Appendix to report:

SBJ-33-C5-OON-22-RE-017

DESIGN OF BRIDGE GIRDER

Appendix title:

APPENDIX C – OPTIMALIZATION STUDY OF BOTTOM PLATE STIFFENERS

Contract no:	18/91094
Project number:	5187772/12777
Document number:	SBJ-33-C5-OON-22-RE-017 App. C
Date:	15.08.2019
Revision:	0
Number of pages:	33
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CONCEPT DEVELOPMENT FLOATING BRIDGE E39 BJØRNAFJORDEN

Table of Content

1 INTRODUCTION

1.1 Motivation

This study investigates the potential of changing/reducing the stiffeners in the bottom plate of the girder in the mid span where the compressional stresses are smaller. The bridge section considered ranges from 1360 m and 3850 m and has the cross section BCS1, with type 2A stiffeners. In the analysis, certain axial stress levels have been tested on the cross section between stress point P3 and P5. The stress levels tested are -200 MPa, -100 MPa, -50 MPa. Spacing between the stiffeners and the bottom width are held constant while stiffener profile and stiffener cross section has been changed. The profile tested are variations of T-profile, bulbflats-profile and trapezoidal profile.

1.2 Assumptions

The results are based on a constant axial stress distribution between P3 and P5, as this is the most critical situation for the tested stresses. Parts of the stress are a result of axial forces, but in the calculations, it is assumed that all stresses are caused by bending moment, M_y. This because it simplifies later calculations of changes in stress due to reduction in cross section.

In the analysis, external pressure and stress in the transverse direction have been set equal to zero. The distance between sideways support of stiffener/torsional buckling length is kept constant and equal to the length between the cross frames in the girder.

2 ANALYSIS

2.1 Input

A STIPLA analysis has been performed, in accordance with DNV-RP-C201, with input shown in tables below:

Material Properties	
Safety factor for cross section resistance	γm = 1,10
Young's modulus	E = 210000 MPa
Yield strength for plate thickness t ≤ 40mm	f_{y_p} = 420 MPa
Yield strength for trapezoidal stiffeners.	f_{y_s} = 420 MPa
Yield strength for T-profile stiffeners	f_{y_s} = 420 MPa
Yield strength for HP Bulbflats profile	f_{y_s} = 355 MPa

Geometry	
Length between the cross frames in the box girder	L = 4000 mm
Width of the considered cross section, in this case between P3 and P5	Lg = 16500 mm
Plate thickness	t = 12 mm
Stiffener spacing	s1 = s2 = 600 mm
Lat tors buckl length	Lt = 4000 mm

2.2 Span length for the tested stress levels

The corresponding span length for which the tested stress levels occur are given in the table below. The distances are estimated from the global response analyses for the bridge in the range between 1360 m and 3850 m (OO interactive), and it can therefore be some deviations from theoretical values.

Load combination	Axial stress	Length
Comb. 31	- 200 MPa	100 m
	- 100 MPa	70 m
	- 50 MPa	45 m

Comb. 32	- 200 MPa	104 m
	- 100 MPa	60 m
	- 50 MPa	40 m
Comb. 33	- 200 MPa	90 m
	- 100 MPa	55 m
	- 50 MPa	20 m
Comb. 34	- 200 MPa	100 m
	- 100 MPa	60 m
	- 50 MPa	40 m

2.3 Original cross section properties

Table below shows data for original bridge box cross section BCS1 with stiffener type 2A in the bottom part. The values differ slightly from the values from the bridge girder design report, SBJ-33-C5-OON-22-RE-017. This because the values are calculated based on a spreadsheet which do not consider all the details, but the difference is small. Later, the cross section has been updated in upper area of the box girder and one stiffener has been added in the lower section, and therefor the real cross section area is larger than the area used in this report. This will have a small effect on the results, as they are based on changes in area in the lower part of the girder.

Bridge box BCS1	**Symbol**	**Value**
Cross section area	A	1,468 m^2
Moment of inertia weak axis	I_y	2,737 m^4
Distance from bottom of cross section to NA	z_c	1,91 m
Plate thickness, bottom plate	t	12 mm

2.4 Axial stress and shear stress in the analysis

2.4.1 Axial stress

By changing the stiffeners, the neutral axis also changes relative to the original cross section. The stress which occurs in the considered part of the bridge section becomes larger, and the stress have to be re-calculated based on the new neutral axis. The new stress is found by assuming that the tested stresses {-200, -100, -50} MPa are a result of the bending moment, My, alone. The bending moment acting on the original cross section due to the given stresses is equal to the bending moment acting on the modified cross section. Thus, the new stresses due to change in stiffeners can be calculated using $\sigma_x = \frac{M_y}{I_y} * z$. See section 6.1 details.

The table below shows the bending moment corresponding to the tested stress levels.

Axial stress	**Bending moment, M_y**

- 200 MPa	- 286,7 kNm
- 100 MPa	- 143,4 kNm
- 50 MPa	- 71,7 kNm

Note: The values of bending moment and new stresses will vary a little from the values when using the updated cross section.

2.4.2 Shear stress

An estimate gives that most occurring shear stress is around 72 MPa. This is based on the most occurring value of the torsional moment and shear force in y-direction on the interval between 1400 m and 3800 m, respectively 125 MNm and 5 MN. Between 3400 m and 3900 m there is an increase in torsional moment by a factor of 1,24. In this area, the shear stress will be higher than 60 MPa, and the results will not here. See section 6.2 for calculation details.

3 RESULTS

Original stiffener, type 2A (Trapezoidal 300x150/75x8,0), does not meet Stiplas local buckling check, which is based on recommendations and requirements in DNV-RP-C201 for buckling check of plated structures. The buckling checks in DNV-RP-C201 assumes a cross section class 3 for the stiffeners, which is not fulfilled for trapezoidal-stiffener 2A, hence the trapezoidal-stiffener must be treated as a cross section of class 4. This is not persued further in this report, reference is made to bridge girder design report, SBJ-33-C5-OON-22-RE-017. This stiffener 2A is used in the original cross section area, so the results below are based on this stiffener. In the considered interval, between 1360 m and 3850 m, there are 22 pontoons supporting the bridge girder. When excluding the area with increasing torsional moment, it gives 17 spans of 120 m. The calculations are based on a cross section with 27 stiffeners in the considered section of the bridge girder. Note that the updated cross section has 28 stiffeners. See section **Error! Reference source not found.** for drawings of updated cross section with stiffners in the bottom part from the results.

For a summery of the results, se section 3.5.

Note: Results have not been checked against NS-EN 1993-1-5:2006+NA:2009

3.1 T-profile

The table below shows modified geometry:

Plate thickness: 12 mm	T200x150x10x20	T200x120x10x13	T150x100x8x10	T150x100x6x7
New cross section area	A = 1,436	A = 1,399 m^2	A = 1,363 m^2	A = 1,348 m^2
New moment of inertia weak axis	I_y = 2,649 m^4	I_y = 2,533 m^4	I_y = 2,416 m^4	I_y = 2,360 m^4
New distance from bottom of cross section to NA	z_c = 1,94 m	z_c = 1,99 m	z_c = 2,04 m	z_c = 2,06 m

The table shows a summary of the STIPLA analysis, see section **Error! Reference source not found.** details:

Axial stress	Shear stress	Profile	New axial stress	Buckling	Buckling + Yield	Local buckling
-200 MPa	72 MPa	T200x150x10x20	-210 MPa	Ok	OK	OK
-100 MPa	72 MPa	T200x120x10x13	-113 MPa	OK	OK	OK
-100 MPa	72 MPa	T150x100x8x10	-121 MPa	OK	OK	Ok
-100 MPa	72 MPa	T150x100x6x7	-125 MPa	Ok	Ok	OK

By setting Lt = 1600 mm, the T200x120x10x13 would be OK for a stress of 200 MPa. The changes because of this are not calculated here.

The table below shows the impact the different stiffeners have on the area:

Profile	Reduction in area*	Length	Reduction in steel weight pr. 120 m
T200x150x10x20	0,032 m^2	90 m	22,6 ton

T200x120x10x13	0,069 m^2	55 m	29,7 ton
T150x100x8x10	0,105 m^2	55 m	45,3 ton
T150x100x6x7	0,120 m^2	55 m	51,8 ton

*This reduction is in the section where the stiffeners are changed, and is not an average reduction over the span of 120 m.

Note: The lengths are roughly read from the stress profile (Comb. 31-34), and it can therefore be some deviations from the real value.

3.2 Bulbflats-profile

The table below shows modified geometry:

Plate thickness: 12 mm	BF 300x11	BF 160x9	BF 140x7
New cross section area	A = 1,432 m^2	A = 1,354 m^2	A = 1,340 m^2
New moment of inertia weak axis	I_y = 2,622 m^4	I_y = 2,384 m^4	I_y = 2,330 m^4
New distance from bottom of cross section to NA	z_c = 1,95 m	z_c = 2,05 m	z_c = 2,07 m

The table shows a summary of the STIPLA analysis, see section **Error! Reference source not found.** details:

Axial stress	Shear stress	Profile	New axial stress	Buckling	Buckling + Yield	Local buckling
-200 MPa	72 MPa	BF 300x11	-213 MPa	OK	OK	OK
-100 MPa	72 MPa	BF 160x9	-123 MPa	Ok	OK	OK
-50 MPa	72 MPa	BF 140x7	-64 MPa	OK	OK	OK

The table below shows the impact the different stiffeners have on the area:

Profile	Reduction in area*	Length	Reduction in steel weight pr. 120 m
BF 300x11	0,036 m^2	90 m	25,4 ton
BF 160x9	0,114 m^2	55 m	49,2 ton
BF 140x7	0,128 m^2	20 m	20,1 ton

*This reduction is in the section where the stiffeners are changed, and is not an average reduction over the span of 120 m.

Note: The lengths are roughly read from the stress profile (Comb. 31-34), and it can therefore be some deviations from the real value.

3.3 Trapezoidal-profile

The table below shows modified geometry:

Plate thickness: 12 mm	**Trapezoidal 200x100/50x8**	**Trapezoidal 150x60/30x5**	**Trapezoidal 115x50/25x5**
New cross section area	A = 1,413 m^2	A = 1,354 m^2	A = 1,343 m^2
New moment of inertia weak axis	I_y = 2,590 m^4	I_y = 2,386 m^4	I_y = 2,346 m^4
New distance from bottom of cross section to NA	z_c = 1,97 m	z_c = 2,05 m	z_c = 2,06 m

The table shows a summary of the STIPLA analysis, see section **Error! Reference source not found.** details:

Axial stress	**Shear stress**	**Profile**	**New axial stress**	**Buckling**	**Buckling + Yield**	**Local buckling**
-200 MPa	72 MPa	Trapezoidal 200x100/50x8	-218 MPa	OK	OK	OK
-100 MPa	72 MPa	Trapezoidal 150x60/30x5	-123 MPa	Ok	OK	OK
-50 MPa	72 MPa	Trapezoidal 115x50/25x5	-63 MPa	OK	OK	OK

The table below shows the impact the different stiffeners have on the area:

Profile	**Reduction in area**	**Length**	**Reduction in steel weight pr. 120 m**
Trapezoidal 200x100/50x8	0,055 m^2	90 m	38,8 ton
Trapezoidal 150x60/30x5	0,114 m^2	55 m	49,2 ton
Trapezoidal 115x50/25x5	0,125 m^2	20 m	19,6 ton

*This reduction is in the section where the stiffeners are changed, and is not an average reduction over the span of 120 m.

Note: The lengths are roughly read from the stress profile (Comb. 31-34), and it can therefore be some deviations from the real value.

3.4 Plate thickness

It is also possible to reduce the plate thickness from 12 mm to 8 mm, which is the minimum requirement according to N400 Bruprosjektering (N400 Bruprosjektering, 8.10.2.1 Platetykkelser). If so, the stiffeners above does not apply.

