Stiffener calculations

Stiffener Section Modulus Calculation - V00 [LÄSS]

Calculation including differencies in E-modulus

Flange		
t_{fl1}	10	mm
b_{fl}	70	mm
E_{fl}	20	GPa
$Dens_{fl}$	1800	kg/m^3

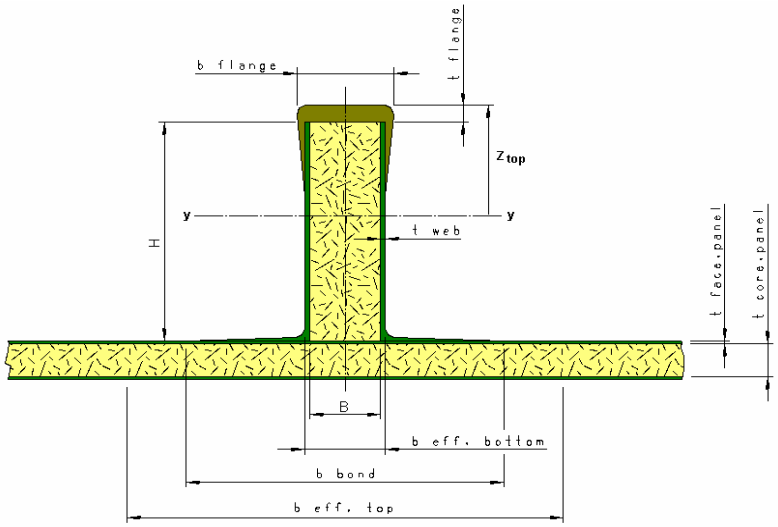
Web		
H	100	mm
B ($t_{w, core}$)	50	mm
$t_{w, face}$	5	mm
$E_{w, face}$	16	GPa
$Dens_{w, face}$	1800	kg/m^3
$Dens_{w, core}$	60	kg/m^3

Panel		
$t_{face, p}$	3	mm
$t_{core, p}$	30	mm
$b_{effective, top}$	56	mm
$b_{effective, bot}$	0	mm
E_{fp}	17	GPa

Extra tabbing		
b_{tabb}	56	mm
t_{tabb}	1.89	mm
E_{tabb}	17	GPa
$Dens_{tabbing}$	1800	kg/m^3

Area (A)			**E * A**	**C_z**	
Flange	700	mm^2	14000000	5	mm
Web	1000	mm^2	16000000	60	mm
Panel, top	168	mm^2	2856000	113.39	mm
Panel, bot	0	mm^2	0	146.39	mm
Extra tabbing	105.84	mm^2	1799280	110.95	mm

Neutral axis			
z_{top}	45	mm	(from top of flange)
Z_{bot}	103	mm	(from bottom panel face laminate)



Moment of Inertia (I) - Neutral axis			**E * I**		**E * I Sum**	
Flange	1.12E+06	mm^4	2.23E+10	Nmm^2		
Web	1.06E+06	mm^4	1.70E+10	Nmm^2		
Panel, top	7.90E+05	mm^4	1.34E+10	Nmm^2	6.06E+10	Nmm2
Panel, bot	0.00E+00	mm^4	0.00E+00	Nmm^2		
Extra tabbing	4.63E+05	mm^4	7.87E+09	Nmm^2		

Section modulus						
Z top, flange	6.76E+04	mm^3	=	6.76E+01	cm^3	at top of top flange
Z top, web-top	1.09E+05	mm^3	=	1.09E+02	cm^3	at top of web laminate (relevant if no flange)
Z bot, panel	3.46E+04	mm^3	=	3.46E+01	cm^3	at bottom of panel bottom laminate

Web area	A_w	10	cm^2

Weight	q	3.7	kg/m	(adjacent panel not included)

Stiffener calculations

Stiffener Section Modulus Calculation - V00 [LÄSS]

Calculation including differencies in E-modulus

Flange		
t_{fl1}	28.9	mm
b_{fl}	120	mm
E_{fl}	21	GPa
$Dens_{fl}$	1800	kg/m^3

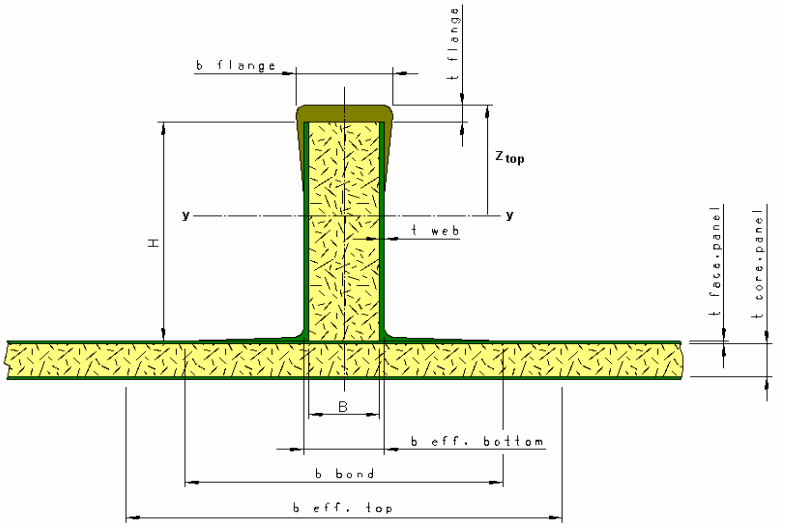
Web		
H	200	mm
B ($t_{w,\ core}$)	50	mm
$t_{w,\ face}$	5	mm
$E_{w,\ face}$	17	GPa
$Dens_{w,\ face}$	1800	kg/m^3
$Dens_{w,\ core}$	60	kg/m^3

Panel		
$t_{face,\ p}$	3	mm
$t_{core,\ p}$	30	mm
$b_{effective,\ top}$	56	mm
$b_{effective,\ bot}$	0	mm
E_{fp}	17	GPa

Extra tabbing		
b_{tabb}	56	mm
t_{tabb}	0	mm
E_{tabb}	17	GPa
$Dens_{tabbing}$	1800	kg/m^3

Area (A)			**E * A**	**C_z**	
Flange	3468	mm^2	72828000	14.45	mm
Web	2000	mm^2	34000000	128.9	mm
Panel, top	168	mm^2	2856000	230.4	mm
Panel, bot	0	mm^2	0	263.4	mm
Extra tabbing	0	mm^2	0	228.9	mm

Neutral axis			
z_{top}	56	mm	(from top of flange)
Z_{bot}	209	mm	(from bottom panel face laminate)



Moment of Inertia (I) - Neutral axis			**E * I**		**E * I Sum**	
Flange	6.10E+06	mm^4	1.28E+11	Nmm^2		
Web	1.74E+07	mm^4	2.96E+11	Nmm^2		
Panel, top	5.14E+06	mm^4	8.73E+10	Nmm^2	5.12E+11	Nmm2
Panel, bot	0.00E+00	mm^4	0.00E+00	Nmm^2		
Extra tabbing	0.00E+00	mm^4	0.00E+00	Nmm^2		

Section modulus						
Z top, flange	4.39E+05	mm^3	=	4.39E+02	cm^3	at top of top flange
Z top, web-top	1.13E+06	mm^3	=	1.13E+03	cm^3	at top of web laminate (relevant if no flange)
Z bot, panel	1.44E+05	mm^3	=	1.44E+02	cm^3	at bottom of panel bottom laminate

Web area	A_w	20	cm^2

Weight	q	11.0	kg/m	(adjacent panel not included)

Stiffener calculations

Stiffener Section Modulus Calculation - V00 [LÄSS]

