sin\beta\right)$$

$V_{℄} = 0$

$x = 70'$

LMV FORM MAR 82 107e PREVIOUS EDITIONS MAY BE USED (FOR USE WITH 10 x 10 GRID)

COMPUTATION SHEET

PROJECT	PAGE 3 OF 18	COMPUTED BY MR	DATE 10/96
SUBJECT		CHECKED BY	DATE

$V_{70} = \frac{0.063 \times 172 \times 3}{2 \cdot 3.14} \left(440 \cdot \sin \frac{2 \cdot 3.14 \cdot 70}{440} + 2(70) \sin \pi \right)$ (sin π = 0)

$= 5.18\ (370)$

$= 1{,}920\ K$

$V_{110} = 5.18 \left(440 \cdot \sin \frac{2 \cdot 3.14 \cdot 110}{440} \right)$

(QUARTER PT)

$= 2{,}280\ K = V_{max}$

$V_{140} = 5.18 \left(440 \cdot \sin \frac{2 \cdot 3.14 \cdot 140}{440} \right)$

$= 2080\ K$

$V_{180} = 5.18 \left(440 \cdot \sin \frac{2 \cdot 3.14 \times 180}{440} \right)$

$= 1{,}235\ K$

Maximum moment occurs when $d \approx 0.89\ L = 392'$

$M_{max} = 1.027\ M_o \qquad \alpha = 0$

$= 1.027 \times 320{,}000$

$= 328{,}600\ 'K$

$\beta = \frac{\pi L}{d} = \frac{\pi \cdot 440}{392} = 3.52$

$M_{\mathbb{C}} = 320{,}000 \cdot \frac{\pi^2}{2 \times 3.52^2} \left(1 - \cos 3.52 - \tfrac{1}{2} \cdot 3.52 \cdot \sin 3.52 \right)$

$= 320{,}000 \cdot 0.398\ (2.58)$

$= 329{,}000\ 'K$

$M_{70} = \left(320{,}000 \cdot \frac{\pi^2}{2 \cdot 3.52^2} \right) \left[\left(\frac{4 \cdot 70^2 - 440^2}{2 \cdot 440^2} \cdot 3.52 \cdot \sin 3.52 \right) + \cos\left(2 \cdot 3.52 \cdot \frac{70}{440}\right) - \cos 3.52 \right]$

$= 127{,}320 \left[0.584 + 0.436 + 0.93 \right]$

$= 248{,}300\ 'K$

$M_{140} = 93{,}600 \times 1.027$

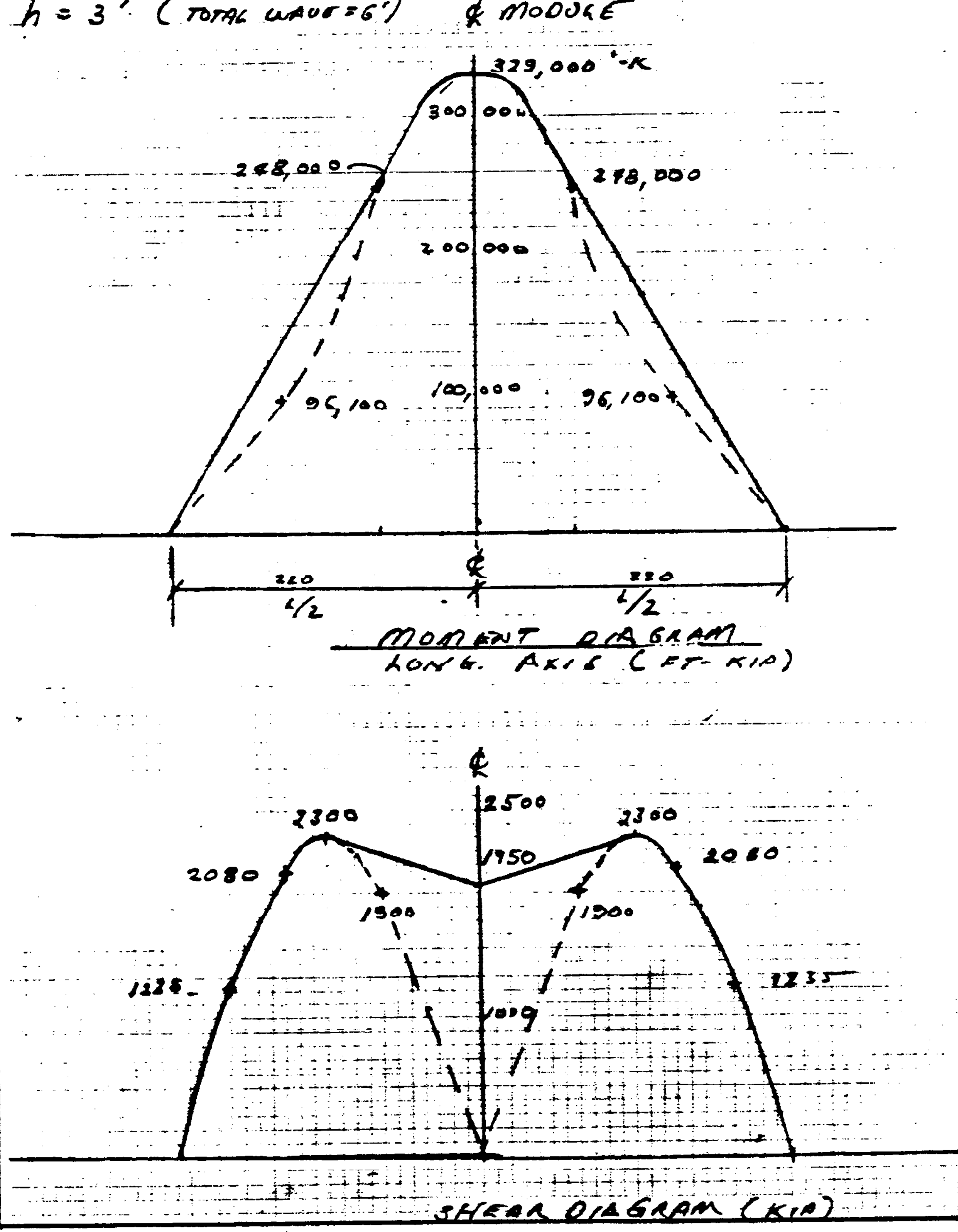
$= 96{,}130\ 'K$

LMV FORM MAR 82 107a PREVIOUS EDITIONS MAY BE USED (FOR USE WITH 10 x 10 GRID)

COMPUTATION SHEET

PROJECT	PAGE 4 OF 18	COMPUTED BY [illegible]	DATE 10/96
SUBJECT		CHECKED BY	DATE

LONGITUDINAL AXIS
$\alpha = 0°$ (HEAD ON)
$h = 3'$ (TOTAL WAVE = 6')



