MISCELLANEOUS STRUCTURES

EAST COAST AIR COMBAT MANEUVERING RANGE
OFFSHORE KITTY HAWK, NORTH CAROLINA

CONTRACT NO. N62477-76-C-0179
MODIFICATION NO. F0001

REPORT NO. D9-001

PREPARED FOR
NAVY FACILITIES ENGINEERING COMMAND
DEPARTMENT OF THE NAVY
CHESAPEAKE DIVISION

By
CREST ENGINEERING INC.
TULSA, OKLAHOMA

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<td>This report contains design calculations relative to the superstructures and structural appurtenances for the four tripod-type ocean structures for the East Coast Air Combat Maneuvering Range offshore Kitty Hawk, North Carolina.</td>
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<td>Jacqueline B. Riley</td>
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<td>202-433-3881</td>
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Prepared for
NAVY FACILITIES ENGINEERING COMMAND
DEPARTMENT OF THE NAVY
CHESAPEAKE DIVISION

By
CREST ENGINEERING, INC.
TULSA, OKLAHOMA

September 1976
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SECTION 1
INTRODUCTION

1.1 INTRODUCTION

This report contains design calculations relative to the superstructures and structural appurtenances for the four tripod-type ocean structures for the East Coast Air Combat Maneuvering Range offshore Kitty Hawk, North Carolina.
1.2 DESIGN CRITERIA

The criteria employed to design each component of the structure are listed as follows:

(a) **Superstructure:**
   - **Live Loads:**
     - Upper Deck: 100 psf
     - Equipment Deck: 150 psf
     - Stairway: 100 psf
   - **Material:** A36 Structural Steel

(b) **Boat Landing:**
   - **Design Loads:**
     - 4,000 lbs. concentrated load or equivalent uniform load.
   - **Minimum Plan Dimensions:** 4 ft. x 6 ft.

(c) **Equipment Supports:**
   - **Wind Load:** 150 knots at EL(+) 30'-0"

1.02
1.3 DESIGN SUMMARY

Pertinent information relative to the superstructure and boat landing are listed as follows:

Superstructure:

Equipment Deck Area 591.5 sq. ft.
Upper Deck Area 362.5 sq. ft.
Structural Steel Weight (including stairways, handrails, and kick plate) 113.5 kips
Paint Area 8,500.0 sq. ft.

Boat Landing:

Overall Dimensions 22 ft. x 12 ft. x 4 ft.
Structural Steel Weight 22.0 kips
Paint Area 1,115.7 sq. ft.
1.4 PERSONNEL RESUMES

The personnel whose resumes follow were actively engaged in this project.
Chingmiin (Charlie) Chern

Senior Engineer

<table>
<thead>
<tr>
<th>University</th>
<th>Degree</th>
<th>Year</th>
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<tbody>
<tr>
<td>National Taiwan University</td>
<td>Bachelor of Science Civil Engineering</td>
<td>1961</td>
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<tr>
<td>North Dakota State University</td>
<td>Master of Science Civil Engineering</td>
<td>1966</td>
</tr>
<tr>
<td>Lehigh University</td>
<td>Ph. D. Civil Engineering</td>
<td>1969</td>
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<tr>
<td>Tulsa University</td>
<td>Graduate Study in Business Administration-Management</td>
<td>1974</td>
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</table>

Societies, Licenses, and Other Activities:
- Member American Society of Civil Engineers
- Member International Association of Structural and Bridge Engineers
- Member American Society of Engineering Education
- Registered Professional Engineer in Oklahoma

Experience:
- 1973 to Present Crest Offshore, Inc.

Senior Civil Engineer

Engaged in the feasibility studies, structural analysis and design of offshore structures, equipment supports and other various types of petroleum related civil engineering works. Assignments include:

- Evaluation of engineering designs from other agencies.
- Analysis and design of offshore structures for oil industry.
- Analysis and design of supports and foundations for onshore refinery facilities.
- Development of a sequence of computer programs for the analysis of offshore structures.
CREST OFFSHORE, INC.

Chingmiin (Charlie) Chem

Senior Civil Engineer

Experience Continued:

1969 to 1973
North Dakota State University
Associate Professor of Civil Engineering
Engaged in full-time lecture instruction for civil engineering (graduate school division) and construction management. Also served as consultant to local industry (undergraduate school division) in the area of computer applications in engineering.

1966 to 1969
Fritz Engineering Laboratory
Research Assistant
Assisted in the design and testing of various types of steel structures.

1966
North Dakota State Highway Department
Highway Engineer
Responsible for construction surveying.

1965
U.S. Forest Service
Assistant Crew Chief
Assisted in surveying responsibilities.
SECTION 2
SUPERSTRUCTURES

2.1 INTRODUCTION

Set forth hereinafter are the design calculations for the superstructure which is common to each platform. Structural steel weights and the surface area to be painted are also tabulated.
2.2 ELEVATION

Scale 1/8" = 1'-0"

EL(+) 75'-0"
Upper Deck

EL(+) 60'-0"
Equipment Deck

EL(+) 46'-0"

Pile Cut-off & W.P.

42" O.D. x 1' WT Cone

12 3/4" O.D. x 5' WT

542" x 30" x 1' WT Cone
2.3 UPPER DECK

Design Live Loads = 100 psf

Scale 1/8" = 1'-0"
Design Live Loads = 100 psf

Scale 1/8" = 1'-0"
CREST OFFSHORE, INC.

By: C. Cherry  Client: U.S. NAVY  Subject: Miscellaneous Structures

Date: 6-10-76  Job No.: 27-72-698  Calculation: Superstructure (Upper Deck)

4 x 1/8 Flat Bars  see Page 9.22
Report on Structural Concept Analysis
Appendix C - 3-pile Structure

Tributary Area = 7.5 x 5.5' = 41.25'

Uniform Loads:

1/4" R 10.2 x 4.1.25 = 420.75#
L.L. 100 x 4.1.25 = 4,125.00#

\[ \text{Bm. Wt.:} \]
\[ W6\times15.5 \quad 15.5 \times 7.5 = 116.25\# \]
\[ 4\times1/8" FB. \quad 6 \times 5.10 \times 5.5 = 84.15\# \]
\[ \frac{2}{2} = 200.40\# \]

Total Weight = 4,746.15#

Equivalent uniform load = 632.82 \#/ft

Say 640 \#/ft

\[ M_{\text{max}} = \frac{1}{8} WL^2 = \frac{1}{8} \times 640 \times (7.5)^2 \times \frac{12}{1000} = 54'' \pi \]

Use W6x15.5  S = 10.0 in^2

\[ \sigma_t = \frac{54}{10.0} = 5.4 \text{ ksi} \]

O.K.
W 8x24

\[ w = 650 \, \text{lb/ft} \]

\[ 14' - 0'' \]

Tributary Area = 12 x 6.5 = 78 \, \text{sq ft}

Uniform Loads:
- \( \frac{1}{4}'' \) IC 10.2 x 78 = 795.6 #
- L.L. 100 x 78 = 7,800.0 #

Beam Wt.:
- W 8x24 24 x 1.4 = 336 #
- 4x3/8'' F.B. 10 x 5.1 x 5.5 \[ \frac{2}{2} \] = 140.3 #

