Faculty of Maritime Engineering and Marine Sciences

Ship's Structure

Quiz 4 – Ship hull stress analysis **August 31st, 2021**

Group 1 (General procedure, framing systems)

1. A shipowner is considering the possibility of using a transverse framing system for its future tanker ship, L_{pp}: 112 m, B: 17.2 m, D: 8.9 m, T_{full}: 6.7 m, and, Δ_{full}: 10285 tons. The sectional inertia of the ship hull structure has been estimated as I_{yy}:175082 m^2cm^2 and the centroid is 4.08 m from base line. Spacing between deck frames is 0.6 m and between longitudinal girders is 2.15 m, plating deck thickness is 11 mm and corrosion allowance is 1 mm. Use the following DNV formulation for the buckling critical stress of rectangular plates, and calculate the maximum bending moment in kN-m that may be applied on the section of the hull.

A 200 Definitions

201 Symbols:

M_{SW} = still water bending moments in kNm
M_W = wave bending moments in kNm as given in Sec.4 B201.
For ships with restricted service the wave bending moment may be reduced as given in Sec.4 B203.

s = spacing in m of transverse beams
l = distance in m between longitudinal stiffeners
t = plating thickness in mm
Z_A = Z_D or Z_B
Z_R = rule section modulus in cm^3

Z_D, Z_B = midship section modulus in cm^3 as built at deck or bottom, respectively.

102 The critical buckling strength σ_{cr} of a transversely stiffened plate may be found from the following formulae:

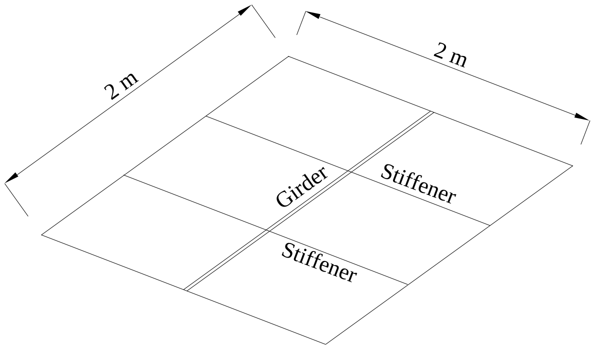
$$\sigma_{cr} = \sigma_e \text{ when } \sigma_e < 0.5\,\sigma_y$$

$$= \sigma_y\left(1 - \frac{\sigma_y}{4\sigma_e}\right) \text{ when } \sigma_e > 0.5\sigma_y$$

$$\sigma_e = 2.3\left[1 + \left(\frac{s}{l}\right)^2\right]^2 \left(\frac{t - t_k}{1000\,s}\right)^2 10^5 \quad (\text{N/mm}^2)$$

Group 2 (Secondary behavior)

3. A reinforced plate panel, clamped on all its edges, supporting uniform pressure of 30 kN/m^2, with one girder and two stiffeners welded to the plate is to be analyzed as a grillage, that is, a combination of three beams. Sectional inertias are: 500 and 100 cm^4, for the girder and stiffeners, respectively. The contact force between the beams has been calculated as 16167.7 N. Calculate the percentage of the total force acting on the panel, which is supported by the two stiffeners.



Group 3 (Plate bending)

4. To reduce the maximum stress in a simply supported rectangular plate, its edges are to be welded to the reinforcements which limit it. Dimensions of the plate and mechanical properties of the material are: *a*x*b*= 1.92x1.2 m, *E*= 6.90E4 N/mm^2, *t*=6mm, ν= 0.30, ρ=6500 kg/m^3. Calculate the reduction in maximum normal stress, as a percentage of the original maximum stress, when a pressure corresponding to a water depth of 1.05 m. Use Timoshenko's result in the following table.

