Appendix to report:

SBJ-33-C5-OON-22-RE-019
DESIGN OF STAY CABLE BRIDGE

Appendix title:

APPENDIX C – DESIGN OF TEMPORARY GIRDER SUPPORT

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CONCEPT DEVELOPMENT FLOATING BRIDGE E39 BJØRNAFJORDEN

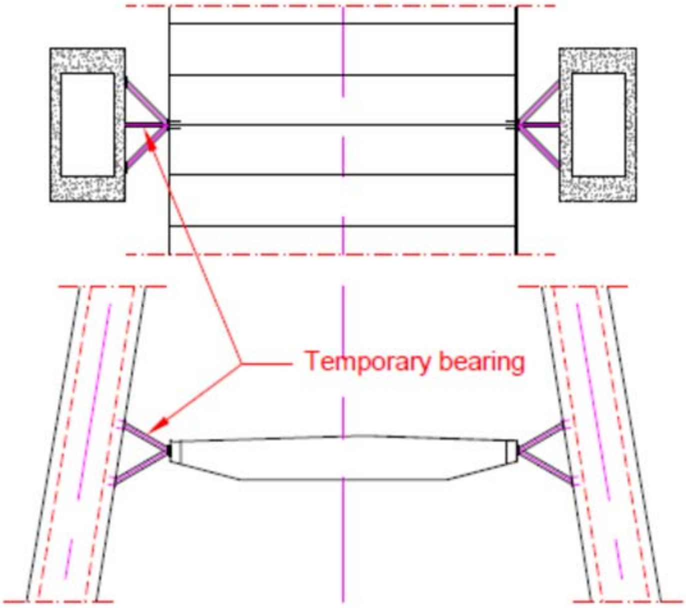
Table of Content

1 INTRODUCTION

This technical note includes dimensioning of the temporary support between the bridge girder and the pylon in order to secure and stabilize the girder during the construction phase.

2 DESIGN OF TEMPORARY SIDE BEARING

When the bridge is finished, the box girder runs freely between the pylon legs with no connection between pylon and girder except for the stays. However, during the construction phase before the floating part of the bridge is installed, the girder needs sideway support at the pylon. Consequently, there is a need for a temporary bearing between the pylon leg and the girder, see figure below.



> *Figure 1 Temporary bearing, plan and cross section*

Each bearing consists of a neoprene block with a Teflon layer and a sliding plate of polished stainless steel supported by three legs. The maximum supporting force (ULS) is 16 MN and the total movement from temperature is about 300 mm. See figure 3.
The size of the neoprene block depends on the strength of the material. A typical TOBE-bearing has a load limit of ca. 45 MPa (ULS). Consequently, the size of a neoprene block carrying a force of 16 MN must be about 600mm x 600mm.

$$A \geq \frac{16 * 10^6}{45} = 355.555\, mm^2 \quad or \quad \approx 600\, x\, 600\, mm$$