Calculation including differencies in E-modulus

Flange		
t_{fl1}	28.9	mm
b_{fl}	120	mm
E_{fl}	21	GPa
$Dens_{fl}$	1800	kg/m^3

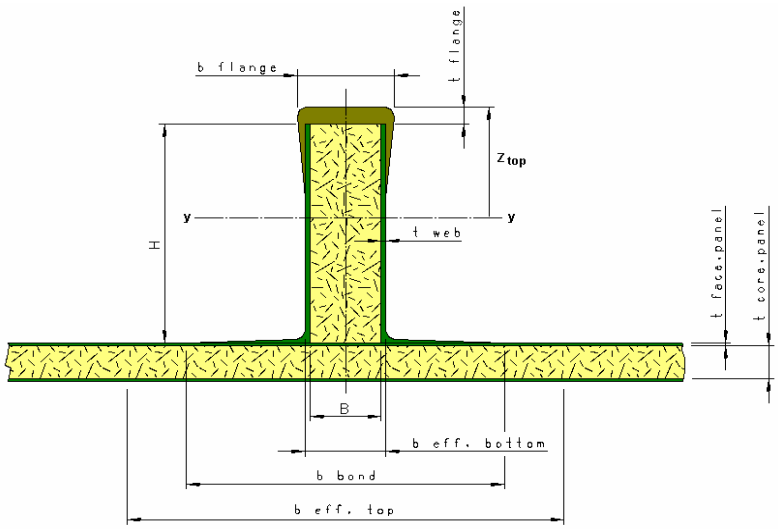
Web		
H	400	mm
B ($t_{w,\ core}$)	100	mm
$t_{w,\ face}$	5	mm
$E_{w,\ face}$	17	GPa
$Dens_{w,\ face}$	1800	kg/m^3
$Dens_{w,\ core}$	60	kg/m^3

Panel		
$t_{face,\ p}$	3	mm
$t_{core,\ p}$	30	mm
$b_{effective,\ top}$	106	mm
$b_{effective,\ bot}$	0	mm
E_{fp}	17	GPa

Extra tabbing		
b_{tabb}	106	mm
t_{tabb}	25.2	mm
E_{tabb}	17	GPa
$Dens_{tabbing}$	1800	kg/m^3

Area (A)			**E * A**	**C_z**	
Flange	3468	mm^2	72828000	14.45	mm
Web	4000	mm^2	68000000	228.9	mm
Panel, top	318	mm^2	5406000	455.6	mm
Panel, bot	0	mm^2	0	488.6	mm
Extra tabbing	2671.2	mm^2	45410400	441.5	mm

Neutral axis			
z_{top}	204	mm	(from top of flange)
Z_{bot}	286	mm	(from bottom panel face laminate)



Moment of Inertia (I) - Neutral axis			**E * I**		**E * I Sum**	
Flange	1.25E+08	mm^4	2.63E+12	Nmm^2		
Web	5.58E+07	mm^4	9.48E+11	Nmm^2		
Panel, top	2.01E+07	mm^4	3.42E+11	Nmm^2	6.48E+12	Nmm2
Panel, bot	0.00E+00	mm^4	0.00E+00	Nmm^2		
Extra tabbing	1.51E+08	mm^4	2.56E+12	Nmm^2		

Section modulus						
Z top, flange	1.51E+06	mm^3	=	1.51E+03	cm^3	at top of top flange
Z top, web-top	2.17E+06	mm^3	=	2.17E+03	cm^3	at top of web laminate (relevant if no flange)
Z bot, panel	1.33E+06	mm^3	=	1.33E+03	cm^3	at bottom of panel bottom laminate

Web area	A_w	40	cm^2

Weight	q	21.7	kg/m	(adjacent panel not included)

Pressure calculations based on scantling calculations found in appendices below

APPENDIX PRESSURE CALCULATIONS

Deck	Area	Height above waterline [m]	Panel size b×h [m2]		Aft Pressure [kPa]	Side Pressure [kPa]	Front Pressure [kPa]	Deck Pressure [kPa]	Design pressure [kPa]	Material				Decisive loadcase
			b	h						Divinycell H	Thickness [mm]	GRP	Thickness [mm]	
11	Exterior	26.8	2.3	14	-	-	-	13	13	80	55	QXLT850	1.95	Dynamic pressure
10	Aft	24.825	5.5	3	2.5	-	-	-	2.5	60	55	QXLT850	0.65	Sea Pressure
10	Side	24.825	2.3	3	-	2.5	-	-	2.5	60	55	QXLT850	0.65	Sea Pressure
10	Front	24.825	5.5	3	-	-	2.5	-	2.5	60	55	QXLT850	0.65	Sea Pressure
10	Exterior	23.45	2.3	6	-	-	-	13	13	80	55	QXLT850	1.95	Dynamic pressure
10	Interior	23.45	2.3	6	-	-	-	5.7	5.7	60	55	QXLT850	0.65	Static pressure
9	Aft	22.075	5.5	3	11	-	-	-	11	80	55	QXLT850	3.25	Sea Pressure
9	Side	22.075	2.3	3	-	11	-	-	11	60	55	QXLT850	1.3	Sea Pressure
9	Front	22.075	5.5	3	-	-	22	-	22	130	55	QXLT850	5.2	Sea Pressure
9	Interior	20.7	2.3	6	-	-	-	5.7	5.7	60	55	QXLT850	0.65	Static pressure
8	Aft	19.325	5.5	3	11	-	-	-	11	80	55	QXLT850	3.25	Sea Pressure
8	Side	19.325	2.3	3	-	11	-	-	11	60	55	QXLT850	1.3	Sea Pressure
8	Front	19.325	5.5	3	-	-	22	-	22	130	55	QXLT850	5.2	Sea Pressure
8	Interior	17.95	2.3	6	-	-	-	5.7	5.7	60	55	QXLT850	0.65	Static pressure
7	Aft	16.475	5.5	3	11	-	-	-	11	80	55	QXLT850	3.25	Sea Pressure
7	Side	16.475	2.3	3	-	11	-	-	11	60	55	QXLT850	1.3	Sea Pressure
7	Front	16.475	5.5	3	-	-	22	-	22	130	55	QXLT850	5.2	Sea Pressure

Stiffener calculations based on DNV rules

APPENDIX STIFFENERS

Type	Load type	Ref. p_{panel} [kPa]	Span l [m]	Spacing b [m]	p_{design} [kPa]	c_1 (ends)	c_1 (mid-span)	M (ends) [Nm]	M (mid-span) [Nm]	σ_u (ends) [MPa]	σ_u (mid-span) [MPa]	Z_{min} (mid-span) [cm^3]	Tz [N]	τ_u [MPa]	$A_{w,min}$ [cm^2]	Aw	Lever
Deck 11																	
Transversal	Acc deck	13	14.0	2.3	13	0	8	0.0E+00	7.2E+05	320	430	5.56E+03	2.05E+05	220	37	40	A3
Deck 10																	
Transversal	Acc deck	13	5.5	2.3	13	0	8	0.0E+00	1.1E+05	320	430	8.57E+02	8.04E+04	220	15	20	A2
Web	Acc deck	2.5	3.3	2.3	3	0	8	0.0E+00	7.7E+03	320	430	5.94E+01	9.28E+03	220	2	10	A1
Girder	Acc deck	13	4.5	5.5	13	0	8	0.0E+00	1.8E+05	300	400	1.51E+03	1.61E+05	220	29	40	A3
Deck 9																	
Transversal	Acc deck	5.7	5.5	2.3	6	0	8	0.0E+00	4.8E+04	320	430	3.76E+02	3.53E+04	220	6	10	A1
Web	Acc deck	11	2.3	2.3	11	0	8	0.0E+00	1.6E+04	320	430	1.21E+02	2.78E+04	220	5	10	A1
Girder	Acc deck	5.7	4.5	5.5	6	0	8	0.0E+00	7.9E+04	300	400	6.61E+02	7.05E+04	220	13	20	A2
Deck 8																	
Transversal	Acc deck	5.7	5.5	2.3	6	0	8	0.0E+00	4.8E+04	320	430	3.76E+02	3.53E+04	220	6	10	A1
Web	Acc deck	11	2.3	2.3	11	0	8	0.0E+00	1.6E+04	320	430	1.21E+02	2.78E+04	220	5	10	A1
Girder	Acc deck	5.7	4.5	5.5	6	0	8	0.0E+00	7.9E+04	300	400	6.61E+02	7.05E+04	220	13	20	A2
Deck 7																	
Web	Acc deck	11	2.3	2.3	11	0	8	0.0E+00	1.6E+04	320	430	1.21E+02	2.78E+04	220	5	10	A1

