Document 100-T11

STRUCTURAL CALCULATIONS

Per ABS Rules for Building and Classing Steel Vessels For Service on Rivers and Intracoastal Waterways, 2022

For a

48' x 18' FERRY TOWBOAT

For

TENNESSEE DEPARTMENT OF TRANSPORTATION

HOUSTON - BENTON COUNTY FERRY

Prepared by

SEACRAFT DESIGN, LLC

File 20029

Revision A

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48' x 18' FERRY TOWBOAT
TENNESSEE DEPT. OF TRANSPORTATION

3-1-1 DEFINITIONS

3.3 Length, L

Length, molded hull — **L = 48.00 feet**

5 Breadth, B

Greatest molded breadth — **B = 18.00 feet**

7 Depth, D

Molded depth at side, at middle of L — **D = 6.33 feet**

9 Draft, d

Molded draft to summer load line — **d = 4.50 feet**

17 Block Coefficient, Cb

Molded volume of displacement at draft d — V = 2480 cubic feet
Cb = V/(L*B*d) — **Cb = 0.64**

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3-2-4/5 LONGITUDINAL STRENGTH

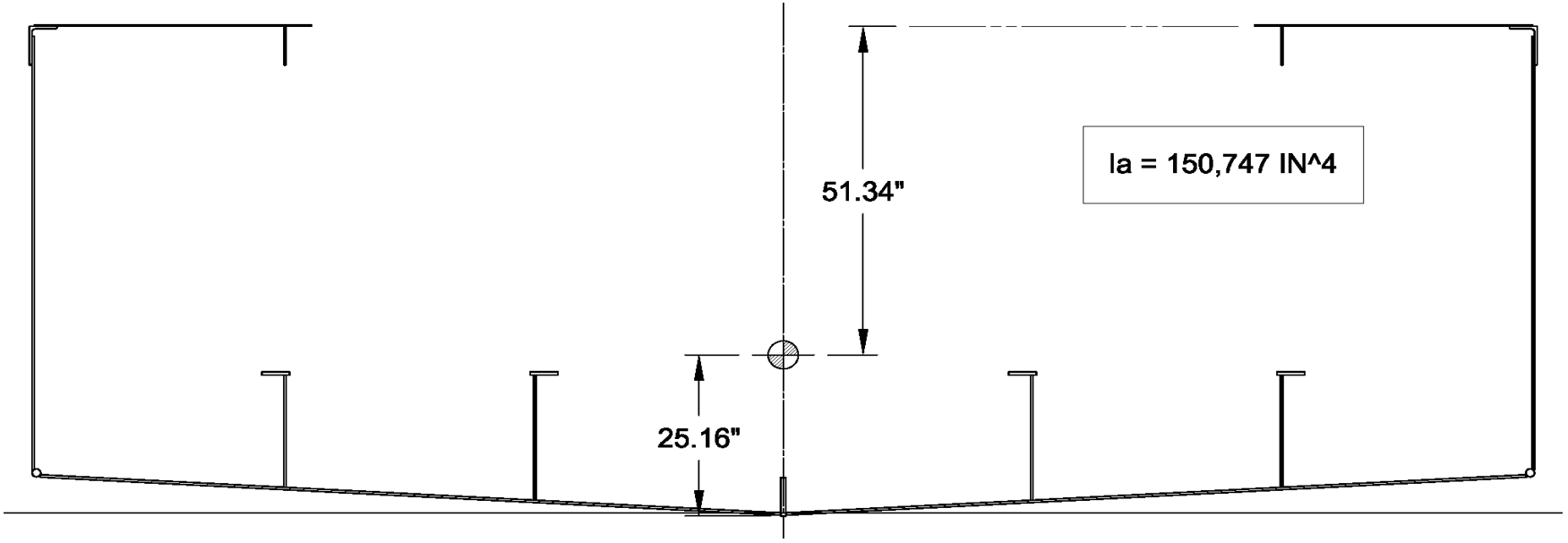
5 Longitudinal Strength

Required hull girder Section Modulus within the midship 0.5L:

SMr = (0.011) B D L

SMr = 60.19 in^2-ft

Ia from AutoCAD (see below)	**Ia =**	**150,747**	**in^4**
Distance from neutral axis to highest point		51.340	in
Distance from neutral axis to lowest point		25.160	in
SECTION MODULUS = In/c	**SMa =**	**244.7**	**in^2-ft**



48' x 18' FERRY TOWBOAT
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3-2-4/7 DECK PLATING

7.1 Strength Decks

The thickness of deck plating throughout is not to be less than 0.01 times the beam spacing (s)

Location	s (in)	**req'd t (in)**	offered t
Main deck plate, general	24.0	**0.240**	0.250
		0.000	
		0.000	
		0.000	
		0.000	

7.3 Other Locations

The thickness of plating forming the tops of deep tanks, watertight flats, bulkhead recesses and tunnel tops which may be used for stores space is to be 1 mm (0.04 in.) thicker than required for bulkhead plating at the same level.