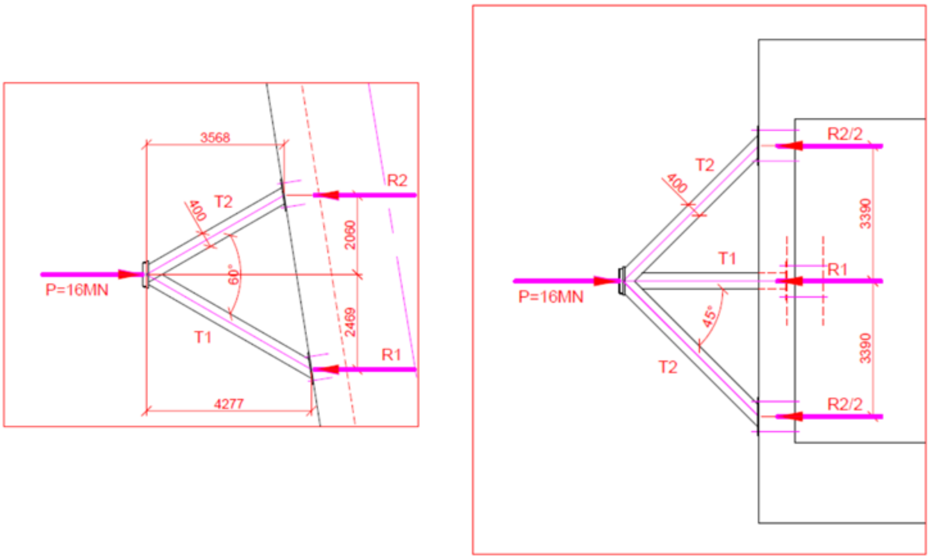


Figure 2 Temporary bearing, details, elevation and plan

Supporting structure, reactions:

$$R1 = \frac{16 * 2060}{4529} = 7{,}3MN \qquad R2 = 16 - 7{,}3 = 8{,}7MN$$

Length of T1: $L_{T1} = \sqrt{4277^2 + 2469^2} = 4938mm$

Length of T2: $L_{T2} = \sqrt{3568^2 + 2060^2 + 3390^2} = 5335mm$

Angle T2-T2 in plane: $2 * \sin^{-1}\left(\frac{3390}{5335}\right) = 2 * 39{,}5^0$

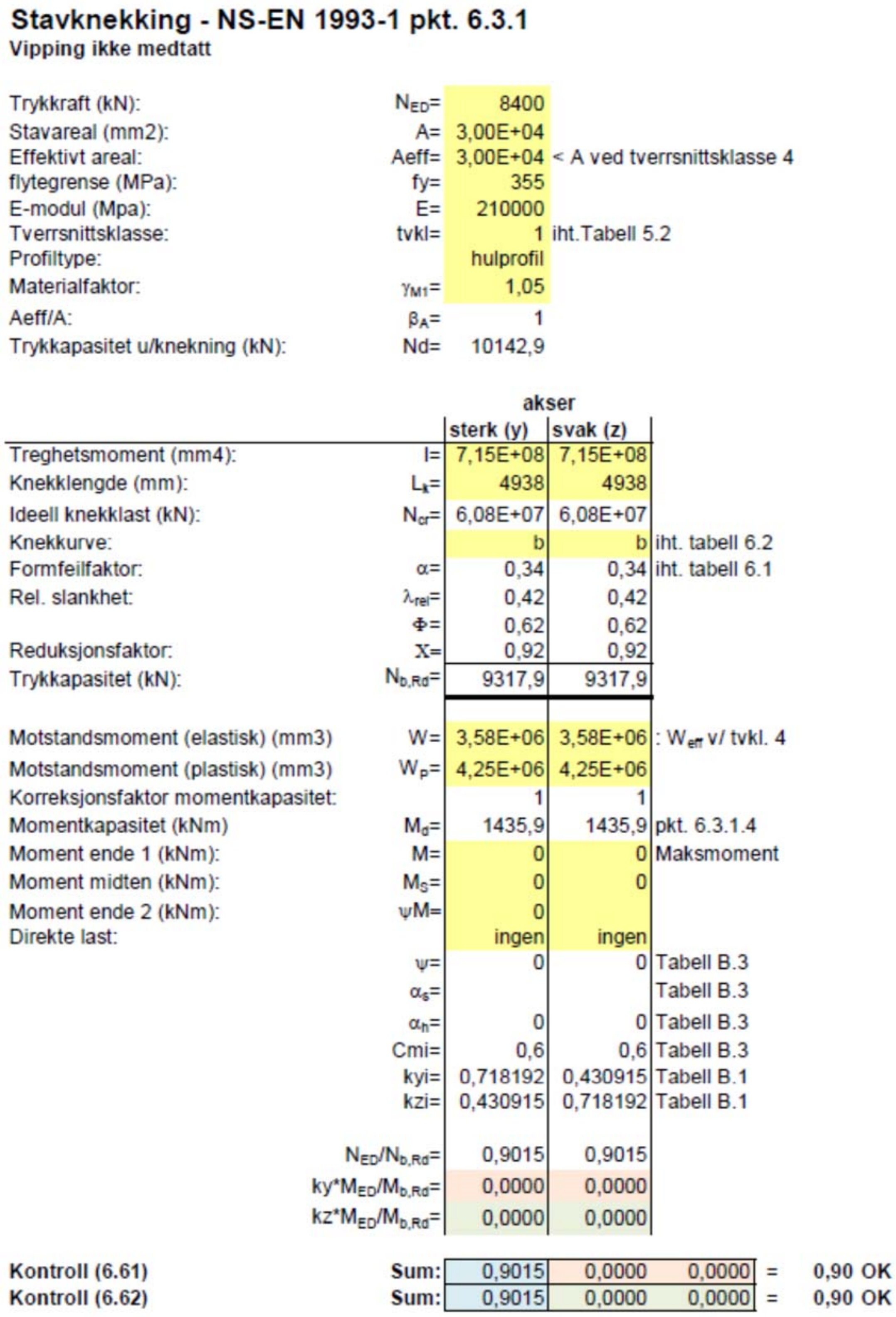
$$T1 = \frac{7{,}3}{\cos 30} = 8{,}4MN$$

