AECOM Imagine it. Delivered.

Liquid-tight pavement Calculation Report Structural Design NTI SE Zandvoort

Shell EPCM NLxxxx
NTI SE Zandvoort Circuit, Zandvoort, Nederland

Shell Station "NTI SE Zandvoort Circuit"
Burgemeester van Alphenstraat 108,
2041 KP Zandvoort,
The Netherlands

Shell Nederland Verkoopmaatschappij B.V.
"PERMIT PHASE"

Project reference: NLxxxx
Project number: xxxx-276503
NLxxxx-276503-FED-XX-RP-S-0002 Rev.B1

October 11, 2019

Quality information

Prepared by	Checked by	Verified by	Approved by
C. Cretu Structural Engineer	W. Lia Project Design Specialist		

Revision History

Revisie	Revision date	Details	Geautoriseerd	Naam	Positie
A1	September 27, 2019	Vergunning		C. Cretu	Structural Engineer
B1	October 11, 2019	Vergunning – zonder portaal		C. Cretu	Structural Engineer

Prepared for:

Shell Nederland Verkoopmaatschappij B.V.
Weena 70
3012 CM Rotterdam
the Netherlands

Prepared by:

C. Cretu
Structural Engineer
M: +40 743 291 647
E: cezar.cretu@aecom.com

AECOM Netherlands B.V.
HNK Den Haag, Oude Middenweg 17
2491 AC Den Haag, The Netherlands

T: +31 (0) 702400898
aecom.com

Printed on environmentally responsible paper. Made from 100% recycled post-consumer waste.

INHOUD

Reference Documents

Document# and revision	Date of issue	Description
9019-0702-000	11 september 2019	Geotechnical Report

1. General

1.1 Introduction

This report contains the structural design of the new built Shell petrol station NTI SE Zandvoort Circuit, located in Zandvoort, Netherlands. Structural calculation has been made for Liquid-tight paving applied under canopy and around fuel dispensers.

This report contains the design calculation as part of the process requirements according to BRL SIKB 7700.

1.2 Project scope of work

As part of the EPCM Shell Verkoopmaatschappij BV is intending to build a new Shell petrol station NTI SE Zandvoort Circuit, located in Zandvoort, Netherlands. The project scope of work includes construction of Shell Express (SE) site with canopy and liquid-tight pavement around dispensers/under canopy and around the filling point.

LTP dimensions are 11.0x12.1m, with and additional of 1.6x4.0 around filling point area.

The footprint of canopy is approximately 7,2x9,0 meter with a total height of 5,5 meters from pavement level.

Fig. New location of Shell petrol station

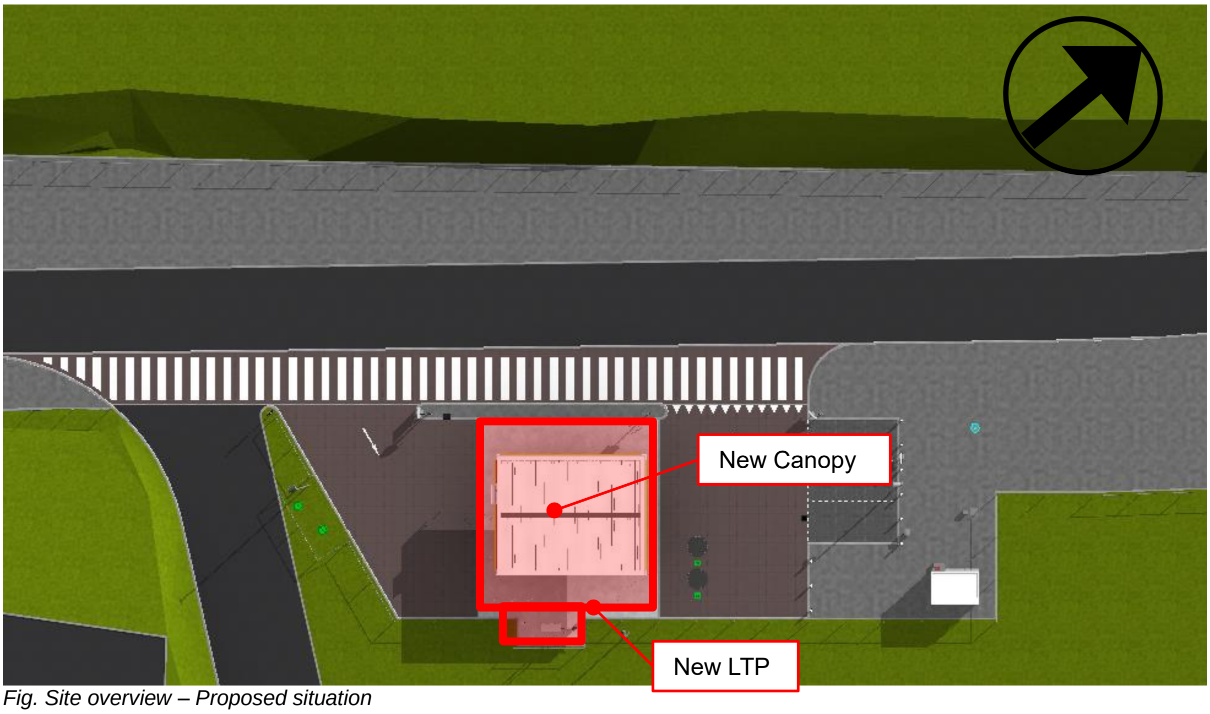


Fig. Site overview – Proposed situation

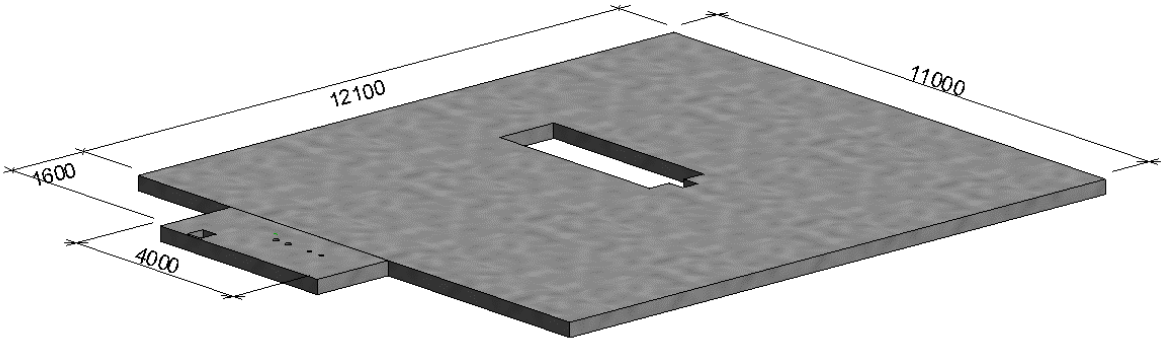


Fig. 3D view – Liquid-tight pavement

Liquid-tight paving is made of reinforced concrete. The design lifetime for liquid-tight pavements is 15 years. Liquid-tight pavement must be applied in accordance with the requirements of the NEN-EN 13670: 2009, BRL SIKB 7700-7702 and the additional requirements in this specification.