Table shows modified geometry:

Plate thickness: 8 mm	Stiffener type 2A (Trapezoidal 300x150/75x8)	Trapezoidal 175x50/25x8
New cross section area	A = 1,402 m^2	A = 1,324 m^2
New moment of inertia weak axis	I_y = 2,489 m^4	I_y = 2,239 m^4
New distance from bottom of cross section to NA	z_c = 1,99 m	z_c = 2,10 m

A summary of the STIPLA analysis for plate thickness 8 mm, se section **Error! Reference source not found.** for details:

Axial stress	Shear stress	Profile	New axial stress	Buckling	Buckling + Yield	Local buckling
-200 MPa	72 MPa	Trapezoidal 300x150/75x8	-230 MPa	OK	OK	**Not OK**
-100 MPa	72 MPa	Trapezoidal 175x50/25x8	-135 MPa	OK	OK	OK

The STIPLA analysis shows that the original stiffeners are OK for "Buckling" and "Buckling + Yield" for stiffener spacing of 1200 mm. This gives a reduction in area of 0,084 m^2. Local buckling check is still not OK according to DNV-RP-C201, which assumes a cross section class 3, hence the trapezoidal-stiffener will be of cross section class 4. This is not persued further in this report, reference is made to bridge girder design report, SBJ-33-C5-OON-22-RE-017.

The table below shows the impact the different stiffeners have on the area:

Profile	Reduction in area*	Length	Reduction in steel weight pr. 120 m
Trapezoidal 300x150/75x8	0,066 m^2	90 m	46,6 ton
Trapezoidal 175x50/25x8	0,144	55 m	62,1 ton

*This reduction is in the section where the stiffeners are changed, and is not an average reduction over the span of 120 m.

3.5 Summary of the results

	Profile	Reduction in area*	Length	Reduction in steel weight pr. 120 m
T-profile	T200x150x10x20	0,032 m^2	90 m	22,6 ton
	T200x120x10x13	0,069 m^2	55 m	29,7 ton
	T150x100x8x10	0,105 m^2	55 m	45,3 ton
	T150x100x6x7	0,120 m^2	55 m	51,8 ton
Bulbflats-profile	BF 300x11	0,036 m^2	90 m	25,4 ton
	BF 160x9	0,114 m^2	55 m	49,2 ton
	BF 140x7	0,128 m^2	20 m	20,1 ton
Trapezoidal-profile:	Trapezoidal 200x100/50x8	0,055 m^2	90 m	38,8 ton
	Trapezoidal 150x60/30x5	0,114 m^2	55 m	49,2 ton
	Trapezoidal 115x50/25x5	0,125 m^2	20 m	19,6 ton
Plate thickness 8 mm	Trapezoidal 300x150/75x8 (stiffeners type 2A)	0,066 m^2	90 m	46,6 ton
	Trapezoidal 175x50/25x8	0,144	55 m	62,1 ton

3.6 Reduction in bending moment

The table below shows the reduction in bending moment at the supports because of reduction in cross section. In the calculations, only self weight is considered, and the original bending moment at the supports is calculated to be 163 MNm by using the original cross section. The considered part of the bridge is simplified to a continuous beam with constant EI. In fact, the bending stiffness, EI, will vary over the span because the change in cross section happens over a shorter length than 120 m. The variation is small and will have little to say in relation to total bending moment. See section **Error! Reference source not found.** for details.

	Profile	Reduction in bending moment at the supports, ΔM	Reduction in %
T-profile	T200x150x10x20	2,66 MNm	1,63 %
	T200x120x10x13	3,51 MNm	2,15 %
	T150x100x8x10	5,34 MNm	3,28 %
	T150x100x6x7	6,10 MNm	3,75 %
Bulbflats-profile	BF 300x11	2,99 MNm	1,84 %
	BF 160x9	5,79 MNm	3,56 %
	BF 140x7	2,37 MNm	1,45 %
Trapezoidal-profile:	Trapezoidal 200x100/50x8	4,57 MNm	2,81 %
	Trapezoidal 150x60/30x5	5,79 MNm	3,56 %
	Trapezoidal 115x50/25x5	2,31 MNm	1,42 %
Plate thickness 8 mm	Trapezoidal 300x150/75x8	5,49 MNm	3,37 %
	Trapezoidal 175x50/25x8	7,32 MNm	4,50 %

4 STIPLA ANALYSES

4.1 T-profile

DNVRPS

Plate/Stiff check based on DNV-RP-C201
Version 2.2
Copyright (C) 2004-2014 StruProg AB

Project: Sensitivitetsstudie stiverkasse | Page: 1/1
Identification: Bjørnafjorden fase 5 | Date: 28.06.2019 | Time: 10:7
File: c:\program files (x86)\struprog 2014\stipla dnvrp db\stivere.drps

Safety Format/Material:

Design Condition:			LRFD	
Allowable Usage Factor:	UF	=	1,00	
Material Factor:	gm	=	1,10	
Plate/Stiffener:			General/General	
Yield stress	fyp/fys	=	420/420	MPa
Youngs modulus	E	=	2,10E+5	MPa

General:

Buckling length	Lk	=	4000	mm
Mom fact - Field	km2	=	24,0	
- Support	km1	=	12,0	
Continuous stiffener				

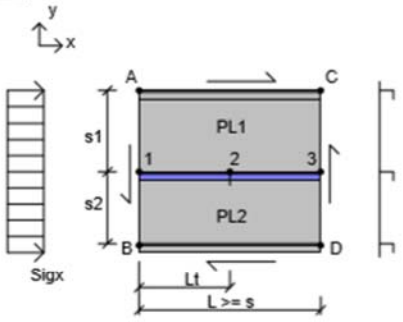
Geometry:

Stiffener span	L	=	4000	mm
Length of girder	Lg	=	16500	mm
Plate thickness	t	=	12,0	mm
Stiffener spacing	s1	=	600	mm
	s2	=	600	mm
Lat tors buckl length	Lt	=	4000	mm

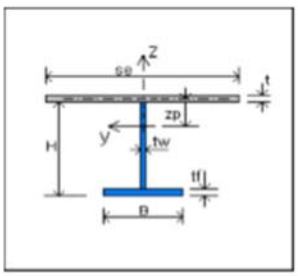
Stresses:

SigxA	=	-125,0	MPa
SigxB	=	-125,0	MPa
SigyA	=	0,0	MPa
SigyC	=	0,0	MPa
Tau	=	72,0	MPa

Figure:



Stiffener: T 150x100x6,0x7,0



Stiffener property:

H	=	150	mm
B	=	100	mm
tw	=	6,0	mm
tf	=	7,0	mm
A	=	1558	mm2
g	=	12,2	kg/m
ez	=	105,2	mm
Iy	=	3,633E+6	mm4
Iz	=	5,833E+5	mm4

Incl. eff. plate:

se	=	415,3	mm
zp	=	26,5	mm
Ae	=	6,542E+3	mm2
Ie	=	1,837E+7	mm4
Wep	=	6,936E+5	mm3
Wes	=	1,418E+5	mm3

Flange: c = 47,0 <= 73,3 OK (Eq 9.1)
Web: hw = 143,0 <= 188,5 OK (Eq 9.2)

STIFFENER BUCKLING CHECK (DNV-RP-C201): (1 = Support, 2 = field; s = stiffener, p = plate)

se = 415,3 mm Sigxsd = -125,0 MPa Sigysd = 0,0 MPa p0 = 0,000 MPa z* = 8,0 mm

UF1s=Nsd/Nks1Rd+(M1Sd-NSd*z)/(Ms1Rd*(1-Nsd/Ne))+u = 1094,8/899,3+(0,0-1094,8*0,008)/(48,3*(1-1094,8/2379,6))+0,107 = 0,99 < 1,00 (Eq 7.50)

UF1p=Nsd/Nkp1Rd-2*NSd/N1Rd+(M1Sd-Nsd*z*)/(Mp1Rd*(1-Nsd/Ne))+u = 1094,8/1336,2-2*1094,8/2497,8+(0,0-1094,8*0,008)/(264,8*(1-1094,8/2379,6))+0,107 = -0,01 < 1,00 (Eq 7.51)

UF2s=Nsd/Nks2Rd-2*NSd/NRd+(M2Sd+NSd*z)/(Mst2Rd*(1-Nsd/Ne))+u = 1094,8/899,3-2*1094,8/2497,8+(0,0+1094,8*0,008)/(54,2*(1-1094,8/2379,6))+0,107 = 0,75 < 1,00 (Eq 7.52)

UF2p=Nsd/Nkp2Rd+(M2Sd+NSd*z)/(Mp2Rd*(1-Nsd/Ne))+u = 1094,8/1336,2+(0,0+1094,8*0,008)/(264,8*(1-1094,8/2379,6))+0,107 = 0,99 < 1,00 (Eq 7.53)

DNVRPS	Project: Sensitivitetsstudie stiverkasse	Page: 1/1
Plate/Stiff check based on DNV-RP-C201 Version 2.2 Copyright (C) 2004-2014 StruProg AB	Identification: Bjørnafjorden fase 5	Date: 28.06.2019 Time: 10:5
File: c:\program files (x86)\struprog 2014\stipla dnvrp db\stivere.drps		

Safety Format/Material:

Design Condition:			LRFD
Allowable Usage Factor:	UF	=	1,00
Material Factor:	gm	=	1,10
Plate/Stiffener:			General/General
Yield stress	fyp/fys	=	420/420 MPa
Youngs modulus	E	=	2,10E+5 MPa

General:

Buckling length	Lk	=	4000 mm
Mom fact - Field	km2	=	24,0
- Support	km1	=	12,0
Continuous stiffener			

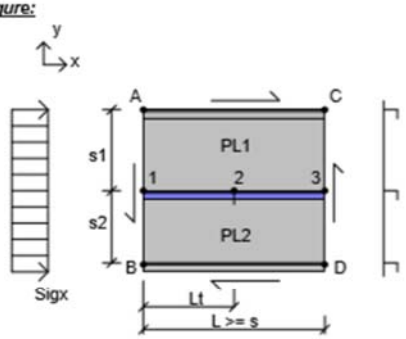
Geometry:

Stiffener span	L	=	4000 mm
Length of girder	Lg	=	16500 mm
Plate thickness	t	=	12,0 mm
Stiffener spacing	s1	=	600 mm
	s2	=	600 mm
Lat tors buckl length	Lt	=	4000 mm

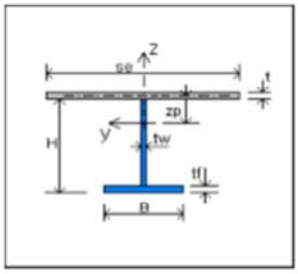
Stresses:

SigxA	=	-121,0 MPa
SigxB	=	-121,0 MPa
SigyA	=	0,0 MPa
SigyC	=	0,0 MPa
Tau	=	72,0 MPa

Figure:



Stiffener: T 150x100x8,0x10,0



Stiffener property:

H	=	150	mm
B	=	100	mm
tw	=	8,0	mm
tf	=	10,0	mm
A	=	2120	mm2
g	=	16,6	kg/m
ez	=	105,4	mm
Iy	=	4,809E+6	mm4
Iz	=	8,333E+5	mm4

Incl. eff. plate:

se	=	415,3	mm
zp	=	33,2	mm
Ae	=	7,104E+3	mm2
Ie	=	2,332E+7	mm4
Wep	=	7,016E+5	mm3
Wes	=	1,900E+5	mm3

Flange: c = 46,0 <= 104,7 OK (Eq 9.1)

Web: hw = 140,0 <= 251,3 OK (Eq 9.2)

STIFFENER BUCKLING CHECK (DNV-RP-C201): (1 = Support, 2 = field; s = stiffener, p = plate)

se = 415,3 mm Sigxsd = -121,0 MPa Sigysd = 0,0 MPa p0 = 0,000 MPa z* = 6,0 mm

UF1s=Nsd/Nks1Rd+(M1Sd-NSd*z)/(Ms1Rd*(1-Nsd/Ne))+u = 1127,7/1263,3+(0,0-1127,7*0,006)/(69,1*(1-1127,7/3020,8))+0,107 = **0,84** < 1,00 (Eq 7.50)

UF1p=Nsd/Nkp1Rd-2*NSd/N1Rd+(M1Sd-Nsd*z*)/(Mp1Rd*(1-Nsd/Ne))+u =
1127,7/1576,7-2*1127,7/2712,4+(0,0-1127,7*0,006)/(267,9*(1-1127,7/3020,8))+0,107 = **-0,05** < 1,00 (Eq 7.51)

UF2s=Nsd/Nks2Rd-2*NSd/NRd+(M2Sd+NSd*z)/(Mst2Rd*(1-Nsd/Ne))+u =
1127,7/1263,3-2*1127,7/2712,4+(0,0+1127,7*0,006)/(72,5*(1-1127,7/3020,8))+0,107 = **0,32** < 1,00 (Eq 7.52)

UF2p=Nsd/Nkp2Rd+(M2Sd+NSd*z)/(Mp2Rd*(1-Nsd/Ne))+u = 1127,7/1576,7+(0,0+1127,7*0,006)/(267,9*(1-1127,7/3020,8))+0,107 = **0,86** < 1,00 (Eq 7.53)