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3-2-4/9 FRAMES

9.1 Bottom Longitudinals

s = member spacing, feet
l = unsupported span of the member, feet
c = 1.08
h = vertical distance from the longitudinal to the deck at side, feet
= for longitudinals in tanks, the vertical distance to the top of the overflow, feet

SM = $0.0041*c*h*s*l^2$ in^3 required section modulus

MEMBER DESCRIPTION	s	l	c	h	**Required SM, in^3**	Offered SM, in^3	Member Offered
Not applicable -			1.08		**0.00**		
Transversely framed			1.08		**0.00**		
			1.08		**0.00**		

9.3 Side and Deck Framing (stiffeners)

s = member spacing, feet
l = unsupported span of the member, feet
c = for side frames, the coeficient appropriate for type of construction, as given in 3-2-4/Figure 1
= 0.70 for deck beams in dry spaces = 1.00 for deck beams in tanks
= 1.08 for side longitudinals, etc. -- see Figure 1 for transverse frames
h = distance in feet, as given in 3-2-4/Figure 1 for side (transverse) frames
= in tanks, the vertical distance from middle of l to top of overflow, but not less than 4.0 ft for deck beams
= 4.0 ft for deck framing. For decks on which stores may be carried, h not less than height of the storage space.

MEMBER DESCRIPTION	s	l	c	h	**Required SM, in^3**	Offered SM, in^3	Member Offered
Side frames, typ. amidship	2.00	5.00	1.45	3.00	**0.89**	6.51	L 5 x 3 x 5/16" on 5/16" pl x 20"
Side frames in way of cooler boxes	2.00	5.00	1.45	3.00	**0.89**	2.05	3/8" x 4" bracket on 3/8" pl x 20"
					0.00		
Deck beam, forward	2.00	6.00	0.70	4.00	**0.83**	4.88	L 4" x 4" x 1/4" on 1/4" pl x 23.75"
Deck beam, fuel tank	2.00	3.00	1.00	4.00	**0.30**	4.73	L 4" x 4" x 1/4" on 1/4" pl x 12"
					0.00		
					0.00		

48' x 18' FERRY TOWBOAT
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3-2-4/11 STANCHIONS

11.1 Permissible Load

A = sectional area of stanchion, in^2
r = least radius of gyration of stanchion section, in
l = length of stanchion, feet

Wa = (7.83 - 0.345(l/r))A long tons Permissible Load

11.3 Calculated Load

n = 0.02 where stanchion supports deck structure, = 0.03 where stanchion supports bottom structure
b = breadth of area supported, feet
s = length of area supported, feet
h = for support of bottom structure, distance from bottom shell at center of area supported to deck at side
= 4.0 ft for support of decks. For decks on which stores may be carried, h not less than height of the storage space.

W = n*b*h*s long tons Calculated Load

Location	b	s	h	n	A	r	l	Calculated Load, W	Permissible Load, Wa	member offered
								0.00		
Fuel tank post	12.00	2.00	6.00	0.03	1.440	0.930	1.25	**4.32**	**10.61**	3x3x1/4
								0.00		
								0.00		
								0.00		
								0.00		
								0.00		
								0.00		
								0.00		
								0.00		
								0.00		
								0.00		
								0.00		

48' x 18' FERRY TOWBOAT
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3-2-4/13 WEB FRAMES, GIRDERS AND STRINGERS

s = member spacing, feet

l = unsupported span of the member, feet

c = 1.00 for bottom and side supporting members, and for deck supporting members in tanks
= 0.70 for deck supporting members in dry spaces

h = for bottom and side members, distance from the center of l to the deck at side, feet
= for bottom and side members in tanks, distance from the center of l to the top of overflow, feet
= 4.0 ft for deck supporting members. For decks on which stores may be carried, h not less than height of the storage space.
= for deck supporting members in tanks, not less than the height of the overflow