	A1	A2	A3
A_W [cm^2]	10.0	20.0	40.0
q [kg/m]	3.7	11.0	21.7
h	100.0	200.0	400.0
b	56.0	56.0	106.0

Sandwich panels calculations

KOCKUMS AB
Karlskronavarvet

Naval Surface Ships / Hull Dept.
Composites & Strength

DNV Sandwich Panel Calculation (HSLC Rules Pt.3 Ch.4 Sec.5)

Panel Designation: LÄSS
DECK 11 EXTERNAL DECK

Date: 2006-09-07

Panel Geometry

L_x	2.3	[m]	**Longest side:**	**a**	14	[m]	(Ly)
L_y	14.0	[m]	**Shortest side:**	**b**	2.25	[m]	(Lx)

Panel support: Partial edge fixity **Panel aspect ratio:** **b/a** 0.16

Laminate Data

Laminate type: #Referens!

Vacuum infusion, 50 Vol%

Laminate thickness (t): 2.0 [mm] $t_{nominal}$ (0.65 mm)

Laminate Safety Factor: 3.3

$\sigma_{nu,\ compr.}$	220	[MPa]
E_{lam}	17	[GPa]
ρ_{lam}	1830	[kg/m3]
$\sigma_{n,\ allowed}$	67	[MPa]

Core Data

Core type: Divinycell H80

Core thickness (t_c): 55 [mm] $t_{nominal}$ (70 mm)

Core Safety Factor: 3.3

τ_u	0.9	[MPa]
E_{core}	65	[MPa]
G_{core}	23	[MPa]
ρ_{core}	80	[kg/m3]
$\tau_{allowed}$	0.27	[MPa]

Design Pressure (p): 13 [kPa] **Panel weight:** **11.5** **[kg/m²]**

Normal stresses in skin laminates

$$\sigma_n = \frac{160\, p\, b^2}{W} C_N\, C_1$$

C_1 = 0.59
C_2 = 0.01
C_3 = 0.74

$C_{N,\ x}$ = 0.74
$C_{N,\ y}$ = 0.23
W = 111

σ_x = 41 [MPa]
σ_y = 13 [MPa]

Core shear stresses at midpoints of panel edges

$$\tau_c = \frac{0{,}52\, p\, b}{d} C_S$$

C_4 = 0.96
C_5 = 0.73

$C_{S,\ Lx}$ = 0.73
$C_{S,\ Ly}$ = 0.96
$d = t + t_c$ = 57.0

τ_{Lx} = 0.20 [MPa]
τ_{Ly} = 0.26 [MPa]

Local skin buckling

$$\sigma_{cr} = 0{,}5 \sqrt[3]{E_{lam}\, E_{core}\, G_{core}}$$

σ_{cr} = 147 [MPa]

Deflections

$$w = \frac{10^6\, p\, b^4}{D_2} \left(C_6\, C_8 + \rho\, C_7 \left(\frac{\pi^2\, D_2}{t\, d^2} \right. \right.$$

C_6 = 12.9
C_7 = 12.4
C_8 = 0.41
D_2 = 5.91E+07

w = 35.9 [mm]
w/b = 0.016

Sandwich panels calculations

KOCKUMS AB
Karlskronavarvet

Naval Surface Ships / Hull Dept.
Composites & Strength

DNV Sandwich Panel Calculation (HSLC Rules Pt.3 Ch.4 Sec.5)

Panel Designation: LÄSS DECK 10 AFT **Date:** 2006-09-07

Panel Geometry

L_x	5.5	[m]	**Longest side:**	**a**	5.5	[m]	(Lx)
L_y	3.0	[m]	**Shortest side:**	**b**	3	[m]	(Ly)

Panel support: Partial edge fixity **Panel aspect ratio:** **b/a** 0.55

Laminate Data

Laminate type: #Referens! Vacuum infusion, 50 Vol%

Laminate thickness (t): 0.7 [mm] ($t_{nominal}$ (0.65 mm))

Laminate Safety Factor: 3.3

$\sigma_{nu,\ compr.}$	220	[MPa]
E_{lam}	17	[GPa]
ρ_{lam}	1830	[kg/m3]
$\sigma_{n,\ allowed}$	67	[MPa]

Core Data

Core type: Divinycell H60

Core thickness (t_c): 55 [mm] ($t_{nominal}$ (78 mm))

Core Safety Factor: 3.3

τ_u	0.6	[MPa]
E_{core}	45	[MPa]
G_{core}	15	[MPa]
ρ_{core}	60	[kg/m3]
$\tau_{allowed}$	0.18	[MPa]

Design Pressure (p): 3 [kPa] **Panel weight:** **5.7** **[kg/m²]**

Normal stresses in skin laminates

$$\sigma_n = \frac{160\, p\, b^2}{W} C_N\, C_1$$

C_1 = 0.73 C_2 = 0.11 C_3 = 0.54

$C_{N,\ x}$ = 0.27 $C_{N,\ y}$ = 0.58 W = 36

σ_x = 20 [MPa] **σ_y = 42 [MPa]**

Core shear stresses at midpoints of panel edges

$$\tau_c = \frac{0{,}52\, p\, b}{d} C_S$$

C_4 = 0.86 C_5 = 0.71

$C_{S,\ Lx}$ = 0.86 $C_{S,\ Ly}$ = 0.71 $d = t + t_c$ = 55.7

τ_{Lx} = 0.06 [MPa] **τ_{Ly} = 0.05 [MPa]**

Local skin buckling

$$\sigma_{cr} = 0{,}5 \sqrt[3]{E_{lam}\, E_{core}\, G_{core}}$$

σ_{cr} = 113 [MPa]

Deflections

$$w = \frac{10^6\, p\, b^4}{D} [C_6\, C_8 + \rho\, C_7 [$$

C_6 = 9.7 C_7 = 11.4

w = 56.0 [mm] **w/b = 0.019**

Sandwich panels calculations

KOCKUMS AB
Karlskronavarvet

Naval Surface Ships / Hull Dept.
Composites & Strength

DNV Sandwich Panel Calculation (HSLC Rules Pt.3 Ch.4 Sec.5)

Panel Designation: LÄSS DECK 10 SIDE **Date:** 2006-09-07

Panel Geometry

L_x	2.3	[m]	**Longest side:**	**a**	3	[m]	(Ly)
L_y	3.0	[m]	**Shortest side:**	**b**	2.25	[m]	(Lx)

Panel support: Partial edge fixity **Panel aspect ratio:** **b/a** 0.75

Laminate Data

Laminate type:	#Referens!			Vacuum infusion, 50 Vol%		
			$t_{nominal}$	$\sigma_{nu,\ compr.}$	220	[MPa]
Laminate thickness (t):	0.7	[mm]	(0.65 mm)	E_{lam}	17	[GPa]
				ρ_{lam}	1830	[kg/m3]
Laminate Safety Factor:	3.3			$\sigma_{n,\ allowed}$	67	[MPa]

Core Data

Core type:	Divinycell H60			τ_u	0.6	[MPa]
			$t_{nominal}$	E_{core}	45	[MPa]
Core thickness (t_c):	55	[mm]	(78 mm)	G_{core}	15	[MPa]
				ρ_{core}	60	[kg/m3]
Core Safety Factor:	3.3			$\tau_{allowed}$	0.18	[MPa]