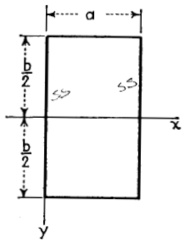


TABLE 8. NUMERICAL FACTORS α, β, γ, δ, n FOR UNIFORMLY LOADED AND SIMPLY SUPPORTED RECTANGULAR PLATES
$\nu = 0.3$

b/a	$w_{max} = \alpha \frac{qa^4}{D}$ α	$(M_x)_{max} = \beta qa^2$ β	$(M_y)_{max} = \beta_1 qa^2$ β_1	$(Q_x)_{max} = \gamma qa$ γ	$(Q_y)_{max} = \gamma_1 qa$ γ_1	$(V_x)_{max} = \delta qa$ δ	$(V_y)_{max} = \delta_1 qa$ δ_1	$R = nqa^2$ n
1.0	0.00406	0.0479	0.0479	0.338	0.338	0.420	0.420	0.065
1.1	0.00485	0.0554	0.0493	0.360	0.347	0.440	0.440	0.070
1.2	0.00564	0.0627	0.0501	0.380	0.353	0.455	0.453	0.074
1.3	0.00638	0.0694	0.0503	0.397	0.357	0.468	0.464	0.079
1.4	0.00705	0.0755	0.0502	0.411	0.361	0.478	0.471	0.083
1.5	0.00772	0.0812	0.0498	0.424	0.363	0.486	0.480	0.085
1.6	0.00830	0.0862	0.0492	0.435	0.365	0.491	0.485	0.086
1.7	0.00883	0.0908	0.0486	0.444	0.367	0.496	0.488	0.088
1.8	0.00931	0.0948	0.0479	0.452	0.368	0.499	0.491	0.090
1.9	0.00974	0.0985	0.0471	0.459	0.369	0.502	0.494	0.091
2.0	0.01013	0.1017	0.0464	0.465	0.370	0.503	0.496	0.092
3.0	0.01223	0.1189	0.0406	0.493	0.372	0.505	0.498	0.093
4.0	0.01282	0.1235	0.0384	0.498	0.372	0.502	0.500	0.094
5.0	0.01297	0.1246	0.0375	0.500	0.372	0.501	0.500	0.095
∞	0.01302	0.1250	0.0375	0.500	0.372	0.500	0.500	0.095

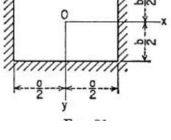
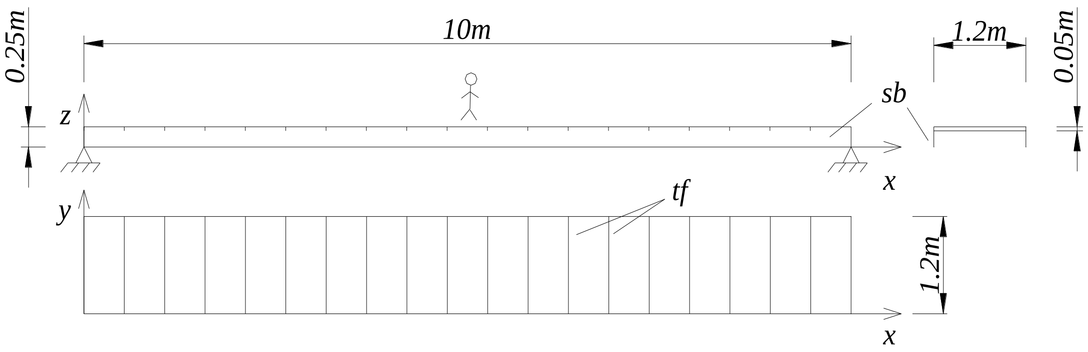


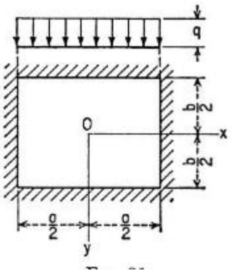
TABLE 35. DEFLECTIONS AND BENDING MOMENTS IN A UNIFORMLY LOADED RECTANGULAR PLATE WITH BUILT-IN EDGES (FIG. 91)
$\nu = 0.3$