2. Codes & Regulations

This calculation has been based on the last expenditures of the European standards with applicable Dutch National Annexes:

- NEN-EN 1990 & NB Basis of structural design
- NEN-EN 1991 & NB Actions on structures
- NEN-EN 1992 & NB Design of concrete structures
- NEN-EN 1997 & NB Geotechnical design
- NEN-EN 206-1 Specification, performance, production and conformity
- NEN-EN 10080 Steel for the reinforcement of concrete
- NEN-EN 13670 Execution of concrete structures

Other standards and regulations:

- NEN 9997-1 Geotechnical design of structures – part 1 – General rules
- National Directives and Recommendations
- Shell Global Innovation & Design Standards

3. Design Criteria

Indicative design working life — *In accordance with Table NB.1 – 2.1 of NEN-EN 1990/NB*

Category 2	15 years	Replaceable structural parts

Consequences classes (CC) — *In accordance with Table NB.20 – B1 of NEN-EN 1990/NB*

CC2	**Medium** consequence for loss of human life, *and/or* economic, social or environmental consequences **considerable**

Reliability classes (RC) — *In accordance with Tables B2 and B3 of NEN-EN 1990*

RC2	$\beta_{(1\ year)} = 4,7$	$\beta_{(50\ years)} = 3,8$	$K_{FI} = 1,0$

Design supervision levels (DSL) — *In accordance with Table B4 of NEN-EN 1990*

DSL 2 i.r.t. RC2	Normal supervision	Checking by different persons that those originally responsible and in accordance with the procedure of the organization

Inspection levels (IL) — *In accordance with Table B5 of NEN-EN 1990*

IL2 i.r.t. RC2	Normal inspection	Inspection in accordance with the procedures of organization

Execution classes (EXC) — *In accordance with material treaties execution standards NEN-EN 13670 and NEN-EN 1090*

EXC2 i.r.t. RC2 and RC1	Office, shopping, domestic and residential areas, industrial structures

Categories of use — *In accordance with Art.6.3 of NEN-EN 1991-1-1/NB*

		Values of Ψ factors *In accordance with Table NB.2 – A1.1 of NEN-EN 1990/NB*		
E2	Industrial areas	$\Psi_0 = 1,0$	$\Psi_1 = 0,9$	$\Psi_2 = 0,8$
G	Traffic and parking areas for medium vehicles	$\Psi_0 = 0,7$	$\Psi_1 = 0,5$	$\Psi_2 = 0,3$

3.1 Remarks

3.1.1 Requirements for the design

- Liquide-tight pavement is necessary where contamination may occur. The design objective is to ensure all contaminated water and/of fuels spillages are contained by the pavement and drained into the leak tight drainage system. Is necessary to have leak tight pavement on vehicle refueling positions and delivery tanker discharge area.
- The forecourt leak tight pavement area for passenger cars/HGV must at least be extended in both directions from the dispenser hose columns for 'hose length + 1 meter'. Standard hose length is <4,0 meters. For bikers and 2/3 wheeled vehicles must at least be extended in both directions from the standard dispenser hose length is < 2.0 meters.
- For delivery tanker discharge area minimal dimensions are 3x4 meters and at least 1.0 meter from all center lines of the fill points. The curb may be included in the 1 meter, if sealed properly.
- The outside refueling positions without a passing lane are only 3,0 meters wide. The leak tight pavement does not have to extend onto the pedestrian or green areas in that case, although the leak tight area must be finished by a raised curb and sealed properly. Drainage must be inward from that point.
- All pavements areas must have an even and uniform surface and must have a minimum fall of 1:100 to ensure the surface water drains adequately into the site drainage systems. The leak tight forecourt must be designed such that the falls are directed to the middle of the area and not to the outside.
- The liquid-tight concrete pavement must be applied in accordance with the requirements of the NEN-EN 13670: 2009, BRL SIKB 7700-7702 and the additional requirements in this specification.
- The concrete needs to be poured in one piece, without interruption. The capacity of the concrete mixing plant and the number of trucks must be adjusted accordingly. The time between the preparation of the concrete mortar and its processing must be as short as possible for proper processing and compaction and must not exceed 90 minutes. The length of time between successive pourings should not be longer than 2 hours.
- The liquid-tight paving must be applied by the KIWA or another civil contractor recognized by the Accreditation Council.
- Any imperfections to specifically liquid-tight concrete floors must be repaired in accordance with the guidelines BRL 7700 SIKB construction or repair of a liquid-tight concrete facility. The execution method must be approved by the executive board.
- The joint pattern of liquid-tight concrete floors must be applied in accordance with the statement of the builder. The joints must be made in accordance with CUR / PBV Recommendation 65 "Design, construction and repair of liquid-tight facilities made of concrete". The joints must be sawn within 24 hours after pouring. The right moment of sawing should be determined based on the setting time of the floor in relation to the weather conditions. To prevent adverse influence of the curing compound on the adhesion of the joint sealants, sawing can only be done after the after-treatment time has elapsed. The joint seals, pre-treatment of the bonding surfaces and the application of the backing material with joint filling materials must be applied according to the regulations of the supplier. The adhesive primer to be applied should be suitable for this surface. The cut should have a right course. Along a row of 2 m, the1 size deviation in the horizontal plane must not exceed 5 mm. The finished concrete surfaces must afterwards be treated with curing compound in accordance with NEN 2743.

3.1.2 Environmental Factors

- Concrete pump island, liquid-tight – as indicated on the plans

  Manufacturer: Projects in Prefab.
  Type: standard pump island.
  Color: standard concrete grey.
  Dimensions: according to order list.
  Strength: concrete quality C45 / 55.
  Reinforcement: FeB500.
  Environmental class: XA3 / XF4.
  Finish: top with two-sided slope and a non-slip structure.
  Accessories: lifting facilities.

- Before putting into service, the liquid-tight paving must be tested.
- The contractor is responsible for the check of the oil and gas separator of the liquid-tight floor that needs to be installed.

- Geotechnical influences on surroundings elements. Avoid influences on underground storage tanks. Take in consideration excavation impact during maintenance on underground tanks.

3.1.3 Type of geotechnical design

- At this moment maximum Earth Stress is approx.:
  - ULS = 140,4 kN/m^2
  - SLS = 94,0 kN/m^2
- allowable soil pressure σ_d = ~200 kN/m^2.
- For soil a bedding is used of approx. k_s=10.000 kN/m^3

4. Material

4.1 Concrete

4.1.1 Quality

Concrete quality *In accordance with Table 3.1 of NEN-EN 1992-1-1/NB*

Blinding layer	C12/15	f_{ck} = 12 N/mm^2	$f_{ck;cube}$ = 15 N/mm^2
In situ concrete	C30/37	f_{ck} = 30 N/mm^2	$f_{ck;cube}$ = 37 N/mm^2

Quality of the reinforcement steel *In accordance with Annex C of NEN-EN 1992-1-1/NB and NEN-EN 10080*

	B500B	f_{yk} = 500 N/mm^2	with dented or ribbed surface

4.1.2 Partial factors

Partial factors for materials *In accordance with Art.2.4.2.4 of NEN-EN 1992-1-1/NB*

Design situation	γ_C for concrete	γ_S for reinforcing steel
Persistent & Transient	1,5	1,15
Accidental	1,2	1,0
Fatigue	1,35	1,15
Serviceability	1,0	1,0

Partial factors for materials for foundation *In accordance with Art 2.4.2.5 of NEN-EN 1992-1-1/NB*

k_f = 1,1

4.1.3 Sustainability

Specific aspects related to sustainability such as environmental class, concrete cover, conservation, etc. (if needed) mentioned in specifications and drawings.