Total Weight = 8,595.6 + 476.3 = 9,071.9 #

Equivalent uniform load = 648 #/ft

Say 650 #/ft

\[ M_{max} = \frac{1}{8} \times 650 \times (14)^2 \times \frac{12}{1000} = 191.1 \, \text{in} \cdot \text{lb} \]

Use W 8x24  S = 20.8 in^2  T_e = 9.2 ksi  o.k.
2.4 **EQUIPMENT DECK**

Design Live Loads = 150 psf

**Scale** $\frac{1}{8}" = 1'-0"$
Design Live Loads = 150 psf

Scale 1" = 1'-0"
**CREST OFFSHORE, INC.**

By C. Chern  Client U.S. NAVY  Subject Miscellaneous Structures
Date 6-12-76  Job No. 22-728-98  Calculation Superstructures (Equipment Deck)

**W 6x15.5**

Tributary Area  2' 6" x 11'-0"

D.L.

\[
\frac{1}{4} \times 10.2 \times 2.5 = 25.5 \text{ ft}^2
\]

Bm W6x15.5  15.5

\[
= 41.0 \text{ ft}^2
\]

L.L.  150 x 2.5 = 375 \text{ ft}^2

Total  \[
\omega = 416.0 \text{ ft}^2
\]

**M_{max} = \frac{1}{8} \omega d^2 = \frac{416.0 \times 11^2 \times 12}{8 \times 1000} = 75.5 \text{ in}^3**

A36 steel  \[\sigma_t = 22 \text{ ksi}\]

\[S = \frac{75.5}{22} = 3.43 \text{ in}^3\]

Use W 6x15.5  \[\sigma_x = 10.0 \text{ in}^3\]

\[\sigma_t = \frac{75.5}{10.0} = 7.5 \text{ ksi}\]

AISC 2-48 Allowable load  = 14.8 kips

> 416 x 11 = 4.58 kips

AISC 2-95 Allowable moment  = 19 ft-kips

= 22.8 ft-k > 75.6 ft-k

Use W 6x16 for Min. Thickness \(\frac{1}{4}"\) (wet)
**CREST OFFSHORE, INC.**

By G. C. Chern, Client U.S. Navy | Subject: Miscellaneous Structures

Date 6-10-74 | Job No. 27-271-98 | Calculation: Superstructures (Equipment Deck)

**W 8x24**

\[ W = 760 \text{ *}/\text{ft} \]

**Tributary Area**

\[ 14' \times 1.25' + \frac{1}{2} \times 7.5' \times 12' \]

\[ = 17.5 + 45 \]

\[ = 62.5 \text{ sq. ft} \]

**Uniform Loads:**

- 4' F: \[ 10.2 \times 62.5 = 637.5 \text{ *} \]
- L.L.: \[ 150 \times 62.5 = 9375.0 \text{ *} \]

\[ \frac{9375.0}{10,012.5} \]

**Beam Wt.:**

- W 8x24: \[ 24 \times 14 = 336 \text{ *} \]
- W 6x15.5: \[ 15.5 \times (6.5+5+3.5+2) = 264 \text{ *} \]

\[ \frac{264}{600} \text{ *} \]

**Total Weight:** \[ 10,612.5 \text{ *} \]

**Equivalent Uniform Load:** \[ 750.0 \text{ *}/\text{ft} \]

**Say 760 \text{ *}/\text{ft}**
\[ M_{\text{max}} = \frac{1}{8} wL^2 = \frac{1}{8} \times 760 \times 14^2 \times \frac{12}{1000} = 223.44 \text{ in}^3 \]

A36 Steel \( f = 22 \text{ ksi} \)

\[ S = \frac{223.44}{22} = 10.2 \text{ in}^3 \]

Use W8 x 24 \( S = 20.8 \text{ in}^3 \)

\[ f_t = \frac{223.44}{20.8} = 10.74 \text{ ksi} \]

AISC 2-47 Allowable Load = 23.8 kips
                                 \( \geq 10.6 \) kips

AISC 2-95 Allowable moment = 38 ft-kips
                                 \( = 456 \text{ in-kip} \geq 223.44 \text{ in-kip} \)
                                 O.K.
**CREST OFFSHORE, INC.**

**By C. Chern**  
**Client U.S. NAVY**  
**Date 6-10-76**  
**Job No. 27-271-98**  
**Subject Miscellaneous Structures**  
**Calculation Superstructures (Equipment Deck)**

**W 18x50**

\[ W = 760 \text{ lb/ft} \]

**Tributary Area**  
\[ \text{Tributary Area} = \frac{1}{2} \times 29' \times \left(\frac{1}{3} \times 25'\right) = 120.83 \text{ sq. ft} \]

**Uniform Loads:**

- 4" R: \[ 10.2 \times 120.83 = 1,232.5 \text{ #} \]
- L.L.: \[ 150 \times 120.83 = 18,124.5 \text{ #} \]

\[ \text{Beam Wt.} \]

\[ W 18x50 \times 29 \times 50 = 1,450 \text{ #} \]

\[ W 8x24 \times 24 \times (7 + 7) = 336 \text{ #} \]

\[ W 6x15.5 \times 15.5 \times (6.5 + 5 + 3.5 + 2) \times 3 = 791 \text{ #} \]

\[ 2,577 \text{ #} \]

Total Wt.: \[ 19,357 + 2,577 = 21,934 \text{ #} \]

Equivalent uniform load: \[ 7.563 \text{ lb/ft} \]

Say: \[ 760 \text{ lb/ft} \]
\[ M_{\text{max}} = \frac{1}{8} wL^2 = \frac{1}{8} \times 760 \times (29)^2 \times \frac{12}{1000} = 958.74 \text{ in}^3 \]

A36 Steel \[ \sigma_t = 22 \text{ ksi} \]

\[ S = \frac{958.74}{22} = 43.6 \text{ in}^3 \]

Use W18x50 \[ S = 89.1 \text{ in}^3 \]

\[ \sigma_t = \frac{958.74}{89.1} = 10.8 \text{ ksi} \]

AISC 2-38 \( \text{Allowable loads} = 49 \text{ kips} \)

\( > 22 \text{ kips} \)

AISC 2-93 \( \text{Unbraced length} = 3' - 0'' \)

\( \text{Allowable moment} = 178 \text{ ft.kip} \)

\[ = 2,136 '' \text{kip} \]

\( > 958.74 '' \text{kip} \)

O.K.
**Addition of Deck Space for Solar Panel**

- Design Live Loads on Deck = 150 PSF
- Design Live Loads on Stairs = 100 PSF (AISC)

Ov 1000 LBS Min.
(CUSAS A641-1968)
Design Live Loads on Deck = 150 psf
Design Live Loads on Stairs = 100 psf (AISC)

0V 1000 LBS Min.
(CUSAS A64-1-1968)
CREST OFFSHORE, INC.