$$T2 = \frac{8{,}7}{2 * \cos 30 * \cos 39{,}5} = 6{,}6MN$$

Choosing dimension RHS 400x400x20 gives utilization for buckling:

T1: 0,9
T2: 0,72

See spreadsheets next 2 pages.



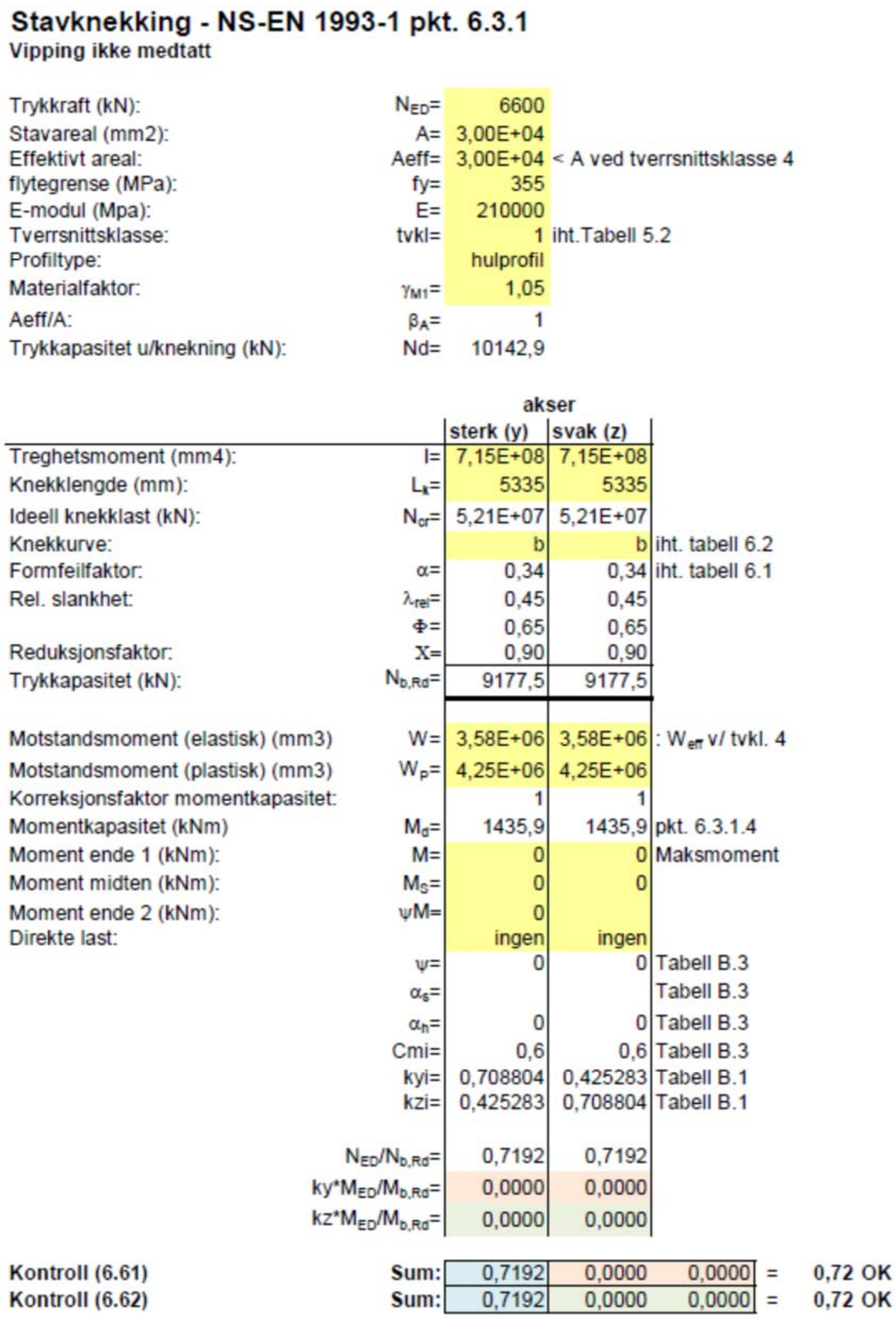
Stavknekking - NS-EN 1993-1 pkt. 6.3.1

Vipping ikke medtatt

Trykkraft (kN):	N_{ED}=	8400	
Stavareal (mm2):	A=	3,00E+04	
Effektivt areal:	Aeff=	3,00E+04	< A ved tverrsnittsklasse 4
flytegrense (MPa):	fy=	355	
E-modul (Mpa):	E=	210000	
Tverrsnittsklasse:	tvkl=	1	iht.Tabell 5.2
Profiltype:		hulprofil	
Materialfaktor:	γ_{M1}=	1,05	
Aeff/A:	β_A=	1	
Trykkapasitet u/knekning (kN):	Nd=	10142,9	

		akser		
		sterk (y)	svak (z)	
Treghetsmoment (mm4):	I=	7,15E+08	7,15E+08	
Knekklengde (mm):	L_k=	4938	4938	
Ideell knekklast (kN):	N_{cr}=	6,08E+07	6,08E+07	
Knekkurve:		b	b	iht. tabell 6.2