Environmental conditions *In accordance with Table 4.1 of NEN-EN 1992-1-1/NB*

Attack mechanism		class	Environment	cover (c) Plate, wall	cover (c) Beam, pedestal, console	cover (c) Column	Crack width (w)
No Corrosion	**X0** (0= "zero risk") No risk of corrosion or attack	X0	For concrete without reinforcement or embedded metal: all exposures except where there is freeze/thaw, abrasion of chemical attack				
Corrosion reinforcement	**XC** (C= "Carbonation") Corrosion induced by carbonation	XC1	Dry or permanently wet	15	25	30	0,4
		XC2	Wet, rarely dry				
		XC3	Moderate humidity	**25**	**30**	**35**	**0,3**
		XC4	**Cyclic wet and dry**				
	XD (D= "Deicing salts") Corrosion induced by chlorides not sea water	**XD1**	**Moderate humidity**				
		XD2	Wet, rarely dry	**30**	**35**	**40**	**0,2**
		XD3	Cyclic wet and dry				
	XS (S= "Seawater") Corrosion induced by chlorides from sea water	XS1	Airborne salt (no contact with sea water)				
		XS2	Permanently submerged	30	35	40	0,2
		XS3	Tidal, splash and spray zones				
Corrosion concrete	**XF** (F= "Frost") Freeze/Thaw attack	**XF1**	**Moderate water saturation, without de-icing agent**	**25**	**30**	**35**	**0,3**
		XF2	Moderate water saturation, with de-icing agent	30	35	40	0,2
		XF3	High water saturation, without de-icing agents	25	30	35	0,3
		XF4	High water saturation, with de-icing agents or sea water	30	35	40	0,2
	XA (A= "Aggressive") Chemical attack	**XA1**	**Slightly aggressive chemical environment**				
		XA2	Moderate aggressive chemical environment	**30**	**35**	**40**	**0,2**
		XA3	Highly aggressive chemical environment				

5. Actions

5.1 Permanent actions

Dead loads of structural structures	*In accordance with Table A1 t/m A12 of NEN-EN 1991-1-1*
Concrete structures	25,0 kN/m³

5.2 Imposed loads

Imposed loads for floors and roofs	*In accordance with Table NB.1 – 6.2 to NB.5 of NEN-EN 1991-1-1/NB*		
Heavy vehicle ≥ 120 kN	Category G	10 kN/m2	200 kN (axle load)

6. Combinations of actions

6.1 ULS – Ultimate Limit States

Table NB.4 – A1.2 (B) – Design values of actions (STR/GEO) (Set B) in accordance with NEN-EN 1990/NB

Persistent and transient design situations	Permanent actions		Leading variable action	Accompanying variable actions	
	Unfavourable	Favourable		Main (if any)	Others
(Eq. 6.10a)	1,35 $G_{kj,sup}$	0,9 $G_{kj,inf}$		1,5 $\psi_{0,1}Q_{k,1}$	1,5 $\psi_{0,i}Q_{k,i}$ $i > 1$
(Eq. 6.10b)	1,2 $G_{kj,sup}$ ζ = 0,89 is included	0,9 $G_{kj,inf}$	1,5 $Q_{k,1}$		1,5 $\psi_{0,i}Q_{k,i}$ $i > 1$

6.2 SLS – Serviceability Limit States

Table A1.4 – Design values of actions for use in the combination of actions in accordance with NEN-EN 1990

Combination	Permanent action G_d		Variable actions G_d	
	Unfavorable	Favorable	Leading	Others
Characteristic	1,0 $G_{kj,sup}$	1,0 $G_{kj,inf}$	1,0 $Q_{k,1}$	1,0 $\psi_{0,i}Q_{k,i}$
Frequent	1,0 $G_{kj,sup}$	1,0 $G_{kj,inf}$	1,0 $\Psi_{1,1}Q_{k,1}$	1,0 $\Psi_{2,i}Q_{k,i}$
Quasi-permanent	1,0 $G_{kj,sup}$	1,0 $G_{kj,inf}$	1,0 $\Psi_{2,1}Q_{k,1}$	1,0 $\Psi_{2,i}Q_{k,i}$

7. Calculations

7.1 Concrete structures

Liquide-tight pavement is necessary where contamination may occur. The design objective is to ensure all contaminated water and/of fuels spillages are contained by the pavement and drained into the leak tight drainage system. Is necessary to have leak tight pavement on vehicle refueling positions and delivery tanker discharge area.

The material to be used is in-situ cast concrete. The surface finish must be brushed concrete to ensure a non-slippery forecourt. The leak tight areas must be segmented into smaller areas by creating expansion/contraction joints. Typically, the maximum concrete slab dimensions can be approximately 5x5 meters, depending on the sub base design, concrete mix and contractor capabilities. The number of joints within the overall leak tight area must be minimized. The material used for joints must be resistant to hydrocarbons, must affix to the concrete slabs and must be able to be applied at ambient temperatures. Typically, poly sulphide sealant is used.

7.1.1 General

Below a schematic overview of the liquid tight pavement concrete structure.