By C. Henry
Client U.S. NAVY
Date 7-2-76
Job No. 22-JUL-76
Calculation: Superstructures (Equipment Deck)

Check W 21x73 Beam

Tributary Area
\[
\frac{1}{2} \times 29' \times \left(\frac{1}{3} \times 25'\right) = 120.83 \text{ sq. ft}
\]
\[
\frac{1}{2} \times (24'+29') \times 5' = 132.50 \text{ sq. ft}
\]
\[
253.33 \text{ sq. ft}
\]

Uniform Loads:
\[
\frac{1}{4}" \text{ Pl } 10.2 \times 253.33 = 2,584.0 \# 
\]
\[
L.L. \quad 150 \times 253.33 = 38,000.0 \#
\]
\[
40,584.0 \#
\]

Beam Wt:
\[
W 21\times73 \quad 29 \times 73 = 2,117 \#
\]
\[
W 8\times24 \quad 24 \times (7+7) = 336 \#
\]
\[
W 6\times15.5 \quad 15.5 \times (6.5+5+3.5+2) \times 3 = 791 \#
\]
\[
W 6\times15.5 \quad 155 \times 4 \times 10 = 620 \#
\]
\[
3,864 \#
\]

Total Weight \[ W = 40,584.0 + 3,864.0 \]
\[ = 44,448 \# \]

Equivalent uniform load \[ W = 1,533 \# / \text{ft} \]
\[ M_{\text{max}} = \frac{1}{8} \times \left(\frac{1.533}{1000}\right) \times 9^2 \times 12 = 1,933.9 \text{ in}^2 \text{kip} \]

Try \( W_{21\times73} \)

\[ S_x = 151 \text{ in}^3 \quad I_x = 1600 \]

\[ \sigma_t = \frac{1,933.9}{151} = 12.8 \text{ ksi} < 22 \text{ ksi} \quad \text{OK} \]

Max. deflection at center \( \delta_c = \frac{5wl^4}{384EI} \)

\[ \delta_c = \frac{5 \times 1.533 \times 29^4 \times 12^3}{384 \times 30,000 \times 1600} = 0.51" < 0.967" \quad \text{OK} \]

\[ \delta_{\text{max}} = \frac{6}{360} = \frac{29 \times 12}{360} = 0.967" \]
Tributary Area = 5x21 = 105 SQ.FT

\[ \frac{7/8\"}{10.2\times84} = 857\# \]

\[ \frac{L.L.}{150\times84} = 12,600\# \]

[13,562\#]

**Beam Wt.:**

\[ W_{8\times24} \times 24 = 432\# \]

\[ W_{6\times15.5} \times 15.5\times4\times5 = 310\# \]

\[ 742\# \]

**Total Weight**

\[ W = 13,562 + 742 \]

\[ = 14,304\# \]

**Equivalent Uniform Load**

\[ w = \frac{795}{14} \]

\[ W_{8\times24} \]

\[ 18'0" \]

**Bending Moment**

\[ M_{max} = \frac{1}{8} \times \frac{795}{1000} \times 18^2 \times 12 = 38.6'K \]

\[ W_{8\times24} \]

\[ S_x = 20.8\text{ in}^3; I_x = 82.5\text{ in}^4 \]

\[ (\sigma_e)_{max} = \frac{38.6}{20.8} = 18.6 \text{ ksi} < 22 \text{ ksi} \]

\[ S_c = \frac{5 \times 795 \times 18^2 \times 12^3}{384 \times 30,000 \times 82.5} = 0.759" \]

\[ AISC \frac{l}{360} = \frac{18\times12}{360} = 0.6" < 0.759" \text{ N.G.} \]
Try $W_{10\times 29}$

$S_x = 30.8 \text{ in}^3$

$I_x = 158 \text{ in}^4$

$(\sigma_t)_{\text{max}} = \frac{386}{30.8} = 12.5 ~\text{ksi}$

$\delta_c = \frac{5 \times 0.795 \times 18.4 \times 12^3}{384 \times 30.000 \times 158} = 0.396 " < 0.5 "$

O.K.
Section D-D

9' - 9"

Top of Equipment Deck

3/4" Th. Cap

W 10 x 29

8\(\frac{1}{8}\)" X .322" WT

30\(\frac{3}{4}\)" x 1" WT
Check 8 5/8" φ x 322" WT

\[ A = 8.4 \text{ sq. in} \]
\[ r = 2.94" \]
\[ L = 13' - 9" \]

\[ n = \frac{KL}{r} = \frac{1 \times 13.75 \times 12}{2.94} = 56 \]

\[ F_a = 17.8 \text{ ksi} \]

Axial Load \( = \left( \frac{1}{2} \times 14,304 \right) \times \sqrt{2} = 10,114 \text{ #} \)

\[ f_a = \frac{10,114}{8.4} = 1.2 \text{ ksi} \ll F_a \quad \text{o.k.} \]
Design Live Loads on Deck = 150 PSF
Design Live Loads on Stairs = 100 PSF (AISC)

or 1000 LBS Min. (USAS AGA 1-1968)
2-£12 @ 2'-6" Back-to-Back
Say 2 - £12x20.7
Sx = 21.5 in²

\[ \text{L.L.} = 100 \times 2.5 \times \frac{12.6}{\sqrt{9^2 + 12.5^2}} \]

\[ \text{L.L.} = 203 \text{ plf} \]

Each Channel
\[ \text{L.L.} = 102 \text{ plf} \]
\[ \text{D.L.} = 21 \times (£12 \times 20.7) \]
\[ \text{Misc} = 5 \]

Total = 127
Say \( W = 130 \text{ plf} \)

\[ M_{\text{max}} = \left( \frac{130}{1000} \right) \times \frac{15.4^2 \times 12}{8} \]

\[ = 46.25''K \]
\[ (\tau_b)_{\text{max}} = \frac{M}{S} = \frac{46.25}{21.5} = 2.15 \text{ ksf} \]
O.K.
Loads from stairs

\[(100 \times 2.5) \times 6.25 + (22 + 10) \times 7.7\]

\[= 1563 \# + 246 \#

\[= 1809 \#

Equivalent uniform load on \(W8\times24\)

\[\omega_i = \frac{1809}{5} = 362 \text{ plf}\]

Uniform load from 100 psf

\[\omega_2 = 100 \times 2 = 200 \text{ psf}\]

Total uniform loads

\[\omega = \omega_i + \omega_2 = 562 \text{ plf}\]

\[M_{\text{max}} = \frac{\omega l^2}{2} = \frac{562 \times 5^4 \times 12}{2} = 84.3 \text{ in}^3\]

\[W8\times24 \quad S_x = 20.8 \text{ in}^3\]

\[(\sigma_y)_{\text{max}} = \frac{84.3}{20.8} = 4.05 \text{ ksi}\]

O.K.
Design Live Loads on Deck = 150 psf
Design Live Loads on Stairs = 100 psf (AISC)

or 1000 lbs Min. (USAS A64-1-1968)
Additional loads due to stairway reactions

\[ W_a = 562 \times 5 + 100 \times 2 \times 5 = 3,810 \text{ lb} \]

Moment due to \( W_a \)

\[ M_a = \frac{W_a L}{4} = \frac{3,810 \times 29 \times 12}{4} = 331.5 \text{"kip} \]

Total moment

\[ M = 958.7 + 331.5 = 1,290.2 \text{"kip} < 2,136 \text{"kip} \]

\[ W18 \times 50 \quad S_x = 89.1 \text{ in}^3 \]

\[ (\sigma_b)_{\text{max}} = \frac{1,290.2}{89.1} = 14.48 \text{ksi} \]

Total loads = 22 + 3.81 = 25.81 k < 49 k o.k.

