15 Creek Rd., Marion, MA 02738
www.foth.com

February 17, 2022

Mr. Chancery Perks, Conservation Agent
New Bedford Conservation Commission
New Bedford City Hall
133 William Street
New Bedford, MA 02744

RE: SE 049-0876, NOI - 1482 E. Rodney French - Gangway and Floating Dock

Ref: Comment letter from Nitsch Engineering dated August 31, 2021, Nitsch Project #9972

Dear Mr. Perks:

We have reviewed the comments provided by Nitsch Engineering through their peer review of the above referenced project and offer the following responses:

1. *The NOI includes a Proposed Site Plan prepared by Foth that references the design plans Proposed Floating Dock Anchor System, Cisco Pier, dated July 27, 2021, provided By AGM Marine. We recommend that the Applicant provide plans and supporting calculations stamped by a Professional Structural Engineer for the proposed anchor system, including sizes/weights/connections.*

Attachment 1 include plans and supporting calculations for the proposed anchor system, stamped by Richard FitzGerald, structural engineer.

2. *The Applicant should review the proposed alteration numbers provided in the NOI form and provide a plan depicting the direct and indirect impacts. We recommend that the direct impact number account for the proposed 12-inch timber piles plus the anchor system (including the anchor blocks, sinkers, and chains).*

Attachment 2 is an annotated plan that provides the calculations for the direct and indirect impacts. Original NOI include 130 sf; through the addition of the chain impacts, the revised area of direct impacts is 173 sf.

3. *On the NOI form, the Applicant should include review impacts for Land Containing Shellfish and Land Subject to Coastal Storm Flowage, as both appear to be relevant to this project based on the information provided in the NOI.*

Attachment 2 includes page 4 of the NOI form which has been revised to include 173 sf impact area for Land Containing Shellfish due to the concrete blocks and chain and 768 sf within Land Subject to Coastal Storm Flowage for the float and gangway. Please note that the float and gangway are located in the waterway, within the flood zone, but are not in contact with "Land Subject to Coastal Storm Flowage".

4. *The Applicant and their Structural Engineer should confirm that the project's location within a Federal Emergency Management Agency (FEMA) Flood Velocity Zone (including potential wave action) were considered in the design of the anchor system.*

Refer to attached calculations which include the following conditions:
- ✓ Boats cannot berth at floating dock with winds > 40 mph
- ✓ Floating docks to be removed from site when hurricane winds (+70 mph) are forecasted
- ✓ Concrete block anchors will be set level with mudline by jetting during installation

5. *The Applicant should include alternatives within the NOI that provide less impacts to the Land Under the Ocean. These may include installation of permanent piers or anchoring from the shore or the existing structure.*

As requested, additional anchor systems were considered and are presented as follows:

Anchoring from Shore: Anchoring from shore would not result in less impacts to Land Under Ocean as the chain would still need to lay on the bottom to connect to the float and in order to cross the chain lines to minimize movement of the float, anchors would still be required to the east of the float. Utilizing the existing pier as the accessway to the floating dock is preferred.

SeaFlex System with Helical Anchors: The Commission requested an evaluation of a Seaflex (elastic rode) and helical anchor system. Attachments include the design and calculation report prepared by SeaFlex. The system consists of:

- ✓ Helical anchors, steel screw type anchors about 5 feet or longer, would be used as anchors. The anchors are installed with divers and topside barge support using a hydraulic machine to screw the anchors into the bottom material. The type of soil, length of the anchor, and diameter and number of screw type flukes on the anchor determines the anchor's capacity. The only part of the anchor above the bottom is a steel eye and section of shaft used to connect the anchor line. There will be four helical anchors installed, one for each corner of the floating dock.
- ✓ The Seaflex anchor lines consist of four elastic cords, similar to a bungy cord, along with a length of polyester line to connect the floating dock to the helical anchors. The Seaflex anchor lines also includes a polyester safety line. There are four anchor lines used to connect the floating dock to the four helical anchors, one at each corner of the dock.
- ✓ The Seaflex anchor lines are installed under tension and remain in tension throughout the tidal and extreme water level changes. This results in the anchor line keeping the floating dock relatively in place without contacting the bottom material.

Block and Chain Anchor System: The float anchor system proposed in the NOI is a concrete block and chain system which is commonly used for anchoring floats throughout harbors. It is further described as follows:

- ✓ Concrete blocks, approximately 4’x4’x2’ and weighing 4800 lbs. each, will be used as anchors. At the 4 anchor locations, 2 blocks will be used. For the concrete blocks to properly serve as anchors, the blocks will be buried into the mudline, which requires water jetting (a temporary impact). The blocks will be connected together to act as a single anchor.
- ✓ 1” steel chain will connect the anchors to the floating dock. The anchors will be located approximately 60 feet from the corners of the floating dock.
- ✓ Smaller concrete blocks, 19”x19”x12” weighing approximately 350 lbs. will be used as sinkers. Sinkers will reduce the lateral and vertical movement of the floating dock during normal operation weather conditions. There will be some movement of the chains and sinkers from the floating dock during both normal and heavy weather conditions.

The proposed block and anchor system was reviewed by the Division of Marine Fisheries and the comments provided to the Commission by email on August 16, 2021, stated:

> “…*The proposed float would be installed in adequate water depth to reduce impacts to underlying shellfish habitat (i.e., > 2 ½ feet depth at MLW). Based on the scope of work as currently proposed, <u>MA DMF has no recommendations for sequencing, timing or methods that would further avoid or minimize impacts to marine resources at this time</u>.”*

DMF did not provide recommendations for methods that would further avoid or minimize impacts at this site compared to the proposed chain and block system. We recognize that the helical anchors and SeaFlex system has less bottom impacts; however, the cost difference between the block and chain anchor system and Seaflex with helical anchor systems is approximately $38,000. This additional expense for an anchor system beyond what is routinely allowed for floats is not justified given the specific site conditions, including sandy nearshore areas.

We appreciate the Commission’s consideration and respectfully request that the Commission authorize the installation of the float anchor system as proposed. Please forward any additional responses from Nitsch so that we can prepare prior to the next scheduled hearing (March 1, 2022).

Sincerely,

Foth Infrastructure & Environment, LLC

Susan E. Nilson, P.E.
Director, Ports and Harbors
Licensed in CT, MA, RI, NY, NJ AND WI

cc: Stephen Silverstein (Cisco)
Richard FitzGerald, P.E. (AGM)

Enclosures:
Attachment 1: “Floating Dock Anchor System for Cisco Brewers Restaurant, New Bedford, MA” prepared by AGM Marine Contractors, Inc., dated 02/08/2022

Attachment 2: Plan “Proposed Floating Dock Anchor System Cisco Pier, New Bedford, MA” prepared by AGM Marine Contractors, Inc., dated 02/08/2022 annotated by Foth to provide impact areas; Page 4 of NOI with revised impact areas

Attachment 3: “Design and Calculation Report, Cisco Pier Floating Dock”, Project Number 4671, prepared by SeaFlex, dated 10-11-2021

Attachment 1

"Floating Dock Anchor System for Cisco Brewers Restaurant, New Bedford, MA" prepared by AGM Marine Contractors, Inc., dated 02/08/2022

AGM
MARINE CONTRACTORS, INC.
Physical: 7 Fish Island, New Bedford, MA 02740
Mailing: 30 Echo Road, Mashpee, MA 02649
Phone: (508) 477-8801 Fax: (508) 477-8804

FLOATING DOCK ANCHOR SYSTEM

For

CISCO BREWERS RESTAURANT

NEW BEDFORD, MA

02/08/2022

Included are:

- Calculations for Anchor and Chain Size and Loadings
- Method for Anchor and Chain Calculations
- Calculations for Anchor and Chain Connections
- Comparison Chart for Mooring Anchors
- Layout Drawing for Floating Dock Anchor System

COMMONWEALTH OF MASSACHUSETTS
RICHARD G.
FITZGERALD
STRUCTURAL
No. 35167
REGISTERED
PROFESSIONAL ENGINEER

FLOATING DOCK - STEEL PONTOONS 38'L x 16'W x 1.5' DRAFT
& 2.5' FREEBOARD

WIND

GUST WIND SPEED = 129 mph (MA BLDG CODE)

FROM U.S. NAVY "UFC - DESIGN OF MOORINGS UFC 4-159-03"
USE 30 SEC WIND SPEED FOR DESIGN

$$\frac{V_{T\,1\,SEC}}{V_{T\,30\,SEC}} = 1.221 \quad \text{FOR HURRICANE WINDS: } \frac{129}{1.221} = 106 \text{ mph}$$

$$\frac{V_{T\,1\,SEC}}{V_{T\,30\,SEC}} = 1.182 \quad \text{FOR NON-HURRICANE WINDS: } \frac{70 \text{ mph}}{1.182} = 59 \text{ mph}$$

WAVES - USACE SHORE PROTECTION MANUAL 1984

FETCH - ±12 MILES @ SE
WATER DEPTH - ±50' OFFSHORE
±20' INSHORE
7' to 12' AT SITE

FROM FIGURE 3-24 DEEPWATER WAVE = ±6' T = 5.2 SEC

$$L_o = \frac{gT^2}{2\pi} = 138.6'$$

FROM TABLE C-1 @ SITE $\frac{d}{L_o} = \frac{12'}{138.6'} = .08658$

$$\frac{H_{12}}{H_o'} = .9476 \quad H_{12} = .9476(6') = 5.7'$$

ANCHOR / CHAIN CALCULATIONS

CASE IV W/ SINKER   FROM "MARINE STRUCTURES ENGINEERING" GREGORY P. TSINKER

w = WEIGHT OF CHAIN - 1"ϕ LONG LINK = 8.3 lbs/ft

wd = WATER DEPTH = 12'

H = HORIZONTAL LOAD: WIND @ 57 mph w/ 2-40' VESSELS AT DOCK
(CONSERVATIVE AS VESSELS NOT TO DOCK w/ WINDS > 40 mph)

WAVE = 5.6' w/ WIND AT 57 MPH

CURRENT = 0.5 KNOTS

TOTAL LOAD = 20.4 kN = 4,600 lbs

= 2300 lbs / ANCHOR LINE

θ_a = CHAIN ANGLE AT ANCHOR - ASSUME 5° MAX.

W_s = WEIGHT OF SINKER 376 lbs AIR 19"x19"x12"

γ_s = UNIT WEIGHT OF SINKER = 150 lbs/ft³

γ_w = UNIT WEIGHT OF WATER = 64 lbs/ft³

S_{ab} = LENGTH OF CHAIN FROM ANCHOR TO SINKER

FLOATING DOCK CONDITIONS

- BOATS CANNOT BERTH AT FLOATING DOCK WITH WINDS > 40 MPH
- FLOATING DOCK TO BE REMOVED FROM SITE WHEN HURRICANE WINDS ARE FORCASTED
- CONCRETE BLOCK ANCHORS WILL BE SET LEVEL W/ MUDLINE BY JETTING DURING INSTALLATION

ANCHOR / CHAIN CALCS. (CONT.)