DNVRPS	Project: Sensitivitetsstudie stiverkasse	Page: 1/1
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File: c:\program files (x86)\struprog 2014\stipla dnvrp db\stivere.drps		

Safety Format/Material:

Design Condition:			LRFD
Allowable Usage Factor:	UF	=	1,00
Material Factor:	gm	=	1,10
Plate/Stiffener:			General/General
Yield stress	fyp/fys	=	420/420 MPa
Youngs modulus	E	=	2,10E+5 MPa

General:

Buckling length	Lk	=	4000 mm
Mom fact - Field	km2	=	24,0
- Support	km1	=	12,0
Continuous stiffener			

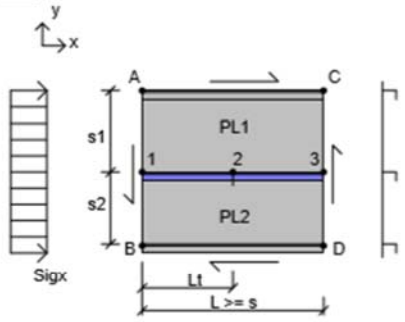
Geometry:

Stiffener span	L	=	4000 mm
Length of girder	Lg	=	16500 mm
Plate thickness	t	=	12,0 mm
Stiffener spacing	s1	=	600 mm
	s2	=	600 mm
Lat tors buckl length	Lt	=	4000 mm

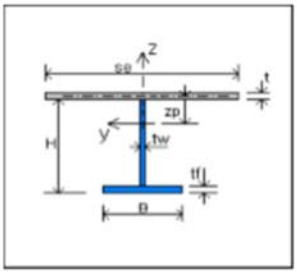
Stresses:

SigxA	=	-113,0	MPa
SigxB	=	-113,0	MPa
SigyA	=	0,0	MPa
SigyC	=	0,0	MPa
Tau	=	72,0	MPa

Figure:



Stiffener: T 200x120x10,0x13,0



Stiffener property:

H	=	200	mm
B	=	120	mm
tw	=	10,0	mm
tf	=	13,0	mm
A	=	3430	mm2
g	=	26,9	kg/m
ez	=	139,0	mm
Iy	=	1,398E+7	mm4
Iz	=	1,872E+6	mm4

Incl. eff. plate:

se	=	415,3	mm
zp	=	59,1	mm
Ae	=	8,414E+3	mm2
Ie	=	5,674E+7	mm4
Wep	=	9,600E+5	mm3
Wes	=	3,863E+5	mm3

Flange: c = 55,0 <= 136,1 **OK** (Eq 9.1)

Web: hw = 187,0 <= 314,2 **OK** (Eq 9.2)

STIFFENER BUCKLING CHECK (DNV-RP-C201): (1 = Support, 2 = field; s = stiffener, p = plate)

se = 415,3 mm Sigxsd = -113,0 MPa Sigysd = 0,0 MPa p0 = 0,000 MPa z* = 11,0 mm

UF1s=Nsd/Nks1Rd+(M1Sd-NSd*z)/(Ms1Rd*(1-Nsd/Ne))+u = 1201,2/1877,2+(0,0-1201,2*0,011)/(144,9*(1-1201,2/7350,3))+0,107 = **0,64** < 1,00 (Eq 7.50)

UF1p=Nsd/Nkp1Rd-2*NSd/N1Rd+(M1Sd-Nsd*z*)/(Mp1Rd*(1-Nsd/Ne))+u =
1201,2/2452,5-2*1201,2/3212,6+(0,0-1201,2*0,011)/(366,6*(1-1201,2/7350,3))+0,107 = **-0,19** < 1,00 (Eq 7.51)

UF2s=Nsd/Nks2Rd-2*NSd/NRd+(M2Sd+NSd*z)/(Mst2Rd*(1-Nsd/Ne))+u =
1201,2/1877,2-2*1201,2/3212,6+(0,0+1201,2*0,011)/(147,5*(1-1201,2/7350,3))+0,107 = **0,11** < 1,00 (Eq 7.52)

UF2p=Nsd/Nkp2Rd+(M2Sd+NSd*z)/(Mp2Rd*(1-Nsd/Ne))+u = 1201,2/2452,5+(0,0+1201,2*0,011)/(366,6*(1-1201,2/7350,3))+0,107 = **0,64** < 1,00 (Eq 7.53)

DNVRPS	Project: Sensitivitetsstudie stiverkasse	Page: 1/1
Plate/Stiff check based on DNV-RP-C201 Version 2.2 Copyright (C) 2004-2014 StruProg AB	Identification: Bjørnafjorden fase 5	Date: 28.06.2019 Time: 10:2
File: c:\program files (x86)\struprog 2014\stipla dnvrp db\stivere.drps		

Safety Format/Material:

Design Condition:			LRFD
Allowable Usage Factor:	UF	=	1,00
Material Factor:	gm	=	1,10
Plate/Stiffener:			General/General
Yield stress	fyp/fys	=	420/420 MPa
Youngs modulus	E	=	2,10E+5 MPa

General:

Buckling length	Lk	=	4000 mm
Mom fact - Field	km2	=	24,0
- Support	km1	=	12,0
Continuous stiffener			

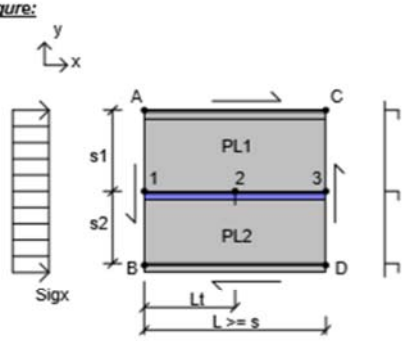
Geometry:

Stiffener span	L	=	4000 mm
Length of girder	Lg	=	16500 mm
Plate thickness	t	=	12,0 mm
Stiffener spacing	s1	=	600 mm
	s2	=	600 mm
Lat tors buckl length	Lt	=	4000 mm

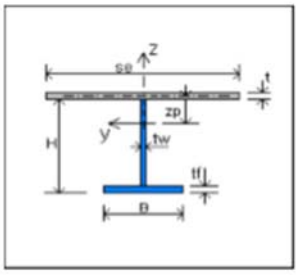
Stresses:

SigxA	=	-210,0	MPa
SigxB	=	-210,0	MPa
SigyA	=	0,0	MPa
SigyC	=	0,0	MPa
Tau	=	72,0	MPa

Figure:



Stiffener: T 200x150x10,0x20,0



Stiffener property:

H	=	200	mm
B	=	150	mm
tw	=	10,0	mm
tf	=	20,0	mm
A	=	4800	mm2
g	=	37,7	kg/m
ez	=	152,5	mm
Iy	=	1,621E+7	mm4
Iz	=	5,625E+6	mm4

Incl. eff. plate:

se	=	415,3	mm
zp	=	77,8	mm
Ae	=	9,784E+3	mm2
Ie	=	7,770E+7	mm4
Wep	=	9,992E+5	mm3
Wes	=	6,059E+5	mm3

Flange: c = 70,0 <= 209,4 **OK** (Eq 9.1)

Web: hw = 180,0 <= 314,2 **OK** (Eq 9.2)

STIFFENER BUCKLING CHECK (DNV-RP-C201): (1 = Support, 2 = field; s = stiffener, p = plate)

se = 415,3 mm Sigxsd = -210,0 MPa Sigysd = 0,0 MPa p0 = 0,000 MPa z* = 3,0 mm

UF1s=Nsd/Nks1Rd+(M1Sd-NSd*z)/(Ms1Rd*(1-Nsd/Ne))+u = 2520,0/2706,7+(0,0-2520,0*0,003)/(231,3*(1-2520,0/10064,6))+0,107 = **0,99** < 1,00 (Eq 7.50)

UF1p=Nsd/Nkp1Rd-2*NSd/N1Rd+(M1Sd-Nsd*z*)/(Mp1Rd*(1-Nsd/Ne))+u =
2520,0/2951,8-2*2520,0/3735,6+(0,0-2520,0*0,003)/(381,5*(1-2520,0/10064,6))+0,107 = **-0,42** < 1,00 (Eq 7.51)

UF2s=Nsd/Nks2Rd-2*NSd/NRd+(M2Sd+NSd*z)/(Mst2Rd*(1-Nsd/Ne))+u =
2520,0/2706,7-2*2520,0/3735,6+(0,0+2520,0*0,003)/(231,3*(1-2520,0/10064,6))+0,107 = **-0,27** < 1,00 (Eq 7.52)

UF2p=Nsd/Nkp2Rd+(M2Sd+NSd*z)/(Mp2Rd*(1-Nsd/Ne))+u = 2520,0/2951,8+(0,0+2520,0*0,003)/(381,5*(1-2520,0/10064,6))+0,107 = **0,99** < 1,00 (Eq 7.53)

4.2 Bulbflats-profile

DNVRPS

Plate/Stiff check based on DNV-RP-C201
Version 2.2
Copyright (C) 2004-2014 StruProg AB

Project: Sensitivitetsstudie stiverkasse | Page: 1/1
Identification: Bjørnafjorden fase 5 | Date: 28.06.2019 | Time: 10:13
File: c:\program files (x86)\struprog 2014\stipla dnvrp db\stivere.drps

Safety Format/Material:

Design Condition:			LRFD	
Allowable Usage Factor:	UF	=	1,00	
Material Factor:	gm	=	1,10	
Plate/Stiffener:			General/General	
Yield stress	fyp/fys	=	420/355	MPa
Youngs modulus	E	=	2,10E+5	MPa

General:

Buckling length	Lk	=	4000	mm
Mom fact - Field	km2	=	24,0	
- Support	km1	=	12,0	
Continuous stiffener				

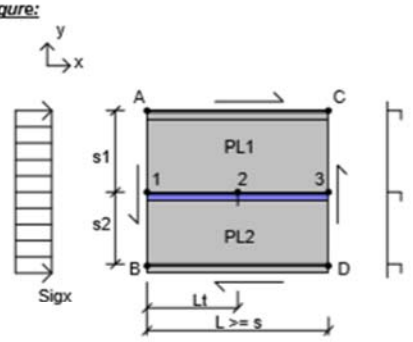
Geometry:

Stiffener span	L	=	4000	mm
Length of girder	Lg	=	16500	mm
Plate thickness	t	=	12,0	mm
Stiffener spacing	s1	=	600	mm
	s2	=	600	mm
Lat tors buckl length	Lt	=	4000	mm

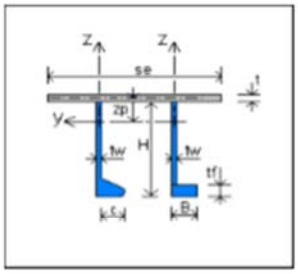
Stresses:

SigxA	=	-64,0	MPa
SigxB	=	-64,0	MPa
SigyA	=	0,0	MPa
SigyC	=	0,0	MPa
Tau	=	72,0	MPa

Figure:



Stiffener: BF 140x7,0



Stiffener property:

H	=	140	mm
tw	=	7,0	mm
c	=	19,0	mm
r	=	5,5	mm
B	=	23,5	mm
tf	=	15,9	mm
A	=	1243	mm2
g	=	9,8	kg/m
ez	=	83,1	mm
Iy	=	2,404E+6	mm4
Iz	=	3,513E+4	mm4

Incl. eff. plate:

se	=	415,3	mm
zp	=	17,8	mm
Ae	=	6,227E+3	mm2
Ie	=	1,037E+7	mm4
Wep	=	5,827E+5	mm3
Wes	=	8,086E+4	mm3

Web: hw = 124,1 <= 239,2 OK (Eq 9.2)

STIFFENER BUCKLING CHECK (DNV-RP-C201): (1 = Support, 2 = field; s = stiffener, p = plate)

se = 415,3 mm Sigxsd = -64,0 MPa Sigysd = 0,0 MPa p0 = 0,000 MPa z* = 3,0 mm

UF1s=Nsd/Nks1Rd-2*NSd/N1Rd+(M1Sd+NSd*z)/(Mst1Rd*(1-Nsd/Ne))+u =
540,4/751,0-2*540,4/2304,1+(0,0+540,4*0,003)/(26,1*(1-540,4/1342,9))+0,131 = **0,49** < 1,00 (Eq 7.54)