Formfeilfaktor:	α=	0,34	0,34	iht. tabell 6.1
Rel. slankhet:	λ_{rel}=	0,42	0,42	
	Φ=	0,62	0,62	
Reduksjonsfaktor:	X=	0,92	0,92	
Trykkapasitet (kN):	$N_{b,Rd}$=	9317,9	9317,9	
Motstandsmoment (elastisk) (mm3)	W=	3,58E+06	3,58E+06	: W_{eff} v/ tvkl. 4
Motstandsmoment (plastisk) (mm3)	W_p=	4,25E+06	4,25E+06	
Korreksjonsfaktor momentkapasitet:		1	1	
Momentkapasitet (kNm)	M_d=	1435,9	1435,9	pkt. 6.3.1.4
Moment ende 1 (kNm):	M=	0	0	Maksmoment
Moment midten (kNm):	M_S=	0	0	
Moment ende 2 (kNm):	ψM=	0		
Direkte last:		ingen	ingen	
	ψ=	0	0	Tabell B.3
	α_s=			Tabell B.3
	α_h=	0	0	Tabell B.3
	Cmi=	0,6	0,6	Tabell B.3
	kyi=	0,718192	0,430915	Tabell B.1
	kzi=	0,430915	0,718192	Tabell B.1
	$N_{ED}/N_{b,Rd}$=	0,9015	0,9015	
	$ky*M_{ED}/M_{b,Rd}$=	0,0000	0,0000	
	$kz*M_{ED}/M_{b,Rd}$=	0,0000	0,0000	