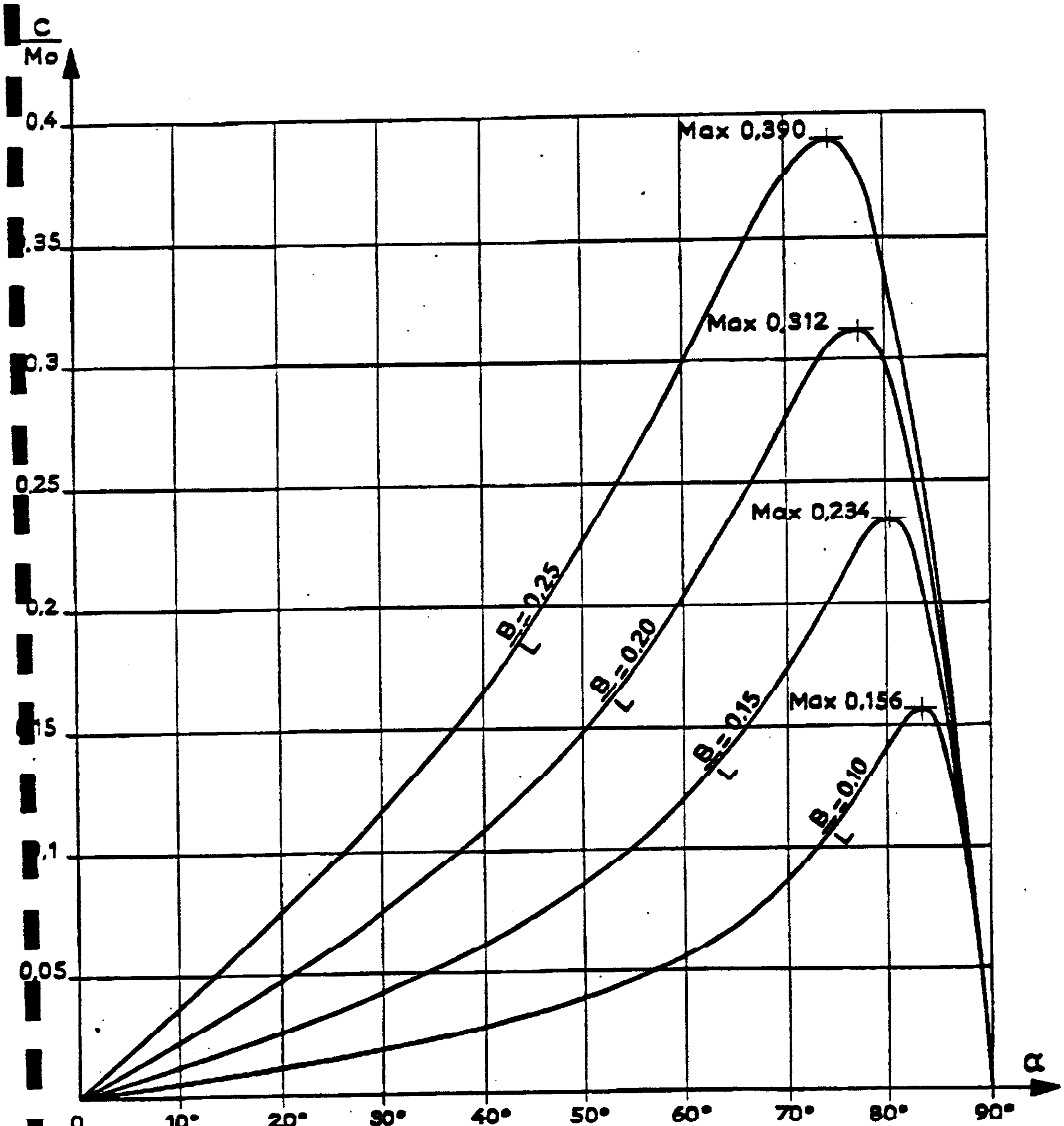


Fig. 16 _ VARIATION OF TORQUE MOMENT VERSUS DIRECTION OF WAVE

@ $d = 0.70L$ $V \approx 0.85 V_0$

$= 0.85 \times 2300$

$= 1950$ K @ ℄

TORQUE $h = 3$ $\alpha = 65°$* (see Fig 16) $\frac{B}{L} = 0.39$

$$C = \frac{\gamma_{H_2O} \cdot B^2 L h}{4} \cdot \frac{\cos(2B\frac{x}{L}) - \cos B}{B} \cdot \frac{\sin\gamma - \gamma\cos\gamma}{\gamma^2}$$

where $\gamma = 0.063$

$B = 172$

$d = L = 440$

$h = 3'$

$$\beta = \frac{\pi \cdot L \cos\alpha}{d}$$

w/ $L = d$

$\beta = \pi \cdot \cos\alpha$

$= 1.33$

$$\gamma = \frac{\pi \cdot B \cdot \sin\alpha}{d}$$

$$= \frac{\pi \cdot 172 \cdot \sin 65}{440}$$

$= 1.11$

$$C_{℄} = \frac{0.063 \cdot 172^2 \cdot 440 \cdot 3}{4} \cdot \frac{\cos 0 - \cos 1.33}{1.33} \cdot \frac{\sin 1.11 - 1.11\cos 1.11}{1.11^2}$$

$= 615,050 \times 0.572 \times 0.326$

$= 115,000$ '-K

$C_{x=70'} = 615,050 \cdot 0.506 \times 0.326$

$= 101,600$

$C_{x=110} = 615,050 \times 0.412 \times 0.326$

$C_{x=140} = 615,050 \times 0.319 \times 0.326$

$= 63,800$K

* $\alpha_{critical} = \tan^{-1}\alpha = 0.893 \frac{L}{B_{65°}} = 0.893 \frac{440}{172}$

$\alpha = 66.5°$ use $65°$

COMPUTATION SHEET

PROJECT	PAGE 6 OF 18	COMPUTED BY MOL	DATE 10/96
SUBJECT		CHECKED BY	DATE

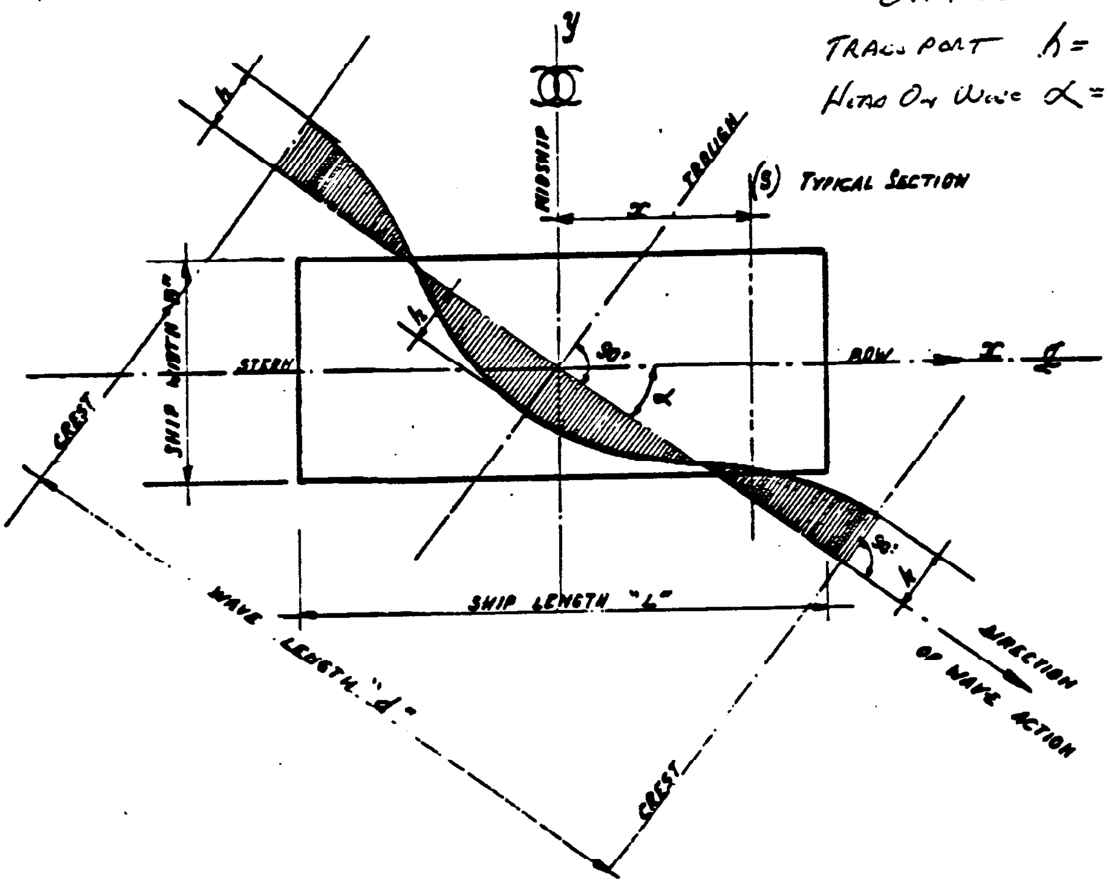
*$M_{max} = \pm 329,000$ 'K @ ℄ (± accounts for hogging & sagging)

$V_{max} = 2300$ 'K @ L/4 From ℄

$T_{max} = 115,000$ 'K @ ℄

* Wave loading acting on short D-Frame that leaves GRADING Site.