V_a = UPLIFT @ ANCHOR = $H \tan \theta_a = (2300 \text{ lbs})(\tan 5^\circ) = 201$ lbs.

$$S_{a1} = \frac{V_a}{W} = \frac{201 \text{ lbs}}{8.3 \text{ lbs/ft}} = 24'$$

$$C = \frac{H}{W} = \frac{2300 \text{ lbs}}{8.3 \text{ lbs/ft}} = 277'$$

$$y_{a1} = \sqrt{S_{a1}^2 + C^2} = \sqrt{24^2 + 277^2} = 278'$$

$$S_{b1} = S_{ab} + S_{a1} = 27' + 24' = 51'$$

$$y_{b1} = \sqrt{S_{b1}^2 + C^2} = \sqrt{51^2 + 277^2} = 282'$$

$$y_s = y_{b1} - y_{a1} = 282' - 278' = 4'$$

$$S_{eq} = \left(\frac{\gamma_s - \gamma_w}{\gamma_s}\right)\frac{W_s}{C} = \left(\frac{150-64}{150}\right)\left(\frac{376}{277}\right) = 0.78$$

$$S_{b2} = S_{b1} + S_{eq} = 51' + 0.78' = 51.8'$$

$$y_{b2} = \sqrt{S_{b2}^2 + C^2} = \sqrt{(51.8)^2 + (277)^2} = 282'$$

$$y_{c2} = y_{b2} + (wd - y_s) = 282' + (12' - 4') = 290'$$

$$S_c = \sqrt{y_{c2}^2 - C^2} = \sqrt{290^2 - 277^2} = 86'$$

$$S_{bc} = S_c - S_{b2} = 86' - 51.8' = 34.2'$$

$$S_{ac} = S_{ab} + S_{bc} = 27' + 34.2' = 61.2'$$

ANCHOR / CHAIN CALCS (CONT.)

$$X_{ac} = c \ln\left[\frac{S_{ac}}{c} + \sqrt{\left(\frac{S_{ac}}{c}\right)^2 + 1}\right] = 277 \ln\left[\frac{61.2}{277} + \sqrt{\left(\frac{61.2}{277}\right)^2 + 1}\right]$$

LENGTH OF CHAIN = 61′

T_c = TENSION IN CHAIN = $w\,y_{cz}$ = 8.3 lbs/ft (290′) = 2407 lbs.

ANCHORS

SINKER – 19″ × 19″ × 12″ = 2.5 ft³ × 150 lbs/ft³ = 375 lbs

CONCRETE ANCHOR BLOCK – 4′ × 4′ × 2′ = 16 ft³ × 150 lbs/ft³ = 2400 lbs

TYPICAL FACTOR FOR CONCRETE BLOCK
ANCHOR CAPACITY = 2 × BLOCK WEIGHT IN AIR

2407 lbs = 2 - 4′ × 4′ × 2′ CONC. BLOCKS

ANCHOR CHAIN CONNECTION

AISC D.5 PIN CONNECTED MEMBERS

CHAIN LOADING = 5000 lbs (2 × calculated load)

(a) TENSILE RUPTURE ON NET EFFECTIVE AREA:

$$P_n = F_u(2tb_e) \qquad \Omega_t = 2.00$$

F_u = 58 ksi

t = thickness of plate = 1"

b_e = 2t + 0.63" (NOT > EDGE OF HOLE TO EDGE OF PLATE IN LOAD DIRECTION)
= 2(1) + 0.63 = 2.63"

P_n = 58 ksi (2(1")(2.63")) = 305 kips

$P_{allow} = \frac{P_n}{\Omega} = \frac{305}{2} = 152.5$ k

DETERMINE EDGE OF HOLE TO EDGE OF PLATE - ASSUME 1" CHAIN

for 1" SHACKLE INSIDE LENGTH = 3.75"
3.75" - 1"φ = 2.75" - 1" CLEARANCE = 1.75"

P_n = 58 ksi (2(1")(1.75")) = 203 k

$P_{allow} = \frac{203k}{2} = 101.5$ k

(b) SHEAR RUPTURE

$$P_n = 0.6 F_u A_{sf}$$

$A_{sf} = 2t(a + \frac{d}{2}) = 2(1")(1.75" + \frac{1.15}{2}) = 4.65$ in²

a = SHORTEST DISTANCE FROM PIN HOLE EDGE TO EDGE OF PLATE = 1.75"
d = φ of PIN = 1.15"
t = plate thickness = 1"

P_n = 0.6 (58 ksi)(4.65 in²) = 161.8 k

$\frac{P_n}{\Omega} = \frac{161.8 \text{ k}}{2} = 80.9$ k

ANCHOR CHAIN CONNECTION (CONT.)

(c) BEARING ON PROJECTED AREA

$$R_n = 1.8\, F_y\, A_{pb}$$

$F_y = 36\ ksi$

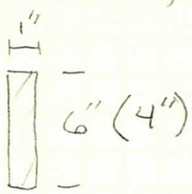
$A_{pb} = 1'' \times 1'' = 1\ sq.in$

$$R_n = 1.8(36\ ksi)(1\ sq\ in.)$$

$$= 64.8\ kips$$

$$R_{Allow} = \frac{R_n}{\Omega} = \frac{64.8\ k}{2} = 32.4\ kips$$

(d) YEILDING ON GROSS SECTION



$$P_n = F_y A_g$$

$$= (36\ ksi)(6'' \times 1'')$$

$$= 216\ k$$

$$P_{Allow} = \frac{P_n}{\Omega} = \frac{216\ k}{1.67} = 129.3\ k$$

for $4'' \times 1''$ $P_{Allow} = 86.2\ k$

ANCHOR CHAIN CONNECTION (CONT).

Crosby 1" ANCHOR SHACKLE WLL = 8½ T = 17 kips

~~3/4" Long-LINK MOORING CHAIN PEERLESS/ACCO CHAIN~~

~~WLL = 15,150 lbs~~
~~INSIDE LENGTH = 2.99"~~ ~~Proof-coil - GRADE 30?~~
~~INSIDE WIDTH = 1.04"~~

~~3/4" LONG-LINK MOORING CHAIN - G43 TITAN MARINE (CANADIAN)~~
~~SAME INSIDE DIMENSIONS~~
~~WLL = 20,200 lbs~~

WASHINGTON CHAIN: OPEN LINK BUOY CHAIN

~~3/4" O.A. LENGTH 4½" - 2(3/4") = 3" INSIDE LENGTH~~
~~O.A. WIDTH 2 11/16 - 2(3/4") = 1 3/16" INSIDE LENGTH~~
~~CARBON STEEL WLL = 16,000 Proof / 2 = 8,000 lbs~~
~~ALLOY STEEL WLL = 32,200 Proof / 2 = 16,100 lbs~~

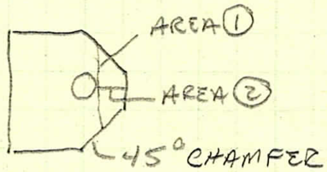
1" O.A. LENGTH = 6" - 2" = 4" INSIDE LENGTH
O.A. WIDTH = 3 9/16 - 2" = 1 9/16 INSIDE WIDTH

CARBON STEEL $W_{LL} = \frac{29{,}000 \text{ Proof}}{2} = 14{,}500$ lbs

ALLOY STEEL $W_{LL} = \frac{54{,}000 \text{ Proof}}{2} = 27{,}000$ lbs

USE 1" CHAIN

DIMENSIONAL REQUIREMENTS D5.2
OF EYEPAD

- Hole located between edges
- Hole to be 1/32" φ > than pin if movement under full load expected - Not doable
- Width of plate @ hole = $2b_e + d$
  use b_e = 1.75" max - for inside length shackle clearence
- $a \geq 1.33\, b_e$ $a \geq (1.33 \times 1.75") = 2.3275"$ 2 3/8"
- 

  A① ≥ A②

USE b_e = 1.5"

∴ a = 1.33(1.5") = 2"   2" < 2.75" OK w/ 1"φ CHAIN

P_n = 58 ksi (2 (1")(1.5")) = 174 kips

$\frac{174}{2}$ = 87 kips

USE b_e = 1.25"

∴ a = 1.33 (1.25") ≈ 1.66"

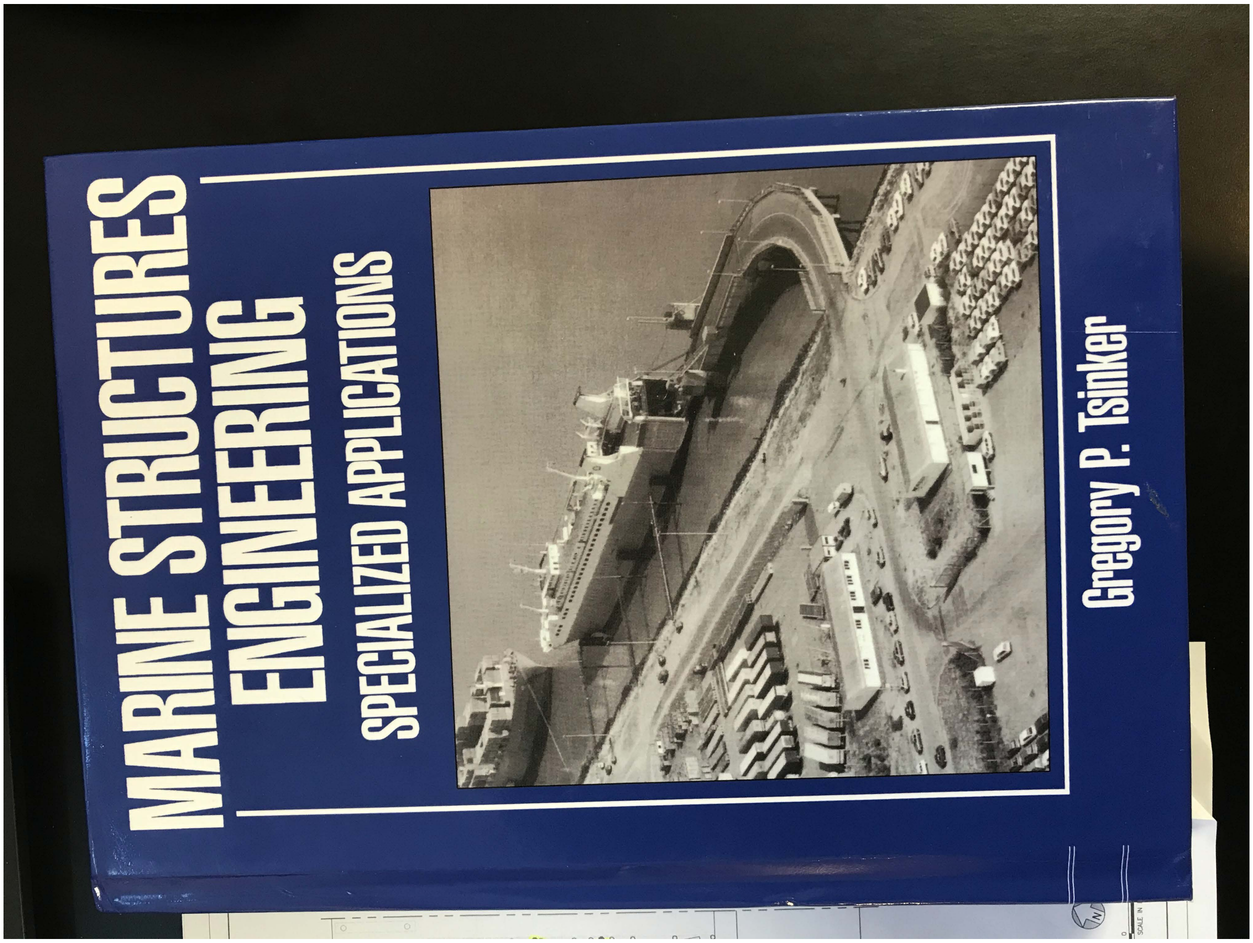
P_n = 58 ksi (2(1")(1.25")) = 145 kips / 2 = 72.5 kips

USE b_e = 1"

∴ a = 1.33(1") = 1.33"

P_n = 58 ksi (2(1")(1")) = 116 k / 2 = 58 kips

USE b_e = 1.25" & a ≈ 1 5/8" OR a = 1 3/4"
HOLE = 1.25" φ



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ν = kinematic viscosity of water (1.4×10^{-5} ft^2/s).