SM = $0.0041*c*h*s*l^2$ in^3 required section modulus

MEMBER DESCRIPTION	s	l	c	h	**Required SM, in^3**	Offered SM, in^3	Member Offered
					0.00		
Bottom frames, typ.	2.00	12.00	1.00	6.33	**7.47**	12.08	L 6" x 4" x 3/8" on 3/8" pl x 24"
					0.00		
					0.00		
Inboard girder, E.R.	6.00	14.00	1.00	6.33	**30.52**	56.12	5/16"x18" web, 1/2"x4" flg on 3/8"x48" pl
(assume least depth @ fr.16)					**0.00**		
					0.00		
					0.00		
					0.00		
					0.00		
E.R transverse deck header, ~ fr 11	1.70	12.00	0.70	4.00	**2.81**	2.86	FB 1/4" x 6" on 1/4" x 12"
E.R. long'l deck header, fr 10-17	1.29	14.00	0.70	4.00	**2.91**	2.92	FB 1/4" x 6" on 1/4" x 19.5"
(assumes no load inbd)					**0.00**		
					0.00		
					0.00		

48' x 18' FERRY TOWBOAT
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3-2-4/15 BULKHEADS

15.3 Construction of Tank Boundary Bulkheads

15.3.1 Plating

s = spacing of stiffeners, inches
h = vertical distance (feet) from the lower edge of the plate to the top of the overflow

$t = s*(h)^{1/2}/460 + 0.07$ inches required plating thickness, but not less than 0.20 inches

Location	s	h	**required t**	offered t
			0.200	
Aft fuel tank bulkhead, fr. 10	18.00	6.50	**0.200**	0.250
			0.200	
Longitudinal bhd, fr. 6-10 (deepest)	24.00	6.50	**0.203**	0.250
			0.200	
			0.200	
			0.200	
			0.200	

15.3.2 Stiffening

s = stiffener spacing, feet
l = unsupported span of the member, feet
h = vertical distance from the middle of l to the top of the overflow, feet

$SM = 0.0041*h*s*l^2$ in^3 required section modulus

Location	s	l	h	**Required SM, in^3**	Offered SM, in^3	Member Offered
				0.00		
Transv. bhd, fr. 10, tank portion only	1.50	4.08	6.50	**0.67**	**2.64**	L 3"x3"x1/4" on 1/4"x12" pl
				0.00		
Long'l bhd, fr. 5 - 9, vertical stiffrs	2.00	4.08	6.50	**0.89**	**2.64**	L 3"x3"x1/4" on 1/4"x12" pl
				0.00		
				0.00		
				0.00		
				0.00		
				0.00		

48' x 18' FERRY TOWBOAT
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3-2-4/15 BULKHEADS

15.5 Construction of Other Watertight Bulkheads

15.5.1 Plating

s = spacing of stiffeners, inches
h = vertical distance (feet) from the lower edge of the plate to the height of the deck at centerline

$t = s*(h)^{1/2}/525 + 0.04$ inches required plating thickness, but not less than 0.18 inches

Location	s	h	**required t**	offered t
			0.180	
Wt Bhd 10	18	6.33	**0.180**	0.25
			0.180	
			0.180	
			0.180	
			0.180	

15.5.2 Stiffening

s = stiffener spacing, feet
l = unsupported span of the member, feet
h = vertical distance from the middle of l to the deck at centerline, feet

$SM = (0.0041)*(0.46)*h*s*l^2$ in^3 required section modulus

Location	s	l	h	**Required SM, in^3**	Offered SM, in^3	Member Offered
				0.00		
				0.00		
Wt Bhd 10 vertical stiffeners	1.50	6.33	3.17	**0.36**	**2.64**	L 3"x3"x1/4" on 1/4"x12" pl
				0.00		
				0.00		
				0.00		
				0.00		
				0.00		

48' x 18' FERRY TOWBOAT
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3-2-4/17 SHELL PLATING

17.1 Bottom Shell

L = 48.00 feet
s = frame spacing, in

t = 0.000825L + 0.007s - 0.02 in (min. t = 0.20 in)

Location	s	**required thickness t, in**	thickness offered, in
Bottom shell, general	24	**0.200**	0.375
		0.200	