CHAMBER
TRANSPORT $h = 3'$
HEAD ON WAVE $\alpha = 0$



SPECIFIC WEIGHT OF LIQUID : ϖ

WAVE LENGTH $= d = \lambda$

TOTAL WAVE HEIGHT $= 2h$ (CREST + TROUGH)

$$\beta = \frac{\pi L \cos\alpha}{d} \qquad \gamma = \frac{\pi B \sin\alpha}{d}$$

$$\beta = \pi \qquad \gamma = 0$$

$L = 446'$
$B = 172'$
$h = 3'$

Characteristic bending moment

$$M_o = \frac{\varpi B L^2 h}{2\pi^2} = \frac{V_o L}{\pi}$$

Characteristic shear force

$$V_o = \frac{\varpi B L h}{2\pi} = \frac{\pi M_o}{L}$$

Fig. 8 - WAVE ACTION ON RECTANGULAR SHIP - NOTATIONS AND DIMENSIONS

COMPUTATION SHEET

PROJECT	PAGE 8 OF 18	COMPUTED BY mr	DATE 10/96
SUBJECT		CHECKED BY	DATE

h = 3' (Hw = 6')
Hw = Wave height = 6'
L = 440
B = 172

Hogging & Sagging Coeff. taken from pg 207 of "Principles of Naval Architecture", Rossell & Chapman.

STA	DIST FROM END	HOGGING COEFF (CREST @ ℄)	HOGGING DIST.	HOGGING PRESSURE K/SF	SAGGING COEFF. (CREST @ ENDS)	SAG DIST	SAG PRESSURE
0	0	1.00	6'	64.5	0.0	0	0
1	22	0.982	5.9	63.4	0.034	0.2	2.2
2	44	0.927	5.56	59.8	0.128	0.77	8.3
3	66	0.839	5.0	53.8	0.266	1.6	17.2
4	88	0.720	4.3	46.2	0.421	2.5	26.9
5	110	0.577	3.5	37.6	0.577	3.5	37.6
6	132	0.421	2.5	26.9	0.720	4.3	46.2
7	154	0.266	1.6	17.2	0.839	5.0	53.8
8	176	0.128	0.77	8.3	0.927	5.56	59.8
9	198	0.034	0.2	2.2	0.982	5.9	63.4
℄ 10	220	0.0	0	0	1.00	6'	64.5

SYMMETRIC @ ℄

PRINCIPLES OF NAVAL ARCHITECTURE

VOLUME ONE

Written by a Group of Authorities

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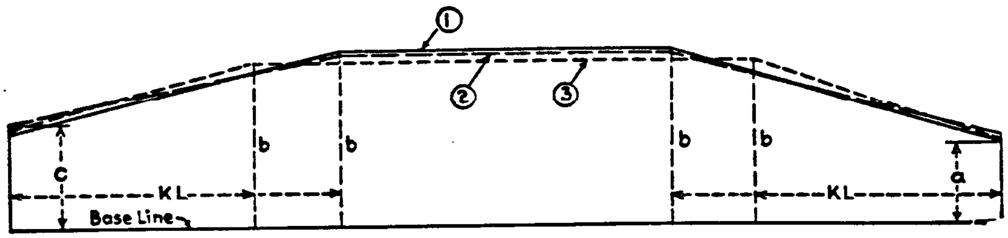


K	1	2	3
K	.333	.333	.250
a	.567	.596	.572
b	1.195	1.174	1.125
c	.653	.706	.676
C.G. Aft	.0052L	.0017L	.0054L

Ordinate = Coeff. x $\frac{\text{Hull W}}{\text{Length}}$
1 Fine Ships - Merchant Type
2 Full Ships - Merchant Type
3 Great Lakes Bulk Freighters

FIG. 5.—APPROXIMATION TO HULL WEIGHT CURVE WITH PARALLEL MIDDLE BODY

(*b*) *The Buoyancy Curve.* When the vessel is assumed to be supported on a wave, the buoyancy curve is predicated on the following assumptions:

(1) That the wave is trochoidal in form.

(2) That the wave length between crests is equal to the length of the vessel = L.

(3) That the wave height is equal to $L/20$.

(4) That the direction of wave travel is opposite to that of the vessel; i.e., that the vessel is head-on into the waves.

(5) It is customary to assume at least two conditions of wave support; one with the wave crest amidships, the other with the trough amidships. These two conditions of support are termed, respectively:

(*a*) *Hogging.* A condition of the vessel wherein the buoyancy is more than the weight over approximately the midship half-length with less buoyancy than weight at both ends, so that the tendency of the vessel is to arch up or hog amidships. Such a condition results in a bending moment, denoted hogging moment, which stresses the top members of the vessel in tension, the bottom members in compression. The stresses are termed hogging stresses.

(*b*) *Sagging.* The condition opposite to hogging, wherein the excess of weight over buoyancy amidships with a corresponding excess of buoyancy over weight at the ends causes a tendency to arch down or sag at about mid-length. Thus the sagging moment will result in the sagging stresses of compression in the top members and tension in the bottom members.

The buoyancy curve of a vessel among waves is made by laying out the wave profile on that of the ship so that correct heights for Bonjean's curve readings may be obtained. The wave profile may be constructed geometrically by the methods given in Chapter I, Volume II, or by use of the coefficients in Table 1, in which the length is divided into 20 equal spaces, and the distance, measured down from the wave crest, is the factor f_w multiplied by the wave height a_w. Since the wave is symmetrical about the middle of its length, the ordinates need be given for one-half length only. For the standard calculations a_w will be $0.05L$, so that for any station the distance of the wave contour below the line of crests will be equal to $0.05 f_w L$.

TABLE 1.—f_w COEFFICIENTS FOR CONSTRUCTION OF TROCHOIDAL WAVE PROFILE

	Station No.	f_w Hogging	f_w Sagging
End perpendicular	0	1.000	0.000
	1	0.982	0.034
	2	0.927	0.128
	3	0.839	0.266
	4	0.720	0.421
	5	0.577	0.577
	6	0.421	0.720
	7	0.266	0.839
	8	0.128	0.927
	9	0.034	0.982
½*LBP*	10	0.000	1.000

Ordinarily sufficient accuracy may be obtained by the use of 10 instead of 20 displacement stations, half-stations being introduced near the ends of the ship. In that case the correct station number may be obtained by dividing the first column of figures in the table by two.

The wave contour must be moved vertically to obtain the correct displacement, and it must be trimmed longitudinally to bring the center of buoyancy in vertical line with the center of gravity.