Propeller drag is the form drag of the vessel's propeller with a locked shaft. Propeller drag is given by the following equation:

$$F_{x\,prop} = -\tfrac{1}{2}\rho_w V_c^2 A_p \cos(\theta_c) \quad (4\text{–}22)$$

where

A_p = propeller expanded (or developed) blade area

C_{prop} = propeller drag coefficient = 1.0

A_p is given by:

$$A_p = \frac{A_{Tpp}}{0.838} \quad (4\text{–}23)$$

where

A_{Tpp} = total projected propeller area

$$A_{Tpp} = \frac{L_{wL}B}{A_R} \quad (4\text{–}24)$$

Table 4–2 shows the area ratio, A_R, for six major vessel groups. (The area ratio is defined as the ratio of the waterline length times the beam to the total projected propeller area.)

Current yaw moment is determined using the following equation:

$$M_{xyc} = F_{yc}\left(\frac{e_c}{L_{wL}}\right)L_{wL} \quad (4\text{–}25)$$

where

M_{xyc} = current yaw moment

e_c/L_{wL} = ratio of eccentricity.

Table 4–2. A_R for Propeller Drag

Vessel Type	A_R
Destroyer	100
Cruiser	160
Carrier	125
Cargo	240
Tanker	270
Submarine	125

The value of (e_c/L_{wL}) is given in Figure 4–17 as a function of current angle, θ_c, and vessel type.

4.6 DESIGN OF MOORING COMPONENTS

4.6.1 Selection of Anchor Chain

The maximum mooring-chain tension is always higher than the horizontal load on the chain; however, normally only the horizontal load is known. The maximum tension can be approximated from the horizontal tension as follows:

$$T = 1.12H \quad (4\text{–}26)$$

where

T = maximum tension in mooring chain

H = horizontal tension in mooring chain.

This equation provides conservative estimates of mooring-chain tension for water depths of 30 m or less.

According to the U.S. Navy (1985), the maximum allowable working load for mooring chain loaded in direct tension is:

$$T_{design} = 0.35T_{break} \quad (4\text{–}27)$$

where

T_{design} = maximum allowable working load on mooring chain

T_{break} = breaking strength of the chain.

Similarly, the U.S. Navy (1985) stipulates the following for mooring chain that passes through hawse pipes, chocks, chain stoppers, or other fittings that cause the chain to change direction abruptly within its loaded length:

$$T_{design} = 0.25T_{break}. \quad (4\text{–}28)$$

The American Bureau of Shipping Rules for Classing Single Point Moorings (1975) call for anchor legs to be designed with a factor of safety of 3 based on the breaking strength of the chain, i.e.:

$$T_{design} = 0.33T_{break}. \quad (4\text{–}29)$$

Chains and fittings should be selected with a breaking strength equal to or exceeding T_{break}. The breaking strength of a chain can be found in manufacturers' catalogs. A useful summary of breaking strengths for various types of chains and chain fittings are presented in U.S. Navy (1986). It is common practice to round up to the nearest 6 mm (1/4-inch) size when selecting chain or fittings and it may be desirable to specify the next largest size of chain or fitting if excessive wear is expected.

The weight per shot of chain presented in manufacturers' catalogs is often given in air. The weight of chain in water can be obtained by multiplying the weight in air by 0.87. When tables of actual chain weights are unavailable, the weight of a stud link chain may be approximated as follows:

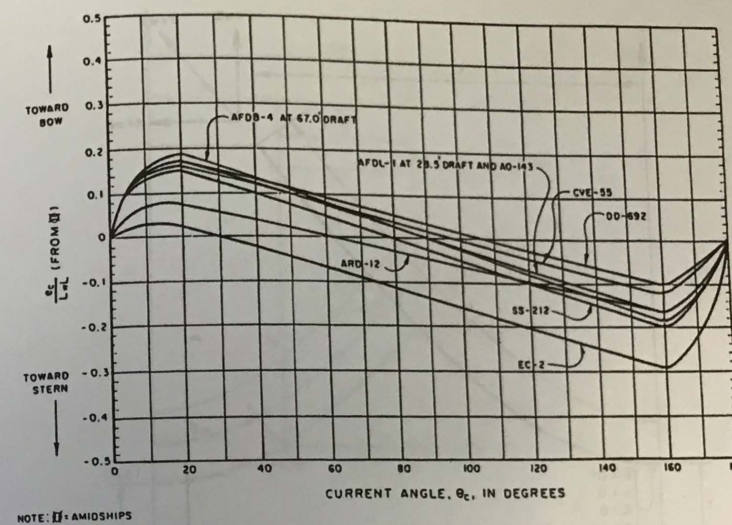


Figure 4–17. E_c/L_{wL} for various vessel types. (U.S. Navy, 1985.)

$$w_{air} = 9.05d^2 \quad (4\text{–}30)$$

$$w_{submerged} = 8.26d^2 \quad (4\text{–}31)$$

where

w_{air} = weight of chain (in air) in pounds/foot of length

$w_{submerged}$ = weight of chain (in water) in pounds/foot of length

d = diameter of chain in inches.

4.6.2 Computation of Chain Length and Tension

A chain mooring line supported at the surface by a buoy and extending through the water column to the seafloor behaves as a catenary. Figure 4–18 presents a definition sketch for use in catenary analysis. At any point (x, y) the following hold:

$$V = wS = T\sin(\theta) \quad (4\text{–}32)$$

$$H = wc = T\cos(\theta) \quad (4\text{–}33)$$

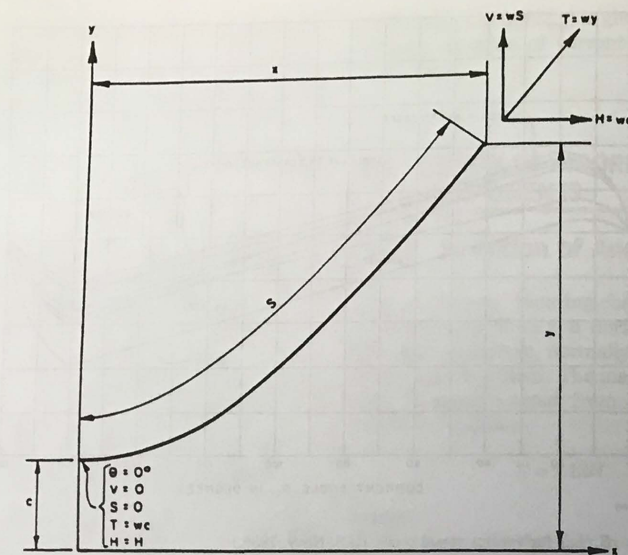


Figure 4–18. Catenary definition sketch. (U.S. Navy.)

$$T = wy \quad (4\text{–}34)$$

$$c = \frac{H}{w} \quad (4\text{–}35)$$

where

V = vertical force at point (x, y)
w = submerged unit weight of chain
S = length of curve (chain length) from $(0, c)$ to point (x, y)
T = line tension at point (x, y)
θ = angle of mooring line with horizontal
H = horizontal force at point (x, y)
c = distance from origin to y-intercept.

The shape of the catenary is governed by the following equations:

$$y^2 = S^2 + c^2 \quad (4\text{–}36)$$

$$y - c\cosh\left(\frac{x}{c}\right) \quad (4\text{–}37)$$

$$S = c\sinh\left(\frac{x}{c}\right). \quad (4\text{–}38)$$

Equation (4–38) may be more conveniently expressed as:

$$x = c\ \ln\left(\frac{S}{c} + \sqrt{\left(\frac{S}{c}\right)^2 + 1}.\right) \quad (4\text{–}39)$$

Note that, in the above equations, the horizontal load in the chain is the same at every point and that all measurements of x, y, and S are referenced to the catenary origin.

When catenary properties are desired at point (x_m, y_m), as shown in Figure 4–19, the following equations are used:

$$\sqrt{S_{ab}^2 - wd^2} = 2c\sinh\left(\frac{x_{ab}}{2c}\right) \quad (4\text{–}40)$$

$$\frac{wd}{S_{ab}} = \tanh\left(\frac{x_m}{c}\right) \quad (4\text{–}41)$$

$$x_m = x_a + \frac{x_{ab}}{2} \quad (4\text{–}42)$$

$$x_b = x_m + \frac{x_{ab}}{2} \quad (4\text{–}43)$$

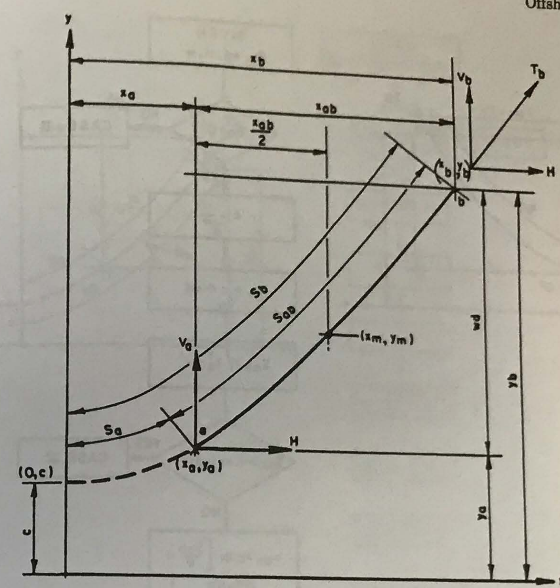


Figure 4–19. Catenary definition sketch. (U.S. Navy, 1985.)

where the terms in the above equations are defined in Figure 4–19. Equation (4–41) is more conveniently written as:

$$x_m = \frac{c}{2}\left[\ln\left(1 + \frac{wd}{S_{ab}}\right) - \ln\left(1 - \frac{wd}{S_{ab}}\right)\right] \quad (4\text{–}44)$$

4.6.3 Some Applications of the Catenary Equations

4.6.3.1 Case I

The known variables are the mooring-line angle at the anchor, θ_a (which is zero: $\theta_a = 0°$); the water depth, wd; the horizontal load, H; and the submerged unit weight of the chain, w. The length of mooring line, S_{ab}; the horizontal distance from the anchor to the buoy, x_{ab}; and the tension in the mooring line at the buoy or surface, T_b, are desired. Procedures for determining these values are outlined in Figure 4–20. Check to determine if the entire chain has been lifted off the bottom by comparing the computed chain length from anchor to buoy, S_{ab}, to the actual chain length, S_{actual}. If the actual chain length is less than the computed, then Case I cannot be used and Case V must be used.

4.6.3.2 Case II

The known variables are the mooring-line angle at the anchor, θ_a (or equivalently, a specified vertical load at the anchor, V_a); the water depth, wd; the horizontal load at the surface, H; and the submerged unit weight of the chain, w. This situation arises when a drag anchor is capable of sustaining a small prescribed angle at the anchor, or an uplift-resisting anchor of given vertical capacity, $V_a = H\tan\theta_a$, is specified. The origin of

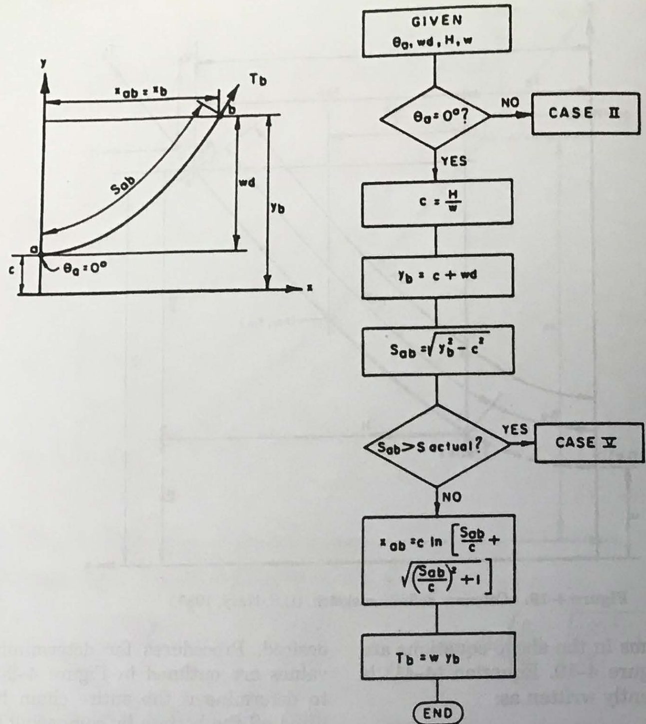


Figure 4–20. Case I. (U.S. Navy, 1985.)

the catenary is not at the anchor, but is some distance below the bottom. The length of the chain from anchor to buoy, S_{ab}, the tension in the mooring line at the buoy or surface, T_b, and the horizontal distance from the anchor to the surface, x_{ab}, are desired. Procedures for determining these values are presented in Figure 4–21.