UF1p=Nsd/Nkp1Rd+(M1Sd+NSd*z)/(Mp1Rd*(1-Nsd/Ne))+u = 540,4/885,5+(0,0+540,4*0,003)/(222,5*(1-540,4/1342,9))+0,131 = **0,75** < 1,00 (Eq 7.55)

UF2s=Nsd/Nks2Rd+(M2Sd-NSd*z)/(Ms2Rd*(1-Nsd/Ne))+u = 540,4/751,0+(0,0-540,4*0,003)/(25,9*(1-540,4/1342,9))+0,131 = **0,75** < 1,00 (Eq 7.56)

UF2p=Nsd/Nkp2Rd-2*NSd/NRd+(M2Sd-NSd*z)/(Mp2Rd*(1-Nsd/Ne))+u =
540,4/885,5-2*540,4/2304,1+(0,0-540,4*0,003)/(222,5*(1-540,4/1342,9))+0,131 = **0,26** < 1,00 (Eq 7.57)

DNVRPS	Project: Sensitivitetsstudie stiverkasse	Page: 1/1
Plate/Stiff check based on DNV-RP-C201 Version 2.2 Copyright (C) 2004-2014 StruProg AB	Identification: Bjørnafjorden fase 5	Date: 28.06.2019 Time: 10:12
File: c:\program files (x86)\struprog 2014\stipla dnvrp db\stivere.drps		

Safety Format/Material:

Design Condition:			LRFD
Allowable Usage Factor:	UF	=	1,00
Material Factor:	gm	=	1,10
Plate/Stiffener:			General/General
Yield stress	fyp/fys	=	420/355 MPa
Youngs modulus	E	=	2,10E+5 MPa

General:

Buckling length	Lk	=	4000 mm
Mom fact - Field	km2	=	24,0
- Support	km1	=	12,0
Continuous stiffener			

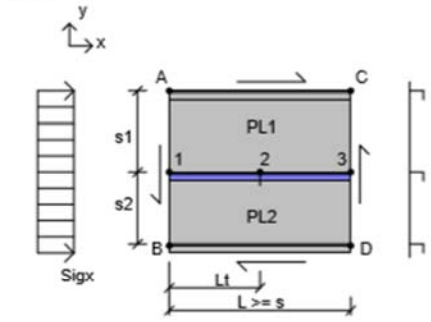
Geometry:

Stiffener span	L	=	4000 mm
Length of girder	Lg	=	16500 mm
Plate thickness	t	=	12,0 mm
Stiffener spacing	s1	=	600 mm
	s2	=	600 mm
Lat tors buckl length	Lt	=	4000 mm

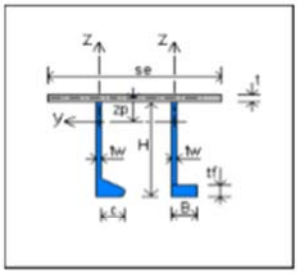
Stresses:

SigxA	=	-123,0	MPa
SigxB	=	-123,0	MPa
SigyA	=	0,0	MPa
SigyC	=	0,0	MPa
Tau	=	72,0	MPa

Figure:



Stiffener: BF 160x9,0



Stiffener property:

H	=	160	mm
tw	=	9,0	mm
c	=	22,0	mm
r	=	6,0	mm
B	=	28,3	mm
tf	=	17,6	mm
A	=	1780	mm2
g	=	14,0	kg/m
ez	=	93,6	mm
Iy	=	4,475E+6	mm4
Iz	=	6,670E+4	mm4

Incl. eff. plate:

se	=	415,3	mm
zp	=	26,2	mm
Ae	=	6,764E+3	mm2
Ie	=	1,755E+7	mm4
Wep	=	6,694E+5	mm3
Wes	=	1,255E+5	mm3

Web: hw = 142,4 <= 307,5 OK (Eq 9.2)

STIFFENER BUCKLING CHECK (DNV-RP-C201): (1 = Support, 2 = field; s = stiffener, p = plate)

se = 415,3 mm Sigxsd = -123,0 MPa Sigysd = 0,0 MPa p0 = 0,000 MPa z* = 3,0 mm

UF1s=Nsd/Nks1Rd-2*NSd/N1Rd+(M1Sd+NSd*z)/(Mst1Rd*(1-Nsd/Ne))+u =
1104,5/1085,0-2*1104,5/2477,4+(0,0+1104,5*0,003)/(40,5*(1-1104,5/2272,8))+0,107 = **0,39** < 1,00 (Eq 7.54)

UF1p=Nsd/Nkp1Rd+(M1Sd+NSd*z)/(Mp1Rd*(1-Nsd/Ne))+u = 1104,5/1294,6+(0,0+1104,5*0,003)/(255,6*(1-1104,5/2272,8))+0,107 = **0,99** < 1,00 (Eq 7.55)

UF2s=Nsd/Nks2Rd+(M2Sd-NSd*z)/(Ms2Rd*(1-Nsd/Ne))+u = 1104,5/1085,0+(0,0-1104,5*0,003)/(39,5*(1-1104,5/2272,8))+0,107 = **0,96** < 1,00 (Eq 7.56)

UF2p=Nsd/Nkp2Rd-2*NSd/NRd+(M2Sd-NSd*z)/(Mp2Rd*(1-Nsd/Ne))+u =
1104,5/1294,6-2*1104,5/2477,4+(0,0-1104,5*0,003)/(255,6*(1-1104,5/2272,8))+0,107 = **0,04** < 1,00 (Eq 7.57)

DNVRPS	Project: Sensitivitetsstudie stiverkasse	Page: 1/1
Plate/Stiff check based on DNV-RP-C201 Version 2.2 Copyright (C) 2004-2014 StruProg AB	Identification: Bjørnafjorden fase 5	Date: 28.06.2019 Time: 10:9
File: c:\program files (x86)\struprog 2014\stipla dnvrp db\stivere.drps		

Safety Format/Material:

Design Condition:			LRFD
Allowable Usage Factor:	UF	=	1,00
Material Factor:	gm	=	1,10
Plate/Stiffener:			General/General
Yield stress	fyp/fys	=	420/355 MPa
Youngs modulus	E	=	2,10E+5 MPa

General:

Buckling length	Lk	=	4000 mm
Mom fact - Field	km2	=	24,0
- Support	km1	=	12,0
Continuous stiffener			

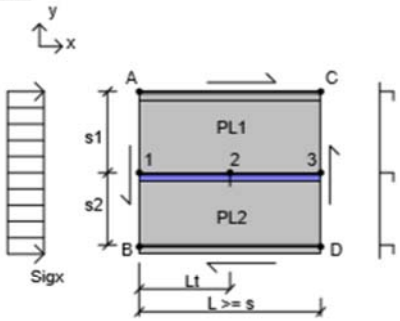
Geometry:

Stiffener span	L	=	4000 mm
Length of girder	Lg	=	16500 mm
Plate thickness	t	=	12,0 mm
Stiffener spacing	s1	=	600 mm
	s2	=	600 mm
Lat tors buckl length	Lt	=	4000 mm

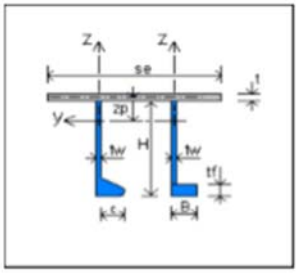
Stresses:

SigxA	=	-213,0	MPa
SigxB	=	-213,0	MPa
SigyA	=	0,0	MPa
SigyC	=	0,0	MPa
Tau	=	72,0	MPa

Figure:



Stiffener: BF 300x11,0



Stiffener property:

H	=	300	mm
tw	=	11,0	mm
c	=	43,0	mm
r	=	13,0	mm
B	=	48,2	mm
tf	=	37,1	mm
A	=	4678	mm2
g	=	36,7	kg/m
ez	=	188,7	mm
Iy	=	4,171E+7	mm4
Iz	=	7,260E+5	mm4

Incl. eff. plate:

se	=	415,3	mm
zp	=	94,3	mm
Ae	=	9,662E+3	mm2
Ie	=	1,333E+8	mm4
Wep	=	1,413E+6	mm3
Wes	=	6,294E+5	mm3

Web: hw = 262,9 <= 375,9 **OK** (Eq 9.2)

STIFFENER BUCKLING CHECK (DNV-RP-C201): (1 = Support, 2 = field; s = stiffener, p = plate)

se = 415,3 mm Sigxsd = -213,0 MPa Sigysd = 0,0 MPa p0 = 0,000 MPa z* = 7,0 mm

UF1s=Nsd/Nks1Rd+(M1Sd-NSd*z)/(Ms1Rd*(1-Nsd/Ne))+u = 2530,0/2611,1+(0,0-2530,0*0,007)/(201,7*(1-2530,0/17262,3))+0,107 = **0,97** < 1,00 (Eq 7.50)

UF1p=Nsd/Nkp1Rd-2*NSd/N1Rd+(M1Sd-Nsd*z*)/(Mp1Rd*(1-Nsd/Ne))+u =
2530,0/3011,4-2*2530,0/3412,6+(0,0-2530,0*0,007)/(539,7*(1-2530,0/17262,3))+0,107 = **-0,57** < 1,00 (Eq 7.51)

UF2s=Nsd/Nks2Rd-2*NSd/NRd+(M2Sd+NSd*z)/(Mst2Rd*(1-Nsd/Ne))+u =
2530,0/2611,1-2*2530,0/3412,6+(0,0+2530,0*0,007)/(203,1*(1-2530,0/17262,3))+0,107 = **-0,30** < 1,00 (Eq 7.52)

UF2p=Nsd/Nkp2Rd+(M2Sd+NSd*z)/(Mp2Rd*(1-Nsd/Ne))+u = 2530,0/3011,4+(0,0+2530,0*0,007)/(539,7*(1-2530,0/17262,3))+0,107 = **0,99** < 1,00 (Eq 7.53)

4.3 Trapezoidal profilE

DNVRPS

Plate/Stiff check based on DNV-RP-C201
Version 2.2
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Project: Sensitivitetsstudie stiverkasse | Page: 1/1
Identification: Bjørnafjorden fase 5 | Date: 28.06.2019 | Time: 10:16
File: c:\program files (x86)\struprog 2014\stipla dnvrp db\stivere.drps

Safety Format/Material:

Design Condition:			LRFD	
Allowable Usage Factor:	UF	=	1,00	
Material Factor:	gm	=	1,10	
Plate/Stiffener:			General/General	
Yield stress	fyp/fys	=	420/420	MPa
Youngs modulus	E	=	2,10E+5	MPa

General:

Buckling length	Lk	=	4000	mm
Mom fact - Field	km2	=	24,0	
- Support	km1	=	12,0	
Continuous stiffener				

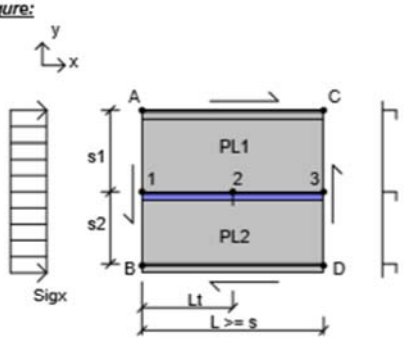
Geometry:

Stiffener span	L	=	4000	mm
Length of girder	Lg	=	16500	mm
Plate thickness	t	=	12,0	mm
Stiffener spacing	s1	=	600	mm
	s2	=	600	mm
Lat tors buckl length	Lt	=	4000	mm

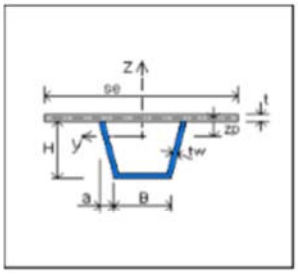
Stresses:

SigxA	=	-63,0	MPa
SigxB	=	-63,0	MPa
SigyA	=	0,0	MPa
SigyC	=	0,0	MPa
Tau	=	72,0	MPa

Figure:



Stiffener: Trapez 115x50/25x5,0



Stiffener property:

H	=	115	mm
B	=	50	mm
a	=	25	mm
tw	=	5,0	mm
A	=	1376	mm2
g	=	10,8	kg/m
ez	=	65,4	mm
Iy	=	1,812E+6	mm4

Incl. eff. plate:

se	=	496,2	mm
zp	=	13,4	mm
Ae	=	7,330E+3	mm2
Ie	=	7,588E+6	mm4
Wep	=	5,659E+5	mm3
Wes	=	7,053E+4	mm3

Web: hw = 110,0 <= 157,1 **OK** (Eq 9.2)