Design Pressure (p): 3 [kPa] **Panel weight:** **5.7** **[kg/m²]**

Normal stresses in skin laminates

$$\sigma_n = \frac{160\, p\, b^2}{W} C_N\, C_1$$

C_1 = 0.84 C_2 = 0.18 C_3 = 0.41

$C_{N,\ x}$ = 0.46 $C_{N,\ y}$ = 0.30 W = 36

σ_x = 22 [MPa] **σ_y = 14 [MPa]**

Core shear stresses at midpoints of panel edges

$$\tau_c = \frac{0{,}52\, p\, b}{d} C_S$$

C_4 = 0.77 C_5 = 0.69

$C_{S,\ Lx}$ = 0.69 $C_{S,\ Ly}$ = 0.77 $d = t + t_c$ = 55.7

τ_{Lx} = 0.04 [MPa] **τ_{Ly} = 0.04 [MPa]**

Local skin buckling

$$\sigma_{cr} = 0{,}5 \sqrt[3]{E_{lam}\, E_{core}\, G_{core}}$$

σ_{cr} = 113 [MPa]

Deflections

$$w = \frac{10^6\, p\, b^4}{D} C_6\, C_8 \rho\, C_7 [$$

C_6 = 7.3 C_7 = 10.0

w = 16.1 [mm] **w/b = 0.007**

BL112.01

Sandwich panels calculations

KOCKUMS AB
Karlskronavarvet

Naval Surface Ships / Hull Dept.
Composites & Strength

DNV Sandwich Panel Calculation (HSLC Rules Pt.3 Ch.4 Sec.5)

Panel Designation: LÄSS DECK 10 FRONT **Date:** 2006-09-07

Panel Geometry

L_x	5.5	[m]	**Longest side:**	**a**	5.5	[m]	(Lx)
L_y	3.0	[m]	**Shortest side:**	**b**	3	[m]	(Ly)

Panel support: Partial edge fixity **Panel aspect ratio:** **b/a** 0.55

Laminate Data

Laminate type: #Referens! Vacuum infusion, 50 Vol%

Laminate thickness (t): 0.7 [mm] ($t_{nominal}$ (0.65 mm))

Laminate Safety Factor: 3.3

$\sigma_{nu,\ compr.}$	220	[MPa]
E_{lam}	17	[GPa]
ρ_{lam}	1830	[kg/m3]
$\sigma_{n,\ allowed}$	67	[MPa]

Core Data

Core type: Divinycell H60

Core thickness (t_c): 55 [mm] ($t_{nominal}$ (78 mm))

Core Safety Factor: 3.3

τ_u	0.6	[MPa]
E_{core}	45	[MPa]
G_{core}	15	[MPa]
ρ_{core}	60	[kg/m3]
$\tau_{allowed}$	0.18	[MPa]

Design Pressure (p): 3 [kPa] **Panel weight:** **5.7** **[kg/m²]**

Normal stresses in skin laminates

$$\sigma_n = \frac{160\ p\ b^2}{W} C_N\ C_1$$

C_1 = 0.73, C_2 = 0.11, C_3 = 0.54
$C_{N,\ x}$ = 0.27, $C_{N,\ y}$ = 0.58, W = 36

σ_x = 20 [MPa]
σ_y = 42 [MPa]

Core shear stresses at midpoints of panel edges

$$\tau_c = \frac{0{,}52\ p\ b}{d} C_S$$

C_4 = 0.86, C_5 = 0.71
$C_{S,\ Lx}$ = 0.86, $C_{S,\ Ly}$ = 0.71, $d = t + t_c$ = 55.7

τ_{Lx} = 0.06 [MPa]
τ_{Ly} = 0.05 [MPa]

Local skin buckling

$$\sigma_{cr} = 0{,}5\ \sqrt[3]{E_{lam}\ E_{core}\ G_{core}}$$

σ_{cr} = 113 [MPa]

Deflections

$$w = \frac{10^6\ p\ b^4}{\quad} C_6\ C_8 \rho\ C_7$$

C_6 = 9.7, C_7 = 11.4

w = 56.0 [mm]
w/b = 0.019

Sandwich panels calculations

KOCKUMS AB
Karlskronavarvet

Naval Surface Ships / Hull Dept.
Composites & Strength

DNV Sandwich Panel Calculation (HSLC Rules Pt.3 Ch.4 Sec.5)

Panel Designation: LÄSS
DECK 10 EXTERNAL DECK

Date: 2006-09-07

Panel Geometry

L_x	2.3	[m]	**Longest side:**	**a**	5.5	[m]	(Ly)
L_y	5.5	[m]	**Shortest side:**	**b**	2.25	[m]	(Lx)

Panel support: Partial edge fixity **Panel aspect ratio:** **b/a** 0.41

Laminate Data

Laminate type: #Referens! Vacuum infusion, 50 Vol%

Laminate thickness (t): 2.0 [mm] $t_{nominal}$ (0.65 mm)

Laminate Safety Factor: 3.3

$\sigma_{nu,\ compr.}$	220	[MPa]
E_{lam}	17	[GPa]
ρ_{lam}	1830	[kg/m3]
$\sigma_{n,\ allowed}$	67	[MPa]

Core Data

Core type: Divinycell H80

Core thickness (t_c): 55 [mm] $t_{nominal}$ (70 mm)

Core Safety Factor: 3.3

τ_u	0.9	[MPa]
E_{core}	65	[MPa]
G_{core}	23	[MPa]
ρ_{core}	80	[kg/m3]
$\tau_{allowed}$	0.27	[MPa]

Design Pressure (p): 13 [kPa] **Panel weight:** **11.5** **[kg/m²]**

Normal stresses in skin laminates

$$\sigma_n = \frac{160\ p\ b^2}{W} C_N\ C_1$$

C_1 = 0.66
C_2 = 0.06
C_3 = 0.63

$C_{N,\ x}$ = 0.65
$C_{N,\ y}$ = 0.25
W = 111

σ_x = 41 [MPa]
σ_y = 16 [MPa]

Core shear stresses at midpoints of panel edges

$$\tau_c = \frac{0{,}52\ p\ b}{d} C_S$$

C_4 = 0.91
C_5 = 0.72

$C_{S,\ Lx}$ = 0.72
$C_{S,\ Ly}$ = 0.91
$d = t + t_c$ = 57.0

τ_{Lx} = 0.19 [MPa]
τ_{Ly} = 0.24 [MPa]

Local skin buckling

$$\sigma_{cr} = 0{,}5\ \sqrt[3]{E_{lam}\ E_{core}\ G_{core}}$$

σ_{cr} = 147 [MPa]

Deflections

$$w = \frac{10^6\ p\ b^4}{\quad} C_6\ C_8 \rho\ C_7$$

C_6 = 11.1
C_7 = 12.0

w = 34.7 [mm]
w/b = 0.015

BL112.01

Sandwich panels calculations

KOCKUMS AB
Karlskronavarvet

Naval Surface Ships / Hull Dept.
Composites & Strength

DNV Sandwich Panel Calculation (HSLC Rules Pt.3 Ch.4 Sec.5)

Panel Designation: LÄSS DECK 10 INTERNAL **Date:** 2006-09-07

Panel Geometry

L_x	2.3	[m]	**Longest side:**	**a**	5.5	[m]	(Ly)
L_y	5.5	[m]	**Shortest side:**	**b**	2.25	[m]	(Lx)

Panel support: Partial edge fixity **Panel aspect ratio:** **b/a** 0.41

Laminate Data

Laminate type: #Referens! Vacuum infusion, 50 Vol%

Laminate thickness (t): 0.7 [mm] ($t_{nominal}$ (0.65 mm))

Laminate Safety Factor: 3.3

$\sigma_{nu,\ compr.}$	220	[MPa]
E_{lam}	17	[GPa]
ρ_{lam}	1830	[kg/m3]
$\sigma_{n,\ allowed}$	67	[MPa]

Core Data

Core type: Divinycell H60

Core thickness (t_c): 55 [mm] ($t_{nominal}$ (78 mm))