4.6.3.3 Case III

The known variables are the horizontal distance from the anchor to the buoy, x_{ab}; the water depth, wd; the horizontal load, H; and the submerged unit weight of the chain, w. This situation arises when it is necessary to limit the horizontal distance from buoy to anchor due to space limitations. The length of chain from anchor to buoy, S_{ab}; the tension in the mooring line at the buoy, T_b; and the vertical load at the anchor, V_a, are required. Procedures for determining these values are outlined in Figure 4–22.

4.6.3.4 Case IV

The known variables are the water depth, wd; the horizontal load, H; the submerged unit weight of the chain, w; the angle at

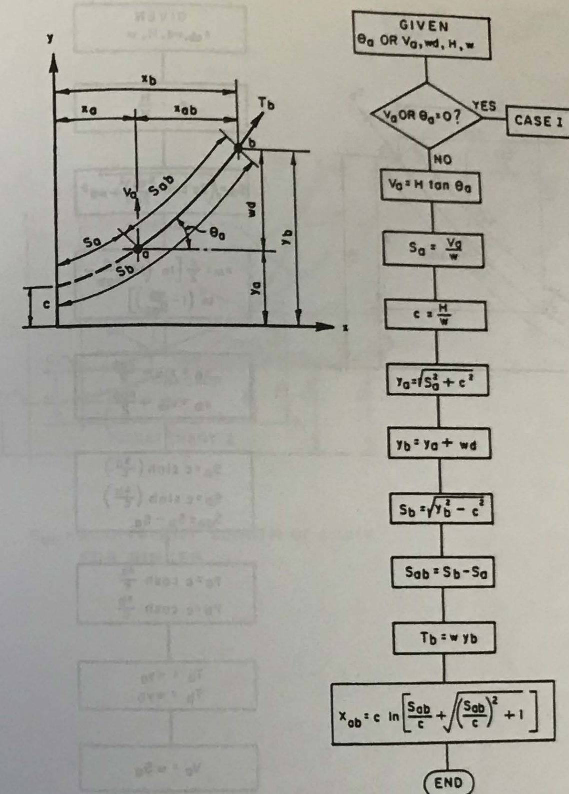


Figure 4–21. Case II. (U.S. Navy, 1985.)

the anchor, θ_a; the sinker weight, W; the unit weight of the sinker, γ_s; the unit weight of water, γ_w; and the length of chain from anchor to sinker, S_{ab}. The mooring consists of a chain of constant unit weight with a sinker attached to it. The total length of chain, S_{ac}; the distance of the top of the sinker off the bottom, y_s; and the tension in the mooring line at the buoy, T_{c2}, are desired. The solution to this problem is outlined in Figure 4–23.

4.6.3.5 Case V

The known variables are the water depth, wd, the horizontal load on the chain, H, the submerged unit weight of the chain, w, and the length of chain from anchor to buoy, S_{ab}.

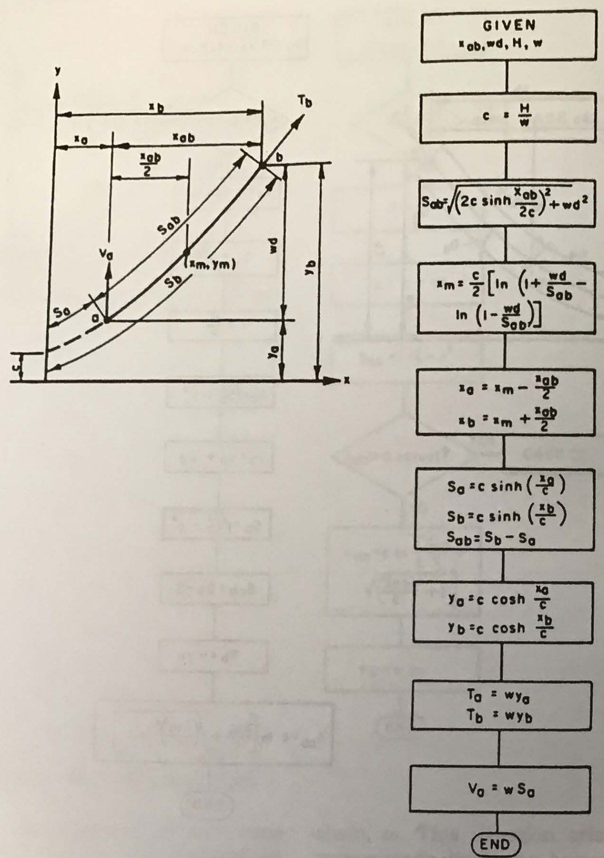


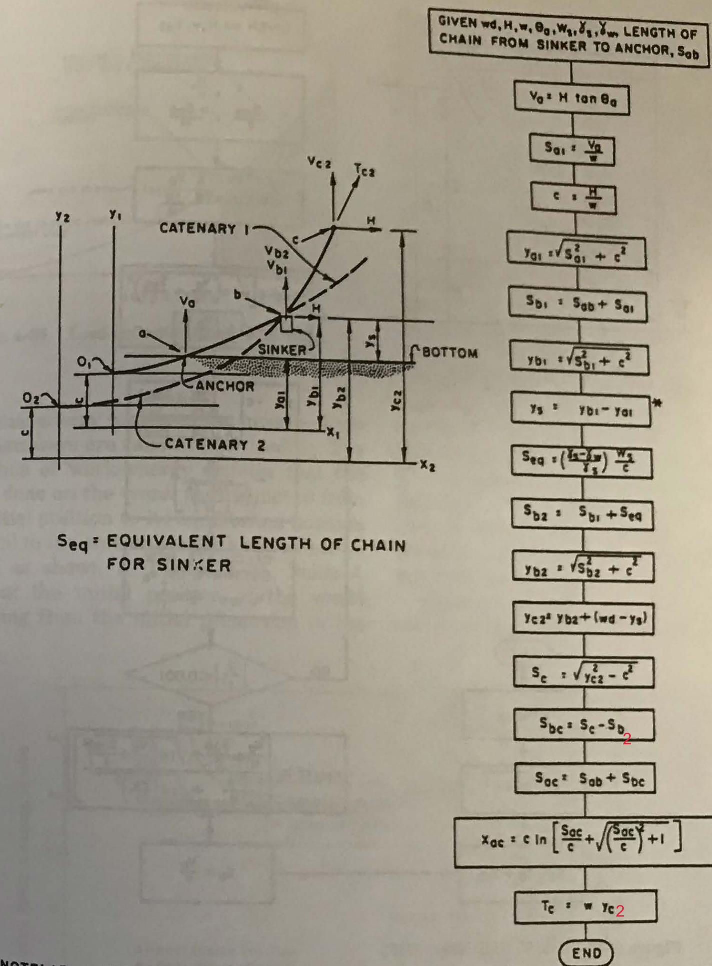
Figure 4–22. Case III. (U.S. Navy, 1985.)

The horizontal load, H, is sufficiently large to lift the entire chain off the bottom, resulting in an unknown vertical load at the anchor, V_a. This situation arises when one is computing points on a load–deflection curve for higher values of load.

The solution involves determining the vertical load at the anchor, V_a, using the trial-and-error procedure presented in Figure 4–24. The problem is solved efficiently using a Newton–Raphson iteration method (Gerald, 1980); this method gives accurate solutions in two or three iterations, provided the initial estimate is close to the final answer.

4.6.3.6 Load–Deflection Curve

On loading, a vessel connected to a mooring will deflect from its initial position in the



* NOTE: IF $y_s \leq 0$, GO TO CASE V

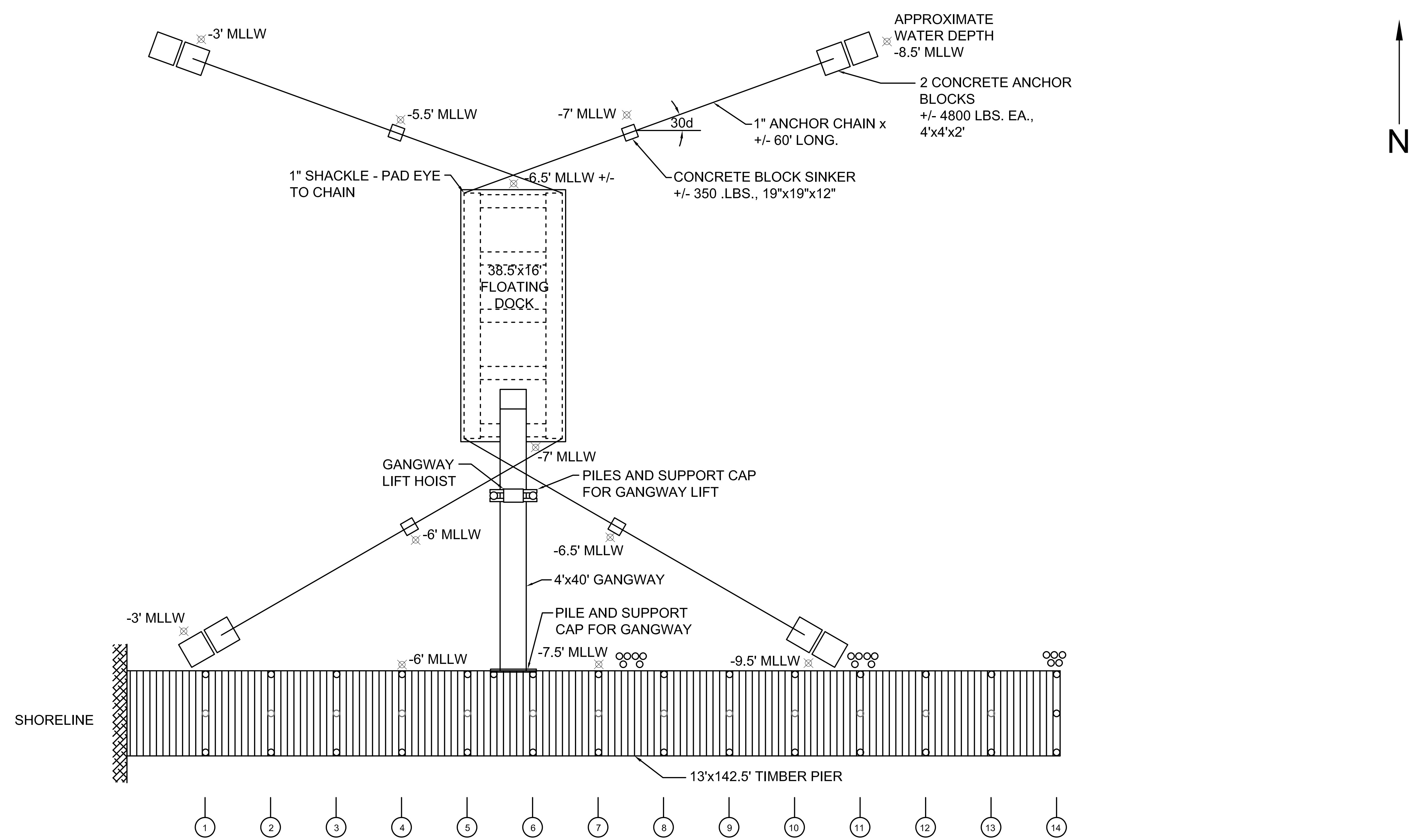
Figure 4–23. Case IV. (U.S. Navy, 1985.)

direction of the applied load. As the vessel moves, the restraining force in the mooring chain will increase from its initial or pretension value. A plot of the restraining force in the catenary mooring chain versus the deflection of the vessel is known as a load–deflection curve and an example load–deflection curve is shown in Figure 4–25. A load–deflection curve can be used to determine vessel movement for a given applied load.