17.3 Side Shell

s = frame spacing, in

t = 0.000825L + 0.007s - 0.04 in for L < 240 ft (min. t = 0.20 in)
t = 0.000825L + 0.007s - 0.06 in for L >= 240 ft (min. t = 0.20 in)

Location	s	**required thickness t, in**	thickness offered, in
Side shell, general	24	**0.200**	0.313
		0.200	

17.5 Bilge and Tunnel Plating

Where radiused bilges are used, the bottom thickness is to extend to the upper turn of the bilge. Where the radius at the bilge exceeds 12 inches, the thickness of the plating should be at least 0.06 inches greater than the required thickness for side plating. The shell plating in tunnels in way of propellers is to be increased above the requirements of this Subsection.

17.7 Bilge Angles

Where angles are used at the bilges or gunwales they are to have a thickness at least 0.06 inches greater than that of the thinner of the two plates joined.

At gunwale, L 6 x 4 x 3/8" angle is used, joining 1/4" deck plate & 5/16" side plate

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3-2-4/19 DECKHOUSES

19.1 Scantlings

Deckhouses on towboats are to be of adequate construction, consideration being given to their size and the loads which may be imposed upon them. **The plating of the deckhouses is to be not less than 10 gauge**, and where the spacing of stiffeners exceeds 24 inches, the plating thickness is to be increased. **Stiffeners are not to be less than 2.5 inches in depth** and this depth is to be increased if the length of the stiffeners is over 8 feet.

Offered deckhouse Plating:	Sides and Ends: 3/16" plate
Offered deckhouse Stiffeners:	Front: L 3x2x3/16, 16" max. spacing Sides and aft: L 3x2x3/16", 16" max. spacing

The scantlings of decks and platforms above the main deck are to be determined from 3-2-4/9.3 and 3-2-4/13 using an h not less than 2.0 ft for the first level above the main deck and 1.5 ft for the second level or higher:

s = member spacing, feet
l = unsupported span of the member, feet
c = 0.70 for deck supporting members
h = 2.0 ft for first deck level above main deck, = 1.5 ft for second level or higher above main deck

$SM = 0.0041*c*h*s*l^2$ in^3 required section modulus

MEMBER DESCRIPTION	s	l	h	**Required SM, in^3**	Offered SM, in^3	Member Offered
01 deck beams (PH void deck)	1.33	11.50	2.00	**1.01**	1.53	L 3x2x3/16" on 3/16" p, 16" c-c
PH deck	1.33	9.25	2.00	**0.65**	1.53	L 3x2x3/16" on 3/16" p, 16" c-c
PH top	1.33	9.17	2.00	**0.64**	1.53	L 3x2x3/16" on 3/16" p, 16" c-c
				0.00		
				0.00		
				0.00		

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3-2-4/21 KEELS, STEMS AND STERNFRAMES

21.1 Bar Keels

Required:			Offered:		
t =	**0.67**	inches = 0.0062L + 0.37	t =	0.75	inches
h =	**4.33**	inches = 0.0127L + 3.72	h =	6.00	inches
SM =	**2.09**	in^3	SM =	4.50	in^3
I =	**4.52**	in^4	I =	13.50	in^4

21.3 Flat Plate Keels

Flat plate keels are not to be of less thickness than required for bottom plating.

21.5 Bar Stems

Required:			Offered:		
t =	**0.46**	inches = 0.0046L + 0.44	t =	0.75	inches
h =	**3.21**	inches = 0.0131L + 3.15	h =	6.00	inches
SM =	**0.79**	in^3	SM =	4.50	in^3
I =	**1.27**	in^4	I =	13.50	in^4

21.7 Sternposts

Not applicable

21.9 Stern Frames

Not applicable

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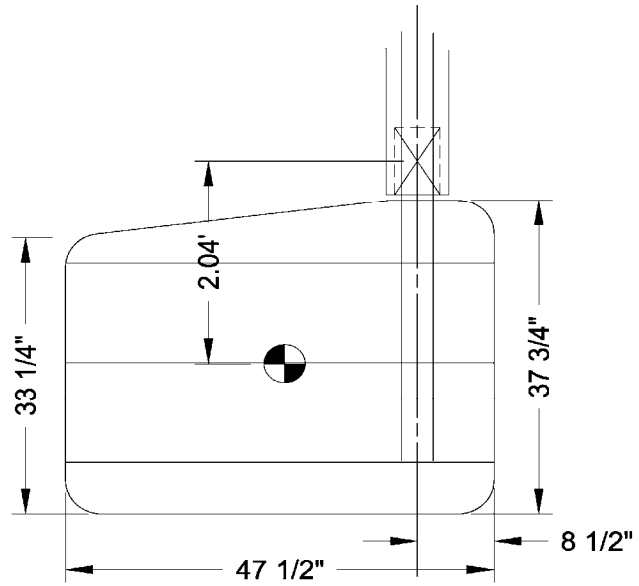
RUDDERS - TAKEN FROM ABS RULES FOR STEEL VESSELS UNDER 90M