(AISC Allowable)
ELEVATION  
\[ \theta_1 + 23.5' = 109.5' \times 110' = 940 \text{ RSPF} \]  
\[ 100 = 605'' \]  
\[ 90 = 470'' \]

WAVE FORCE  
\[ \text{AVERAGE} \]

PAINTED \[ 1.9'' \times 0.145 \]

\[ \frac{5}{8}'' \times 0.520 \]

\[ A_k = 12.76' \]
\[ L = 295' \times (7.7+3) \]

\[ 9.2' \]

\[ = 43.4 \]

\[ \text{D.L.} = 59.2 \text{ SAT 60 RSPF} \]

\[ = 247.5 \text{ RF SAT 250 RSPF} \]
CREST OFFSHORE, INC.

By _M3_ Client _LX_ Date _8.14.78_ Job No. _21-71-98_ Calculation _Superstructure_

**STRINGER**

There is no axial force on STRINGER.

Or \( P = 0 \) \( \Rightarrow F_3 = 0 \)

**UPPER**

\[ \frac{\sqrt{b_2 + h_2^2}}{F_k} \leq 1.0 \]

\[ \begin{align*}
M_y &= 0.25 \left( \frac{0.5}{2} \right)^2 \times 12.5^2 \Rightarrow f_{h_1} = \frac{12.5 \times 12}{24.5} = 0.12 \\
M_x &= 0.720 \times \left( 12 \right) \times (20)^{2/3} = 27.6^1 \Rightarrow f_{h_2} = \frac{27.6 \times 12}{24.5} = 13.52 \\
\end{align*} \]

\[ f_{h_1} = \frac{14.84}{0.5 \times 30 \times 1.33} \]

\[ \frac{8.8^\circ \times 0.5 \times 0.125}{0.1} \]

**HUNDRED**

\[ \omega = 130 \times \left( \frac{3}{2} \right) = 195^2 \]

\[ M_2 = 0.123 \times 8 = 0.98 \text{ in} \]

\[ \bar{w} = \frac{0.35 \times 1.2''}{0.16 \times 30 \times 1.33} = 0.18^2 \text{ m}^2 < 0.5\text{ m}^2 \]

**PALASTER**

Load from Handout = 123 \times 7'' = 861''

\[ M = 0.34 \times 3.5'' + 0.35 \times 1.5'' = 3.87 \text{ in} \]

\[ \bar{w} = \frac{3.5'' \times 1.2''}{21.6 \times 1.33} = 1.62 \text{ m}^2 \]

\[ 2.375^\circ \times 0.375 \text{ PALASTER'S} \]

\[ \omega/\delta = 2.37 \\]
**CREST OFFSHORE, INC.**

**Subject:** Miscellaneous Structures

**Date:** 8-10-76  
**Job No.:** 27-71-98  
**Calculation:** Superstructure

---

**Loading**

\[ \delta_1 + 28.5^\circ \text{ TCA, } s = 110' \]

Max. wave force at ELEV 110' above mud line = 90.85 kbf

**Section Properties**

- \( A_x = 6.85 \times 0.001 \)
- \( I_x = 13.43 \times 13.72 \)
- \( S_y = 52.11 \times 0.11 \)
- \( 4.85 \times 10.33 \times 4.85 \)
- \( 1.9 \times 0.145 \times 0.199 \)

**Landing Beam - Interior - km**

\[ w_i = w_{l} + w_{u} = 5' \times 5.375' + (1.25' \times 5' + 37.7') = 62.0' \]

\[ k = 0.02 \times 425' / 1.85 \]

\[ c = 1.05 \times 12.21 \times 1.0 \times 3.03 \times 13.72 \]

Wave loading on % km.

\[ M = 0.01 + (2.7) \times (2.75') / 3 = 0.30 \]

\[ c = 3.0 \times 12 / (21.7 \times 1.53) = 1.26 \]

\[ 6.85 \times 0.001 \text{ kbf} \times 0.1 \]

**Knee Clearance**

\[ F = [2 \times 0.55(180' + 132') + 7'(221' + 221')] = 114' \]

\[ a = 184' \]

\[ b = 0.02 < 0.15 \]

\[ F_1 = 18.44 \]

\[ F_2 = \left[ 0.42 \times (2.75' / 3) \right] \times 12.21 / 21.7 = 0.20 \]

\[ F_0 = 21.00 \]

\[ F_0 \times 3.37 \text{ kbf per 0.1' } \]

**Handrail**

\[ \omega = 0.4 \times (3 / 2) = 0.3 \]

\[ M = 0.18 \times 5' \times 0.05' / 2 = 0.14' \]

\[ G = 0.4 \times 12 / 21.7 = 0.17' < 0.31' \]

\[ F_0 = 1.9 \times 0.145 \text{ Handrail} < 1' \]

**Balance**

\[ M = 0.18 \times 5' \times (3 + 1.5') = 3.36' \]

\[ G = 2.5 \times 12 / 21.7 = 1.48' \]

Use 2.75' \( 6' \times 1.637 \) minimum w/s x = 1.637
**ELEVATION STAIRWAY #2**

**SECTION PROPERTIES**

- **Ax =** 1.14
- **Iy =** 14.7
- **Fy =** 4.47
- **Sy =** 1.86

<table>
<thead>
<tr>
<th>Section</th>
<th>A</th>
<th>Ix</th>
<th>Iy</th>
<th>Fx</th>
<th>Sy</th>
<th>Zy</th>
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<tbody>
<tr>
<td>12x25</td>
<td>7.35</td>
<td>14.4</td>
<td>24.1</td>
<td>4.47</td>
<td>1.86</td>
<td>0.780</td>
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<td>1.9x1.5</td>
<td>0.799</td>
<td>2.72</td>
<td>0.810</td>
<td>0.920</td>
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<td></td>
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<tr>
<td>2.4x2.4x4.4</td>
<td>1.19</td>
<td>4.4l</td>
<td>0.794</td>
<td>0.941</td>
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<td></td>
</tr>
</tbody>
</table>

**LOADING**

- **Dead Loads:**
  - **Stringer:** 23 PLF
  - **Handrail:** 2"
  - **Treads:** 10"/8

- **Live Load:**
  - 180 lbs/ft x 1.25 = 225"

- **Total Load:** 225 PLF

**Wave Loading**

- **81 + 80 = 151**
- **B1 + 86 = 109.5**
- **B1 + 104 = 104.8**
- **B1 + 94 = 94.8**

Assume 10000#S.F.
By   [WS]  Client  E. G.  Subject  Miscellaneous Structures  Date  11.17.98  Job No.  27-77-98  Calculation  Superstructure

HANDRAIL

\[ \omega_{w0} = 1000 \times \frac{4}{(3)^2} = 1667 \ \text{PLF} \]

\[ M = 0.167 \cdot (c)^2 / L = 0.752 \ \text{k} \]

\[ S_p = 0.752 \times 12 / (21.6 \times 1.33) = 0.314 \ \text{m}^3 < 0.09 \text{ft}^3 \]

BALASTERS

\[ P = 167 \times 0.01 = 1.0 \ \text{k} \]

\[ M = 1.0 \times 3' + 1.0 \times 1.5' = 4.5 \ \text{k} \]

\[ S_p = 4.5 \times 12 / (21.6 \times 1.33) = 1.8 \ \text{m}^3 \]

\[ 0.06 \times 0.73 \times 0.375 \]

STAIRWAY

\[ \omega_{w0} = 1000 \times 2.3 \times 1' = 10.0 \ \text{PLF} \]

\[ w_m = 225 \ \text{lb} \]

\[ f_{mx} = \frac{M_{x}}{w_m} = \frac{0.225 \times (0.29)^2}{225} \times 12 = 0.067 < 21.6 \ \text{lb} < 0.1 \]