TABLE 1. COMPARISON OF BREAKOUT FORCE FOR MOORING ANCHORS

	CONCRETE BLOCKS					MUSHROOMS			DOR-MOR	HELICALS
Test	BoatU.S.	Vineyard Haven	Vineyard Haven	BoatU.S.	Sarasota Sailing Squadron	BoatU.S.	Vineyard Haven	Vineyard Haven	BoatU.S.	BoatU.S. Vineyard Haven Sarasota Sailing Squadron
Anchor dry weight	8,000 lbs.	6,000 lbs.	3,000 lbs.	2,000 lbs.	1,500 lbs.	500 lbs.	500 lbs.	350 lbs.	650 lbs.	Various sizes
Breakout force	4,000 lbs.	3,200 lbs.	2,100 lbs.	800 lbs.	800 lbs.	1,200 lbs.	1,700 lbs.	2,000 lbs.	4,500 lbs.	10,000 - 20,800 lbs.
Holding Ratio*	0.5	0.5	0.7	0.4	0.5	2.4	3.4	5.7	6.9	

BoatU.S. – 1995 BoatU.S. Insurance pull-test conducted by BoatU.S., MIT, and *Cruising World* in Newport, RI
Vineyard Haven – Test performed at Vineyard Haven, MA by Helix Moorings with harbormasters, marine writers, and BoatU.S. in attendance
Sarasota Sailing Squadron – 2007 *Practical Sailor* test conducted at the Sarasota Sailing Squadron
*Holding ratio is defined as breakout force/anchor dry weight and represents the breakout pounds per pound of anchor dry weight.



PROPOSED FLOATING DOCK ANCHOR SYSTEM CISCO PIER NEW BEDFORD, MA.	
SCALE: NTS	SHEET NO. 1 OF 1.
DATE: SEPT. 2021	
DRAWN BY: RGF	
AGM MARINE CONTRACTORS, INC. 30 ECHO ROAD, MASHPEE, MA 02649	

Attachment 2

Plan "Proposed Floating Dock Anchor System Cisco Pier, New Bedford, MA" prepared by AGM Marine Contractors, Inc., dated 02/08/2022 annotated by Foth to provide impact areas; Page 4 of NOI with revised impact areas

2/10/2022 Foth Calculation of Impact Areas:

Concrete Anchor Blocks:
8 Blocks, each at 4' x 4' = 128 sf

Concrete Sinkers:
4 Blocks, each at 19" x 19" = 10 sf

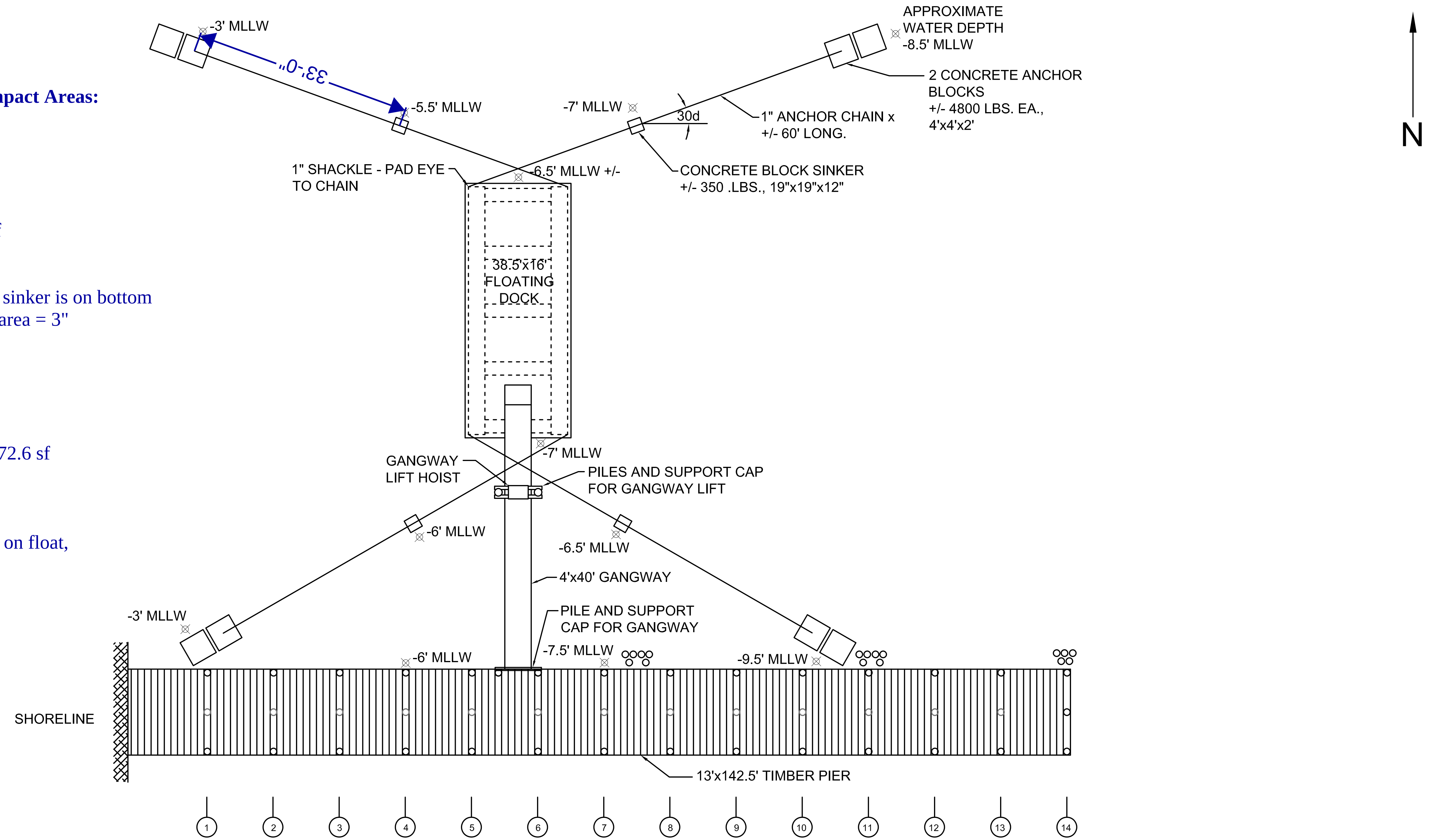
Chain:
Assume length (33') from block to sinker is on bottom
Assume 2X chain width is impact area = 3"
4 Chains, each 33' x 3" = 33 sf

12" Diameter Timber Piles:
2 Piles, each @ 0.785 sf = 1.57 sf

Total of direct bottom impacts = 172.6 sf

Indirect Impacts:
Float: 38.5' x 16' = 616 sf
Gangway: Assume min. 2' overlap on float,
38' x 4' = 160 sf

Total of indirect impacts = 768 sf



PROPOSED FLOATING DOCK
ANCHOR SYSTEM
CISCO PIER
NEW BEDFORD, MA.

SCALE: NTS	SHEET NO. 1 OF 1.
DATE: SEPT. 2021	
DRAWN BY: RGF	

AGM MARINE CONTRACTORS, INC.
30 ECHO ROAD, MASHPEE, MA 02649

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands

WPA Form 3 – Notice of Intent

Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

Provided by MassDEP:

MassDEP File Number

Document Transaction Number

New Bedford
City/Town

B. Buffer Zone & Resource Area Impacts (temporary & permanent) (cont'd)

Online Users: Include your document transaction number (provided on your receipt page) with all supplementary information you submit to the Department.

Check all that apply below. Attach narrative and supporting documentation describing how the project will meet all performance standards for each of the resource areas altered, including standards requiring consideration of alternative project design or location.

Resource Area	Size of Proposed Alteration	Proposed Replacement (if any)
a. ☐ Designated Port Areas	Indicate size under Land Under the Ocean, below	
b. ☒ Land Under the Ocean	130 SF impact (768 SF float /gangway, no direct impact)	173 sf impact (blocks and chain)
	2. cubic yards dredged	
c. ☐ Barrier Beach	Indicate size under Coastal Beaches and/or Coastal Dunes below	
d. ☐ Coastal Beaches	1. square feet	2. cubic yards beach nourishment
e. ☐ Coastal Dunes	1. square feet	2. cubic yards dune nourishment

	Size of Proposed Alteration	Proposed Replacement (if any)
f. ☐ Coastal Banks	1. linear feet	
g. ☐ Rocky Intertidal Shores	1. square feet	
h. ☐ Salt Marshes	1. square feet	2. sq ft restoration, rehab., creation
i. ☐ Land Under Salt Ponds	1. square feet	
	2. cubic yards dredged	
j. ☐ Land Containing Shellfish	173 sf (blocks and chain) 1. square feet	
k. ☐ Fish Runs	Indicate size under Coastal Banks, inland Bank, Land Under the Ocean, and/or inland Land Under Waterbodies and Waterways, above	
	1. cubic yards dredged	
l. ☐ Land Subject to Coastal Storm Flowage	768 sf 1. square feet	

4. ☐ Restoration/Enhancement
If the project is for the purpose of restoring or enhancing a wetland resource area in addition to the square footage that has been entered in Section B.2.b or B.3.h above, please enter the additional amount here.

a. square feet of BVW

b. square feet of Salt Marsh

5. ☐ Project Involves Stream Crossings

a. number of new stream crossings

b. number of replacement stream crossings

Attachment 3

"Design and Calculation Report, Cisco Pier Floating Dock", Project Number 4671, prepared by SeaFlex, dated 10-11-2021

CISCO PIER FLOATING DOCK

PROJECT NUMBER: 4671

Abstract

Design and calculation report

Publish date

2021-10-11

SEAFLEX AB	Stöcksjö Kustväg 77, SE-90580 Umeå, Sweden	P +46 90 160 650	info@seaflex.com
SEAFLEX, INC.	16902 Bolsa Chica St., #204, Huntington Beach, CA 92649, USA	P (310) 548 9100	seaflex.inc@seaflex.net

PREFACE

The design and calculation report performed by Seaflex AB, describes besides the design results, **section 6**, also the methodology of calculating the forces acting on the flexible Seaflex mooring system, see **section 1 to 5**. The method and formulas are mainly based on the British Standard™ [1] but also references below:

[1] "British Standard™ – Design of inshore moorings and floating structures", BS 6349-6:1989
[2] "Structural Design Actions Part 2 - Wind actions", AS/NZS 1170.2:2011
[3] "Australian Standard™ - Guidelines for design of marinas", AS 3962- 2001
[4] "Minimum Design Loads For Buildings and Other Structures," ASCE/SEI 7-05, ISBN 0-7844-0809-2, (2005)
[5] "Planning and design guidelines for small craft harbours", American Society of Civil Engineers, ISBN 0-7844-0033-4, (2000)
[6] B. Tobiasson, P.E. Kollmeyer, "MARINAS and Small Craft Harbours", Westviking press, Medfield Massachusetts, ISBN 0-9675437-0-3, (2000).
[7] Y. Goda, "Random Seas and Design of Maritime structures", ISBN 981-02-3256-X.
[8] J.P. Hooft, Advanced Dynamics of Marine Structures, Ocean Engineering, John Wiley & Sons inc, New York, (1982).
[9] K.Tanizawa, M. Minami, S. Naito, "Estimation of Wave Drift Force by Numerical Wave Tank". ISOPE-99 9th International Offshore and Polar Engineering Conference, Brest, France (1999).
[10] Salvage engineers handbook, V1, Direction of Commander, Naval Sea System, Command, (1997)
[11] P. Le Tirant, J. Meunier, "Design Guides for offshore structures: anchoring of floating structures", France (1990)

The overall process is to consider the forces that make the floating structure drift and then transfer that load into the mooring system. Short term impulse loads are adequate for the integrity of structure, but Seaflex AB consider forces which gives a mean drift force over time, normally 30 seconds and higher.