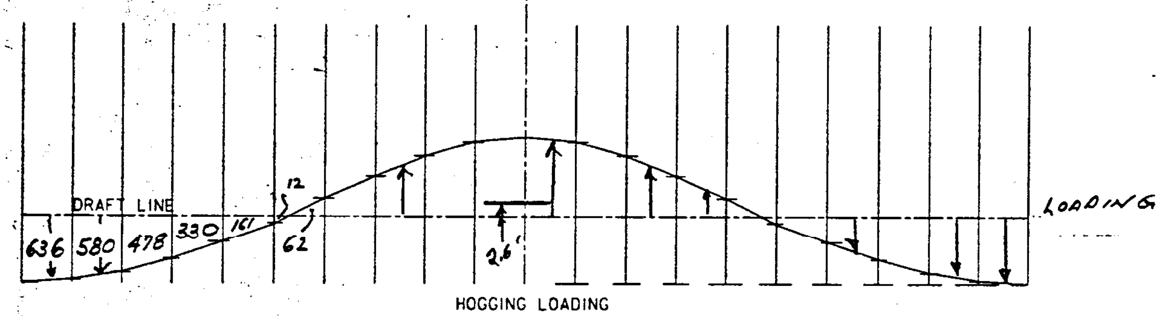
Since the area under a trochoid is less than the length times half the height, the line of centers

Ship Lock Chamber

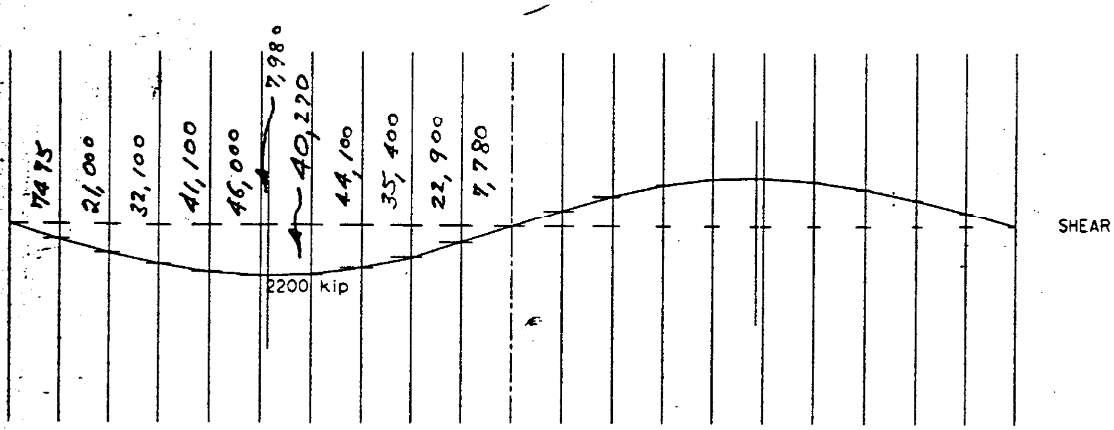
TRANSPORTATION - HOGGING CASE

$H_{wave} = 6'$

$L_{wave} = L_{module}$

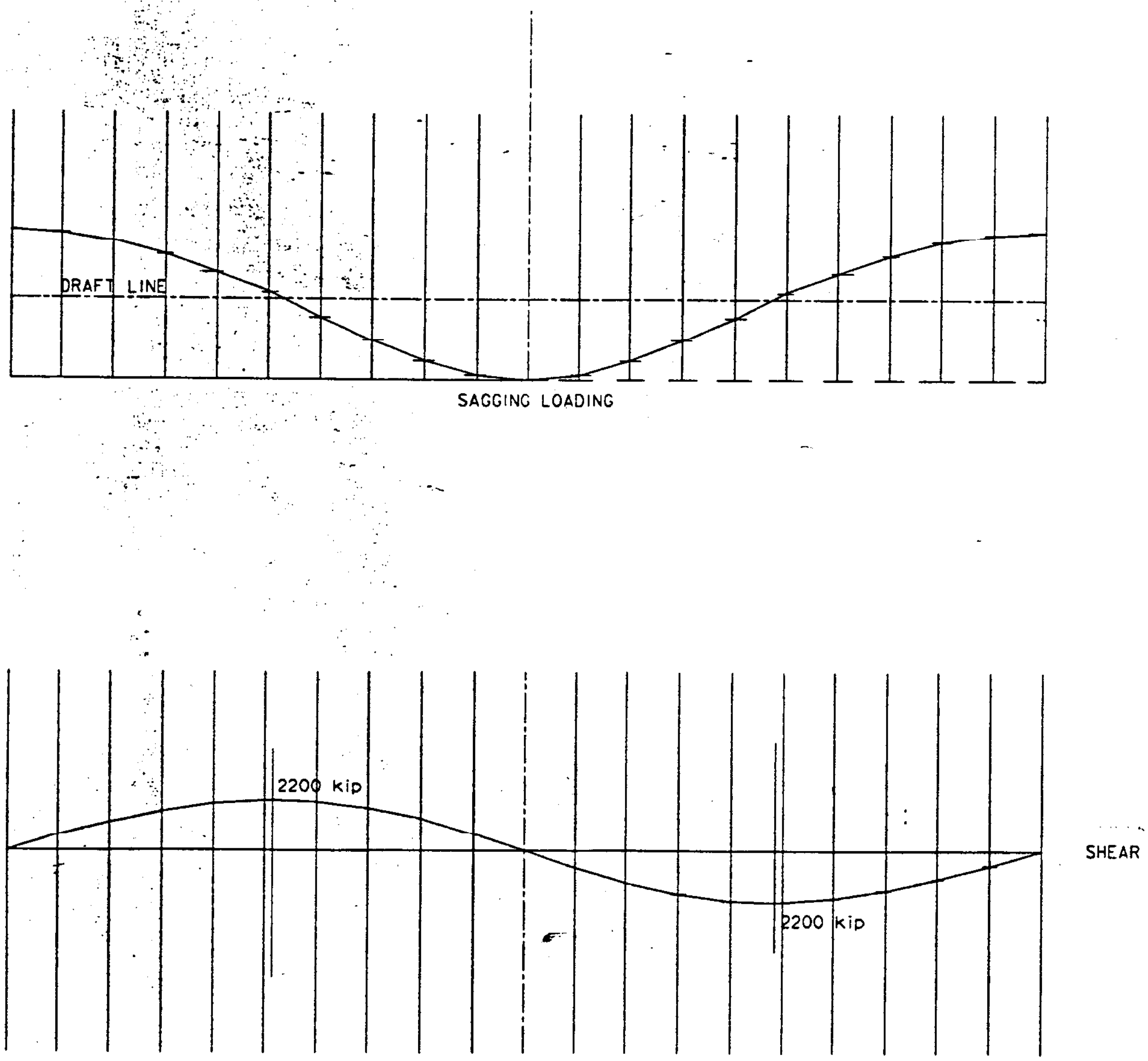


$V_{max} = 2200$ K



$M_{℄} = -306,100$ 'K (Tension on Top Flange)

SHIP LOCK CHAMBER
TRANSPORTATION - SAGGING CASE
$H_{wave} = 6'$



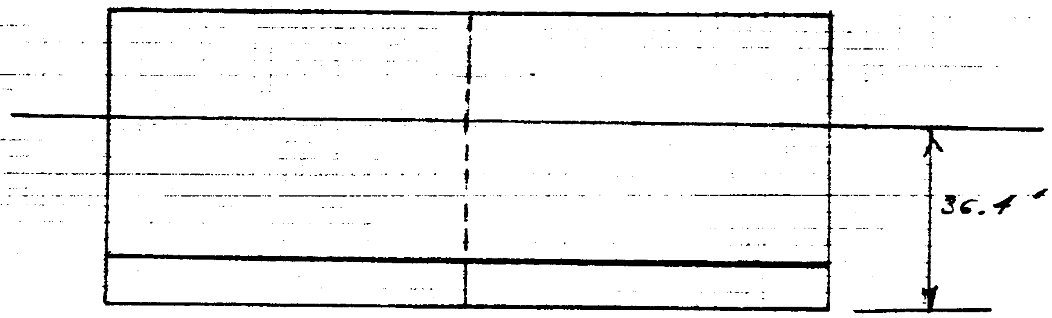
$M_{C\!\!\!L} = +306,100'\text{-}k$ (comp. on Top Flange)