Note: For wave force the whole deck was taken as 0.25/36

\[ I = 7.35 \times (30)^2 / 12 = 1054 \ \text{m}^4 \]

\[ S_y = \frac{1.0 \times 12}{110} = 0.8 \]

\[ f_{ny} = \frac{N_{y4}}{S_y} = 1.0 \times (0.29)^2 \times 12 / 110 = 10.47 \ \text{lb} < 21.6 \times 1.33 \]

Deck deflection

\[ \Delta_{w0} = \frac{1}{4} \times 0.29 \times 0.66 = 0.04 \] m

\[ \Delta = \frac{5 \times (0.235 \times 29 \times 144)}{24 \times 29 \times 144} = 0.66'' < 1.0'' \]

L: 12 x 23 x 0.1
SECTION PROPERTIES:

<table>
<thead>
<tr>
<th>Section</th>
<th>A</th>
<th>I_x</th>
<th>S_x</th>
<th>W_x</th>
<th>Unit</th>
<th>Sq</th>
</tr>
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<tbody>
<tr>
<td>L2 x 25</td>
<td>1.36</td>
<td>114</td>
<td>21</td>
<td>1</td>
<td>ft</td>
<td></td>
</tr>
<tr>
<td>W12 x 7</td>
<td>1.95</td>
<td>204</td>
<td>54.2</td>
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<tr>
<td>42&quot; x 377</td>
<td>4,597</td>
<td>9613</td>
<td>4,272</td>
<td>4.73</td>
<td>ft</td>
<td></td>
</tr>
</tbody>
</table>

LOADING:

wave = 18.4 ft

INTERIOR LANDING BEAM:

\[ w = w_{1} + w_{2} = 0.5 \times 50 + 7.36 \times 5.82 = 814 \text{ lb} \]

\[ M = 0.814 \times 4 \times 2 = 1,028 \text{ in-lb} \]

\[ \tau = \frac{1,028 \times 21.0}{21.0^2} = 0.104 \text{ in}^3 < 34.2 \text{ in}^3 \]

BM SUPPORTING STAIRS STRINGER:

\[ w = \frac{1}{2} \times 4 \times 12 = 814 / 2 = 407 \text{ lb} \]

\[ P_{t} = 0.22 \times 12 = 26.4 \text{ k} \]

\[ P_{P} = 1.031 \times 27 \frac{1}{2} = 14.5 \text{ k} \]

\[ N = 0.907 \times 12 / 2 + 3.26 \times 4 + 3.26 \times 1.5 = 21.8 \text{ k} \]

\[ f_{0} = \frac{12}{7.95} = 1.52 \text{ k} \]

\[ f_{0} = 21.8 \times 12 = 256 \text{ km} \]

\[ f_{t} = \frac{P_{t} + f_{0}}{2} = \frac{26.4 + 11.8}{2} = 0.03 < 1.0 \text{ k} \]

OUTSIDE STRINGER:

\[ M_{p} = 0.784 \times 5 \times 6 = 24.5 \text{ k} \]

\[ N_{x} = (2 \times 150 + 2 \times 7.36 + 25) \times 5 \times 6 = 1,000 \text{ in-lb} \]

\[ f_{0y} = \frac{24.5 \times 6}{1,000} = 15.04 \text{ k} \]

\[ f_{x} = \frac{1,000 \times 12}{24.1} = 5.3 \text{ k} \]

\[ f_{y} = \frac{f_{0y} + f_{x}}{f_{y}} = \frac{15.04 + 5.3}{21.6 \times 12} = 0.57 < 1.0 \text{ k} \]
**STAIRWALT #3**

**SECTION PROPERTIES**

<table>
<thead>
<tr>
<th>Section</th>
<th>Ax</th>
<th>Ix</th>
<th>Ex</th>
<th>Sy</th>
<th>E</th>
<th>A</th>
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<tbody>
<tr>
<td>12 X 25</td>
<td>7.85</td>
<td>144</td>
<td>24.1</td>
<td>1.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.9 X 1.45</td>
<td>0.99</td>
<td>0.810</td>
<td>0.926</td>
<td>2.72</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**STAIR STRINGER**

Wkt = 225 psf (Spec 5.2)

\[
M = 0.225 \times (18) \frac{1}{2} = 9.11 \text{ k}
\]

\[
\delta = \frac{9.11 \times 12}{21.16 \times 6.00} < 24 \text{ in}
\]

**CK DEFORMATION**

\[
\delta = \frac{5 \times (0.225)(18)^{0.5}}{844 \times 29 \times 144} = 0.13 \text{ in}
\]

**WAVE FORCE = 557 psf**

Two stair stringers & forl of trends D.R.T. TOSS 0/SX = 110 w^2 (Spec #2)

\[
M = 0.557 \times (18) \frac{1}{2} = 21.75 \text{ k}
\]

\[
\delta = \frac{21.75 \times 12}{110} = 2.37 \text{ in} < 21.6 \text{ in} \text{ O.K.}
\]

**Handrails & Screened**

**NERCERED BY INSPECTOR**
**CREST OFFSHORE, INC.**

By: [Name]
Client: [Client]
Subject: Miscellaneous Structures
Date: [Date]
Job No.: 21.17
Calculation: Superstructure

---

**LANDING #3 0.635V, 60' - 0.4**

**VERT LOAD FL. 60%:**

\[ P_v = 0.635 \times 15.2 = 2,025 \text{ kN} \]

**LATERAL LOAD:**

\[ P_h = 0.357 \times 15.2 = 5.6 \text{ kN} \]

\[ W = 2.1 \times 15.2 = 32.0 \text{ kN} \]

\[ M = 0.35 (2.5)^{1/2} + 2.025 (2.5 + f) = 19.5 \text{ kN}\cdot\text{m} \]

\[ k = 2 \times 5 \times 12 / (1 + 2) = 79 \approx 16.4 \]

\[ f = P / A = 4.823 \times 2 = 0.25 \text{ kN} \]

\[ f_b = \frac{M}{6} = \frac{11.5 \times 12}{36} = 0.86 \text{ kN} \]

\[ f_b = 0.86 + 0.35 = 0.34 \times 1.0 = 0.3 \]

**NOTE:** NO WAVE ON LANDING ITSELF

**INT. BUCK**

\[ w = 2.025 \times 4 \]

\[ k = 0.35 (4)^{1/2} = 0.71 \text{ kN} \]

\[ f_b = 0.71 \times 12 / 20.3 = 0.40 \text{ kN} < 2.0 \text{ kN} \]

**HORIZONTAL**

NEGLIGENCE BY INSPECTION
Section Properties

<table>
<thead>
<tr>
<th>Section</th>
<th>A</th>
<th>Ix</th>
<th>Iy</th>
<th>Gx</th>
<th>Gy</th>
<th>Sx</th>
<th>Sy</th>
<th>Hx</th>
<th>Hy</th>
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</thead>
<tbody>
<tr>
<td>10x15.3</td>
<td>4.49</td>
<td>67.4</td>
<td>13.5</td>
<td>2.07</td>
<td>1.16</td>
<td>0.73</td>
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<tr>
<td>10x18.5</td>
<td>5.76</td>
<td>82.4</td>
<td>20.8</td>
<td>2.42</td>
<td>1.61</td>
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<tr>
<td>10x27.5</td>
<td>7.45</td>
<td>264</td>
<td>54.2</td>
<td>5.07</td>
<td>5.03</td>
<td>1.52</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Loadings

Note: No wave load will occur on this stair.