STIFFENER BUCKLING CHECK (DNV-RP-C201): (1 = Support, 2 = field; s = stiffener, p = plate)

se = 496,2 mm Sigxsd = -63,0 MPa Sigysd = 0,0 MPa p0 = 0,000 MPa z* = 2,0 mm

UF1s=Nsd/Nks1Rd-2*NSd/N1Rd+(M1Sd+NSd*z)/(Mst1Rd*(1-Nsd/Ne))+u =
540,3/640,6-2*540,3/2798,6+(0,0+540,3*0,002)/(26,9*(1-540,3/983,0))+0,217 = **0,76** < 1,00 (Eq 7.54)

UF1p=Nsd/Nkp1Rd+(M1Sd+NSd*z)/(Mp1Rd*(1-Nsd/Ne))+u = 540,3/714,2+(0,0+540,3*0,002)/(216,1*(1-540,3/983,0))+0,217 = **0,98** < 1,00 (Eq 7.55)

UF2s=Nsd/Nks2Rd+(M2Sd-NSd*z)/(Ms2Rd*(1-Nsd/Ne))+u = 540,3/640,6+(0,0-540,3*0,002)/(26,9*(1-540,3/983,0))+0,217 = **0,97** < 1,00 (Eq 7.56)

UF2p=Nsd/Nkp2Rd-2*NSd/NRd+(M2Sd-NSd*z)/(Mp2Rd*(1-Nsd/Ne))+u =
540,3/714,2-2*540,3/2798,6+(0,0-540,3*0,002)/(216,1*(1-540,3/983,0))+0,217 = **0,58** < 1,00 (Eq 7.57)

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Plate/Stiff check based on DNV-RP-C201 Version 2.2 Copyright (C) 2004-2014 StruProg AB	Identification: Bjørnafjorden fase 5	Date: 28.06.2019 Time: 10:15
File: c:\program files (x86)\struprog 2014\stipla dnvrp db\stivere.drps		

Safety Format/Material:

Design Condition:			LRFD
Allowable Usage Factor:	UF	=	1,00
Material Factor:	gm	=	1,10
Plate/Stiffener:			General/General
Yield stress	fyp/fys	=	420/420 MPa
Youngs modulus	E	=	2,10E+5 MPa

General:

Buckling length	Lk	=	4000 mm
Mom fact - Field	km2	=	24,0
- Support	km1	=	12,0
Continuous stiffener			

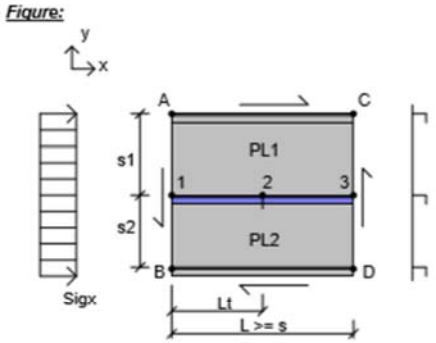
Geometry:

Stiffener span	L	=	4000 mm
Length of girder	Lg	=	16500 mm
Plate thickness	t	=	12,0 mm
Stiffener spacing	s1	=	600 mm
	s2	=	600 mm
Lat tors buckl length	Lt	=	4000 mm

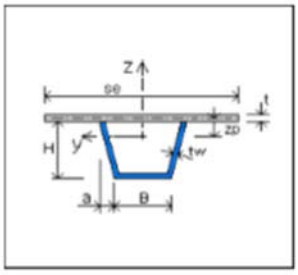
Stresses:

SigxA	=	-123,0	MPa
SigxB	=	-123,0	MPa
SigyA	=	0,0	MPa
SigyC	=	0,0	MPa
Tau	=	72,0	MPa

Figure:



Stiffener: Trapez 150x60/30x5,0



Stiffener property:

H	=	150	mm
B	=	60	mm
a	=	30	mm
tw	=	5,0	mm
A	=	1779	mm2
g	=	14,0	kg/m
ez	=	85,1	mm
Iy	=	3,994E+6	mm4

Incl. eff. plate:

se	=	511,4	mm
zp	=	20,5	mm
Ae	=	7,915E+3	mm2
Ie	=	1,553E+7	mm4
Wep	=	7,579E+5	mm3
Wes	=	1,146E+5	mm3

Web: hw = 145,0 <= 157,1 OK (Eq 9.2)

STIFFENER BUCKLING CHECK (DNV-RP-C201): (1 = Support, 2 = field: s = stiffener, p = plate)

se = 511,4 mm Sigxsd = -123,0 MPa Sigysd = 0,0 MPa p0 = 0,000 MPa z* = 2,0 mm

UF1s=Nsd/Nks1Rd-2*NSd/N1Rd+(M1Sd+NSd*z)/(Mst1Rd*(1-Nsd/Ne))+u =
1104,4/1132,5-2*1104,4/3022,2+(0,0+1104,4*0,002)/(43,7*(1-1104,4/2011,1))+0,107 = **0,46** < 1,00 (Eq 7.54)

UF1p=Nsd/Nkp1Rd+(M1Sd+NSd*z)/(Mp1Rd*(1-Nsd/Ne))+u = 1104,4/1279,1+(0,0+1104,4*0,002)/(289,4*(1-1104,4/2011,1))+0,107 = **0,99** < 1,00 (Eq 7.55)

UF2s=Nsd/Nks2Rd+(M2Sd-NSd*z)/(Ms2Rd*(1-Nsd/Ne))+u = 1104,4/1132,5+(0,0-1104,4*0,002)/(43,7*(1-1104,4/2011,1))+0,107 = **0,97** < 1,00 (Eq 7.56)

UF2p=Nsd/Nkp2Rd-2*NSd/NRd+(M2Sd-NSd*z)/(Mp2Rd*(1-Nsd/Ne))+u =
1104,4/1279,1-2*1104,4/3022,2+(0,0-1104,4*0,002)/(289,4*(1-1104,4/2011,1))+0,107 = **0,22** < 1,00 (Eq 7.57)

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Plate/Stiff check based on DNV-RP-C201 Version 2.2 Copyright (C) 2004-2014 StruProg AB	Identification: Bjørnafjorden fase 5	Date: 28.06.2019 Time: 10:14
File: c:\program files (x86)\struprog 2014\stipla dnvrp db\stivere.drps		

Safety Format/Material:

Design Condition:			LRFD
Allowable Usage Factor:	UF	=	1,00
Material Factor:	gm	=	1,10
Plate/Stiffener:			General/General
Yield stress	fyp/fys	=	420/420 MPa
Youngs modulus	E	=	2,10E+5 MPa

General:

Buckling length	Lk	=	4000 mm
Mom fact - Field	km2	=	24,0
- Support	km1	=	12,0
Continuous stiffener			

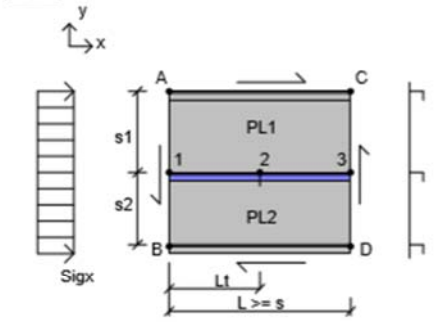
Geometry:

Stiffener span	L	=	4000 mm
Length of girder	Lg	=	16500 mm
Plate thickness	t	=	12,0 mm
Stiffener spacing	s1	=	600 mm
	s2	=	600 mm
Lat tors buckl length	Lt	=	4000 mm

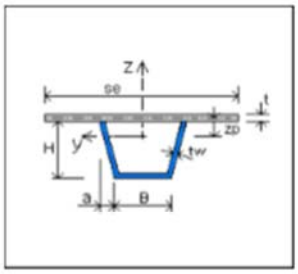
Stresses:

SigxA	=	-218,0	MPa
SigxB	=	-218,0	MPa
SigyA	=	0,0	MPa
SigyC	=	0,0	MPa
Tau	=	72,0	MPa

Figure:



Stiffener: Trapez 200x100/50x8,0



Stiffener property:

H	=	200	mm
B	=	100	mm
a	=	50	mm
tw	=	8,0	mm
A	=	3967	mm2
g	=	31,1	kg/m
ez	=	116,2	mm
Iy	=	1,612E+7	mm4

Incl. eff. plate:

se	=	567,4	mm
zp	=	45,0	mm
Ae	=	1,078E+4	mm2
Ie	=	5,361E+7	mm4
Wep	=	1,192E+6	mm3
Wes	=	3,329E+5	mm3

Web: hw = 192,0 <= 251,3 **OK** (Eq 9.2)

STIFFENER BUCKLING CHECK (DNV-RP-C201): (1 = Support, 2 = field; s = stiffener, p = plate)

se = 567,4 mm Sigxsd = -218,0 MPa Sigysd = 0,0 MPa p0 = 0,000 MPa z* = 2,0 mm

UF1s=Nsd/Nks1Rd-2*NSd/N1Rd+(M1Sd+NSd*z)/(Mst1Rd*(1-Nsd/Ne))+u =
2434,3/2657,6-2*2434,3/4114,4+(0,0+2434,3*0,002)/(127,1*(1-2434,3/6944,5))+0,107 = **-0,10** < 1,00 (Eq 7.54)

UF1p=Nsd/Nkp1Rd+(M1Sd+NSd*z)/(Mp1Rd*(1-Nsd/Ne))+u = 2434,3/2867,1+(0,0+2434,3*0,002)/(455,2*(1-2434,3/6944,5))+0,107 = **0,97** < 1,00 (Eq 7.55)

UF2s=Nsd/Nks2Rd+(M2Sd-NSd*z)/(Ms2Rd*(1-Nsd/Ne))+u = 2434,3/2657,6+(0,0-2434,3*0,002)/(127,1*(1-2434,3/6944,5))+0,107 = **0,96** < 1,00 (Eq 7.56)

UF2p=Nsd/Nkp2Rd-2*NSd/NRd+(M2Sd-NSd*z)/(Mp2Rd*(1-Nsd/Ne))+u =
2434,3/2867,1-2*2434,3/4114,4+(0,0-2434,3*0,002)/(455,2*(1-2434,3/6944,5))+0,107 = **-0,24** < 1,00 (Eq 7.57)

4.4 Plate thickness

DNVRPS

Plate/Stiff check based on DNV-RP-C201
Version 2.2
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Project: Sensitivitetsstudie stiverkasse | Page: 1/1
Identification: Bjørnafjorden fase 5 | Date: 28.06.2019 | Time: 10:17
File: c:\program files (x86)\struprog 2014\stipla dnvrp db\stivere.drps

Safety Format/Material:

Design Condition:			LRFD	
Allowable Usage Factor:	UF	=	1,00	
Material Factor:	gm	=	1,10	
Plate/Stiffener:			General/General	
Yield stress	fyp/fys	=	420/420	MPa
Youngs modulus	E	=	2,10E+5	MPa

General:

Buckling length	Lk	=	4000	mm
Mom fact - Field	km2	=	24,0	
- Support	km1	=	12,0	
Continuous stiffener				

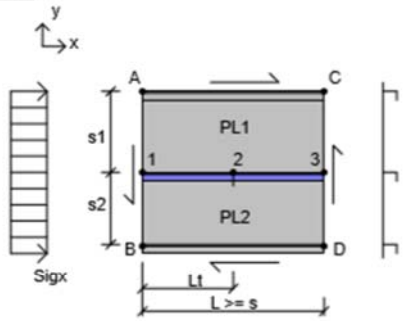
Geometry:

Stiffener span	L	=	4000	mm
Length of girder	Lg	=	16500	mm
Plate thickness	t	=	8,0	mm
Stiffener spacing	s1	=	600	mm
	s2	=	600	mm
Lat tors buckl length	Lt	=	4000	mm

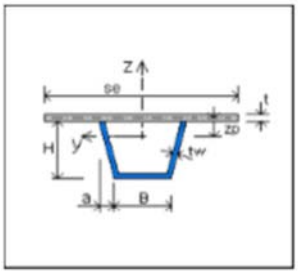
Stresses:

SigxA	=	-230,0	MPa
SigxB	=	-230,0	MPa
SigyA	=	0,0	MPa
SigyC	=	0,0	MPa
Tau	=	72,0	MPa

Figure:



Stiffener: Trapez 300x150/75x8,0



Stiffener property:

H	=	300	mm
B	=	150	mm
a	=	75	mm
tw	=	8,0	mm
A	=	6016	mm2
g	=	47,2	kg/m
ez	=	175,9	mm
Iy	=	5,584E+7	mm4