SHIP LOCK - CHAMBER MODULE
SAGGING CONDITION Hw = 6'

COMPUTATION SHEET

PROJECT	PAGE 11 OF 18	COMPUTED BY [illegible]	DATE 10/96
SUBJECT CHAMBER - CONSTRUCTION		CHECKED BY	DATE

FULL WALL - STILL WATER



WT REQ'D TO SETTLE MODULE

$\text{Bouyancy}_{max} = (53 \times 0.0625) \times 172 \times 446 = 254,100\,k$

$\text{STRUCT. WT} = (36.4 \times 0.0625) \times 172 \times 446 = 174,500\,k$

MIN. BALLAST = 79,600 k

Fill 95% w/ CONCRETE SO RE FLOAT IS POSSIBLE

$\text{WT. CONC}_{max} = (254,100 \times 0.95) - 175,900 = 65,500\,k$

$\text{BASE}_{CONC} = (1030 - 306)^{\#} \times 400 \times 0.15 = 43,440$ CONC

(VOIDS w/ TENSION PILES)

CULVERT VOIDS$_{CONC}$ $4 \times 71 \times 400 \times 0.15 = 17,040$ CONC

LOWER WALL VOID $253 \times 2 \times 400 \times 0.0625 = 12,650$ H_2O

MID-HT WALL VOID $178 \times 2 \times 400 \times 0.0625 = 9,900$

83,030 k > 79,600

NOTE: BALLAST WT NEEDED FOR SETTING PILE DESIGN WILL BE ADDED ONCE MODULE IS ON SETTING PADS. SEE SETTING PILE DESIGN

COMPUTATION SHEET

PROJECT	PAGE 12 OF 13	COMPUTED BY MS	DATE 10/96
SUBJECT		CHECKED BY	DATE

CONSTRUCTION SEQUENCE

1) UPPER WALLS COMPLETED - UNIFORM LOAD IN LONG. DIR.

2) PLACE CONCRETE BALLAST IN IT'S ENTIRETY. FINISH BALLAST W/ WATER PLACE IN UPPER WALL AFTERWARDS

3) CONSIDER 3 BALLAST PLACEMENT STAGES. MINIMUM OF 4 PANEL ROWS PER PLACEMENT

STAGE 1 - FILL 4 CENTER PANELS

STAGE 2 - 4 CENTER PANELS FILLED, THEN FILL 4 @ QUARTER POINTS (CONSIDER 1ST TO HEAVIER END)

STAGE 3 - STAGE 2 PLUS 4 PANELS @ OPPOSITE QUARTER POINT (LEVEL)

UNIFORM LOAD IS EXCEEDED BY CONC BALLAST PLACED IN BASE & WALL

$$w_u/LF = \frac{43,440 + 17,040}{446} = 135.6\ K/LF$$

$$\text{Bouyant Draft @ STAGE 1} = \frac{(135.6 \times 14 \times 4) + 174,500}{172 \times 446 \times 0.0625}$$ (4 = # PANELS)

= 38.0'

Bouyant Force = 38.0 × 0.0625 = 2.38 KSF
= 408.5 K/LF

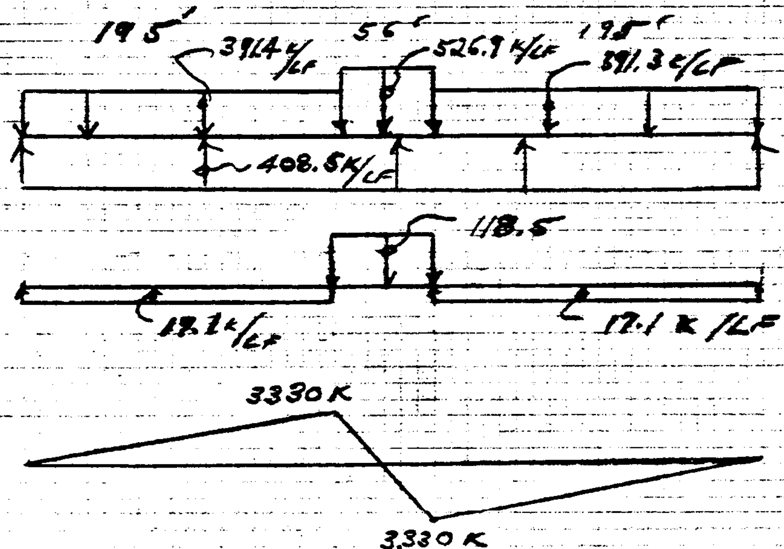
UNBALLASTED STRUCT. UNIFORM LOAD = 36.4 × 0.0625 = 2.28 KSF
= 391.4 K/LF

BALLASTED SECTION UNIFORM LOAD = $2.28 + \frac{135.6}{172}$ = 3.06 KSF
= 526.9 K/LF

COMPUTATION SHEET

PROJECT	PAGE 13 OF 18	COMPUTED BY MFG	DATE 10/96
SUBJECT		CHECKED BY	DATE

STAGE 1



$V_{max} = 3330\ K$

$M_{max} = (3330 \times 195/2) + (3330 \times 28/2) = 371{,}300\ '\text{-}K$

STAGE 2

Bouyant Draft (8 panels ballasted) $= \dfrac{174{,}500 + (135.6 \times 14 \times 8)}{172 \times 446 \times 0.0625} = 39.56'$

Bouyant Force $= (39.56 \times 0.0625) = 2.47\ KSF$
$= 425.3\ K/LF$

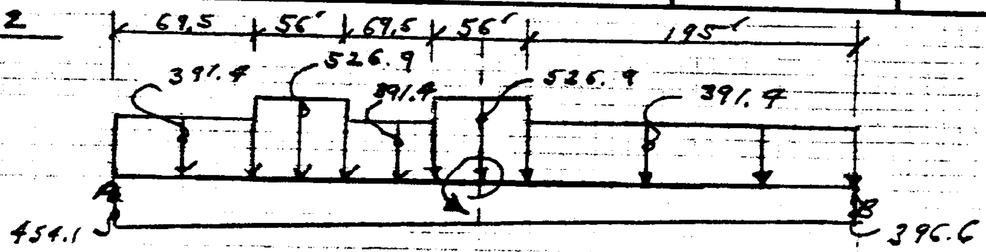
UNBALLASTED STRUCT UNIFORM LOAD $= 2.28\ KSF$
$= 391.4\ K/LF$

BALLASTED PANEL $= 3.06\ KSF$
(UNIFORM LOAD) $= 526.9\ KSF$

COMPUTATION SHEET

PROJECT	PAGE 14 OF 18	COMPUTED BY MG	DATE 10/96
SUBJECT		CHECKED BY	DATE

STAGE 2



DETERMINED UNBALANCED BOOYANT FORCE

$M_{@\mathbb{C}} = (391.4 \times 69.5 \times 188.25) + (56 \times 526.9 \times 125.5) + (391.4 \times 69.5 \times 62.75) - (391.4 \times 195 \times 125.5)$

+CCW

$= 952,294$ '-K

$P = 189,687$ K

$A = 172 \times 446 = 76,712$ #

$I = \frac{172 \times 446^3}{12} = 1271.6 \times 10^6$

$\sigma_A = P/A + Mc/I = \frac{189,687}{76,712} + \frac{952,294 \times 223}{1271.6 \times 10^6}$