Design Load = Actual
Live Load = 150 psf
CREST OFFSHORE, INC.

By: [Name]  Client: [Client Name]  Subject: Miscellaneous Structures
Date: [Date]  Job No: 21-171-98  Calculation: Superstructure

STAIR # 4

HANDRAILS: NEGLECT BY INSPECTION

STRINGERS

\[ w_f = w_b + w_c = 1.25 \times 10 + 15.3 + 1.25 \times 150 = 215 \text{ lb} \]

\[ M = 0.25 \times (20)^{\frac{3}{2}} = 10.8 \text{ k} \]

\[ h_b = 10.5 \times 12 / 13.5 = 9.50 < 21.0 \text{ in.} \]

WIND: 23 RPS

\[ M = 0.025 \times (20)^{\frac{3}{2}} = 125 \]

\[ f_h = 1.25 \times 12 / 1.10 = 12.93 \]

(CRAKES FORMS TRUSSES IF WIND WILL BE INSignificant)

\[ b = 6 \text{ in.} \]

\[ f_b = 1.25 \times 12 / 100 = 0.15 < 21.0 \]

Check deflection \[ \Delta_{defl} = 4 / 360 - 20 \times 12 / 600 = 0.07 \]

\[ \Delta_{defl} = \frac{5 (0.225 \times 20) \times (17.8)}{3.24 \times 2.9 \times 0.7} = 0.414 < 0.07 \]

LOWER LANDING

For from stringers: 10' x 215 lb = 2150

\[ M = (5.0 + 2.5) \times (2.15)^{\frac{3}{2}} + (2 \times 170^{\frac{3}{2}}) = 20.37 \text{ k} \]

\[ f_b = \frac{20.37^{\frac{3}{2}} \times 12}{20.8 \text{ in.}} = 11.75 \text{ k} \]

Check deflection \[ \Delta_{defl} = 4 / 360 - 5 \times 12 / 600 = 0.17 \]

\[ \Delta_{defl} = \frac{(2 \times 17 \times 5)^{\frac{3}{2}}}{3.24 \times 2.9 \times 2.9} + \frac{2 \times (5)^{\frac{3}{2}}}{3.24 \times 2.9 \times 2.9} + \frac{2 \times 17.8}{3.24 \times 2.9 \times 2.9} \]

\[ = 0.019 + 0.005 + 0.020 = 0.044 < 0.17 \]

UPPER LANDING

By inspection if W 8 x 24 works for lower landing, W 12 x 27 will be O.K. for upper landing.
# Dead Weight of Superstructure

<table>
<thead>
<tr>
<th>Member Size</th>
<th>Member Length (FT)</th>
<th>No. Required</th>
<th>Total Length (FT)</th>
<th>Unit Weight (LBS/FT)</th>
<th>Total Weight (LBS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>42&quot; x 1.0&quot; WT</td>
<td>5.0</td>
<td>3</td>
<td>15.0</td>
<td>473.39</td>
<td>7,100.9</td>
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<tr>
<td>30&quot; x 1.0&quot; WT</td>
<td>50.5</td>
<td>3</td>
<td>151.5</td>
<td>309.73</td>
<td>46,924.1</td>
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<tr>
<td>42&quot; x 30' x 1' WT Cone</td>
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<td>3</td>
<td>9.0</td>
<td>391.56</td>
<td>3,524.0</td>
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<tr>
<td>14&quot; x .5&quot; WT</td>
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<td>3</td>
<td>97.95</td>
<td>72.09</td>
<td>7,061.2</td>
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<td>12.5&quot; x .5&quot; WT</td>
<td>29.0</td>
<td>3</td>
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<td><strong>Equipment Deck</strong></td>
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<td>W18 x 50</td>
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<td>2</td>
<td>58.0</td>
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<td>29.0</td>
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<tr>
<td>W 10 x 29</td>
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<tr>
<td>W 8 x 24</td>
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<td>4.0</td>
<td>24</td>
<td>96.0</td>
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<td>W 6 x 16*</td>
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<td>7</td>
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<td>Unit Weight</td>
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<td>Unit Weight</td>
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<td>14.0</td>
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**TOTAL STAIRS**

**13,272.5 LBS**
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Total: 2,160.2
Summary

Superstructure Leg & Tubular Braces 70,302 LBS
Equipment Deck 16,781 LBS
Upper Deck 11,006 LBS
Stairs 13,273 LBS
Hand Rails (Decks) 2,160 LBS

113,522 LBS

113.5 Kips
(56.34 Tons)

* W6x16 changed to W6x15.5
2.7 **PAINT AREA**

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<th>MEMBER SIZE</th>
<th>MEMBER LENGTH (C. to C.)</th>
<th>SURFACE AREA</th>
<th>NO. REQUIRED</th>
<th>TOTAL AREA</th>
<th>NOTES</th>
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Total: 401.2
SUMMARY

Superstructure Leg & Tubular Braces 2,089 SQ.FT
Equipment Deck 2,492 SQ.FT
Upper Deck 1,350 SQ.FT
Stairs 2,167 SQ.FT
Handrails & Kick Plates (Decks) 401 SQ.FT

8,499 SQ.FT

(8,500 SQ.FT)

*W 6x16 was changed to W 6x15.5
Lifting Eyes - Superstructure

Weight of Superstructure = 120k

Assume entire weight is at one lifteye.
Assume impact factor of 2.0.
Assume total applied load of 240k can be acting completely vertical or completely horizontal.
Assume sling θ = 60°.

Check Shear in Pin:

Use 3.25" Diameter Pin -

\[ P = \frac{280k}{2 \times (\pi \times 1.625^2)} = 16.9 \text{ ksi} \]

\[ F_s = 0.9 \times (36 \text{ ksi}) \times 1.33 = 19.2 \text{ ksi} \]

16.9 < 19.2

Check Bearing on Plate

\[ P = \frac{280k}{(3.25)(3.25)} = 26.5 \text{ ksi} \]

\[ F_{br} = 0.9 \times (36 \text{ ksi}) = 32.4 \text{ ksi} \]

26.5 < 32.4
Check Pin Shearing Through Plates

\[ A = 9 \left[ (5 - 1.75) \times 1.0 \right] + 2 \left[ (6 - 1.75) \times 1.25 \right] \]

\[ A = 13.0 + 10.6 = 23.6 \, \text{in}^2 \]

\[ f_s = \frac{280}{23.6 \, \text{in}^2} = 11.9 \, \text{ksi} \]

\[ F_s = 0.4 \times (36 \, \text{ksi}) \times 1.33 = 19.2 \, \text{ksi} \]

11.9 < 19.2
Tension Through Lift Eye

\[ A = 4 \left[ 3.25 \times 1.0 \right] + 2 \left[ 4.25 \times 1.25 \right] = 23.6 \text{ in}^2 \]

\[ f_t = \frac{280}{23.6 \text{ in}^2} = 11.9 \text{ ksi} \]

\[ F_t = 0.1 \times 36 \text{ ksi} \times 1.33 = 28.7 \text{ ksi} \]

\[ 11.9 < 28.7 \]