Incl. eff. plate:

se	=	511,2	mm
zp	=	107,1	mm
Ae	=	1,011E+4	mm2
Ie	=	1,347E+8	mm4
Wep	=	1,257E+6	mm3
Wes	=	6,840E+5	mm3

Web: hw = 292,0 <= 251,3 **NOK** (Eq 9.2)

STIFFENER BUCKLING CHECK (DNV-RP-C201): (1 = Support, 2 = field; s = stiffener, p = plate)

se = 511,2 mm Sigxsd = -230,0 MPa Sigysd = 0,0 MPa p0 = 0,000 MPa z* = 1,0 mm

UF1s=Nsd/Nks1Rd-2*NSd/N1Rd+(M1Sd+NSd*z)/(Mst1Rd*(1-Nsd/Ne))+u =
2487,6/3280,5-2*2487,6/3858,4+(0,0+2487,6*0,001)/(261,2*(1-2487,6/17444,9))+0,107 = **-0,41** < 1,00 (Eq 7.54)

UF1p=Nsd/Nkp1Rd+(M1Sd+NSd*z)/(Mp1Rd*(1-Nsd/Ne))+u = 2487,6/3343,7+(0,0+2487,6*0,001)/(480,1*(1-2487,6/17444,9))+0,107 = **0,86** < 1,00 (Eq 7.55)

UF2s=Nsd/Nks2Rd+(M2Sd-NSd*z)/(Ms2Rd*(1-Nsd/Ne))+u = 2487,6/3280,5+(0,0-2487,6*0,001)/(261,2*(1-2487,6/17444,9))+0,107 = **0,85** < 1,00 (Eq 7.56)

UF2p=Nsd/Nkp2Rd-2*NSd/NRd+(M2Sd-NSd*z)/(Mp2Rd*(1-Nsd/Ne))+u =
2487,6/3343,7-2*2487,6/3858,4+(0,0-2487,6*0,001)/(480,1*(1-2487,6/17444,9))+0,107 = **-0,44** < 1,00 (Eq 7.57)

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Plate/Stiff check based on DNV-RP-C201 Version 2.2 Copyright (C) 2004-2014 StruProg AB	Identification: Bjørnafjorden fase 5	Date: 28.06.2019 Time: 10:31
File: c:\program files (x86)\struprog 2014\stipla dnvrp db\stivere.drps		

Safety Format/Material:

Design Condition:			LRFD
Allowable Usage Factor:	UF	=	1,00
Material Factor:	gm	=	1,10
Plate/Stiffener:			General/General
Yield stress	fyp/fys	=	420/420 MPa
Youngs modulus	E	=	2,10E+5 MPa

General:

Buckling length	Lk	=	4000 mm
Mom fact - Field	km2	=	24,0
- Support	km1	=	12,0
Continuous stiffener			

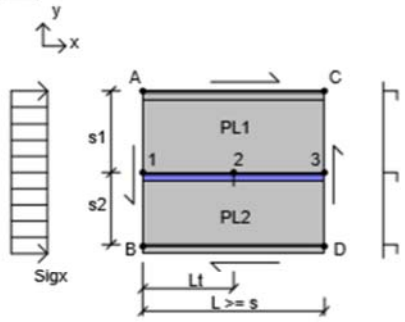
Geometry:

Stiffener span	L	=	4000 mm
Length of girder	Lg	=	16500 mm
Plate thickness	t	=	8,0 mm
Stiffener spacing	s1	=	600 mm
	s2	=	600 mm
Lat tors buckl length	Lt	=	4000 mm

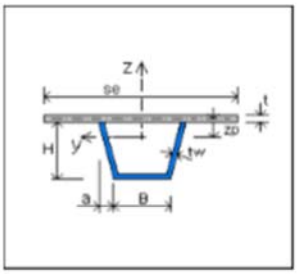
Stresses:

SigxA	=	-135,0	MPa
SigxB	=	-135,0	MPa
SigyA	=	0,0	MPa
SigyC	=	0,0	MPa
Tau	=	72,0	MPa

Figure:



Stiffener: Trapez 175x50/25x8,0



Stiffener property:

H	=	175	mm
B	=	50	mm
a	=	25	mm
tw	=	8,0	mm
A	=	3099	mm2
g	=	24,3	kg/m
ez	=	94,8	mm
Iy	=	8,942E+6	mm4

Incl. eff. plate:

se	=	389,7	mm
zp	=	49,3	mm
Ae	=	6,216E+3	mm2
Ie	=	2,413E+7	mm4
Wep	=	4,899E+5	mm3
Wes	=	1,860E+5	mm3

Web: hw = 167,0 <= 251,3 OK (Eq 9.2)

STIFFENER BUCKLING CHECK (DNV-RP-C201): (1 = Support, 2 = field; s = stiffener, p = plate)

se = 389,7 mm Sigxsd = -135,0 MPa Sigysd = 0,0 MPa p0 = 0,000 MPa z* = 2,0 mm

UF1s=Nsd/Nks1Rd-2*NSd/N1Rd+(M1Sd+NSd*z)/(Mst1Rd*(1-Nsd/Ne))+u =
1066,4/1389,6-2*1066,4/2373,5+(0,0+1066,4*0,002)/(71,0*(1-1066,4/3125,4))+0,107 = **0,02** < 1,00 (Eq 7.54)

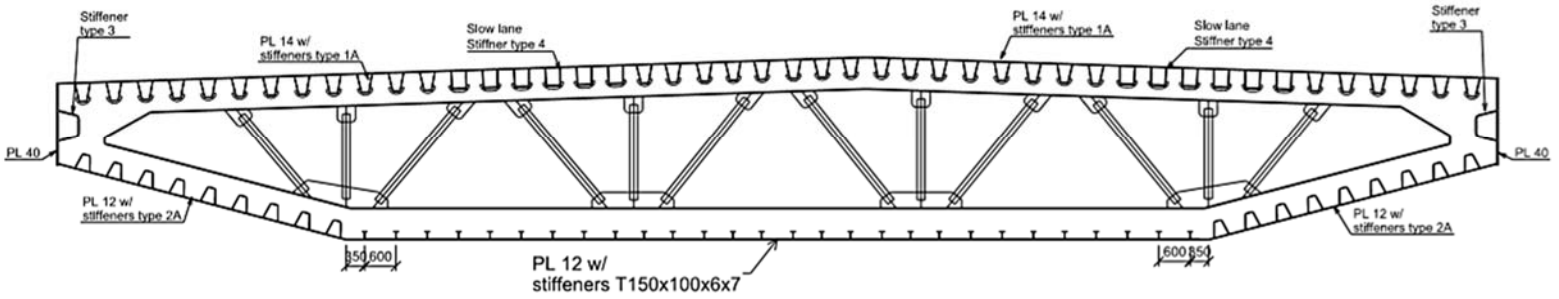
UF1p=Nsd/Nkp1Rd+(M1Sd+NSd*z)/(Mp1Rd*(1-Nsd/Ne))+u = 1066,4/1481,8+(0,0+1066,4*0,002)/(187,0*(1-1066,4/3125,4))+0,107 = **0,84** < 1,00 (Eq 7.55)

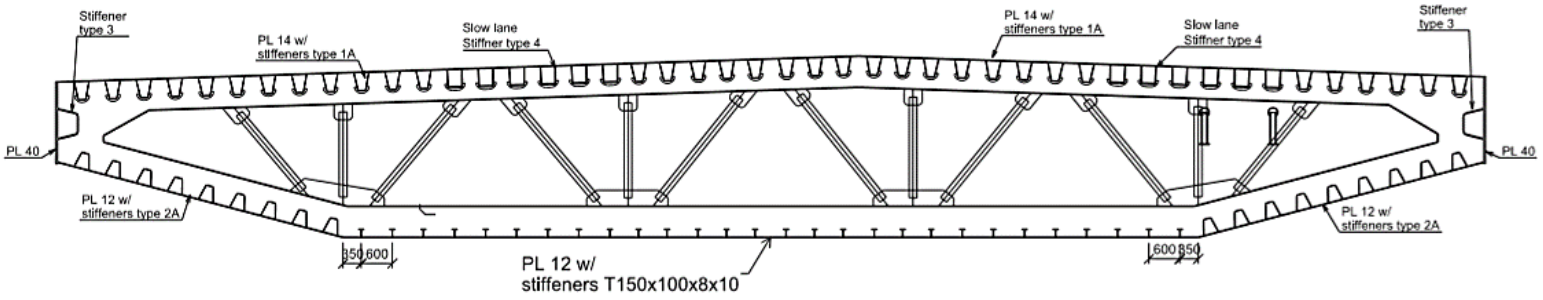
UF2s=Nsd/Nks2Rd+(M2Sd-NSd*z)/(Ms2Rd*(1-Nsd/Ne))+u = 1066,4/1389,6+(0,0-1066,4*0,002)/(71,0*(1-1066,4/3125,4))+0,107 = **0,83** < 1,00 (Eq 7.56)

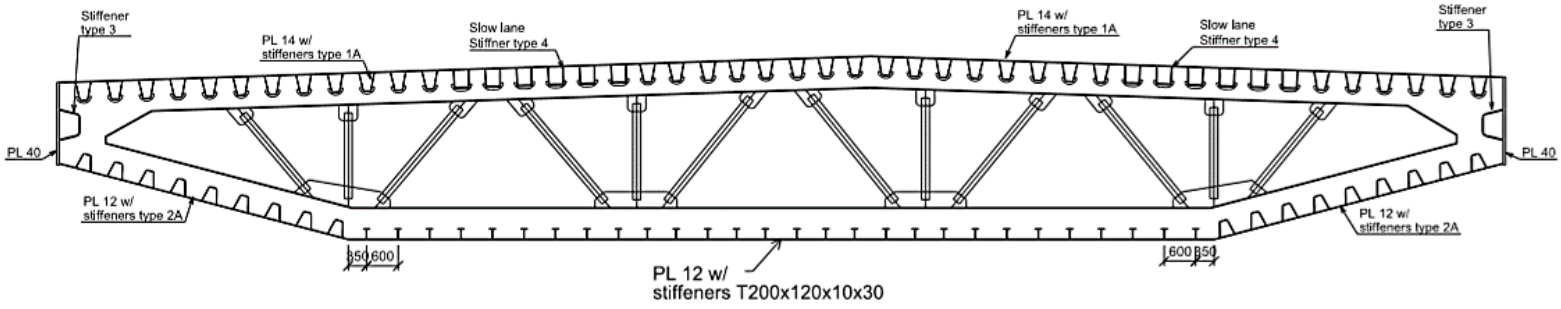
UF2p=Nsd/Nkp2Rd-2*NSd/NRd+(M2Sd-NSd*z)/(Mp2Rd*(1-Nsd/Ne))+u =
1066,4/1481,8-2*1066,4/2373,5+(0,0-1066,4*0,002)/(187,0*(1-1066,4/3125,4))+0,107 = **-0,09** < 1,00 (Eq 7.57)