Core Safety Factor: 3.3

τ_u	0.6	[MPa]
E_{core}	45	[MPa]
G_{core}	15	[MPa]
ρ_{core}	60	[kg/m3]
$\tau_{allowed}$	0.18	[MPa]

Design Pressure (p): 6 [kPa] **Panel weight:** **5.7** **[kg/m^2]**

Normal stresses in skin laminates

$$\sigma_n = \frac{160\ p\ b^2}{W} C_N\ C_1$$

C_1 = 0.66, C_2 = 0.06, C_3 = 0.63
$C_{N,x}$ = 0.65, $C_{N,y}$ = 0.25, W = 36

σ_x = 55 [MPa]
σ_y = 21 [MPa]

Core shear stresses at midpoints of panel edges

$$\tau_c = \frac{0{,}52\ p\ b}{d} C_S$$

C_4 = 0.91, C_5 = 0.72
$C_{S,Lx}$ = 0.72, $C_{S,Ly}$ = 0.91
d = t + t_c = 55.7

τ_{Lx} = 0.09 [MPa]
τ_{Ly} = 0.11 [MPa]

Local skin buckling

$$\sigma_{cr} = 0{,}5\ \sqrt[3]{E_{lam}\ E_{core}\ G_{core}}$$

σ_{cr} = 113 [MPa]

Deflections

$$w = \frac{10^6\ p\ b^4}{\quad} [C_6\ C_8 + \rho\ C_7 [$$

C_6 = 11.1, C_7 = 12.0

w = 43.7 [mm]
w/b = 0.019

BL112.01

Sandwich panels calculations

KOCKUMS AB
Karlskronavarvet

Naval Surface Ships / Hull Dept.
Composites & Strength

DNV Sandwich Panel Calculation (HSLC Rules Pt.3 Ch.4 Sec.5)

Panel Designation: LÄSS DECK 9 AFT **Date:** 2006-09-07

Panel Geometry

L_x	5.5	[m]	**Longest side:**	**a**	5.5	[m]	(Lx)
L_y	3.0	[m]	**Shortest side:**	**b**	3	[m]	(Ly)

Panel support: Partial edge fixity **Panel aspect ratio:** **b/a** 0.55

Laminate Data

Laminate type: #Referens! Vacuum infusion, 50 Vol%

Laminate thickness (t): 3.3 [mm] ($t_{nominal}$ (0.65 mm))

Laminate Safety Factor: 3.3

$\sigma_{nu,\ compr.}$	220	[MPa]
E_{lam}	17	[GPa]
ρ_{lam}	1830	[kg/m3]
$\sigma_{n,\ allowed}$	67	[MPa]

Core Data

Core type: Divinycell H80

Core thickness (t_c): 55 [mm] ($t_{nominal}$ (70 mm))

Core Safety Factor: 3.3

τ_u	0.9	[MPa]
E_{core}	65	[MPa]
G_{core}	23	[MPa]
ρ_{core}	80	[kg/m3]
$\tau_{allowed}$	0.27	[MPa]

Design Pressure (p): 11 [kPa] **Panel weight:** **16.3** **[kg/m²]**

Normal stresses in skin laminates

$$\sigma_n = \frac{160\ p\ b^2}{W} C_N\ C_1$$

C_1 = 0.73, C_2 = 0.11, C_3 = 0.54
$C_{N,\ x}$ = 0.27, $C_{N,\ y}$ = 0.58, W = 189

σ_x = 17 [MPa]
σ_y = 35 [MPa]

Core shear stresses at midpoints of panel edges

$$\tau_c = \frac{0{,}52\ p\ b}{d} C_S$$

C_4 = 0.86, C_5 = 0.71
$C_{S,\ Lx}$ = 0.86, $C_{S,\ Ly}$ = 0.71, $d = t + t_c$ = 58.3

τ_{Lx} = 0.25 [MPa]
τ_{Ly} = 0.21 [MPa]

Local skin buckling

$$\sigma_{cr} = 0{,}5 \sqrt[3]{E_{lam}\ E_{core}\ G_{core}}$$

σ_{cr} = 147 [MPa]

Deflections

$$w = \frac{10^6\ p\ b^4}{\quad} C_6\ C_8 \rho\ C_7$$

C_6 = 9.7, C_7 = 11.4

w = 50.9 [mm]
w/b = 0.017

BL112.01

Sandwich panels calculations

KOCKUMS AB
Karlskronavarvet

Naval Surface Ships / Hull Dept.
Composites & Strength

DNV Sandwich Panel Calculation (HSLC Rules Pt.3 Ch.4 Sec.5)

Panel Designation: LÄSS DECK 9 SIDE **Date:** 2006-09-07

Panel Geometry

L_x	2.3	[m]	**Longest side:**	**a**	3	[m]	(Ly)
L_y	3.0	[m]	**Shortest side:**	**b**	2.25	[m]	(Lx)

Panel support: Partial edge fixity **Panel aspect ratio:** **b/a** 0.75

Laminate Data

Laminate type: #Referens! Vacuum infusion, 50 Vol%

Laminate thickness (t): 1.3 [mm] ($t_{nominal}$ (0.65 mm))

Laminate Safety Factor: 3.3

$\sigma_{nu,\ compr.}$	220	[MPa]
E_{lam}	17	[GPa]
ρ_{lam}	1830	[kg/m3]
$\sigma_{n,\ allowed}$	67	[MPa]

Core Data

Core type: Divinycell H60

Core thickness (t_c): 55 [mm] ($t_{nominal}$ (78 mm))

Core Safety Factor: 3.3

τ_u	0.6	[MPa]
E_{core}	45	[MPa]
G_{core}	15	[MPa]
ρ_{core}	60	[kg/m3]
$\tau_{allowed}$	0.18	[MPa]

Design Pressure (p): 11 [kPa] **Panel weight:** **8.1** **[kg/m²]**

Normal stresses in skin laminates

$$\sigma_n = \frac{160\ p\ b^2}{W} C_N\ C_1$$

C_1 = 0.84, C_2 = 0.18, C_3 = 0.41
$C_{N,\ x}$ = 0.46, $C_{N,\ y}$ = 0.30, W = 73

σ_x = 47 [MPa]
σ_y = 31 [MPa]

Core shear stresses at midpoints of panel edges

$$\tau_c = \frac{0{,}52\ p\ b}{d} C_S$$

C_4 = 0.77, C_5 = 0.69
$C_{S,\ Lx}$ = 0.69, $C_{S,\ Ly}$ = 0.77, $d = t + t_c$ = 56.3

τ_{Lx} = 0.16 [MPa]
τ_{Ly} = 0.18 [MPa]

Local skin buckling

$$\sigma_{cr} = 0{,}5\ \sqrt[3]{E_{lam}\ E_{core}\ G_{core}}$$

σ_{cr} = 113 [MPa]

Deflections

$$w = \frac{10^6\ p\ b^4}{\quad} C_6\ C_8 \rho\ C_7$$

C_6 = 7.3, C_7 = 10.0

w = 37.8 [mm]
w/b = 0.017

BL112.01

Sandwich panels calculations

KOCKUMS AB
Karlskronavarvet

Naval Surface Ships / Hull Dept.
Composites & Strength

DNV Sandwich Panel Calculation (HSLC Rules Pt.3 Ch.4 Sec.5)

Panel Designation: LÄSS DECK 9 FRONT **Date:** 2006-09-07

Panel Geometry

L_x	5.5	[m]	**Longest side:**	**a**	5.5	[m]	(Lx)
L_y	3.0	[m]	**Shortest side:**	**b**	3	[m]	(Ly)

Panel support: Partial edge fixity **Panel aspect ratio:** **b/a** 0.55

Laminate Data

Laminate type: #Referens! Vacuum infusion, 50 Vol%

Laminate thickness (t): 5.2 [mm] ($t_{nominal}$ (0.65 mm))

Laminate Safety Factor: 3.3

$\sigma_{nu,\ compr.}$	220	[MPa]
E_{lam}	17	[GPa]
ρ_{lam}	1830	[kg/m3]
$\sigma_{n,\ allowed}$	67	[MPa]