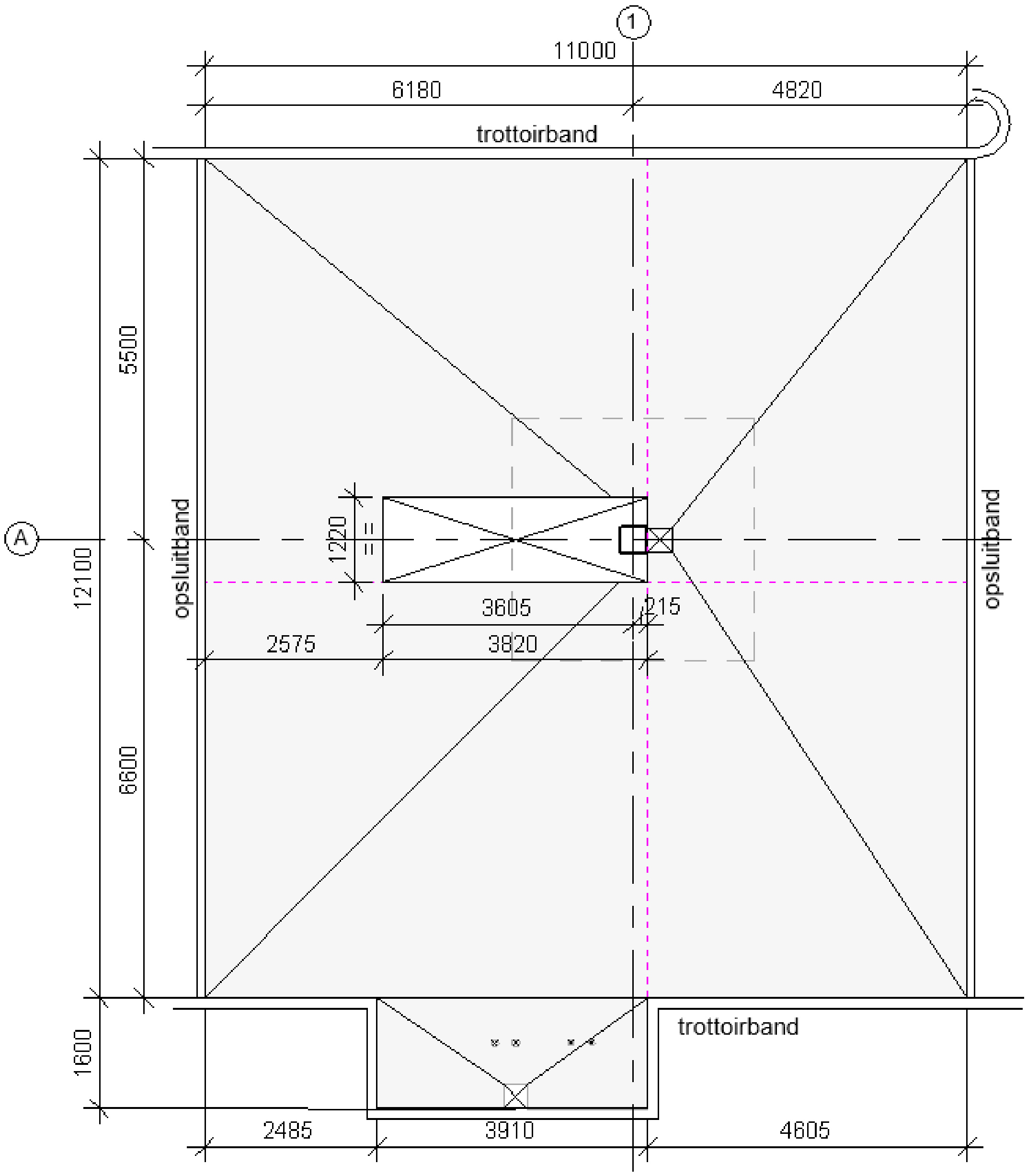


Fig. 3D view – Liquid-tight pavement

Materials

Blinding layer	C12/15
In situ concrete	C30/37

Section Properties

Prop	Layer	Material
1	220 mm	C30/37
2	50 mm	C12/15

7.1.2 Design situations

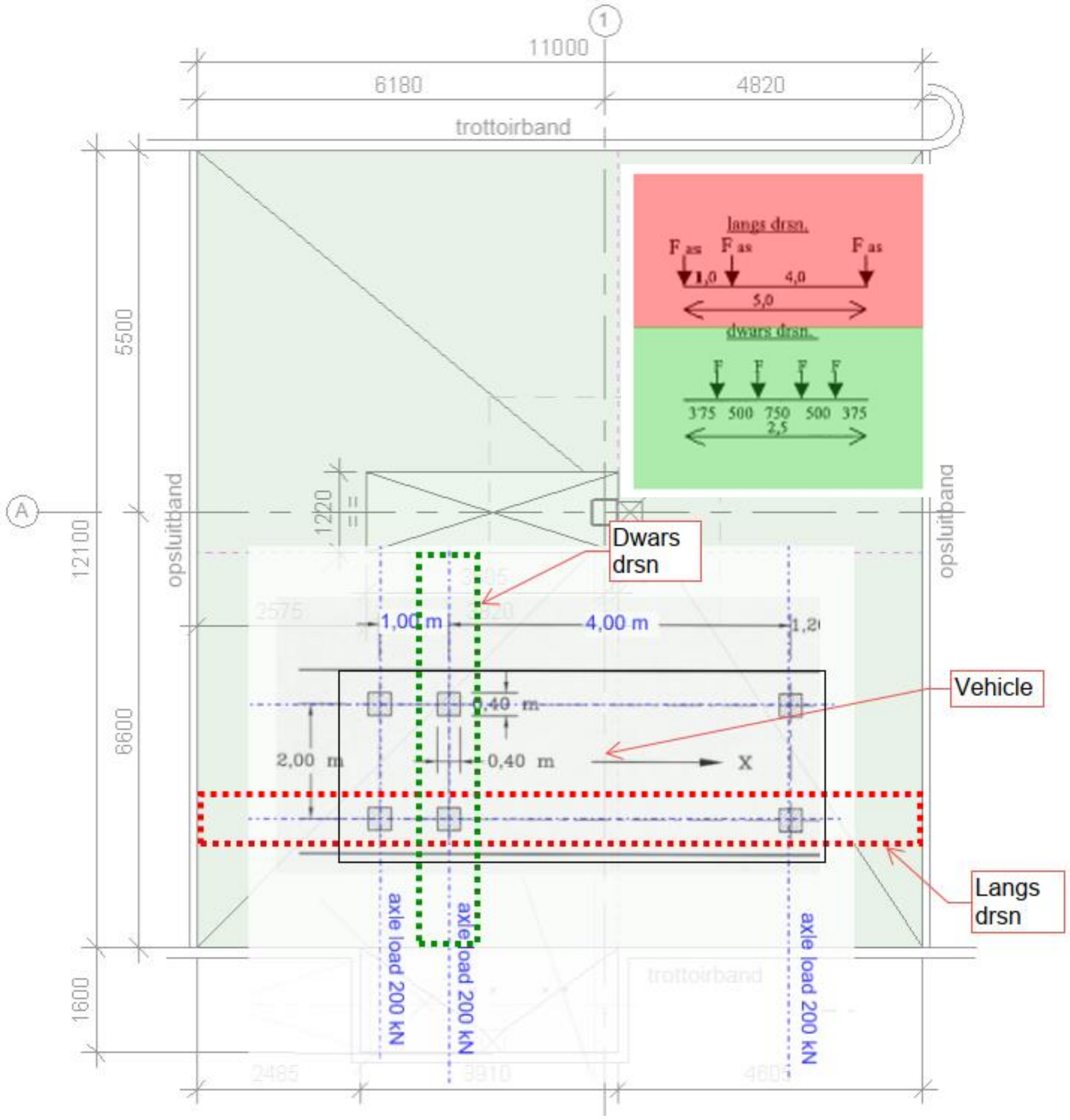


Fig. Loads configurations – LTP

For technosoft calculation of 1st design situation (langst drsn.), see Appendix A.

For technosoft calculation of 2nd design situation (dwars drsn.), see Appendix B.

Appendix A – 1st design situation

Technosoft Liggers release 6.29

Component....: langs drsn. - 1st design situation – liquid tight pavement
Struct. eng..: Cezar Cretu
Dimensions...: kN/m/rad

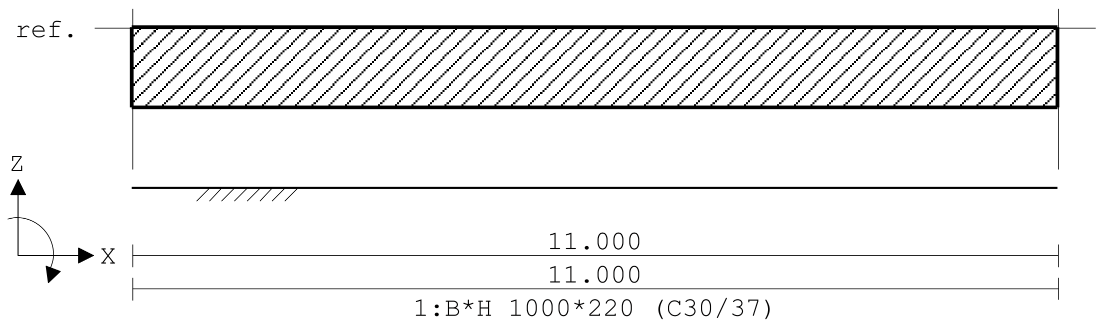
Physical linear: Calculations are based on E-modulus from MATERIALS table.
Phy.NLE.short : Calculations are based on corrected E-modulus. (short term)
These E-mod. are calculated from the forces of the Physical linear calculation.