CONTENT

1 GENERAL INFORMATION ABOUT SEAFLEX

The SEAFLEX mooring system consists of SEAFLEX and rope, see **Figure 1**. SEAFLEX is the active part of the mooring, adjusting for water level changes while also taking care of forces. Note that SEAFLEX does not cover all the distance from anchor to pontoon. SEAFLEX is always tensioned at lowest water level.

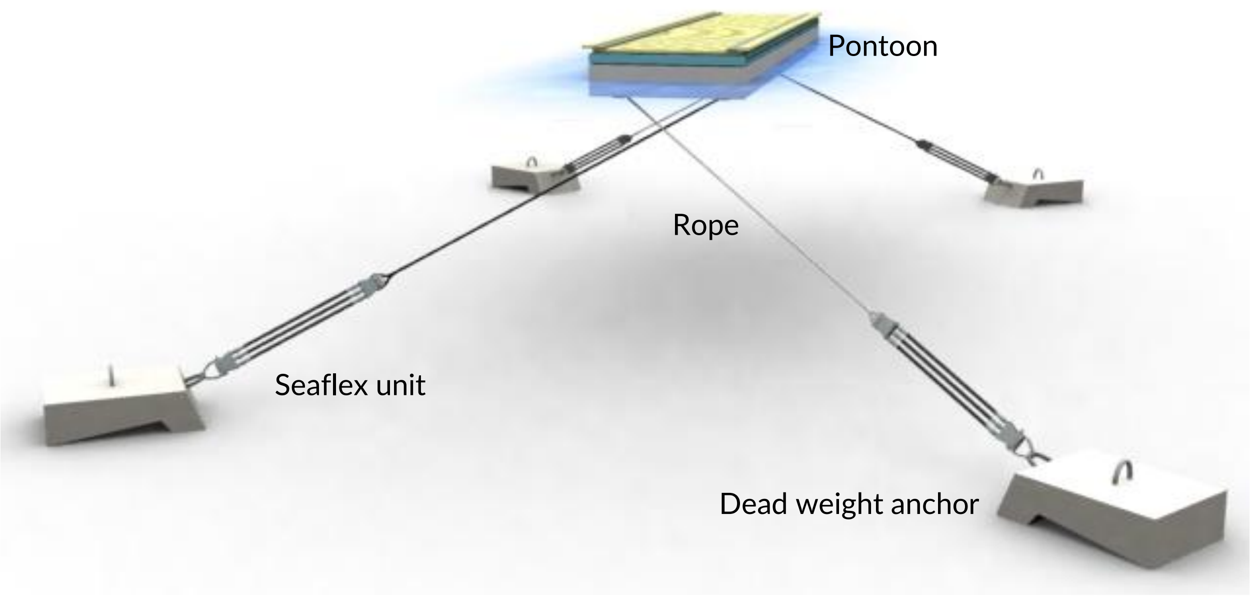


Figure 1. *Principle sketch for SEAFLEX. Shown in figure are dead weight anchors but it could also be technical, as example helical anchors.*

2 DIMENSIONING PARAMETERS

The parameters in **Table 1** have been used to calculate the forces acting on the structure for the project 4671, Cisco Pier Floating Dock.

Table 1. *Dimensioning parameters.*

Max wind speed (30s gust, @10m height)	40mph (17.88m/s)
Depth at lowest water level	Avg. 5ft (1.52m) (Design Lowest Water Level: -1ft (-0.3m))
Water level variation	11.5ft (3.5m) – max design
Wave height	8ft (2.44m) – H max 5.6ft (1.71m) – H sig, (H sig = 0.7 * H max)
Current	0.5kn (0.26m/s)

3 DESCRIPTION OF METHODOLOGY

The following sections describe the methodology of calculating the forces acting on the flexible Seaflex mooring system. The method and formulas are mainly based on the British Standard[1].

The overall process is to consider the forces that make the structure drift and then transfer that load into the mooring system. Short term impulse loads are adequate for the integrity of structure, but we consider forces which gives a mean drift force over time, normally 30 seconds and higher.

On a pontoon, the forces due to wind are low compared to the wave forces. This is because of the low wind catching surface when there are no boats moored to the pontoons.

3.1 FORCES DUE TO WIND

The total wind force is calculated as follows

$$F_w = q_z \cdot \sum_i C_{D_i} \cdot A_i \quad (1)$$

Where

F_w = Total force due to wind and the exposed area of the boats and buildings, unit [N].

q_z = Wind pressure, see equation 3 below, unit [Pa].

$\sum_i C_{D_i} \cdot A_i$ = The sum of drag coefficient times exposed area for each component, i.e., all vessel moored to the structure, unit [m^2]. The mean value of drag coefficient $C_{D_i} = 1{,}0$ for vessels is normally used in calculations, see AS 3962 – 2001 cl. 4.8.3.3.

Australian Standard[1] states that a steady state wind of 30 s duration should be considered. This is adopted for wind force calculations with the flexible Seaflex mooring system. **Table 2** shows the exposed area for some vessel with different length.

1 Australian Standard™ - Guidelines for design of marinas AS 3962-2001 (Originated as AS 3962-1991, second edition 2001).

Table 2. *Exposed area of vessel, see AS 3962 – 2001 cl. 4.8.3.3.*

Vessel length in meters	Motor Vessels Exposed area, m^2		Yachts Exposed area, m^2	
	Head	Beam	Head	Beam
8	5	16	4	11
10	7	22	5	15
12	11	29	6	20
15	18	45	9	28
18	22	64	11	40
20	24	76	12	44
25	30	95	15	60
30	45	120	35	92
35	54	167	36	122
40	78	213	40	182
45	85	264	50	210
50	90	285	60	249

3.1.1 WIND REDUCTION

The reason for using the reduction coefficient for wind is that most winds are recorded or reported at a standard height of 10 m above the ground surface, but marinas height is approximately 2 m above sea level. The reduction coefficient for wind is calculated from the equation

$$R_C = \left(\frac{H_e}{H_m} \right)^a \quad (2)$$

Where

R_c = Reduction coefficient for wind, unitless.

H_e = Height above the water level where we want to estimate the wind speed. For marinas, H_e is set to 2 m, unit [m].

H_m = Height above the water level where the wind was measured, unit [m].

a = Coefficient depending on surface roughness where 0.143 is used for open country and 0.1 for coastal situations, unitless.

Normally the exposed objects in a marina are located at a lower altitude and the wind should be reduced by the reduction coefficient. As an example, a marina with moderate sized boats with the standard H_e equal to 2 m gives a reduction coefficient of 0.85. In cases with higher boats or buildings other values of the reduction coefficient are considered. The wind pressure with reduction coefficient is given by the equation

$$q_Z = 0{,}0006 \cdot (R_C \cdot v)^2 \quad (3)$$

Where

q_z = Wind pressure, unit [kPa].

v = Wind speed (30 s gust 10 m above ground surface), unit [m/s].

3.1.2 WIND GUSTS

The wind speed is normally measured for 3 s gust or 10 min average speed at 10 meters standard elevation. To convert wind speeds from one averaging time to another Durst (Minimum Design Loads for Buildings and Other Structures, ASCE/SEI 7-05, ISBN 0-7844-0809-2, 2005) introduced the curve in **Figure 2**. The Durst Curve describes the relation between sought wind speed and speed averaging over one hour.

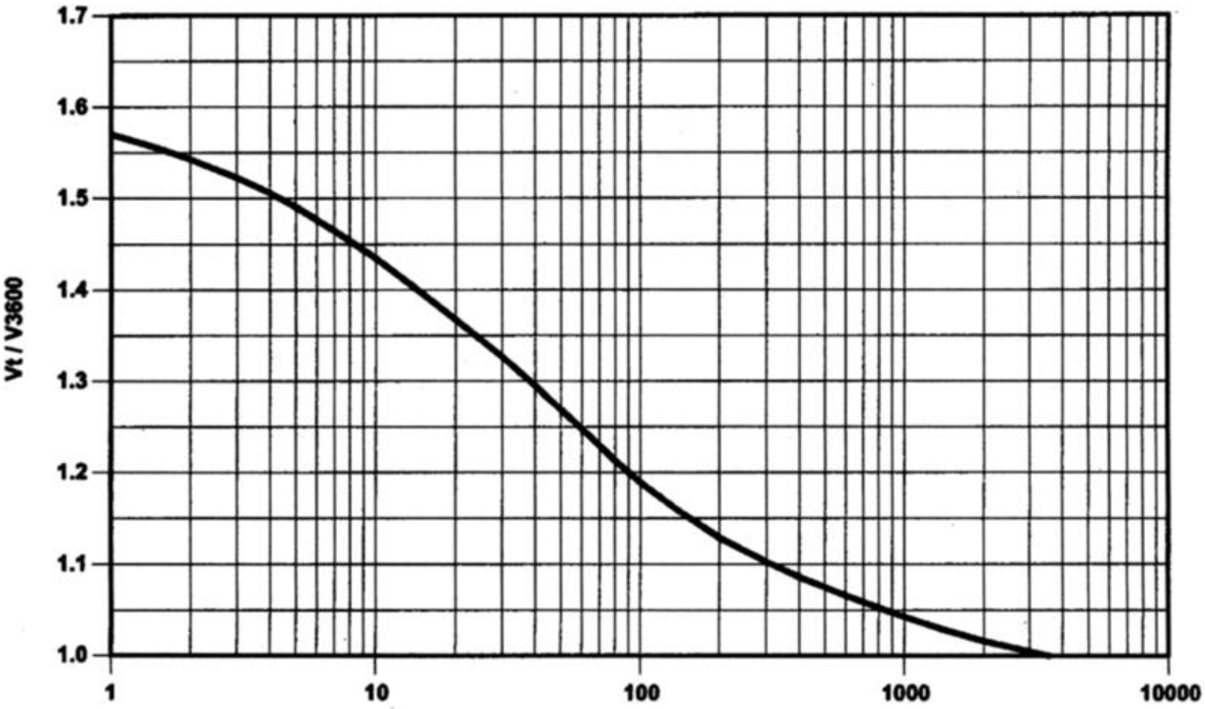


Figure 2. *Showing the Durst curve: averaged wind speed at specific time interval relative to averaged wind speed for 1 hour (3600 s). This curve can be used for to convert wind speeds from one averaging time to another.*

3.2 FORCES DUE TO WAVES

Australian Standard mainly considers inner marinas and does not deal with wave loads in detail. The force of waves on a moored structure could be analysed with a non-linear simulation in the time domain for the wave spectrum or other spectrum-based methods for the actual site. British Standard[2] notes however that

The primary wave-induced forces on a vessel or structure are oscillatory and have, in general, the same frequency characteristics as the waves themselves. They are usually defined as "first order" forces, which are proportional to wave amplitude. In addition to the oscillatory forces there are slowly varying drift forces which act on the vessel or structure and are primarily due to non-linear second order terms in the pressure field associated with the waves. These drift forces are proportional to the square of the wave amplitude and have a much smaller frequency than the first order forces. The magnitude of the forces is small compared to first order forces. There is a resulting mean value, commonly called the mean drift force. This mean drift force is similar to the wave "set-up" observed when a wave reflects off a fixed wall or shoreline.