Core Data

Core type: Divinycell H130

Core thickness (t_c): 55 [mm] ($t_{nominal}$ (63 mm))

Core Safety Factor: 3.3

τ_u	1.7	[MPa]
E_{core}	130	[MPa]
G_{core}	40	[MPa]
ρ_{core}	130	[kg/m3]
$\tau_{allowed}$	0.52	[MPa]

Design Pressure (p): 22 [kPa] **Panel weight:** **26.2** **[kg/m²]**

Normal stresses in skin laminates

$$\sigma_n = \frac{160\, p\, b^2}{W} C_N\, C_1$$

C_1 = 0.73 C_2 = 0.11 C_3 = 0.54

$C_{N,\ x}$ = 0.27 $C_{N,\ y}$ = 0.58 W = 313

σ_x = 20 [MPa] **σ_y = 43 [MPa]**

Core shear stresses at midpoints of panel edges

$$\tau_c = \frac{0{,}52\, p\, b}{d} C_S$$

C_4 = 0.86 C_5 = 0.71

$C_{S,\ Lx}$ = 0.86 $C_{S,\ Ly}$ = 0.71 $d = t + t_c$ = 60.2

τ_{Lx} = 0.49 [MPa] **τ_{Ly} = 0.41 [MPa]**

Local skin buckling

$$\sigma_{cr} = 0{,}5 \sqrt[3]{E_{lam}\, E_{core}\, G_{core}}$$

σ_{cr} = 223 [MPa]

Deflections

$$w = \frac{10^6\, p\, b^4}{\quad} C_6\, C_8 \rho\, C_7$$

C_6 = 9.7 C_7 = 11.4

w = 59.1 [mm] **w/b = 0.020**

Sandwich panels calculations

KOCKUMS AB
Karlskronavarvet

Naval Surface Ships / Hull Dept.
Composites & Strength

DNV Sandwich Panel Calculation (HSLC Rules Pt.3 Ch.4 Sec.5)

Panel Designation: LÄSS
DECK 9 INTERNAL DECK

Date: 2006-09-07

Panel Geometry

L_x	2.3	[m]	**Longest side:**	**a**	5.5	[m]	(Ly)
L_y	5.5	[m]	**Shortest side:**	**b**	2.25	[m]	(Lx)

Panel support: Partial edge fixity **Panel aspect ratio:** **b/a** 0.41

Laminate Data

Laminate type: #Referens! Vacuum infusion, 50 Vol%

Laminate thickness (t): 0.7 [mm] ($t_{nominal}$ (0.65 mm))

Laminate Safety Factor: 3.3

$\sigma_{nu,\ compr.}$	220	[MPa]
E_{lam}	17	[GPa]
ρ_{lam}	1830	[kg/m3]
$\sigma_{n,\ allowed}$	67	[MPa]

Core Data

Core type: Divinycell H60

Core thickness (t_c): 55 [mm] ($t_{nominal}$ (78 mm))

Core Safety Factor: 3.3

τ_u	0.6	[MPa]
E_{core}	45	[MPa]
G_{core}	15	[MPa]
ρ_{core}	60	[kg/m3]
$\tau_{allowed}$	0.18	[MPa]

Design Pressure (p): 6 [kPa] **Panel weight:** **5.7** **[kg/m²]**

Normal stresses in skin laminates

$$\sigma_n = \frac{160\ p\ b^2}{W} C_N\ C_1$$

C_1 = 0.66
C_2 = 0.06
C_3 = 0.63

$C_{N,\ x}$ = 0.65
$C_{N,\ y}$ = 0.25
W = 36

σ_x = 55 [MPa]
σ_y = 21 [MPa]

Core shear stresses at midpoints of panel edges

$$\tau_c = \frac{0{,}52\ p\ b}{d} C_S$$

C_4 = 0.91
C_5 = 0.72

$C_{S,\ Lx}$ = 0.72
$C_{S,\ Ly}$ = 0.91
$d = t + t_c$ = 55.7

τ_{Lx} = 0.09 [MPa]
τ_{Ly} = 0.11 [MPa]

Local skin buckling

$$\sigma_{cr} = 0{,}5\ \sqrt[3]{E_{lam}\ E_{core}\ G_{core}}$$

σ_{cr} = 113 [MPa]

Deflections

$$w = \frac{10^6\ p\ b^4}{\quad} C_6\ C_8 \rho\ C_7$$

C_6 = 11.1
C_7 = 12.0

w = 43.7 [mm]
w/b = 0.019

BL112.01

Sandwich panels calculations

KOCKUMS AB
Karlskronavarvet

Naval Surface Ships / Hull Dept.
Composites & Strength

DNV Sandwich Panel Calculation (HSLC Rules Pt.3 Ch.4 Sec.5)

Panel Designation: LÄSS DECK 8 AFT **Date:** 2006-09-07

Panel Geometry

L_x	5.5	[m]	**Longest side:**	**a**	5.5	[m]	(Lx)
L_y	3.0	[m]	**Shortest side:**	**b**	3	[m]	(Ly)

Panel support: Partial edge fixity **Panel aspect ratio:** **b/a** 0.55

Laminate Data

Laminate type: #Referens! Vacuum infusion, 50 Vol%

Laminate thickness (t): 3.3 [mm] ($t_{nominal}$ (0.65 mm))

Laminate Safety Factor: 3.3

$\sigma_{nu,\ compr.}$	220	[MPa]
E_{lam}	17	[GPa]
ρ_{lam}	1830	[kg/m3]
$\sigma_{n,\ allowed}$	67	[MPa]

Core Data

Core type: Divinycell H80

Core thickness (t_c): 55 [mm] ($t_{nominal}$ (70 mm))

Core Safety Factor: 3.3

τ_u	0.9	[MPa]
E_{core}	65	[MPa]
G_{core}	23	[MPa]
ρ_{core}	80	[kg/m3]
$\tau_{allowed}$	0.27	[MPa]

Design Pressure (p): 11 [kPa] **Panel weight:** **16.3** **[kg/m²]**

Normal stresses in skin laminates

$$\sigma_n = \frac{160\ p\ b^2}{W} C_N\ C_1$$

C_1 = 0.73, C_2 = 0.11, C_3 = 0.54
$C_{N,\ x}$ = 0.27, $C_{N,\ y}$ = 0.58, W = 189

σ_x = 17 [MPa]
σ_y = 35 [MPa]

Core shear stresses at midpoints of panel edges

$$\tau_c = \frac{0{,}52\ p\ b}{d} C_S$$

C_4 = 0.86, C_5 = 0.71
$C_{S,\ Lx}$ = 0.86, $C_{S,\ Ly}$ = 0.71, $d = t + t_c$ = 58.3

τ_{Lx} = 0.25 [MPa]
τ_{Ly} = 0.21 [MPa]

Local skin buckling

$$\sigma_{cr} = 0{,}5\ \sqrt[3]{E_{lam}\ E_{core}\ G_{core}}$$

σ_{cr} = 147 [MPa]

Deflections

$$w = \frac{10^6\ p\ b^4}{\quad} C_6\ C_8 \rho\ C_7$$

C_6 = 9.7, C_7 = 11.4

w = 50.9 [mm]
w/b = 0.017

BL112.01

Sandwich panels calculations

KOCKUMS AB
Karlskronavarvet

Naval Surface Ships / Hull Dept.
Composites & Strength

DNV Sandwich Panel Calculation (HSLC Rules Pt.3 Ch.4 Sec.5)

Panel Designation: LÄSS DECK 8 SIDE **Date:** 2006-09-07

Panel Geometry

L_x	2.3	[m]	**Longest side:**	**a**	3	[m]	(Ly)
L_y	3.0	[m]	**Shortest side:**	**b**	2.25	[m]	(Lx)