$= 2.473 + 0.167$

$= 2.64$ KSF $= 454.1$

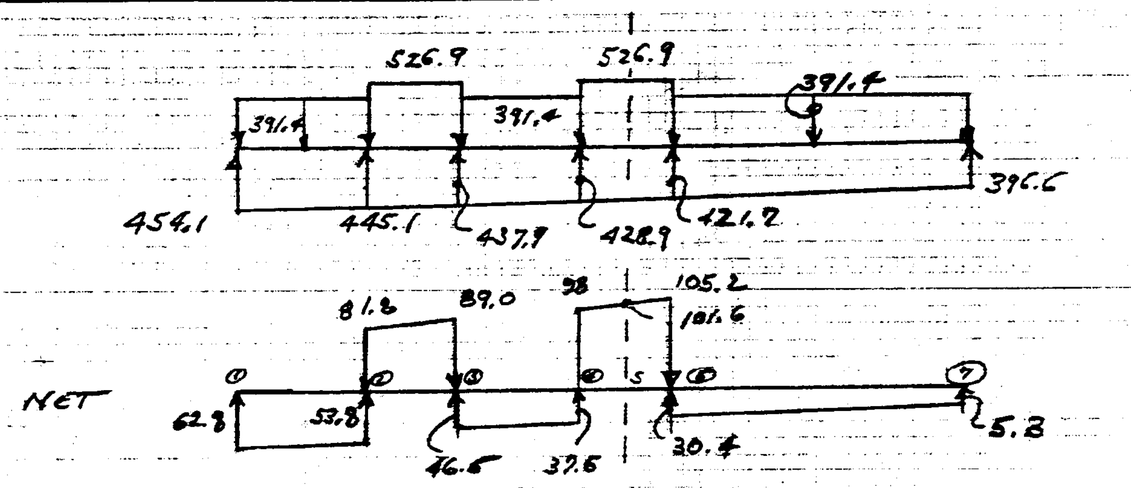
$\sigma_B = 2.473 - 0.167$

$= 2.306$ KSF

$= 396.6$ K/LF

COMPUTATION SHEET

PROJECT	PAGE 15 OF 18	COMPUTED BY MHG	DATE 10/96
SUBJECT		CHECKED BY	DATE

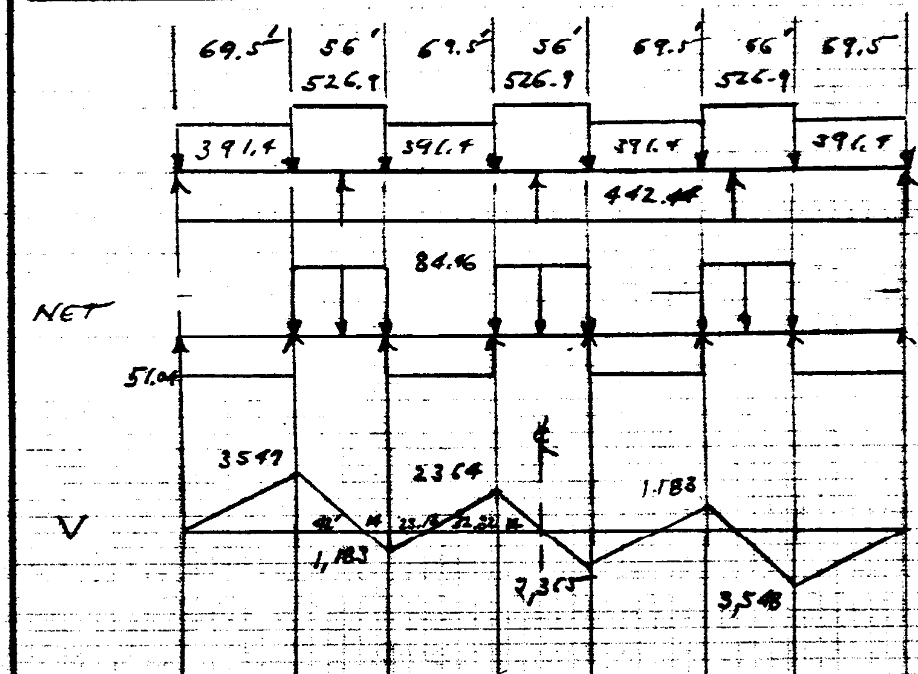


V_{max} = 4052 K

M_{max} = 318,000 'K @ Center

C FRAME RESULTS (PINNED JOINT 7 MINIMAL EFFECT)

STAGE 3



V_{max} = 3550 K

M_{max} @ ℄ = (3549 × 69.5/2) + (3549 × 42/2) − (1183 × 37.6/2) + (2364 × 46.6/2)

= +231,100 'K

LMV FORM MAR 62 107e PREVIOUS EDITIONS MAY BE USED (FOR USE WITH 10 x 10 GRID)

```
010 CHAMBER LONG. WVE LOADING\\ STILL WATER CONSTRUCT. STAGE 2*
015 FILE C:\PRECAST.LOC\WAVCHST2.CFR
020 KSI FT FT IN KIP
030 7 6 1 3000 0.15
(   1 0 0 2 69.5 0 3 125.5 0 4 195 0 5 223 0 6 251 0 7 446 0
05u FIX X 7
060 FIX Y 7
070 GM 1 1 2 6 1 1
080 986000 2280 2280 1 TO 6
090 LOAD CASE 1 0 6 0 0
100 0 -62.8 69.5 -53.8 0 1
110 0 81.8 56 89 0 2
120 0 -46.6 69.5 -37.6 0 3
130 0 98 28 101.6 0 4
140 0 101.6 28 105.2 0 5
150 0 -30.6 195 -5.5 0 6
```

^P
COMMAND MUST BE ONE OF THE FOLLOWING
 D N F A L N E S
E

LOAD CASE 1

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	.0000E+00	-.2102E+11	.3928E+07
2	.0000E+00	-.1775E+11	.3928E+07
3	.0000E+00	-.1511E+11	.3928E+07
4	.0000E+00	-.1183E+11	.3928E+07
5	.0000E+00	-.1051E+11	.3928E+07
6	.0000E+00	-.9191E+10	.3928E+07
7	.0000E+00	.0000E+00	.3928E+07

STRUCTURE REACTIONS

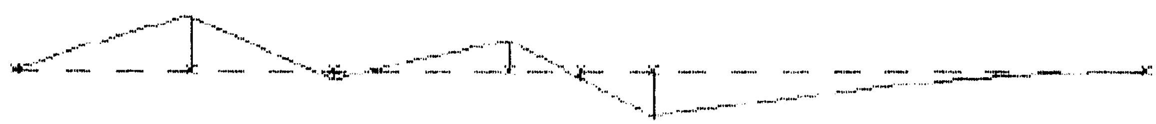
JOINT	FORCE X KIP	FORCE Y KIP	MOMENT FT-KIP
7	.0000E+00	.3627E+02	-.6232E+04

TOTAL .0000E+00 .2627E+02

MEMBER END FORCES

MEMBER	LOAD CASE	JOINT	AXIAL KIP	SHEAR KIP	MOMENT FT-KIP	MOMENT EXTREMA FT-KIP	LOCATION FT
1	1	1	.0000E+00	-.3256E+00	.1935E+01	.1444E+06	69.50
		2	.0000E+00	-.4052E+04	.1444E+06	.1935E+01	.00
2	1	2	.0000E+00	.4050E+04	.1444E+06	.2422E+06	48.16
		3	.0000E+00	.7325E+03	.2391E+06	.1444E+06	.00
3	1	3	.0000E+00	-.7307E+03	.2392E+06	.2937E+06	69.50
		4	.0000E+00	-.2195E+04	.2937E+06	.2334E+06	16.68
4	1	4	.0000E+00	.2191E+04	.2937E+06	.3180E+06	21.84
		5	.0000E+00	.6032E+03	.3163E+06	.2937E+06	.00
5	1	5	.0000E+00	-.6127E+03	.3162E+06	.3162E+06	.00
		6	.0000E+00	.3508E+04	.2588E+06	.2588E+06	28.00
6	1	6	.0000E+00	-.3507E+04	.2587E+06	.2587E+06	.00
		7	.0000E+00	.2627E+02	-.6232E+04	-.6232E+04	195.00