Applied standards according to Eurocode with Dutch NA

Loads	NEN-EN 1990:2002	C2:2010	NB:2011(nl)
	NEN-EN 1991-1-1:2002	C1:2009	NB:2011(nl)
Concrete	NEN-EN 1992-1-1:2011(nl)	C2/A1:2015(nl)	NB:2016(nl)

K82509

GEOMETRY Beam:1



FIELD LENGTHS Beam:1

Field	From	To	Length
1	0.000	11.000	11.000

MATERIALS

Mt	Description	E-modulus[N/mm2]	S.W.	Pois.	Exp. coeff.
1	C30/37	9465	25.0	0.20	1.0000e-05

MATERIALS contd.

Mt	Description	Cement	Creep coeff.
1	C30/37	N	2.47

SECTIONS [mm]

Sect.	Description	Material	Area	Inertia	Formf.
1	B*H 1000*220	1:C30/37	2.2000e+05	8.8733e+08	0.00

SECTIONS contd. [mm]

Sect.	Bar type	Width	Height	e	Type	w1	h1	w2	h2
1	0:Normal	1000	220	110.0	0:RH				

CROSS-SECTIONS Beam:1

sector	From	To	Length	Section begin	z-begin	Section end	z-end
1	0.000	11.000	11.000	1:B*H 1000*220	0.000	1:B*H 1000*220	0.000

sector	From	To	Length	End code	Elast.f	Bw.[mm]
1	0.000	11.000	11.000	1:Fixed	10000	1000

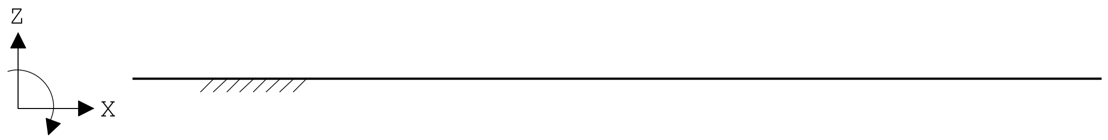
LOAD CASES

L.C.	Description	Loaded/unloaded	ψ_0	ψ_1	ψ_2	s.w.
1	DL	2:Permanent EN1991				-1.00
2	LL-cars	0:All at once	0.70	0.50	0.30	0.00

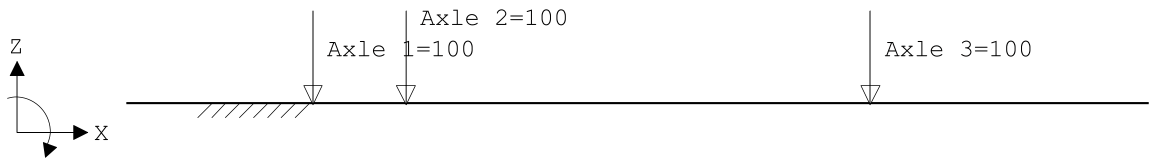
LOAD CASES

LCa	Description	Type
1	DL	1 Permanent load
2	LL-cars	6 Var. load by vehicles

FIELD LOADS Beam:1 LCa:1 DL



FIELD LOADS Beam:1 LCa:2 LL-cars



FIELD LOADS Beam:1 LCa:2 LL-cars

Load Ref.	Type	Description	q1/p/m	q2	psi	Dist.	Length
1	8:Point load	Axle 1	-100.000			2.000	
2	8:Point load	Axle 2	-100.000			3.000	
3	8:Point load	Axle 3	-100.000			8.000	

LOAD COMBINATIONS

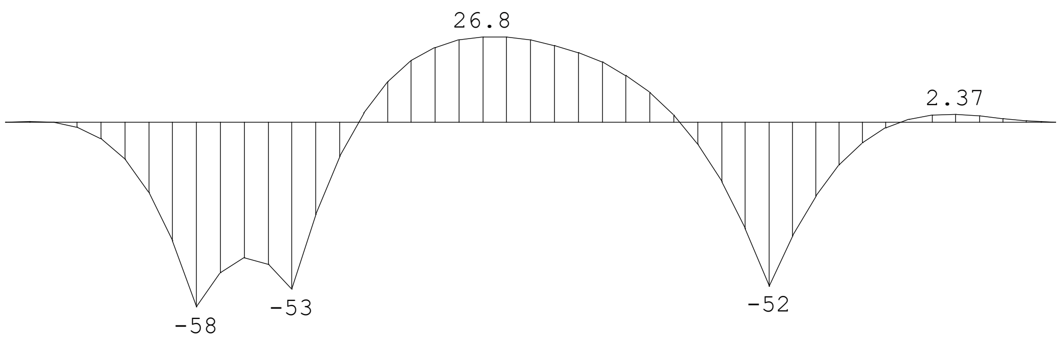
LCo	Type	LCa	Gen.	Factor	LCa	Gen.	Factor	LCa	Gen.	Factor	LCa	Gen.	Factor
1	Fund.	1	Perm	1.35	2	Extr	1.50						
2	Char.	1	Perm	1.00	2	Extr	1.00						
3	Freq.	1	Perm	1.00	2	Extr	0.60						

FAVOURABLE PARTS OF PERMANENT ACTION

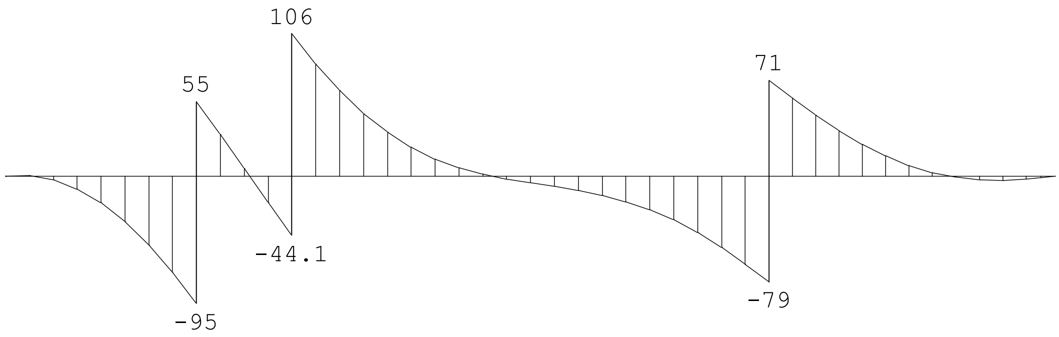
LCo	Fields with favourable parts of permanent action
1	No beams

CONTOUR OF THE FUNDAMENTAL COMBINATIONS

MOMENTS Phys. linear model Beam:1 Fundamental combination



SHEAR FORCES Phys. linear model Beam:1 Fundamental combination



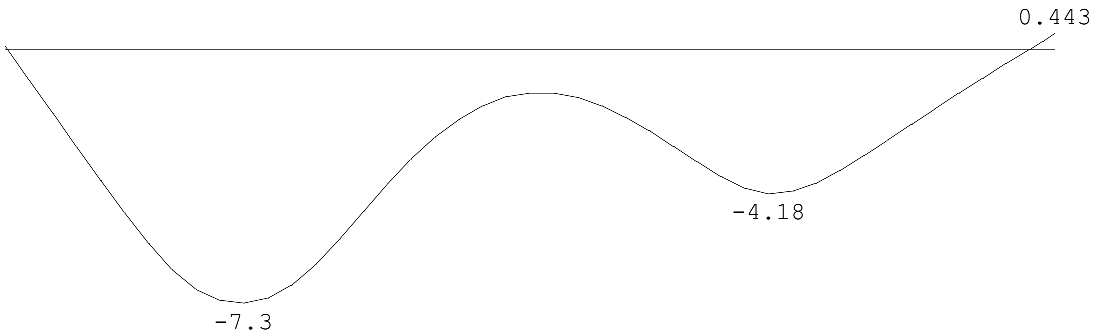
FIELD VALUES Phys. linear model Beam:1 Fundamental combination