3-2-11 RUDDERS (ABS 90m Rules)



3.1 Rudder Force

n =	0.00123	constant			
A =	11.82	ft^2 total projected area of rudder			
b =	2.98	ft mean height of rudder area			
k_R =	0.92	= $(b^2/A+2)/3$, but not > 1.33	Astern Condition		
k_C =	1.00	section coef., from Table 1A	k_C =	1.00	section coef., from Table 1A
k_l =	1.00	coefficient from Table 2			
V =	10.00	knots max. design speed, ahead	Va =	5.00	knots maximum astern speed
Cr =	$n*k_R*k_C*k_l*A*V^2$		Cra =	$n*k_R*k_C*k_l*A*Va^2$	
Cr =	**1.333**	long tons rudder force ahead	**Cra =**	**0.333**	long tons rudder force astern

5.3 Rudder Torque for Scantlings

Af =	2.18	ft^2 area of rudder forward of stock centerline			
c =	3.96	ft mean breadth of rudder area	Astern Condition		
α =	0.33	coefficient from Table 3	α =	0.66	coefficient from Table 3
r =	0.58	= c(α-Af/A) but not < 0.1c	ra =	1.88	= c(α-Af/A)
Qr =	Cr*r		Qra =	Cra*ra	
Qr =	**0.769**	ft-l. tons rudder torque, ahead	**Qra =**	**0.628**	ft-l. tons rudder torque, astern

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3-2-11 RUDDERS (ABS 90m Rules)

7.5 Bending Moment

ln = 2.04 ft distance from center of neck bearing to the centroid of rudder area

Mn = Cr*ln Mna = Cra*ln

Mn = 2.720 ft-l. tons bending mom. ahead **Mna = 0.680** ft-l. tons bending mom. astern

1.3 Rudder Stock Material Factor

ny = 34,000 psi
material: AISI 1018 cold drawn steel
y = 54,000 psi yield strength of material
u = 64,000 psi ulimate tensile strength of material :
Y = 44,800 = y, but not greater than 0.7u or 65,000 psi
e = 0.75

Ks = $(ny/Y)^e$
Ks = 0.813

7.1 Upper Rudder Stocks

Nu = 2.39

S = $Nu*(Qr*Ks)^{1/3}$ Sa = $Nu*(Qra*Ks)^{1/3}$

S = 2.043 inches dia. using ahead forces **Sa = 1.910** inches dia. using astern forces

upper stock diameter offered: **2.75** inches

7.3 Lower Rudder Stocks

Sl = $S[1+(4/3)(Mn/Qr)^2]^{1/6}$ Sla = $Sa[1+(4/3)(Mna/Qra)^2]^{1/6}$

Sl = 3.30 inches dia. using ahead forces **Sla = 2.23** inches dia. using astern forces

lower stock diameter offered: **3.50** inches

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3-2-11 RUDDERS (ABS 90m Rules)

19 Single Plate Rudders

19.3 Blade Thickness

s = 12.00 inches spacing of stiffener arms, not to exceed 39 inches
V = 10.00 knots design speed

tb = 0.0015*s*V + 0.1 required blade thickness

tb = 0.280 inches thickness offered: **0.38** inches

19.5 Arms

C1 = 3.25 feet horizontal distance from aft edge of rudder to centerline of stock
Q = 1.00 = 1.0 for ordinary strength steel; as defined in 3-2-1/7.5 for higher strength steel
thickness = not less than the blade thickness obtained above

thickness = 0.280 inches

SM = $= 0.0000719*s*C1^2*V^2*Q$

SM = 0.911 in^3 section modulus of each set of arms about the axis of the rudder stock

member offered: **2 x FB 3/8" x 3"**

SM offered: **2.54** in^3