CHAMBER LONG. WVE LOADING
FILE C:



|___| = 4052.   KIP   SHEAR   96/10/10   13.50.57

LOA CASE 1

ENTER'OUTPUT GRAPHICS COMMAN

COMPUTATION SHEET

PROJECT	PAGE 16 OF 18	COMPUTED BY MGL	DATE 10/96
SUBJECT		CHECKED BY	DATE

Bouyant DRAFT = $\frac{(391.4 \times 278) + (526.9 \times 168)}{172 \times 446 \times 0.0625}$ = 41.157'

Bouyant FORCE = 41.157 × 0.0625 = 2.572 KSF
= 442.44 K/LF

UNBALLAST Len = 391.4 K/LF

BALLASTED Len = 526.9 K/LF

GOVERNING LOAD

V_{max} = 4050 K STAGE 2

M_{max} = 371,300 'K STAGE 1

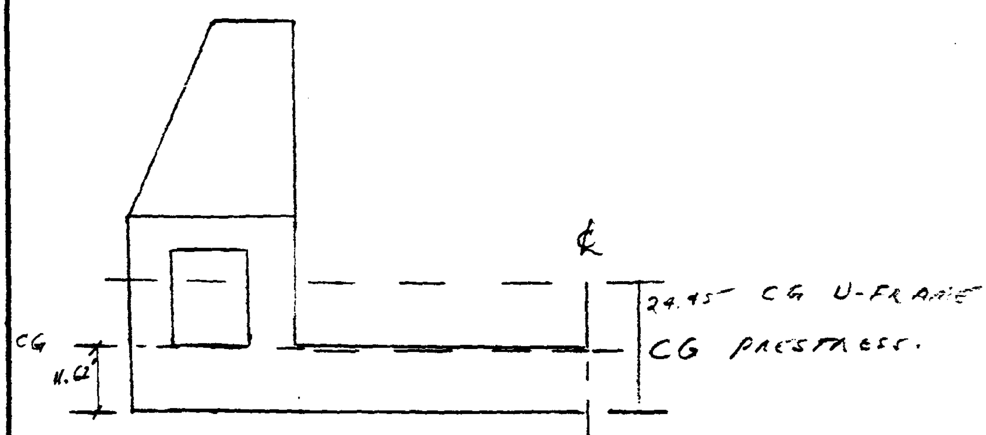
STRESSES BASED ON CONCRETE SHELL

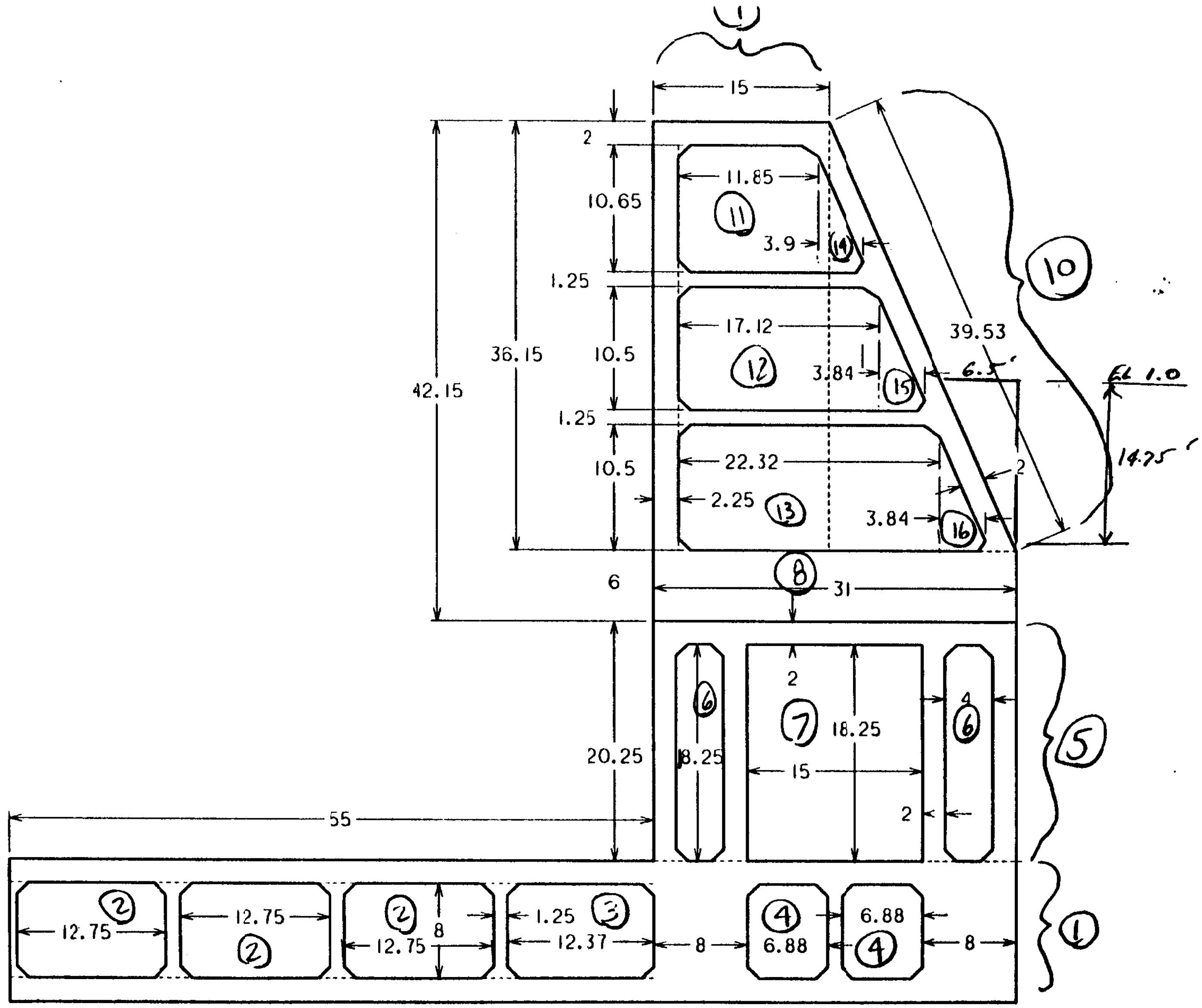
$v = \frac{4050}{2282\ \#}$ = 1.77 KSF
= 12.3 psi < $1.1\sqrt{5000}$ = 78 psi
(f'_c ave)

$f_{comp} = f_{Top} = \frac{371{,}300 \times 49.75}{9.86 \times 10^5}$ = 18.81 KSF
= 130 psi < $0.45 f'_c$
= 1800 psi

$f_{Ten} = f_{BOT} = \frac{371{,}300 \times 24.45}{9.86 \times 10^5}$ = 9.21 KSF
= 64 psi < $6\sqrt{f'_c}$
= 460 psi

EFFECT OF PRESTRESSED BASE




15
2
11.85
10.65
11
3.9
14
1.25
17.12
36.15
10.5
12
3.84
15
42.15
1.25
22.32
10.5
2.25
13
3.84
16
39.53
6.5
El 1.0
14.75
2
10
8
31
6
2
7
18.25
15
4
6
8.25
20.25
2
5
55
12.75
2
12.75
2
12.75
8
1.25
3
12.37
8
4
6.88
6.88
4
8
1