Field	Pos.	Transl. [mm]	Shear force	Moment	Earth stress [kN/m2]
1	0.000	0.18	0.00	0.00	
1	0.250		0.49	0.14	
1	0.289		0.00		
1	0.427			0.00	
1	2.000		-94.55	-58.24	
1	2.000		55.45	-58.24	
1	2.500	-10.92	5.44	-42.90	109.151
1	2.554		0.00		
1	3.000		-44.09	-52.72	
1	3.000		105.91	-52.72	
1	3.697			0.00	
1	5.000		1.45	26.83	
1	5.101		0.00		
1	5.500	-1.82	-5.01	25.83	18.191
1	5.500	-1.82	-5.01	25.83	18.191
1	7.059			0.00	
1	8.000	-6.18	-78.72	-51.64	61.832
1	8.000	-6.18	71.28	-51.64	61.832
1	9.390			0.00	
1	9.898		0.00		
1	9.956		-0.86	2.37	
1	10.445		-3.37		
1	11.000	0.79	0.00	0.00	

Maximum earth stress value = 109.151 [kN/m2] and is smaller than assumed allowable soil pressure: σd = ~200 kN/m2.

CONTOUR OF THE CHARACTERISTIC COMBINATIONS

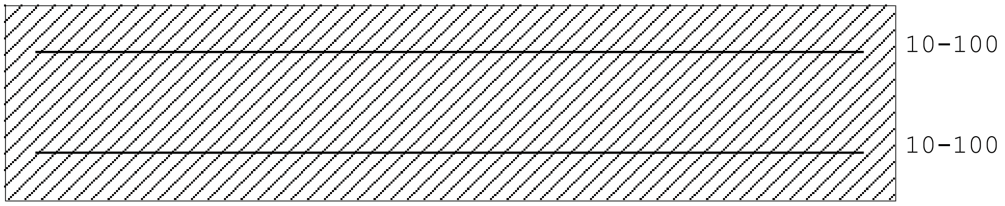
TRANSLATIONS [mm] Phys. linear modelBeam:1 Characteristic combination



SECTION DATA Floor	**[N][mm]** rel. to section:1 B*H 1000*220		
General			
Material	: C30/37		
Area	: 2.200000e+05	Inertia	: 8.8733e+08
Bar type	: 0:normal	Shape fact.:	0.00

Cross section

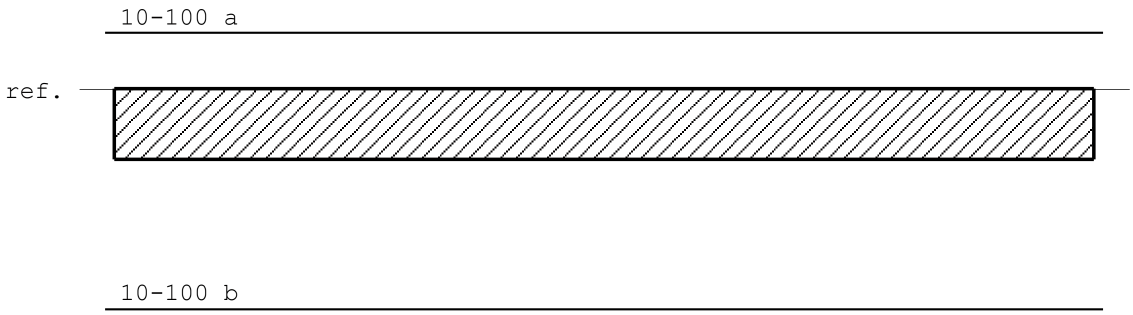
width : 1000 height : 220 center of gravity bott.side : 110
Reference : Top



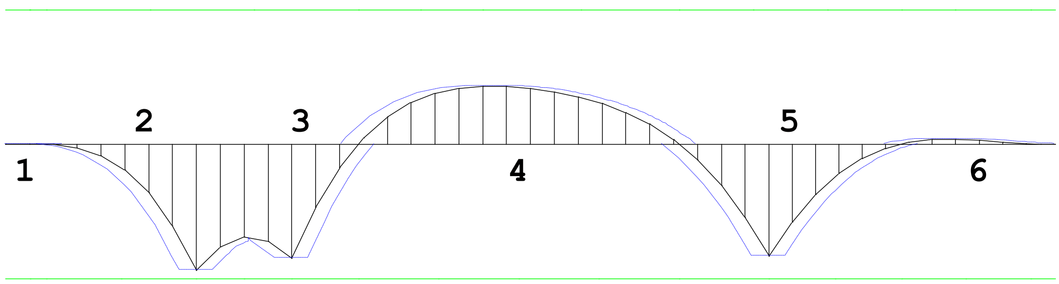
Nominal size : 180.3
Bearing width a_b 6.1(10) : 0

Concrete quality element : C30/37 Creep coeff. : 2.5
Tensile str. $f_{ct,eff}$ art. 7.1(2): $f_{ctm,fl}$ (4.00 N/mm²)
Steel quality main reinforcement: 500 ε_{uk} : 5.00

Main reinforcement Phys. linear modelBeam:1Fundamental combination



MEd covering Phys. linear model Beam:1 Fundamental combination



Main reinforcement Beam:1

Sect.	Pos. [mm]	M_{Ed} [kNm]	M_{Rd} [kNm]	z [mm]	T/B	A_r [mm²]	A_d [mm²]	Main reinforcement +Aux. reinforcement	Rem.
4	5000	26.83	62.15	115	T	408*	786	10-100	1,54
2	2000	-58.24	-62.15	115	B	778	786	10-100	

Crack formation according to article 7.3.4 Beam:1

Geb.	Pos. [mm]	Side	$M_{E;freq}$ [kNm]	$s_{r,max}$ [mm]	$\varepsilon_{sm}-\varepsilon_{cm}$ [‰]	w_k [mm]	k_x	w_{max} [mm]	U.C.	Opm.
1	5000	Top	10.73	260	0.249	0.065	1.14	0.229	0.28	
1	2000	Bot	-23.30	260	0.541	0.141	1.33	0.400	0.35	

Course of main reinforcement Beam:1

Mark	T/B	Reinforcement	From [mm]	To [mm]	Length [mm]	$L_{bd;begin}$ [mm]	$L_{bd;eind}$ [mm]
a	Top	10-100	-100	11100	11200	100	100
b	Btm.	10-100	-100	11100	11200	100	100

Appendix B – 2nd design situation

Technosoft Liggers release 6.29

Component....: dwars drsn. - 2nd design situation - liquid tight pavement
Struct. eng..: Cezar Cretu
Dimensions...: kN/m/rad

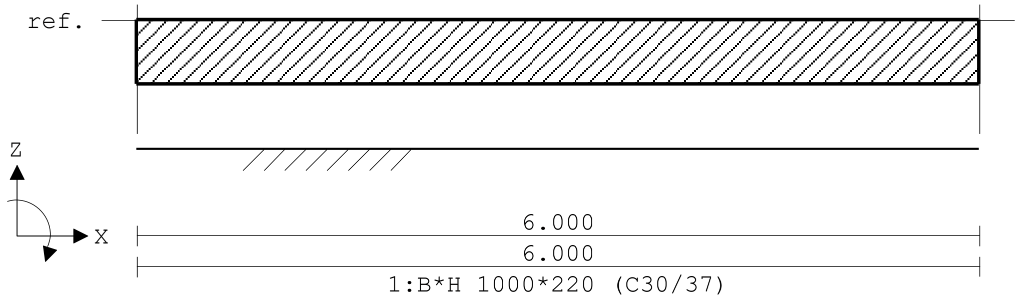
Physical linear: Calculations are based on E-modulus from MATERIALS table.
Phy.NLE.short : Calculations are based on corrected E-modulus. (short term)
These E-mod. are calculated from the forces of the Physical linear calculation.