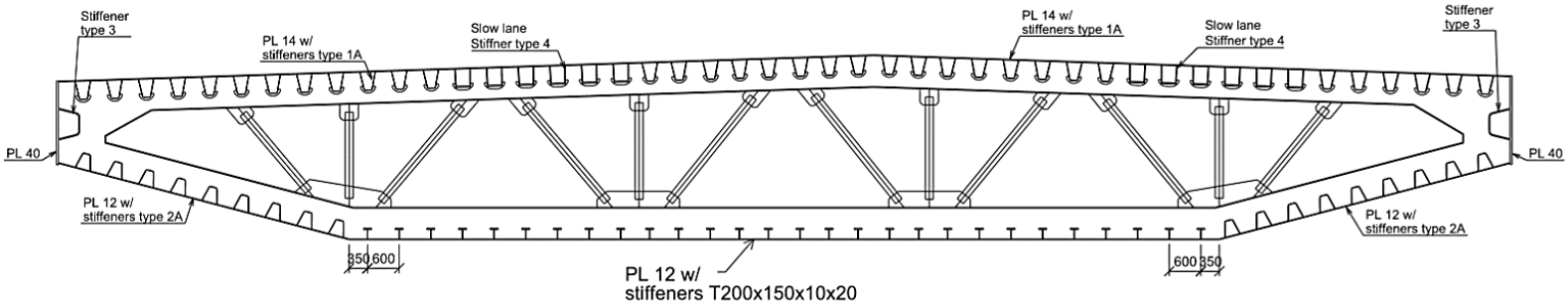
5 CROSS-SECTION DRAWINGS

T-profile

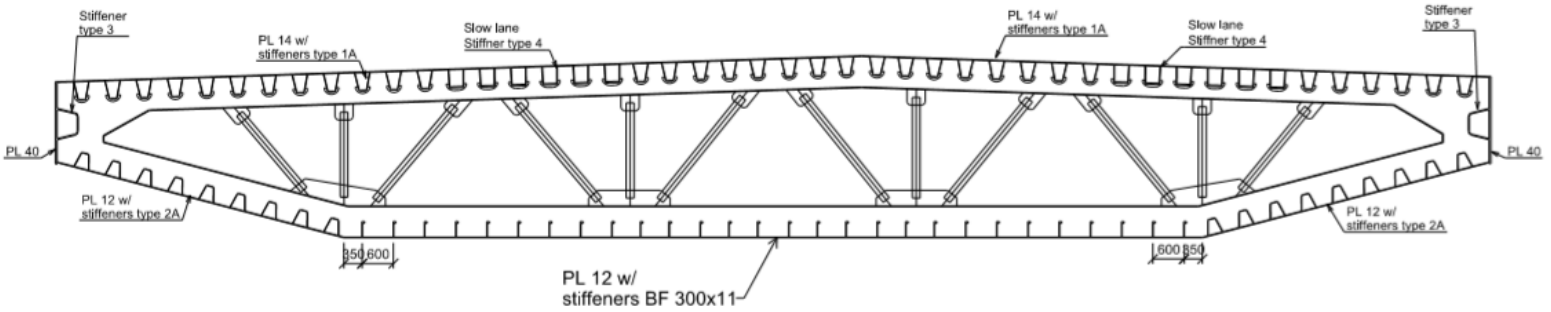


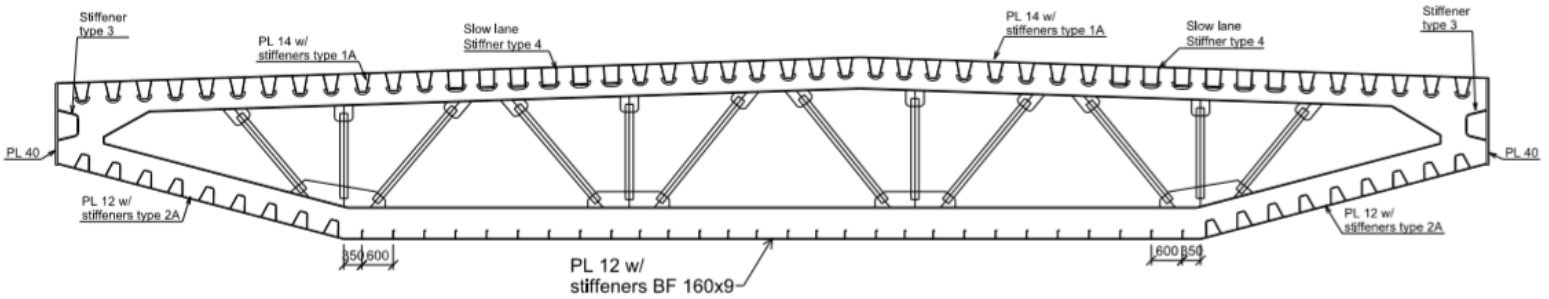


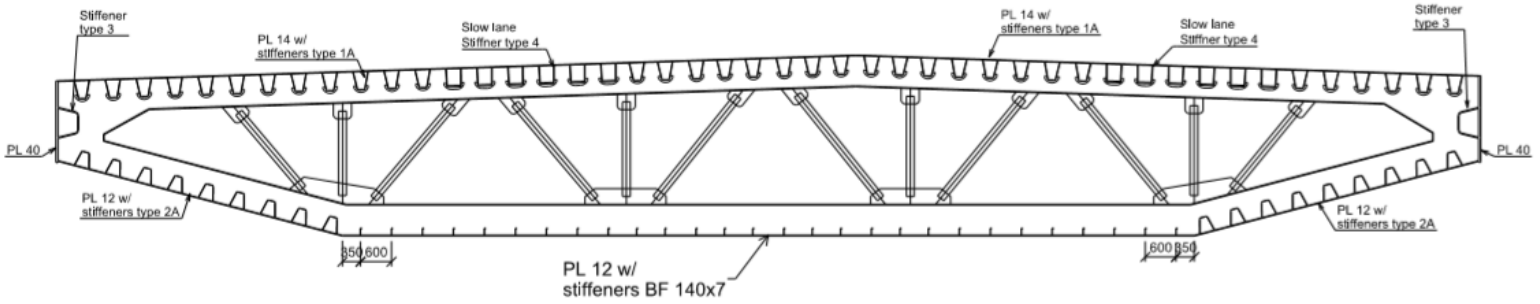




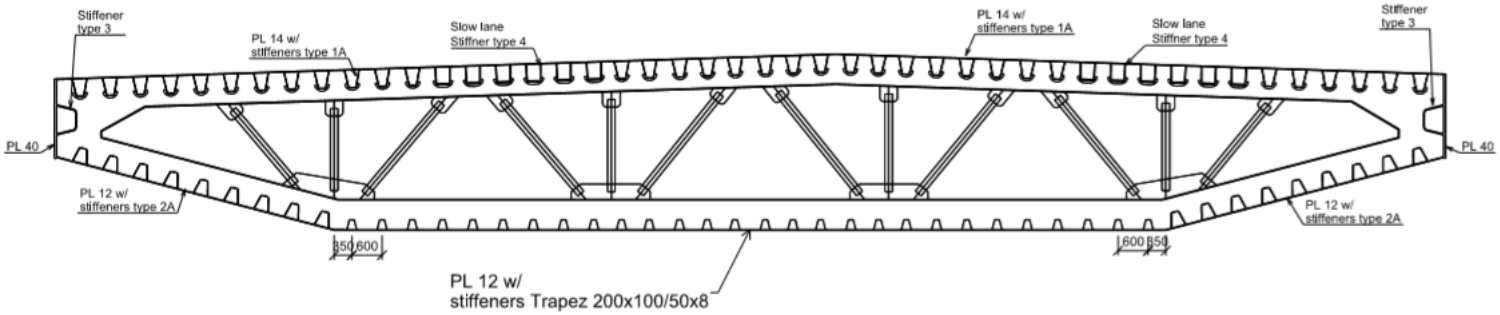
BF-profile

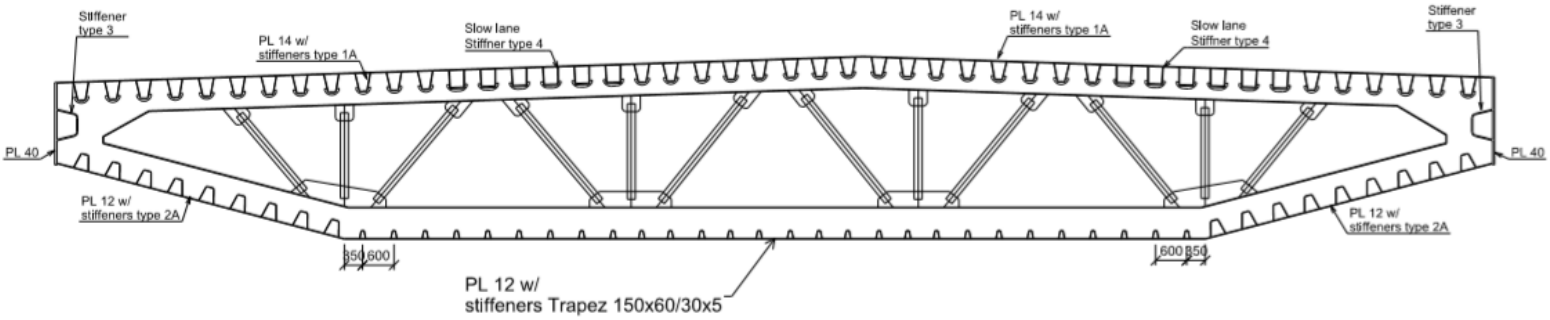






Trapezoidal profile


Stiffener type 3
PL 14 w/ stiffeners type 1A
Slow lane Stiffner type 4
PL 14 w/ stiffeners type 1A
Slow lane Stiffner type 4
Stiffener type 3
PL 40
PL 40
PL 12 w/ stiffeners type 2A
PL 12 w/ stiffeners type 2A
350 600
600 350
PL 12 w/
stiffeners Trapez 200x100/50x8


Stiffener type 3
PL 14 w/ stiffeners type 1A
Slow lane Stiffner type 4
PL 14 w/ stiffeners type 1A
Slow lane Stiffner type 4
Stiffener type 3
PL 40
PL 40
PL 12 w/ stiffeners type 2A
PL 12 w/ stiffeners type 2A
350 600
600 350
PL 12 w/
stiffeners Trapez 150x60/30x5

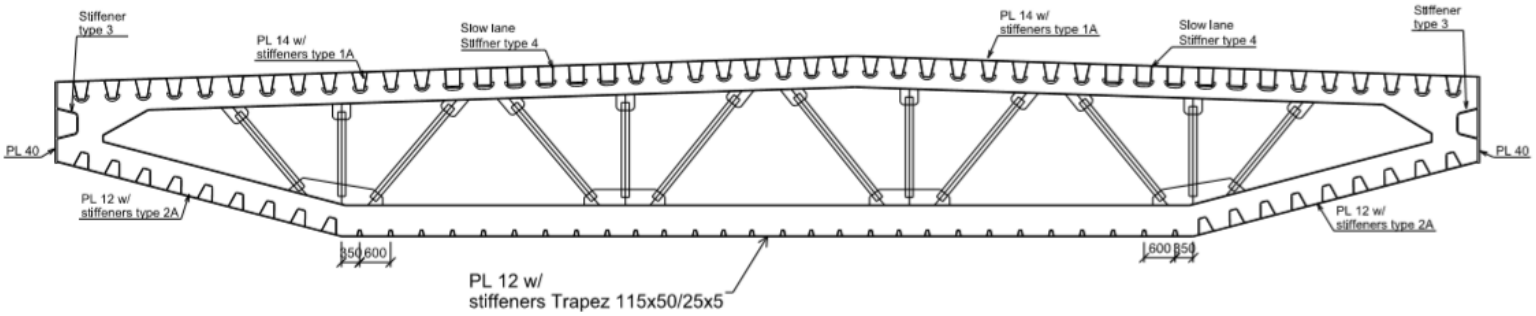
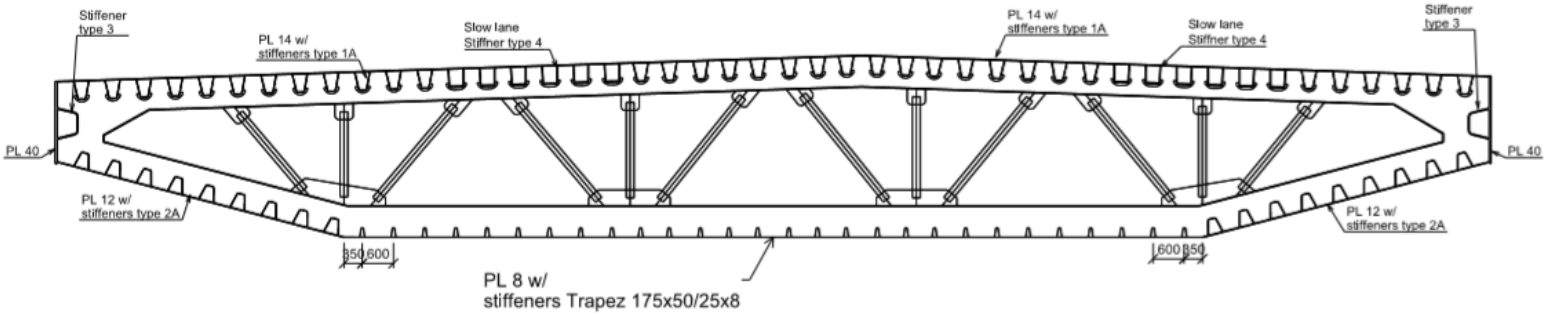
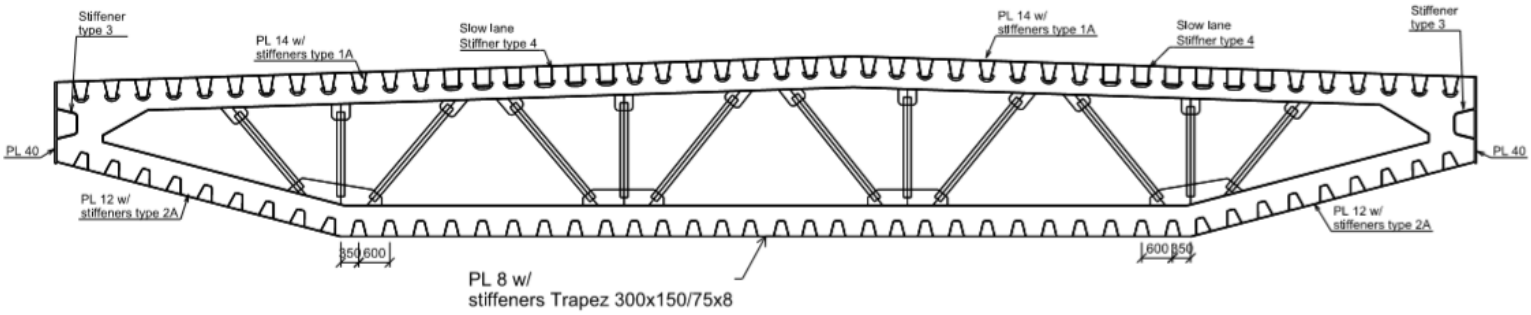