And

Drift forces and slowly varying motions. The mean drift force acting on a vessel or structure should be considered as a steady force which acts in combination with steady forces due to wind and current. For locations where the significant wave height is less than 2 m, it is sufficient to make a simple estimate of mean drift force as outlined in 2.4.4. Slowly varying drift forces and resultant motions may be neglected provided that the mean drift force is shown to be small.

The mean wave drift load described by British Standard[2] has proven successful with Seaflex in installations for many years. If the waves are large enough the pontoon will swing back and forth but for small waves the result will be a steady drift load.

[2] BRITISH STANDARD 6349-6:1989

Code of practice for maritime structures — Part 6: Design of inshore moorings and floating structures.

Seaflex recommend thus the mean drift force as a first approach when wave loads are to be determined. The mean drift force is described as the force, which moves a floating object in the wave direction. Already 1960 drift force were studied by H. Maruo[3]. The drift force formula is given by

$$F = \frac{1}{2} \cdot \rho \cdot g \cdot (R \cdot H)^2 \cdot L \cdot \sin(\alpha) \quad (4)$$

Where

F = Force due to wave, unit [N].

ρ = Density of water, unit [kg/m^3].

g = Standard acceleration due to gravity, unit [kgm/s^2].

R = Reflection coefficient, unitless.

L = The length of the structure (pontoon), unit [m].

H = The actual wave amplitude, unit [m].

α = Incident wave angle where 90° is perpendicular to structure (pontoon), unit degrees [°].

Below, in **Table 3**, some values of the reflection coefficient are shown.

Table 3. *Reflection coefficient for different structural type.*

Structural type	Reflection coefficient
Vertical wall with crown above water	0.7-1.0
Vertical wall with submerged crown	0.5-0.7

Furthermore, the reflection coefficient also depends on the wavelength of waves and the geometry of the structures (pontoons). Normally, Seaflex uses R = 0.5 - 0.95 for concrete wave attenuators and R = 0.2 - 0.4 for light pontoons, such as modular plastic floats.

[3] H. Maruo, The drift of a body floating on waves, Journal of Ship Research, 4 (1960).

3.3 FORCES DUE TO CURRENT

The pressure due to current is calculated from

$$p = \frac{1}{2} \cdot \rho \cdot C_D \cdot v^2 \tag{5}$$

Where

p = Pressure in pascal, unit [Pa].

ρ = Water density, unit [kg/m^3].

C_D = Coefficient of drag, unitless.

v = Current velocity, unit [m/s].

Then the force on the object due to current can be achieved by equation

$$F = p \cdot \sum A \tag{6}$$

Where

F = Force, unit [N].

p = Pressure, unit [Pa].

A = Exposed area, unit [m^2].

3.4 SHIELDING

Australian Standard states that the total load shall be based on the full force on the windward boats and 20% on the leeward boats, see **Figure 3** below.

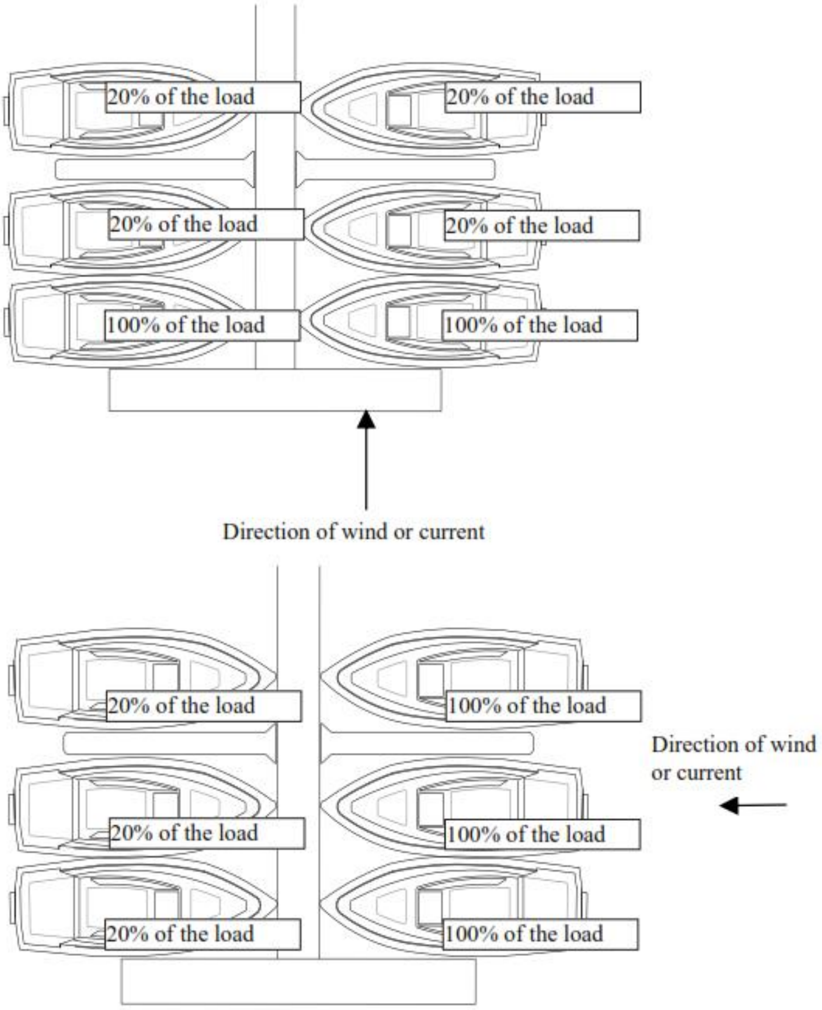


Figure 3. *Showing the load on windward and leeward boats depending on the direction of wind or current.*

4 FORCES IN THE SEAFLEX RUBBER HAWSER

The horizontal force F_H is not acting directly in-line with Seaflex rubber hawser. There is a horizontal and a vertical angle that must be considered, see **Figure** 4. Then the force on Seaflex unit is

$$F_{SFX} = \frac{F_H}{\cos(\alpha_H) \cdot \cos(\alpha_V)} \tag{7}$$

Where

F_{SFX} = Force acting directly in-line with Seaflex unit [N].
F_H = Horizontal force [N].

α_H = The horizontal angle of Seaflex [°].
α_V = The vertical angle of Seaflex [°].

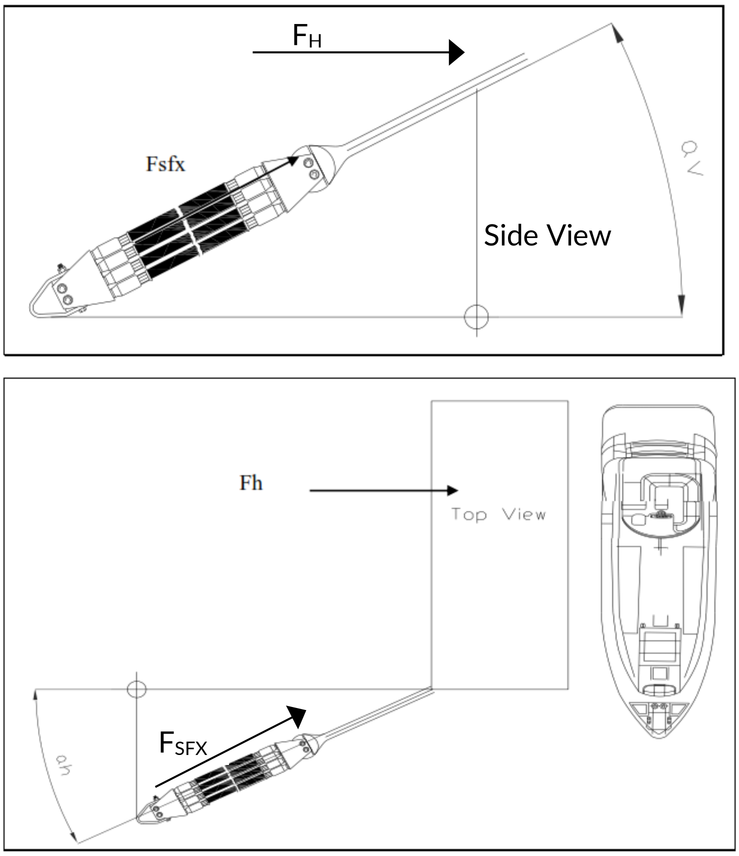


Figure 4. *Showing the active forces as well as the horizontal and vertical angle of Seaflex.*

4.1 DEPTH EFFECT OF VERTICAL ANGLE

The depth has an influence on the position of anchors. The deeper the water is the further out the anchor needs to be. To ensure a simple installation and a secure layout we state that the anchors must be installed in relation to the depth. This relation is independent of type of anchor, being concrete deadweight, helical, manta ray or another technical anchor.

As standard this relation is with a scope of two to one (2:1) at medium water level, but could be different if needed, for example three to one (3:1). Scope 2:1 means that the horizontal distance to anchors is twice the water depth at medium water level. See **Figure 5** below. For condition at the Cisco Pier Floating Dock, a scope of 2.5:1 has been used.

The vertical angle used for this project mooring lines are calculated for 2.5:1 scope. As it is more conservative in that case.

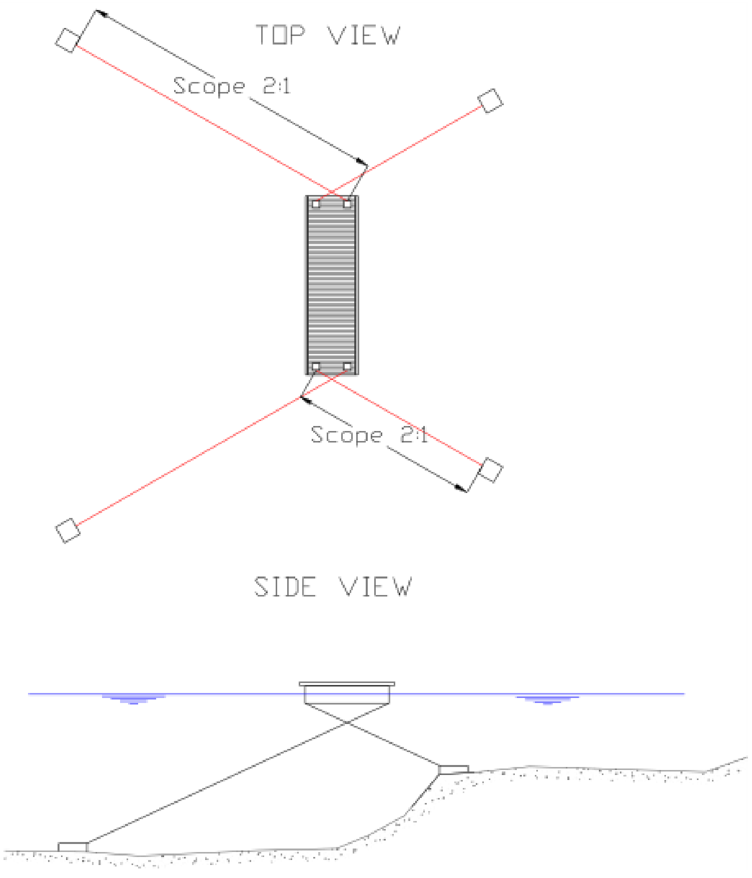


Figure 5. *Pontoons with different depths at anchors.*

This method of positioning of each anchor in proportion to the water depth gives that every Seaflex has the same vertical angle at medium water level, and only small variance at highest or lowest water levels. Normally, Seaflex installations is performed at medium water level with vertical angle of 27º (scope 2:1). The symmetric distribution of Seaflex and small vertical angle variance dependent of water depth, a Seaflex moored pontoon will stay in the same horizontal position independent of the water level.

5 JFLEX

JFlex is an application program which helps to determine and decide what type and number of Seaflex that is necessary to withstand the environmental forces acting upon structures like walkways (pontoons).