Applied standards according to Eurocode with Dutch NA

Loads	NEN-EN 1990:2002	C2:2010	NB:2011(nl)
	NEN-EN 1991-1-1:2002	C1:2009	NB:2011(nl)
Concrete	NEN-EN 1992-1-1:2011(nl)	C2/A1:2015(nl)	NB:2016(nl)

K82509

GEOMETRY Beam:1



FIELD LENGTHS Beam:1

Field	From	To	Length
1	0.000	6.000	6.000

MATERIALS

Mt	Description	E-modulus[N/mm2]	S.W.	Pois.	Exp. coeff.
1	C30/37	9465	25.0	0.20	1.0000e-05

SECTIONS [mm]

Sect.	Description	Material	Area	Inertia	Formf.
1	B*H 1000*220	1:C30/37	2.2000e+05	8.8733e+08	0.00

CROSS-SECTIONS Beam:1

sector	From	To	Length	Section begin	z-begin	Section end	z-end
1	0.000	6.000	6.000	1:B*H 1000*220	0.000	1:B*H 1000*220	0.000

sector	From	To	Length	End code	Elast.f	Bw.[mm]
1	0.000	6.000	6.000	1:Fixed	10000	1000

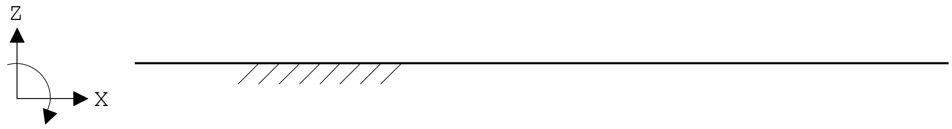
LOAD CASES

L.C.	Description	Loaded/unloaded	ψ_0	ψ_1	ψ_2	s.w.
1	DL	2:Permanent EN1991				-1.00
2	LL-cars	0:All at once	0.70	0.70	0.60	0.00

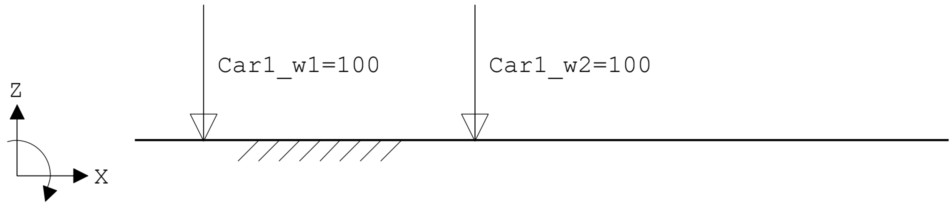
LOAD CASES

LCa	Description	Type
1	DL	1 Permanent load
2	LL-cars	6 Var. load by vehicles

FIELD LOADS Beam:1 LCa:1 DL



FIELD LOADS Beam:1 LCa:2 LL-cars



FIELD LOADS Beam:1 LCa:2 LL-cars

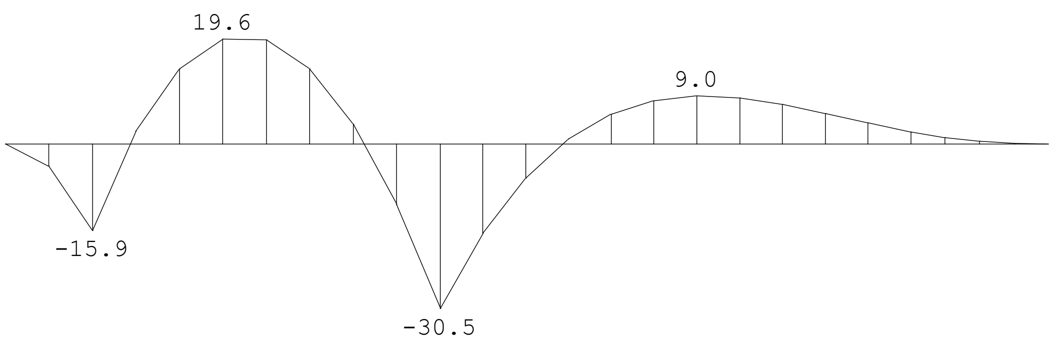
Load Ref.	Type	Description	q1/p/m	q2	psi	Dist.	Length
1	8:Point load	Car1_w1	-100.000			0.500	
2	8:Point load	Car1_w2	-100.000			2.500	

LOAD COMBINATIONS

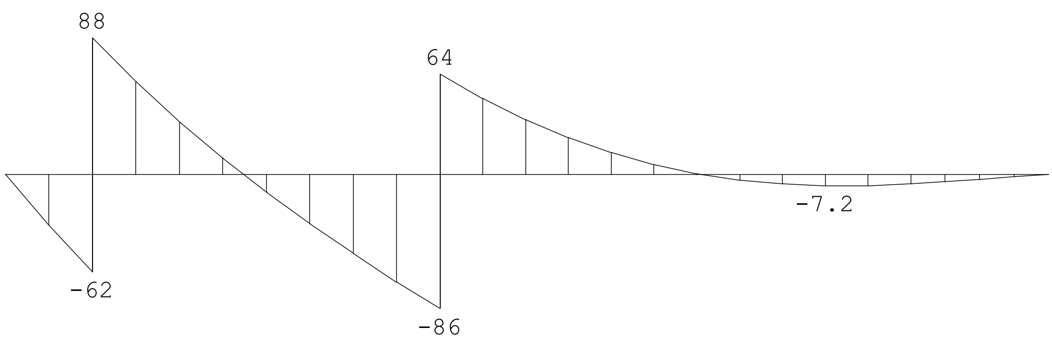
LCo	Type	LCa	Gen.	Factor	LCa	Gen.	Factor	LCa	Gen.	Factor	LCa	Gen.	Factor
1	Fund.	1	Perm	1.35	2	Extr	1.50						
2	Char.	1	Perm	1.00	2	Extr	1.00						
3	Freq.	1	Perm	1.00	2	Extr	0.70						