b/a	$(w)_{x=0,y=0}$	$(M_x)_{x=a/2,y=0}$	$(M_y)_{x=0,y=b/2}$	$(M_x)_{x=0,y=0}$	$(M_y)_{x=0,y=0}$
1.0	$0.00126qa^4/D$	$-0.0513qa^2$	$-0.0513qa^2$	$0.0231qa^2$	$0.0231qa^2$
1.1	$0.00150qa^4/D$	$-0.0581qa^2$	$-0.0538qa^2$	$0.0264qa^2$	$0.0231qa^2$
1.2	$0.00172qa^4/D$	$-0.0639qa^2$	$-0.0554qa^2$	$0.0299qa^2$	$0.0228qa^2$
1.3	$0.00191qa^4/D$	$-0.0687qa^2$	$-0.0563qa^2$	$0.0327qa^2$	$0.0222qa^2$
1.4	$0.00207qa^4/D$	$-0.0726qa^2$	$-0.0568qa^2$	$0.0349qa^2$	$0.0212qa^2$
1.5	$0.00220qa^4/D$	$-0.0757qa^2$	$-0.0570qa^2$	$0.0368qa^2$	$0.0203qa^2$
1.6	$0.00230qa^4/D$	$-0.0780qa^2$	$-0.0571qa^2$	$0.0381qa^2$	$0.0193qa^2$
1.7	$0.00238qa^4/D$	$-0.0799qa^2$	$-0.0571qa^2$	$0.0392qa^2$	$0.0182qa^2$
1.8	$0.00245qa^4/D$	$-0.0812qa^2$	$-0.0571qa^2$	$0.0401qa^2$	$0.0174qa^2$
1.9	$0.00249qa^4/D$	$-0.0822qa^2$	$-0.0571qa^2$	$0.0407qa^2$	$0.0165qa^2$
2.0	$0.00254qa^4/D$	$-0.0829qa^2$	$-0.0571qa^2$	$0.0412qa^2$	$0.0158qa^2$
∞	$0.00260qa^4/D$	$-0.0833qa^2$	$-0.0571qa^2$	$0.0417qa^2$	$0.0125qa^2$

Problem: A pedestrian bridge, completely built from 3-mm thick standard steel plate, is to be analyzed. The structure is 10 m long by 1.2 m width, and is designed to support 22 "standard Ecuadorian" pedestrians plus its own structural weight (423 kgf). The bridge has two longitudinal side beams, *sb*, and 18 transversal frames, *tf*, strengthening the walking surface. The longitudinal on the sides and the transverse frames are 25 and 5 cm in height, respectively. Please keep the directional system shown in the figure. Start by including a short factual discussion on the model and process you are going to follow, and, at the end include comments on your results.



$$\sigma_x = \frac{12\, z\, M_x}{t^3}$$



b/a	$(w)_{x=0,y=0}$	$(M_x)_{x=a/2,y=0}$	$(M_y)_{x=0,y=b/2}$	$(M_x)_{x=0,y=0}$	$(M_y)_{x=0,y=0}$
1.0	$0.00126qa^4/D$	$-0.0513qa^2$	$-0.0513qa^2$	$0.0231qa^2$	$0.0231qa^2$
1.1	$0.00150qa^4/D$	$-0.0581qa^2$	$-0.0538qa^2$	$0.0264qa^2$	$0.0231qa^2$
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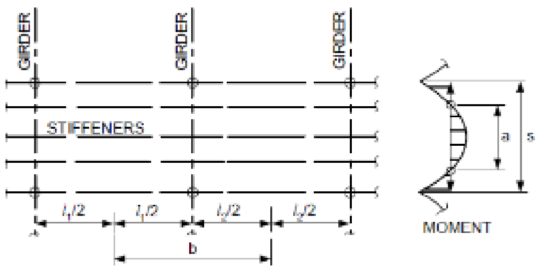
From DNV rules: **402** The effective plate flange area is defined as the cross-sectional area of plating within the effective flange width. Continuous stiffeners within the effective flange may be included. The effective flange width be is determined by the following formula: $b_e = C\, b$ (m)

Table C2 Values of C								
a/b	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*≥ 7*
C (r ≥ 6)	0.00	0.38	0.67	0.84	0.93	0.97	0.99	1.00
C (r = 5)	0.00	0.33	0.58	0.73	0.84	0.89	0.92	0.93
C (r = 4)	0.00	0.27	0.49	0.63	0.74	0.81	0.85	0.87
C (r ≤ 3)	0.00	0.22	0.40	0.52	0.65	0.73	0.78	0.80

a = distance between points of zero bending moments
= S for simply supported girders
= 0.6 S for girders fixed at both ends
r = number of point loads.



Equivalent von Mises stress: $\sigma_{eq} = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_y + 3\tau^2}$.

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