IHNC Lock Replacement

Setting Conditions - determination of Neutral Axis & Moment of Inertia — CHAMBER

Determine Neutral Axis

Area No.	# of Areas	'b' (ft)	'h' (ft)	A (sf)	y (ft)	y*A (cf)
1	1	86	12	1032	6.000	6192.00
2	-3	12.75	8	-306	6.000	-1836.00
3	-1	12.37	8	-98.96	6.000	-593.76
4	-2	6.88	8	-110.08	6.000	-660.48
5	1	31	20.25	627.75	22.125	13888.97
6	-2	4	18.25	-146	21.125	-3084.25
7	-1	15	18.25	-273.75	21.125	-5782.97
8	1	31	6	186	35.250	6556.50
9	1	15	36.15	542.25	56.325	30542.23
10	1	16	36.15	289.2	50.300	14546.76
11	-1	11.85	10.65	-126.203	67.075	-8465.03
12	-1	17.12	10.5	-179.76	55.250	-9931.74
13	-1	22.32	10.5	-234.36	43.500	-10194.66
14	-1	3.9	10.65	-20.7675	65.300	-1356.12
15	-1	3.84	10.5	-20.16	53.500	-1078.56
16	-1	3.84	10.5	-20.16	41.750	-841.68
		Sum (A) =		1141	Sum (y*A) =	27901.21

Centroid = $\frac{27901.21}{1141}$ = 24.45 ft from bottom of slab

Determine Moment of Inertia

Ix=Sum(I+Ad^2) = Sum(bh^3/12+Ad^2) for a rectangular shape

= Sum(bh^3/36+Ad^2) for a triangular shape

Area No.	# of Areas	'b' (ft)	'B' (in)	'h' (ft)	'H' (in)	'd' (ft)	'D' (in)	'a' (sf)	'A' (sq. in)	I	
1	1	86	1032	12	144	18.453	221.440	1032.00	148608.00	7.54E+09	
2	-3	12.75	153	8	96	18.453	221.440	102.00	14688.00	-2.19E+09	
3	-1	12.37	148.44	8	96	18.453	221.440	98.96	14250.24	-7.10E+08	
4	-2	6.88	82.56	8	96	18.453	221.440	55.04	7925.76	-7.89E+08	
5	1	31	372	20.25	243	2.328	27.940	627.75	90396.00	5.15E+08	
6	-2	4	48	18.25	219	3.328	39.940	73.00	10512.00	-1.18E+08	
7	-1	15	180	18.25	219	3.328	39.940	273.75	39420.00	-2.20E+08	
8	1	31	372	6	72	10.797	129.560	186.00	26784.00	4.61E+08	
9	1	15	180	36.15	433.8	31.872	382.460	542.25	78084.00	1.26E+10	
10	1	16	192	36.15	433.8	25.847	310.160	289.20	41644.80	4.44E+09	
11	-1	11.85	142.2	10.65	127.8	42.622	511.460	126.20	18173.16	-4.78E+09	
12	-1	17.12	205.44	10.5	126	30.797	369.560	179.76	25885.44	-3.57E+09	
13	-1	22.32	267.84	10.5	126	19.047	228.560	234.36	33747.84	-1.81E+09	
14	-1	3.9	46.8	10.65	127.8	40.847	490.160	20.77	2990.52	-7.21E+08	
15	-1	3.84	46.08	10.5	126	29.047	348.560	20.16	2903.04	-3.55E+08	
16	-1	3.84	46.08	10.5	126	17.297	207.560	20.16	2903.04	-1.28E+08	
									Ix =	1.02E+10	in^4
									=	4.93E+05	ft^4

I_x FULL SECTION = 9.86 E+05 Ft^4

$S_{x\,BOT} = \frac{I_x}{24.45} = 40{,}330\ Ft^3$

$S_{x\,TOP} = \frac{I_x}{(74.4-24.45)} = 19{,}740\ Ft^3$

COMPUTATION SHEET

PROJECT	PAGE 17 OF 18	COMPUTED BY [illegible]	DATE 10/96
SUBJECT		CHECKED BY	DATE

$P_{pe} = (0.60\ f_{pu})\,A = 151.7$ K/BAR $f_{pu} = 160$ KSI

$A_{1\frac{3}{8}} = 1.58^{\text{in}^2}$

$P_{pe} = 2 \times 474 \times 151.7 = 143{,}810$ K

FULL U-FRAME PROPERTIES

$A = 2282\ \text{FT}^2$
$= 328{,}610\ \text{IN}^2$

$I_x = 2.04 \times 10^{10}$

$S_{x_{Top}} = 34{,}110{,}700\ \text{IN}^3$

$S_{x_{BOT}} = 69{,}690{,}240\ \text{IN}^3$

EFFECTIVE STRESS

$e' = (24.45 - 11.12)12 = 154''$

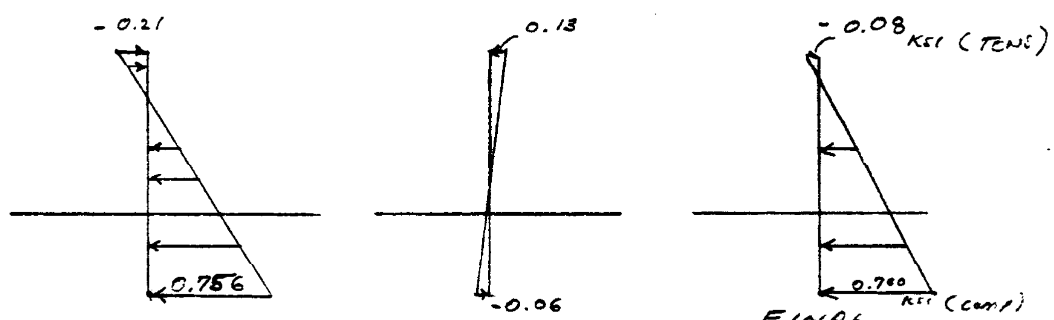
$$\sigma_{Top} = \frac{P}{A} - \frac{Pe'}{S_{x\,TOP}}$$

$$= \frac{143{,}810}{328{,}610} - \frac{143{,}810 \times 154''}{34{,}110{,}700}$$

$$= 0.438 - 0.649 = -0.211\ \text{KSI (Tension)}$$

$$\sigma_{BOT} = 0.438 + \frac{143{,}810 \times 154}{69{,}690{,}240}$$

$$= 0.438 + 0.318 = 0.756\ \text{KSI (COMP)}$$



EFFECTIVE STRESS STAGE I STRESS FINAL STRESS @ S.K.

$\text{Tension}_{max} = 80\ \text{psi} < 2\sqrt{f_c'} = 126\ \text{psi}$

$\text{COMP}_{max} = 0.70\ \text{KSI} < 2.40_{\text{KSI}} = \sigma_{ALL}$

COMPUTATION SHEET

PROJECT	PAGE 18 OF 18	COMPUTED BY	DATE 10/95
SUBJECT		CHECKED BY	DATE

For the one or two day duration the low tensile stress is not a problem. The $2\sqrt{f'_c}$ allowable was recommended by Dr. Moustafa as being a tolerable amount. Where the U-frame will be floating for 6 months - 1 year, the stage 1 moment will only last 1-2 days.

TRANSVERSE DIRECTION

$B = 14$ (I-BEAM WIDTH)

$L = 172'$

$H_w = 6'$

$$M_{o_{\mathcal{C}}} = \frac{\gamma \cdot B \cdot L^2 \cdot h}{2\pi^2}$$

$$= \frac{0.0625 \times 14 \times 172^2 \times 3}{2 \cdot \pi^2}$$

$$= 3940 \ {}^{\prime}K$$

$$V_o = \frac{\gamma \cdot B \cdot L \cdot h}{2\pi}$$

$$= \frac{0.0625 \times 14 \times 172 \times 3}{2\pi}$$

$$= 72 \ K$$

WAVE INDUCED STRESS ARE NEGLIGIBLE