Kontroll (6.61)	**Sum:**	0,9015	0,0000	0,0000	=	**0,90 OK**
Kontroll (6.62)	**Sum:**	0,9015	0,0000	0,0000	=	**0,90 OK**



Stavknekking - NS-EN 1993-1 pkt. 6.3.1

Vipping ikke medtatt

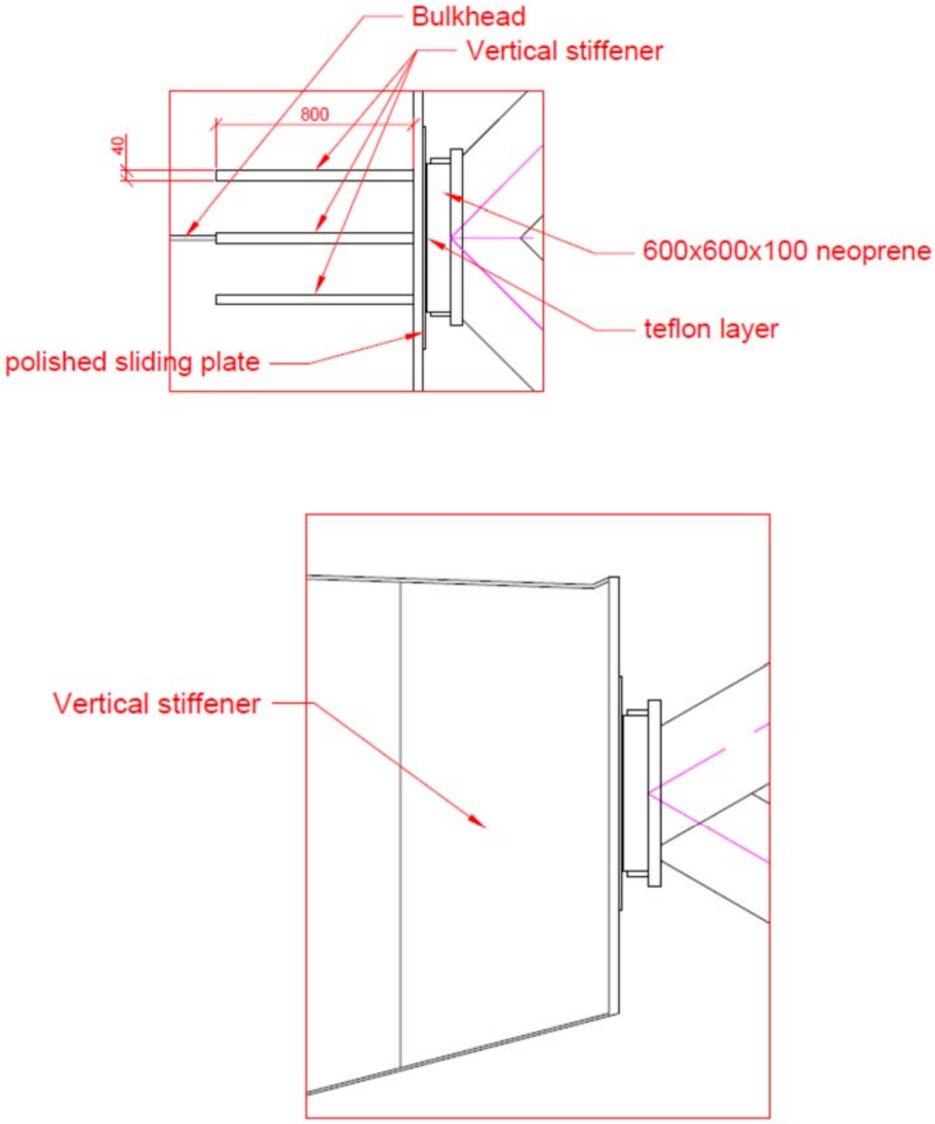
Trykkraft (kN):	N_{ED}=	6600	
Stavareal (mm2):	A=	3,00E+04	
Effektivt areal:	Aeff=	3,00E+04	< A ved tverrsnittsklasse 4
flytegrense (MPa):	fy=	355	
E-modul (Mpa):	E=	210000	
Tverrsnittsklasse:	tvkl=	1	iht.Tabell 5.2
Profiltype:		hulprofil	
Materialfaktor:	γ_{M1}=	1,05	
Aeff/A:	β_A=	1	
Trykkapasitet u/knekning (kN):	Nd=	10142,9	