Stiffener type 3
PL 14 w/ stiffeners type 1A
Slow lane Stiffner type 4
PL 14 w/ stiffeners type 1A
Slow lane Stiffner type 4
Stiffener type 3
PL 40
PL 40
PL 12 w/ stiffeners type 2A
PL 12 w/ stiffeners type 2A
350 600
600 350
PL 12 w/
stiffeners Trapez 115x50/25x5

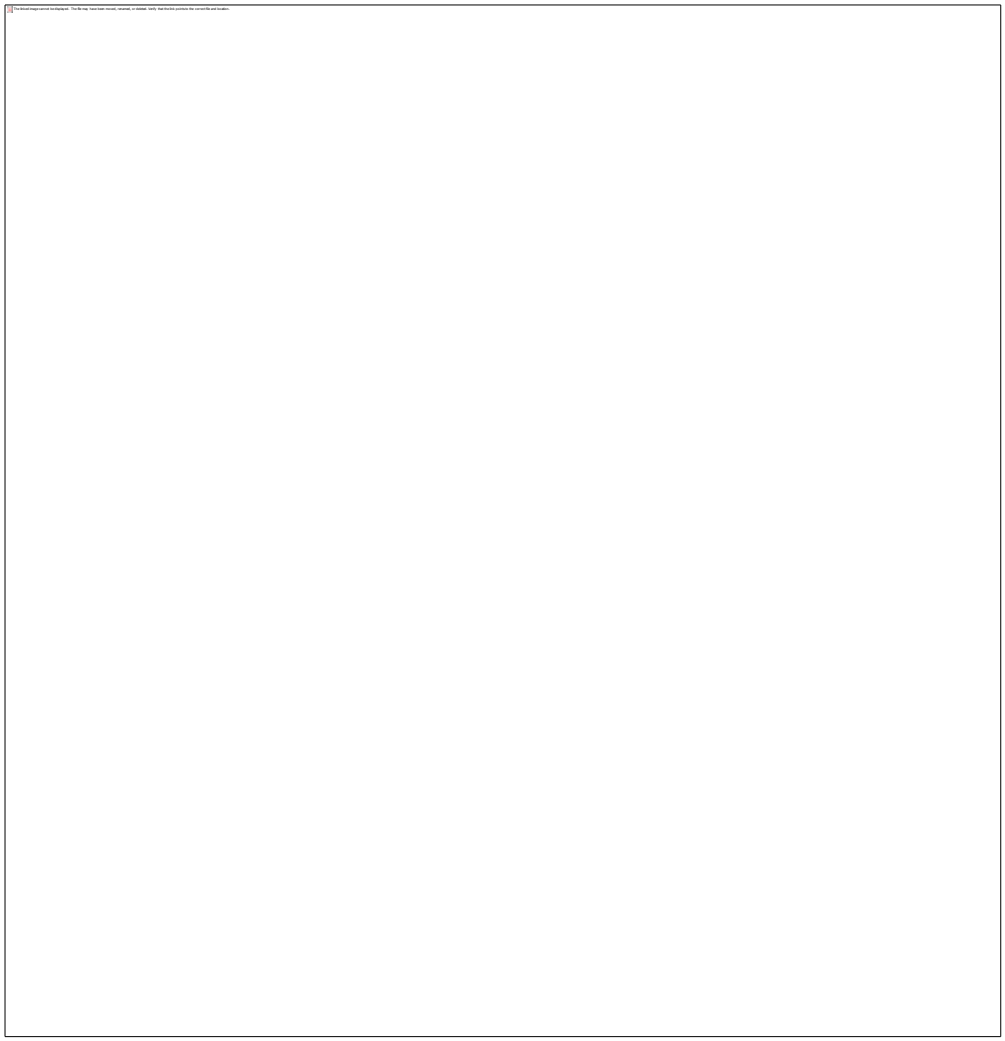
Plate thickness



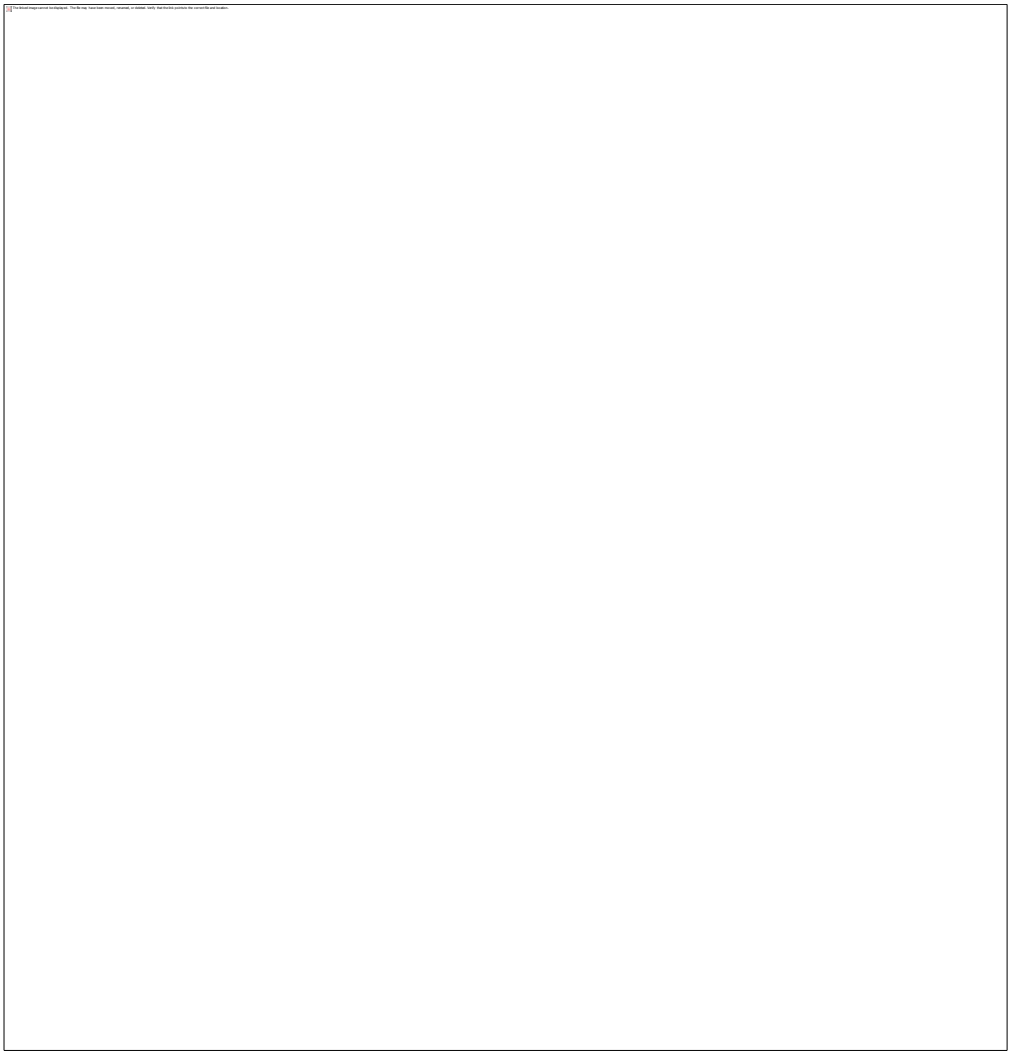


6 LONG HAND CALCULATIONS

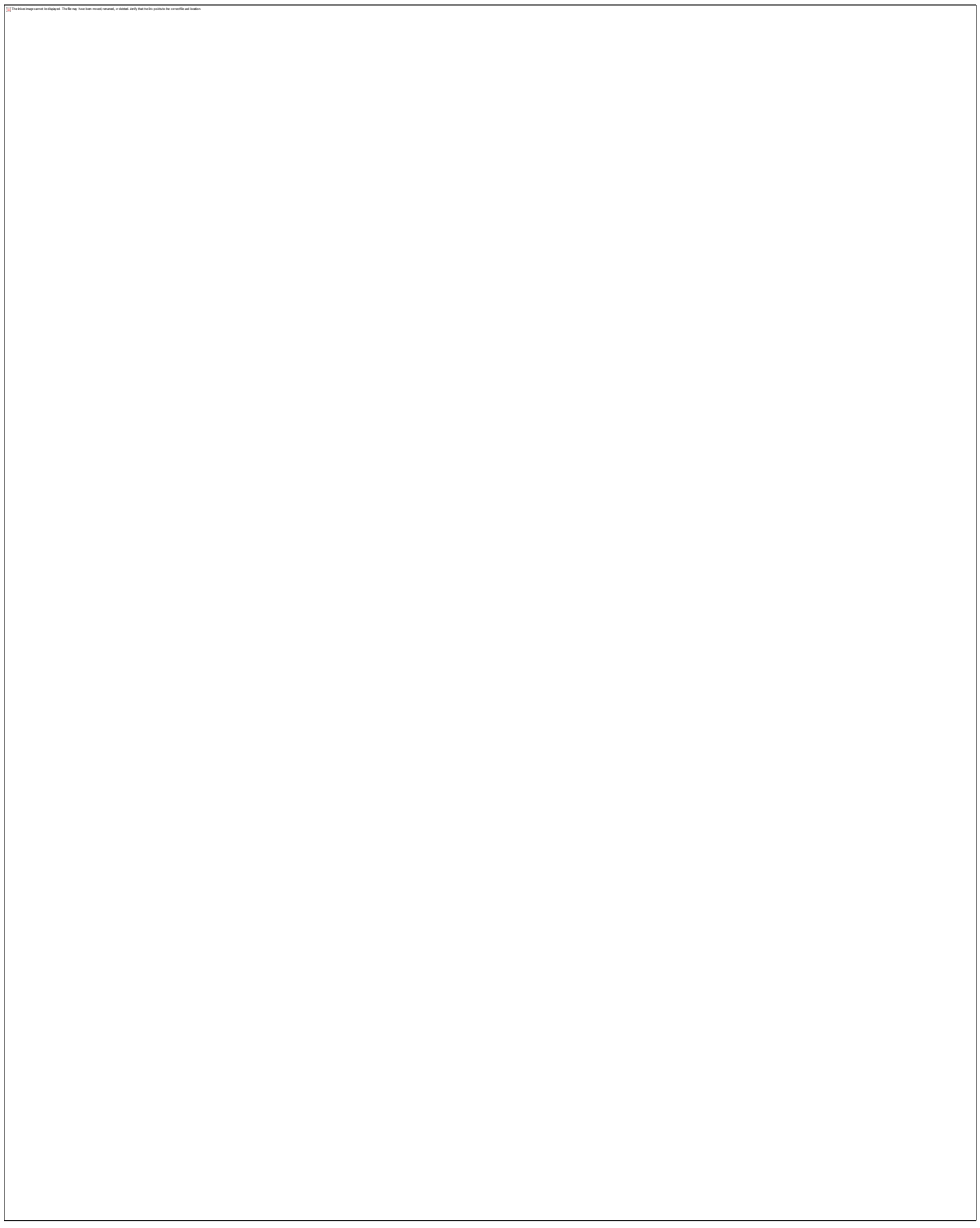
6.1 Bending moment and change in axial stess



6.2 Shear stress



6.3 Reduction in bending moment



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