Check Weld of Check Plates

\[ A_{R} = \frac{1.0}{3.25} = 0.31 \]

\[ A_{\text{total}} = 3.25 \]

\[ P_{\text{shear}} = 0.31 \times 280 \text{ k} = 86.8 \text{ k} \]

\[ \text{Circumference} = \pi (10) = 31.4 \text{ in} \]

\[ \frac{P}{C} = \frac{86.8}{31.4} = 2.8 \text{ k/in} \]

\[ W = \frac{2.8}{11.2} = 0.25 \text{ in} \]

Use \( \frac{3}{8} \)" fillet weld on check plates.
Check Plate Weld to Column

Force due to Moment,
\[ F_m = \frac{d^2}{3} = \frac{900}{3} = 300 \text{ in}^2 \]
\[ f_m = \frac{M}{2S_w} = \frac{2040 \text{ in-lb}}{2(300)} = 3.4 \text{ k/in} \]

Force due to Shear,
\[ A_w = 4 \times 30 \text{ in} = 120 \text{ in} \]
\[ f_3 = \frac{P}{A_w} = \frac{280 \text{ k}}{120 \text{ in}} = 2.3 \text{ k/in} \]

Total Force on Weld,
\[ f = (f_m^2 + f_3^2)^{1/2} = (3.4^2 + 2.3^2)^{1/2} = 4.1 \text{ k/in} \]
\[ w = \frac{f}{t} = \frac{4.1}{0.37} = 11.2 \text{ in.} \]

Use \( \frac{3}{4} \)" fillet weld for lag plate to column.
3.1 INTRODUCTION

The boat landing structural framing presented herein is designed to fit each of the four platform structures. Component details, boat bumpers, grating and stairs associated with the boat landing are not included in this section. Structural steel weights and the surface area to be painted are provided however.
3.2 ELEVATIONS, PLANS AND SECTIONS
ELEVATION (Side View)

W.P. EL (+) 16'-6"
Top of Jet
EL (+) 14'-9"
& EL (+) 12'-0"
& EL (+) 10'-0"
& EL (+) 8'-11"
& EL (+) 6'-0"
MLW EL 0'-0"
& EL (-) 3'-0"
P.O.T. EL 4'-8"

Scale 1/8" = 1'-0"
CREST OFFSHORE, INC.

Sheet 2 of 15

Top of All Pipes Flush @ EL (+) 6'-4 3/8"

PLAN @ EL (+) 6'-0"

Scale 1/4" = 1'-0"

Date: 6/16/76
Job No. 27-771 - Calculation, Boat Landing -

By: C. Choate, U.S. Navy

Subject: Miscellaneous Structures
Check Member Strength

(1) \(65/8\) "F x .432" filled with concrete

Assume no composite action between steel wall and concrete fillup.

\[
\begin{align*}
I_x &= 40.501 \text{ in}^4 \\
S_x &= 12.23 \text{ in}^3
\end{align*}
\]

Span = 9'-0"

\[
M = \frac{PL}{4} \quad M = 0.5S_x
\]

\[
\begin{align*}
L/5\text{e} & \quad 0 = 22 \text{ksi} \\
M &= 22 \times 12.23 = 269.1 \text{ k} \text{f} \\
&= 22.42 \text{ ft-kips}
\end{align*}
\]

\[
P = \frac{4M}{L} = \frac{4 \times 22.42}{9} = 10 \text{ kips}
\]

Consider impact factor of 2.0

\[
P = \frac{10}{2} = 5 \text{ kips}
\]

** 6\(\frac{3}{8}\)" fenders are able to resist a minimum of 5 kips impact force.**
**Moment of Inertia**

\[ \sum A d^2 + \sum I_0^2 \]

8\(\frac{3}{8}\)"x.5"WT \hspace{1cm} A = 12.76 ft \hspace{1cm} I_0 = 105.74 in^4

\[ I = 2 \left[ 12.76 \times 24^2 + 105.74 \right] \]

\[ = 14,911 \text{ in}^4 \]

\[ P = 10 \text{ kips} \hspace{1cm} (=5 \text{ kips} \times 2 \text{ Impact factor}) \]

\[ \sigma_b = \frac{Mc}{I} = \left[ \frac{10 \times 21.5 \times 12}{4} \right] \times \frac{28}{14,911} \]

\[ = 1.21 \text{ ksi} \ll 22 \text{ ksi} \]
(3) **Vertical Load Resistance at Jacket Leg Connections**

Total Dead Weight = 22 kips

Live Load = 4 kips

26 kips

Shear at each connection = \( \frac{26}{6} \) = 4.33 kips

Full penetration field welds on 8\( \frac{3}{8} \)" x 0.5" WT pipe

**Effective shear area** = 12.76 in

\[ \gamma = \frac{4.33}{12.76} = 0.34 \text{ ksi} \]
# 3-3 Dead Weight of Boat Landing

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<th>Member Length</th>
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<th>Unit Weight</th>
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Grating Total: 21,521.7#
# 3.4 Paint Area

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<td>6% x 43% W</td>
<td>47.36 FT</td>
<td>SQ. FT</td>
<td></td>
<td>82.1</td>
<td></td>
</tr>
<tr>
<td>8% x 5% W</td>
<td>58.0</td>
<td>SQ. FT</td>
<td></td>
<td>131.0</td>
<td>EL(+)3'-0&quot;</td>
</tr>
<tr>
<td>6% x 43% W</td>
<td>45.6</td>
<td>SQ. FT</td>
<td></td>
<td>79.1</td>
<td></td>
</tr>
<tr>
<td>12% x 843% W</td>
<td>41.34 FT</td>
<td>SQ. FT</td>
<td></td>
<td>138.0</td>
<td>Verticals</td>
</tr>
<tr>
<td>6% x 43% W</td>
<td>151.9</td>
<td>SQ. FT</td>
<td></td>
<td>263.5</td>
<td></td>
</tr>
<tr>
<td>4% x 33% W</td>
<td>26.63</td>
<td>SQ. FT</td>
<td></td>
<td>31.4</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>1,115.7</td>
<td></td>
</tr>
</tbody>
</table>
3.5 Boat Fenders

**Stiffness Analysis**

- **P** = 100 kN
- **l** = 17.5 × 12 = 234.0 in
- **h** = 4.59 × 12 = 55.06 in
- **I_1** = 1515
- **I_2** = 1515

**k** = \( \frac{h}{l} \) = \( \frac{55.06}{234.0} \) = 0.24

**N** = **k** + 1 = 1.24

**L** = \( \frac{3PL}{8} \) = 8775.0

- **σ_t** = \( \frac{PL}{2I} \) = 11700.0
- **M_0** = \( \frac{PL}{4} \) = 5850.0

**M_C** = \( -\frac{R(3k+4)-2k^2}{6N} \) = -3203.59 in kN

**M_B** = \( -\frac{2k^2-R}{3N} \) = -2367.83 in kN

**M_A** = \( -\frac{M_B}{2} \) = -1183.9 in kN

**M_x** = \( M_0 + \frac{k'}{k} M_B + \frac{k}{k} M_C \) = + 2727.21 in kN

**V_A** = \( \frac{G_r - M_B + M_C}{X} \) = 46.43 in

**V_c** = **P** - **V_A** = 53.57 kN

**H_a** = \( \frac{H_c}{h} = \frac{3M_A}{h} \) = 64.51 in
Bean Stress Check

Max. Moment = \( M_c = 3203.59'' \times 12 \)

\[ \sigma = \frac{M}{S} = \frac{3203.59}{148.3} = 19.03 \text{ ksi} < 21.6 \text{ ksi} \]

\[ F_b = 0.6 F_y = 0.6(36) = 21.6 \text{ ksi} \]