Panel support: Partial edge fixity **Panel aspect ratio:** **b/a** 0.75

Laminate Data

Laminate type: #Referens! Vacuum infusion, 50 Vol%

Laminate thickness (t): 1.3 [mm] ($t_{nominal}$ (0.65 mm))

Laminate Safety Factor: 3.3

$\sigma_{nu,\ compr.}$	220	[MPa]
E_{lam}	17	[GPa]
ρ_{lam}	1830	[kg/m3]
$\sigma_{n,\ allowed}$	67	[MPa]

Core Data

Core type: Divinycell H60

Core thickness (t_c): 55 [mm] ($t_{nominal}$ (78 mm))

Core Safety Factor: 3.3

τ_u	0.6	[MPa]
E_{core}	45	[MPa]
G_{core}	15	[MPa]
ρ_{core}	60	[kg/m3]
$\tau_{allowed}$	0.18	[MPa]

Design Pressure (p): 11 [kPa] **Panel weight:** **8.1** **[kg/m²]**

Normal stresses in skin laminates

$$\sigma_n = \frac{160\ p\ b^2}{W} C_N\ C_1$$

C_1 = 0.84, C_2 = 0.18, C_3 = 0.41
$C_{N,\ x}$ = 0.46, $C_{N,\ y}$ = 0.30, W = 73

σ_x = 47 [MPa]
σ_y = 31 [MPa]

Core shear stresses at midpoints of panel edges

$$\tau_c = \frac{0{,}52\ p\ b}{d} C_S$$

C_4 = 0.77, C_5 = 0.69
$C_{S,\ Lx}$ = 0.69, $C_{S,\ Ly}$ = 0.77, $d = t + t_c$ = 56.3

τ_{Lx} = 0.16 [MPa]
τ_{Ly} = 0.18 [MPa]

Local skin buckling

$$\sigma_{cr} = 0{,}5\ \sqrt[3]{E_{lam}\ E_{core}\ G_{core}}$$

σ_{cr} = 113 [MPa]

Deflections

$$w = \frac{10^6\ p\ b^4}{\quad} C_6\ C_8 \rho\ C_7$$

C_6 = 7.3, C_7 = 10.0

w = 37.8 [mm]
w/b = 0.017

BL112.01

Sandwich panels calculations

KOCKUMS AB
Karlskronavarvet

Naval Surface Ships / Hull Dept.
Composites & Strength

DNV Sandwich Panel Calculation (HSLC Rules Pt.3 Ch.4 Sec.5)

Panel Designation: LÄSS DECK 8 FRONT **Date:** 2006-09-07

Panel Geometry

L_x	5.5	[m]	**Longest side:**	**a**	5.5	[m]	(Lx)
L_y	3.0	[m]	**Shortest side:**	**b**	3	[m]	(Ly)

Panel support: Partial edge fixity **Panel aspect ratio:** **b/a** 0.55

Laminate Data

Laminate type: #Referens! Vacuum infusion, 50 Vol%

Laminate thickness (t): 5.2 [mm] ($t_{nominal}$ (0.65 mm))

Laminate Safety Factor: 3.3

$\sigma_{nu,\ compr.}$	220	[MPa]
E_{lam}	17	[GPa]
ρ_{lam}	1830	[kg/m3]
$\sigma_{n,\ allowed}$	67	[MPa]

Core Data

Core type: Divinycell H130

Core thickness (t_c): 55 [mm] ($t_{nominal}$ (63 mm))

Core Safety Factor: 3.3

τ_u	1.7	[MPa]
E_{core}	130	[MPa]
G_{core}	40	[MPa]
ρ_{core}	130	[kg/m3]
$\tau_{allowed}$	0.52	[MPa]

Design Pressure (p): 22 [kPa] **Panel weight:** **26.2** **[kg/m²]**

Normal stresses in skin laminates

$$\sigma_n = \frac{160\, p\, b^2}{W} C_N\, C_1$$

C_1 = 0.73
C_2 = 0.11
C_3 = 0.54

$C_{N,\ x}$ = 0.27
$C_{N,\ y}$ = 0.58
W = 313

σ_x = 20 [MPa]
σ_y = 43 [MPa]

Core shear stresses at midpoints of panel edges

$$\tau_c = \frac{0{,}52\, p\, b}{d} C_S$$

C_4 = 0.86
C_5 = 0.71

$C_{S,\ Lx}$ = 0.86
$C_{S,\ Ly}$ = 0.71
$d = t + t_c$ = 60.2

τ_{Lx} = 0.49 [MPa]
τ_{Ly} = 0.41 [MPa]

Local skin buckling

$$\sigma_{cr} = 0{,}5 \sqrt[3]{E_{lam}\, E_{core}\, G_{core}}$$

σ_{cr} = 223 [MPa]

Deflections

$$w = \frac{10^6\, p\, b^4}{\quad} C_6\, C_8 + \rho\, C_7$$

C_6 = 9.7
C_7 = 11.4

w = 59.1 [mm]
w/b = 0.020

BL112.01

Sandwich panels calculations

KOCKUMS AB
Karlskronavarvet

Naval Surface Ships / Hull Dept.
Composites & Strength

DNV Sandwich Panel Calculation (HSLC Rules Pt.3 Ch.4 Sec.5)

Panel Designation: LÄSS
DECK 8 INTERNAL DECK

Date: 2006-09-07

Panel Geometry

L_x	2.3	[m]	**Longest side:**	**a**	5.5	[m]	(Ly)
L_y	5.5	[m]	**Shortest side:**	**b**	2.25	[m]	(Lx)

Panel support: Partial edge fixity **Panel aspect ratio:** **b/a** 0.41

Laminate Data

Laminate type: #Referens! Vacuum infusion, 50 Vol%

Laminate thickness (t): 0.7 [mm] ($t_{nominal}$ (0.65 mm))

Laminate Safety Factor: 3.3

$\sigma_{nu,\ compr.}$	220	[MPa]
E_{lam}	17	[GPa]
ρ_{lam}	1830	[kg/m3]
$\sigma_{n,\ allowed}$	67	[MPa]

Core Data

Core type: Divinycell H60

Core thickness (t_c): 55 [mm] ($t_{nominal}$ (78 mm))

Core Safety Factor: 3.3

τ_u	0.6	[MPa]
E_{core}	45	[MPa]
G_{core}	15	[MPa]
ρ_{core}	60	[kg/m3]
$\tau_{allowed}$	0.18	[MPa]

Design Pressure (p): 6 [kPa] **Panel weight:** **5.7** **[kg/m²]**

Normal stresses in skin laminates

$$\sigma_n = \frac{160\ p\ b^2}{W} C_N\ C_1$$

C_1 = 0.66
C_2 = 0.06
C_3 = 0.63

$C_{N,\ x}$ = 0.65
$C_{N,\ y}$ = 0.25
W = 36

σ_x = 55 [MPa]
σ_y = 21 [MPa]

Core shear stresses at midpoints of panel edges

$$\tau_c = \frac{0{,}52\ p\ b}{d} C_S$$

C_4 = 0.91
C_5 = 0.72

$C_{S,\ Lx}$ = 0.72
$C_{S,\ Ly}$ = 0.91
$d = t + t_c$ = 55.7

τ_{Lx} = 0.09 [MPa]
τ_{Ly} = 0.11 [MPa]

Local skin buckling

$$\sigma_{cr} = 0{,}5\ \sqrt[3]{E_{lam}\ E_{core}\ G_{core}}$$

σ_{cr} = 113 [MPa]

Deflections

$$w = \frac{10^6\ p\ b^4}{\quad} C_6\ C_8 \rho\ C_7$$

C_6 = 11.1
C_7 = 12.0

w = 43.7 [mm]
w/b = 0.019

Sandwich panels calculations

KOCKUMS AB
Karlskronavarvet

Naval Surface Ships / Hull Dept.
Composites & Strength

DNV Sandwich Panel Calculation (HSLC Rules Pt.3 Ch.4 Sec.5)