CONTOUR OF THE FUNDAMENTAL COMBINATIONS

MOMENTS Phys. linear model Beam:1 Fundamental combination



SHEAR FORCES Phys. linear model Beam:1 Fundamental combination



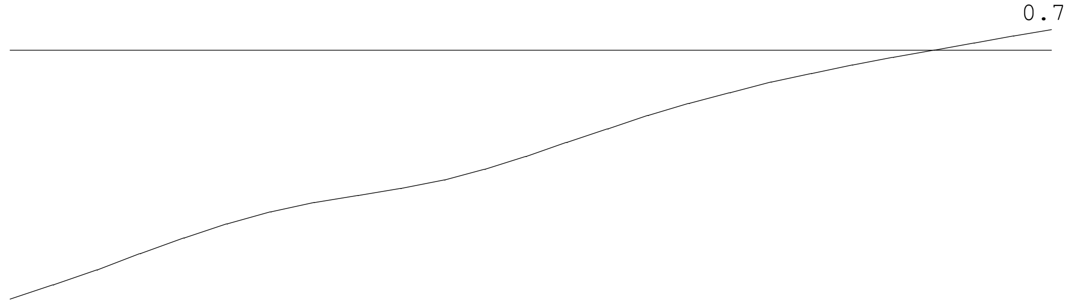
FIELD VALUES Phys. linear model Beam:1 Fundamental combination

Field	Pos.	Transl. [mm]	Shear force	Moment	Earth stress [kN/m2]
1	0.000	-14.03	0.00	0.00	140.347
1	0.500		-62.41	-15.94	
1	0.500		87.59	-15.94	
1	0.717			0.00	
1	1.250		10.41	19.56	
1	1.370		0.00		
1	2.063			0.00	
1	2.500		-85.68	-30.50	
1	2.500		64.32	-30.50	
1	3.205			0.00	
1	3.977		0.69	8.96	
1	4.018		0.00		
1	4.716		-7.21		
1	6.000	1.43	-0.00	-0.00	

Maximum earth stress value = 140.4 [kN/m2] and is smaller than assumed allowable soil pressure: σd = ~200 kN/m2.

CONTOUR OF THE CHARACTERISTIC COMBINATIONS

TRANSLATIONS [mm] Phys. linear modelBeam:1 Characteristic combination



Load combination Quasi-Permanent is missing, physical non-linear calculation is not possible.

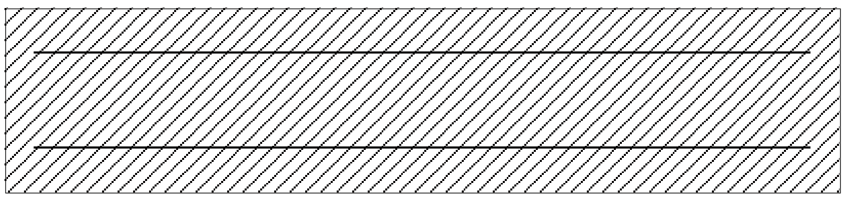
SECTION DATA Floor **[N][mm]** rel. to section:1 B*H 1000*220

General

Material : C30/37
Area : 2.200000e+05 Inertia : 8.8733e+08
Bar type : 0:normal Shape fact.: 0.00

Cross section

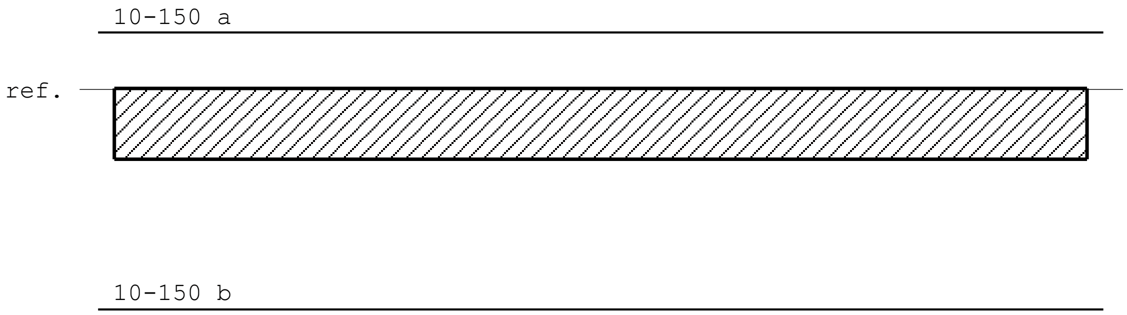
width : 1000 height : 220 center of gravity bott.side : 110
Reference : Top



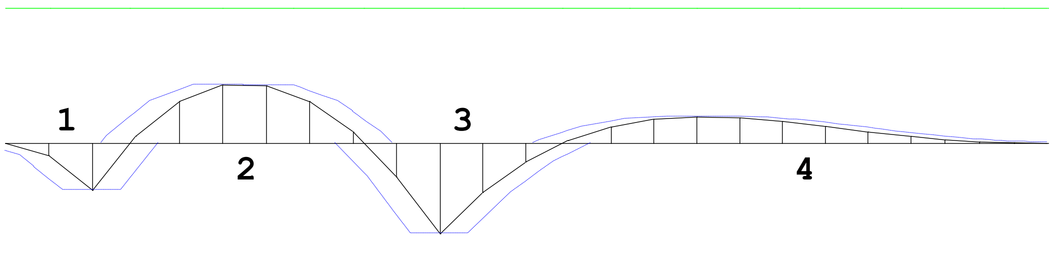
Nominal size : 180.3
Bearing width a_b 6.1(10) : 0

Concrete quality element : C30/37 Creep coeff. : 2.5
Tensile str. $f_{ct,eff}$ art. 7.1(2): $f_{ctm,fl}$ (4.00 N/mm²)
Type of stress-straindiagram : Parabolic - rectangular diagram
Deflection according to 7.3.4(3): Yes
Longterm cracking moment limited: Yes
Steel quality main reinforcement: 500 ε_{uk} : 5.00
Type of stress-straindiagram : Bi-linear diagram with inclined branch
Prefabricated element : No

Main reinforcement Phys. linear modelBeam:1Fundamental combination



MEd covering Phys. linear model Beam:1 Fundamental combination



Main reinforcement Beam:1

Sect.	Pos. [mm]	M_{Ed} [kNm]	M_{Rd} [kNm]	z [mm]	T/B	A_r [mm²]	A_d [mm²]	Main reinforcement +Aux. reinforcement	Rem.
3	2500	-30.50	-45.56	98	B	436*	524	10-150	1
2	1250	19.56	45.56	98	T	325*	524	10-150	1

Remarks
[1] * = Demands for minimum reinforcement are applied. See national annex art. 9.2.1.1(1).

Crack formation according to article 7.3.4 Beam:1

Geb.	Pos. [mm]	Side	$M_{E;freq}$ [kNm]	$s_{r,max}$ [mm]	$\varepsilon_{sm}-\varepsilon_{cm}$ [‰]	w_k [mm]	k_x	w_{max} [mm]	U.C.	Opm.
1	1250	Top	9.14	260	0.323	0.084	1.14	0.229	0.37	
1	2500	Bot	-14.08	260	0.497	0.129	1.33	0.400	0.32	

Course of main reinforcement Beam:1

Mark	T/B	Reinforcement	From [mm]	To [mm]	Length [mm]	$L_{bd;begin}$ [mm]	$L_{bd;eind}$ [mm]
a	Top	10-150	-100	6100	6200	100	100
b	Btm.	10-150	-100	6100	6200	100	100

C. Cretu
Structural Engineer
M: +40 743 291 647
E: cezar.cretu@aecom.com

AECOM Netherlands B.V.
HNK Den Haag, Oude Middenweg 17
2491 AC Den Haag, The Netherlands

T: +31 (0) 702400898
aecom.com