Conclusion

18" x 0.75" Hull with a stress of 19.03 ksi is good and will withstand 100% impact load applied at the mid point of the fender.
SECTION 4
EQUIPMENT SUPPORT DETAILS

4.1 INTRODUCTION

Support details for antenna post and solar panel framing are presented in this section.
4.2 ANTENNA POST

30° leg

4½" x 0.337" steel
From ELEV +30
To ELEV +90
Stirrer supports
every 3'-6"

2" brace
3" below top
3" short bottom of
end of pipe - Cap
Ends of pipe "1/4" RC
Column Leg
A-2

$\frac{3}{4}''$ the Pipe

4$\frac{1}{2}'' \times 0.337''$ the Pipe

See cubic detail for orientation at various sites.
4.3 SOLAR PANEL SUPPORT DETAILS
Wind Forces


APPENDIX C. THREE PILE CONCEPT CALCULATIONS

\[ F = 0.00256 C_s A C_h V_{30}^2 \]

- \( F \) = force in lbs
- \( V_{30} \) = velocity @ EL(+) 30' = 150 knots = 173 mph
- \( C_s = 1.5 \) for flat surfaces
- \( C_s = 1.0 \) for cylindrical surfaces
- \( A \) = projected area of surface (sq. ft)
- \( C_h \) = height coefficient = \((H/30)^{0.7}\)

Let \( g_{30} = 0.00256 C_s C_h V_{30}^2 \)

\[ g_{30} = 0.00256 \times 1.5 \times (173)^2 = 115 \text{ psf} \]

@ EL(+) 64'-6"
\( (60 + \frac{1}{2} \times 10.4 \cos 30^\circ = 64.5' ) \)

\[ C_s = (\frac{64.5}{30})^{0.7} = 1.244 \]

\[ g_{64.5} = 115 \times 1.244 = 143 \text{ psf} \]
Projected Area  \[ A = 11.5 \times (10.5 \cos 30^\circ) \]
\[ = 104.6 \text{ sq. ft} \]

Total Wind Force  \[ F = 143 \times 104.6 \]
\[ = 14,958 \text{ lbs} \]

Assuming that solar panel frames are flexible
so that a uniformly distributed wind load may be
 transferred to the panel supports.

Ref. to wind area shown inPg. 4.09
\[ A = \frac{1}{2} \times 9.5 \times (5.5 \cos 30^\circ) = 22.6 \text{ sq. ft} \]
Wind Force = 143 \times 22.6 = 3,232 \text{ lbs}

Triangular load at peak 3,232 = \frac{1}{2} W \times 9.5
\[ W = 680 \frac{\#}{\text{ft}} \]

AISC 2-198
Case #3
\[ W = 3,232 \# \]
By C. Chern, Client U.S. NAVY, Subject: Miscellaneous Structures
Date 7-22-76, Job No. 27-771-98, Calculation: Solar Panel Support Details

\[ R = V = \frac{W}{2} = 1.616 \text{ in} \]

\[ M_{\text{max}} = \frac{WL}{6} \]

\[ = \frac{3.232 \times 9.5 \times (12)}{6} \]

\[ = 61.4'' \text{ in} \]

\[ \Delta_{\text{max}} = \frac{WL^3}{60EI} \text{ (center)} \]

Try \( 4 \times 5 \times 3 \times \frac{3}{8} \)

\[ S_x = 2.24 \text{ in}^3 \]

\[ I_x = 7.37 \text{ in}^4 \]

\[ \sigma_b = \frac{M}{S_x} = \frac{61.4}{2.24} = 27.4 \text{ ksi} \]

AISC Allowable \( \sigma = 22 \times 1.33 = 29.3 \text{ ksi} > 27.4 \text{ ksi} \)

O.K.
Δ_{max} = \frac{3.232 \times (9.5 \times 12)^3}{60 \times 30,000 \times 7.37} = 0.36" 

Ref. to Wind area shown in Pg. 4.12

\[ A = \frac{1}{2} (10.5 + 5.25) \times 2.2 + \frac{1}{2} (10.5 + 5.25) \times 2.6 \]

= 37.8 sq. ft

Total Wind Force = \( 143 \times 37.8 \times \cos 30^\circ \)

= 4,681 *

Equivalent uniform load = \( \frac{4,681}{10.5} = 446 \text{ #/ft} \)

\( w = 446 \text{ #/ft} \)

\[ M_{max} = \frac{wL^2}{8} = \frac{446 \times 10.5^2 \times 12}{8 \times 1000} \]

= 73.8 "k

Try 4 x 3 x \frac{1}{2}

\[ S_x = 2.91 \text{ in}^3; I_x = 9.45 \text{ in}^4 \]

\[ \sigma = \frac{73.8}{2.91} = 25.4 \text{ ksi} < 29.3 \text{ ksi} \text{ o.k.} \]

\[ \Delta_{max} = \frac{5wxL^4}{384EI} = \frac{5 \times 446 \times (10.5)^2 \times 12^3}{384 \times 30,000 \times 9.45} = 0.43" \]
\[ \Sigma M_A = 0 \quad 14,958 \times (4.5 - 2.8) = (R_{co} \times 5 \sin 31^\circ) \times 2 \]

\[ R_{co} = \frac{14,958 \times 1.7}{2 \times 2.575} = 4,938 \text{ kips} \quad \text{(Comp.)} \]

4\frac{1}{2}'' \Phi \times 0.337'' \text{ WT} \quad A = 4.41 \text{ sq. in.} \]

\[ f_a = \frac{4,938}{4.41} = 1.12 \text{ ksi} \]

\[ r = 1.477'' \]

\[ \frac{KL}{f} = \frac{1 \times 6.1 \times 12}{1.477} = 49.5 \]

\[ F_a = 18.40 \text{ ksi} \]

\[ \frac{f_a}{F_a} = \frac{1.12}{18.40} = 0.06 \]
\[ \Sigma M_c = 0 \quad 14,958 \times 4.5 = 2 \times (R_{AB} \times 5 \sin 31^\circ) \]

\[ R_{AB} = \frac{14,958 \times 4.5}{2 \times 2.575} = 13,070 \text{# (Tens.)} \]

\[ 4\frac{1}{2}'' \phi \times 0.377'' \text{WT} \]
\[ f_a = \frac{13.07}{4.41} = 2.96 \text{ ksi} \quad < 22 \text{ ksi} \quad \text{OK} \]

Joint A (Assuming DA carries no force)

\[ R_{AC} \cdot \frac{L}{\sqrt{2}} = R_{AB} \]
\[ R_{AC} = 13.07 \times \frac{L}{\sqrt{2}} = 18.48 \text{ kips (Comp.)} \]

\[ 4\frac{1}{2}'' \phi \times 0.337'' \text{WT} \]
\[ f_a = \frac{18.48}{4.41} = 4.19 \text{ ksi} \quad < 22 \text{ ksi} \quad \text{O.K.} \]