		akser sterk (y)	 svak (z)	
Treghetsmoment (mm4):	I=	7,15E+08	7,15E+08	
Knekklengde (mm):	L_k=	5335	5335	
Ideell knekklast (kN):	N_{cr}=	5,21E+07	5,21E+07	
Knekkurve:		b	b	iht. tabell 6.2
Formfeilfaktor:	α=	0,34	0,34	iht. tabell 6.1
Rel. slankhet:	λ_{rel}=	0,45	0,45	
	Φ=	0,65	0,65	
Reduksjonsfaktor:	χ=	0,90	0,90	
Trykkapasitet (kN):	$N_{b,Rd}$=	9177,5	9177,5	
Motstandsmoment (elastisk) (mm3)	W=	3,58E+06	3,58E+06	: W_{eff} v/ tvkl. 4
Motstandsmoment (plastisk) (mm3)	W_p=	4,25E+06	4,25E+06	
Korreksjonsfaktor momentkapasitet:		1	1	
Momentkapasitet (kNm)	M_d=	1435,9	1435,9	pkt. 6.3.1.4
Moment ende 1 (kNm):	M=	0	0	Maksmoment
Moment midten (kNm):	M_S=	0	0	
Moment ende 2 (kNm):	ψM=	0		
Direkte last:		ingen	ingen	
	ψ=	0	0	Tabell B.3
	α_s=			Tabell B.3
	α_h=	0	0	Tabell B.3
	Cmi=	0,6	0,6	Tabell B.3
	kyi=	0,708804	0,425283	Tabell B.1
	kzi=	0,425283	0,708804	Tabell B.1
	$N_{ED}/N_{b,Rd}$=	0,7192	0,7192	
	$ky*M_{ED}/M_{b,Rd}$=	0,0000	0,0000	
	$kz*M_{ED}/M_{b,Rd}$=	0,0000	0,0000	

Kontroll (6.61)	**Sum:**	0,7192	0,0000	0,0000	=	**0,72 OK**
Kontroll (6.62)	**Sum:**	0,7192	0,0000	0,0000	=	**0,72 OK**

3 STRENGTHENING OF BOX GIRDER

Horizontal loads on the bridge girder will give a significant shear force transferred to the bearing by the top and bottom plates and the bulkhead. The reaction load from the bearing will be concentrated and consequently the box girder must be locally strengthened. The best way to do that is to make a connection between the bearing and the top and bottom plates. This is done by a local strengthening of the bulkhead and two extra vertical stiffeners, se figure below.



> *Figure 3 Bearing-details and strengthening of box girder*

4 REFERENCES

[1] Håndbok N400 , «Bruprosjektering,» Statens vegvesen Vegdirektoratet, 2015.

[2] NS-EN 1993-1-1:2005+A1:2014+NA:2015, «Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings,» Standard Norge, 2005.

[3] SBJ-32-C4-SVV-90-BA-001, «Design Basis Bjørnafjorden floating bridges,» Statens Vegvesen, 2018.