Panel Designation: LÄSS DECK 7 AFT **Date:** 2006-09-07

Panel Geometry

L_x	5.5	[m]	**Longest side:**	**a**	5.5	[m]	(Lx)
L_y	3.0	[m]	**Shortest side:**	**b**	3	[m]	(Ly)

Panel support: Partial edge fixity **Panel aspect ratio:** **b/a** 0.55

Laminate Data

Laminate type: #Referens! Vacuum infusion, 50 Vol%

Laminate thickness (t): 3.3 [mm] ($t_{nominal}$ (0.65 mm))

Laminate Safety Factor: 3.3

$\sigma_{nu,\ compr.}$	220	[MPa]
E_{lam}	17	[GPa]
ρ_{lam}	1830	[kg/m3]
$\sigma_{n,\ allowed}$	67	[MPa]

Core Data

Core type: Divinycell H80

Core thickness (t_c): 55 [mm] ($t_{nominal}$ (70 mm))

Core Safety Factor: 3.3

τ_u	0.9	[MPa]
E_{core}	65	[MPa]
G_{core}	23	[MPa]
ρ_{core}	80	[kg/m3]
$\tau_{allowed}$	0.27	[MPa]

Design Pressure (p): 11 [kPa] **Panel weight:** **16.3** **[kg/m²]**

Normal stresses in skin laminates

$$\sigma_n = \frac{160\ p\ b^2}{W} C_N\ C_1$$

C_1 = 0.73, C_2 = 0.11, C_3 = 0.54
$C_{N,\ x}$ = 0.27, $C_{N,\ y}$ = 0.58, W = 189

σ_x = 17 [MPa]
σ_y = 35 [MPa]

Core shear stresses at midpoints of panel edges

$$\tau_c = \frac{0{,}52\ p\ b}{d} C_S$$

C_4 = 0.86, C_5 = 0.71
$C_{S,\ Lx}$ = 0.86, $C_{S,\ Ly}$ = 0.71, $d = t + t_c$ = 58.3

τ_{Lx} = 0.25 [MPa]
τ_{Ly} = 0.21 [MPa]

Local skin buckling

$$\sigma_{cr} = 0{,}5\ \sqrt[3]{E_{lam}\ E_{core}\ G_{core}}$$

σ_{cr} = 147 [MPa]

Deflections

$$w = \frac{10^6\ p\ b^4}{\quad} C_6\ C_8 \rho\ C_7$$

C_6 = 9.7, C_7 = 11.4

w = 50.9 [mm]
w/b = 0.017

BL112.01

Sandwich panels calculations

KOCKUMS AB
Karlskronavarvet

Naval Surface Ships / Hull Dept.
Composites & Strength

DNV Sandwich Panel Calculation (HSLC Rules Pt.3 Ch.4 Sec.5)

Panel Designation: LÄSS DECK 7 SIDE **Date:** 2006-09-07

Panel Geometry

L_x	2.3	[m]	**Longest side:**	**a**	3	[m]	(Ly)
L_y	3.0	[m]	**Shortest side:**	**b**	2.25	[m]	(Lx)

Panel support: Partial edge fixity **Panel aspect ratio:** **b/a** 0.75

Laminate Data

Laminate type: #Referens! Vacuum infusion, 50 Vol%

Laminate thickness (t): 1.3 [mm] ($t_{nominal}$ (0.65 mm))

Laminate Safety Factor: 3.3

$\sigma_{nu,\ compr.}$	220	[MPa]
E_{lam}	17	[GPa]
ρ_{lam}	1830	[kg/m3]
$\sigma_{n,\ allowed}$	67	[MPa]

Core Data

Core type: Divinycell H60

Core thickness (t_c): 55 [mm] ($t_{nominal}$ (78 mm))

Core Safety Factor: 3.3

τ_u	0.6	[MPa]
E_{core}	45	[MPa]
G_{core}	15	[MPa]
ρ_{core}	60	[kg/m3]
$\tau_{allowed}$	0.18	[MPa]

Design Pressure (p): 11 [kPa] **Panel weight:** **8.1** **[kg/m²]**

Normal stresses in skin laminates

$$\sigma_n = \frac{160\, p\, b^2}{W} C_N\, C_1$$

C_1 = 0.84, C_2 = 0.18, C_3 = 0.41
$C_{N,\ x}$ = 0.46, $C_{N,\ y}$ = 0.30, W = 73

σ_x = 47 [MPa]
σ_y = 31 [MPa]

Core shear stresses at midpoints of panel edges

$$\tau_c = \frac{0{,}52\, p\, b}{d} C_S$$

C_4 = 0.77, C_5 = 0.69
$C_{S,\ Lx}$ = 0.69, $C_{S,\ Ly}$ = 0.77, $d = t + t_c$ = 56.3

τ_{Lx} = 0.16 [MPa]
τ_{Ly} = 0.18 [MPa]

Local skin buckling

$$\sigma_{cr} = 0{,}5 \sqrt[3]{E_{lam}\, E_{core}\, G_{core}}$$

σ_{cr} = 113 [MPa]

Deflections

$$w = \frac{10^6\, p\, b^4}{\quad} C_6\, C_8 \rho\, C_7$$

C_6 = 7.3, C_7 = 10.0

w = 37.8 [mm]
w/b = 0.017

BL112.01

Sandwich panels calculations

KOCKUMS AB
Karlskronavarvet

Naval Surface Ships / Hull Dept.
Composites & Strength

DNV Sandwich Panel Calculation (HSLC Rules Pt.3 Ch.4 Sec.5)

Panel Designation: LÄSS DECK 7 FRONT **Date:** 2006-09-07

Panel Geometry

L_x	5.5	[m]	**Longest side:**	**a**	5.5	[m]	(Lx)
L_y	3.0	[m]	**Shortest side:**	**b**	3	[m]	(Ly)

Panel support: Partial edge fixity **Panel aspect ratio:** **b/a** 0.55

Laminate Data

Laminate type: #Referens! Vacuum infusion, 50 Vol%

Laminate thickness (t): 5.2 [mm] ($t_{nominal}$ (0.65 mm))

Laminate Safety Factor: 3.3

$\sigma_{nu,\ compr.}$	220	[MPa]
E_{lam}	17	[GPa]
ρ_{lam}	1830	[kg/m3]
$\sigma_{n,\ allowed}$	67	[MPa]

Core Data

Core type: Divinycell H130

Core thickness (t_c): 55 [mm] ($t_{nominal}$ (63 mm))

Core Safety Factor: 3.3

τ_u	1.7	[MPa]
E_{core}	130	[MPa]
G_{core}	40	[MPa]
ρ_{core}	130	[kg/m3]
$\tau_{allowed}$	0.52	[MPa]

Design Pressure (p): 22 [kPa] **Panel weight:** **26.2** **[kg/m²]**

Normal stresses in skin laminates

$$\sigma_n = \frac{160\, p\, b^2}{W} C_N\, C_1$$

C_1 = 0.73, C_2 = 0.11, C_3 = 0.54
$C_{N,\ x}$ = 0.27, $C_{N,\ y}$ = 0.58, W = 313

σ_x = 20 [MPa]
σ_y = 43 [MPa]

Core shear stresses at midpoints of panel edges

$$\tau_c = \frac{0{,}52\, p\, b}{d} C_S$$

C_4 = 0.86, C_5 = 0.71
$C_{S,\ Lx}$ = 0.86, $C_{S,\ Ly}$ = 0.71, $d = t + t_c$ = 60.2

τ_{Lx} = 0.49 [MPa]
τ_{Ly} = 0.41 [MPa]

Local skin buckling

$$\sigma_{cr} = 0{,}5 \sqrt[3]{E_{lam}\, E_{core}\, G_{core}}$$

σ_{cr} = 223 [MPa]

Deflections

$$w = \frac{10^6\, p\, b^4}{\quad} C_6\, C_8 \rho\, C_7$$

C_6 = 9.7, C_7 = 11.4

w = 59.1 [mm]
w/b = 0.020

BL112.01