The system is based on the Australian standard and below is a short summary of the method and calculations that the system uses.

1. Dimension parameters and structures for the marina system are first set.
2. Determine the total exposed area.
   a. **Table 2** is used.
3. The wind pressure is calculated.
4. The shielding effect is considered as described in **section 3.4**.
5. The wind pressure together with shielding effect and the total exposed area gives the wind force acting on the structure.
6. The total horizontal force acting on the structures is calculated as the sum of wind forces and other added extra forces, i.e., wave and current forces.
7. The force in mooring system is calculated from the total force.
8. Type and amount of Seaflex is determined.

6 MOORING DESIGN

The following sections describe the determination of type and amount of Seaflex units for project 4671, Cisco Pier Floating Dock. For that purpose, to calculate forces acting on the mooring system, the parameters in **Table 1** and dimension of structures have been used in JFlex, see **section** 5.

When designing Seaflex we calculate loads for the worst-case scenario. Normally, it would be when the wind, wave and current action are coming from the same direction. For the project worst case scenario is when wind and wave occurring in the perpendicular to longitudinal direction of the pontoon. Calculations are made for perpendicular to longitudinal direction of the pontoon.

The horizontal force $\mathbf{F_H}$ for each section of the wave attenuator calculated in below sections, is transferred down into the mooring system of Seaflex units. Using methods from **section 4** the induced in-line force $\mathbf{F_{SFX}}$ is calculated for the Seaflex rubber hawser. The scope for Seaflex units moored in the project are 2.5:1. The horizontal angles α_H are 30 degrees. By knowing scope and dimension parameters the vertical angle α_V is calculated for highest water level, which is used when calculating the maximal induced in-line force $\mathbf{F_{SFX}}$. Running this in the application program JFlex, see **section 5**, yields the type and number of Seaflex units for each structure, se results below. The effective number of Seaflex units countering environmental loads is the number of units that always will be acting against the environmental force.

6.1 PONTOON

Length: 38ft (11.6m).

Layout for pontoon is shown in **Appendix A**. In this case the most significant force acting on the pontoon is the wind and waves act in perpendicular to longitudinal direction.

6.1.1 WIND

Using methods from **section 3.1** the total horizontal wind force is calculated, presented in **Table 4**. The max wind speed is given as 40mph (18.77m/s) at 10m height over water. These correspond to 0.85kPa at calculated height of the marina and forces from wind will be checked.

Table 4. *Wind force acting on pontoon. (Wind force is perpendicular to the longitudinal direction of the structure).*

Amount of vessels	Length of vessels	Exposed area of vessel for wind	Based wind velocity at 10m height	Height reduction factor for wind at segment height (a=0,1)	Wind pressure at calculated height	Sheltering	**Wind Force**
[-]	[m]	Ax [m^2]	v_b [m/s]	[-]	q_{zx} [kPa]	[%]	F [kN]
1,0	12,0	29	17,88	0,85	0,14	100	4,10
1,0	12,0	29	17,88	0,85	0,14	20	0,82
						Total force	**4,92**

6.1.2 WAVE

Force from 5.61ft (1.71m) significant wave height is calculated for perpendicular direction to alongside of the pontoon, using method from **section 3.2**, and presented in **Table 5.** Reflection coefficient was chosen to 0.3 for the pontoon.

Table 5. *Wave force acting on pontoon. (Wave force is perpendicular to the longitudinal direction of the structure).*

Length	Reflection	Density	Gravity	Sig. wave Height	Angle	Wave force	
L [m]	R	ρ [kg/m^3]	g [kgm/s^2]	H [m]	α [°]	F [kN]	
11,6	0,3	1023	9,82	1,71	90	**15,33**	**Total force**

6.1.3 CURRENT

There is 0.5kn (0.26m/s) current acting at the pontoon, forces from current are calculated in **Table 6.**

Table 6. *Current force acting on pontoon. (Current force is perpendicular to the longitudinal direction of the structure).*

Length	Draught	Area	Drag	Density	Velocity	Pressure	Current Force
L [m]	d [m]	A [m^2]	C_D	ρ [kg/m^3]	v [m/s]	p [kPa]	F [kN]
11,6	0,45	5,2	1,05	1023	0,26	0,0	0,2

6.1.4 TOTAL FORCE

Summing up all forces gives the maximum total horizontal force of the pontoon, presented in **Table 7.**

Table 7. *Total horizontal force on the pontoon. (Force is perpendicular to longitudinal direction of the structure).*

Force	[kN]
Wind	4,9
Wave	15,3
Current	0,2
Total	20,4

Worst case would be for loads acting in perpendicular direction. The total load for the pontoon in perpendicular to the longitudinal direction of structure is 20.4kN. For that case, the mooring lines are calculated against that loads.

6.1.5 FORCES IN SEAFLEX

The total horizontal force F_H, calculated in **section 6.1.4**, is transferred down into the mooring system of Seaflex units. Using methods from **section 4** we can calculate the induced in-line force $\mathbf{F_{SFX}}$ to the Seaflex rubber hawser.

Max horizontal force acting on the wave attenuator in perpendicular direction is 20.4kN.

There will be 4 Seaflex 4040TGBPTH supporting the pontoon.

The horizontal force is transferred down into the Seaflex mooring system. By using equation (7) the Seaflex hawsers in-line force can be determined. The horizontal angles are 30°, in perpendicular direction while the vertical angle is 33° at highest water level. The total maximum in-line force for the Seaflex Mooring System is 28.1kN in perpendicular direction.

There are 2 of 4 Seaflex units in perpendicular direction acting against the force. The total number of Seaflex hawsers will then be:

- 2 x 4 = 8.

The maximal force in each hawser will be:

- 28.1kN / 8 = 3.51kN.

The breaking load of a single hawser is 10kN. The working in-line load for each hawser is set to between 0.5 - 5kN which correspond to 30 - 80 % elongation. Seaflex units with bypass (breaking load of bypass - 150kN), which activates at 80 % elongation, has safety factor set to 3:1 for 4-hawser units.

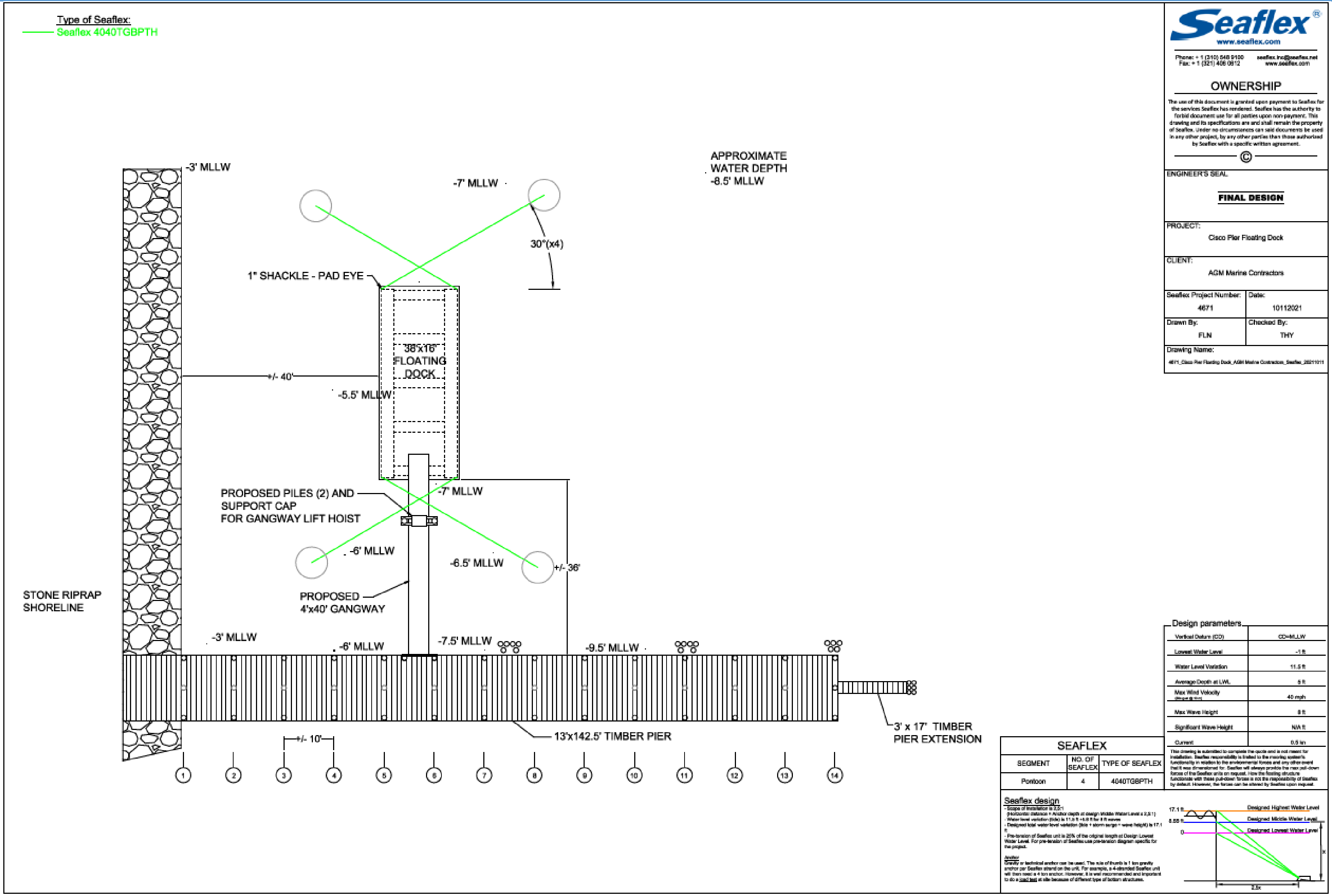
7 SUMMARY

The result of the mooring design for this project is shown in layouts, **Appendix A.** The Seaflex units recommended for this project are listed below, in **Table 8**.

Table 8. *Summary of Seaflex recommended for this project.*

FLOATING STRUCTURE	SEAFLEX
Pontoon	4 x 4040TGBPTH

APPENDIX A



Type of Seaflex:
Seaflex 4040TGBPTH
-3' MLLW
-7' MLLW
APPROXIMATE WATER DEPTH -8.5' MLLW
30°(x4)
1" SHACKLE - PAD EYE
38'x16' FLOATING DOCK
+/- 40'
-5.5' MLLW
PROPOSED PILES (2) AND SUPPORT CAP FOR GANGWAY LIFT HOIST
-7' MLLW
-6' MLLW
-6.5' MLLW
+/- 36'
STONE RIPRAP SHORELINE
PROPOSED 4'x40' GANGWAY
-3' MLLW
-6' MLLW
-7.5' MLLW
-9.5' MLLW
+/- 10'
13'x142.5' TIMBER PIER
3' x 17' TIMBER PIER EXTENSION
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Seaflex
www.seaflex.com
OWNERSHIP
ENGINEER'S SEAL
FINAL DESIGN
PROJECT:
Cisco Pier Floating Dock
CLIENT:
AGM Marine Contractors
Seaflex Project Number: 4671
Date: 10112021
Drawn By: FLN
Checked By: THY
Drawing Name:
Design parameters
Vertical Datum (CD) CD=MLLW
Lowest Water Level -1 ft
Water Level Variation 11.5 ft
Average Depth at LWL 5 ft
Max Wind Velocity 40 mph
Max Wave Height 8 ft
Significant Wave Height N/A ft
Current 0.5 kn
SEAFLEX
SEGMENT | NO. OF SEAFLEX | TYPE OF SEAFLEX
Pontoon | 4 | 4040TGBPTH
Seaflex design
17.1 ft
0
Designed Highest Water Level
Designed Middle Water Level
Designed Lowest Water Level