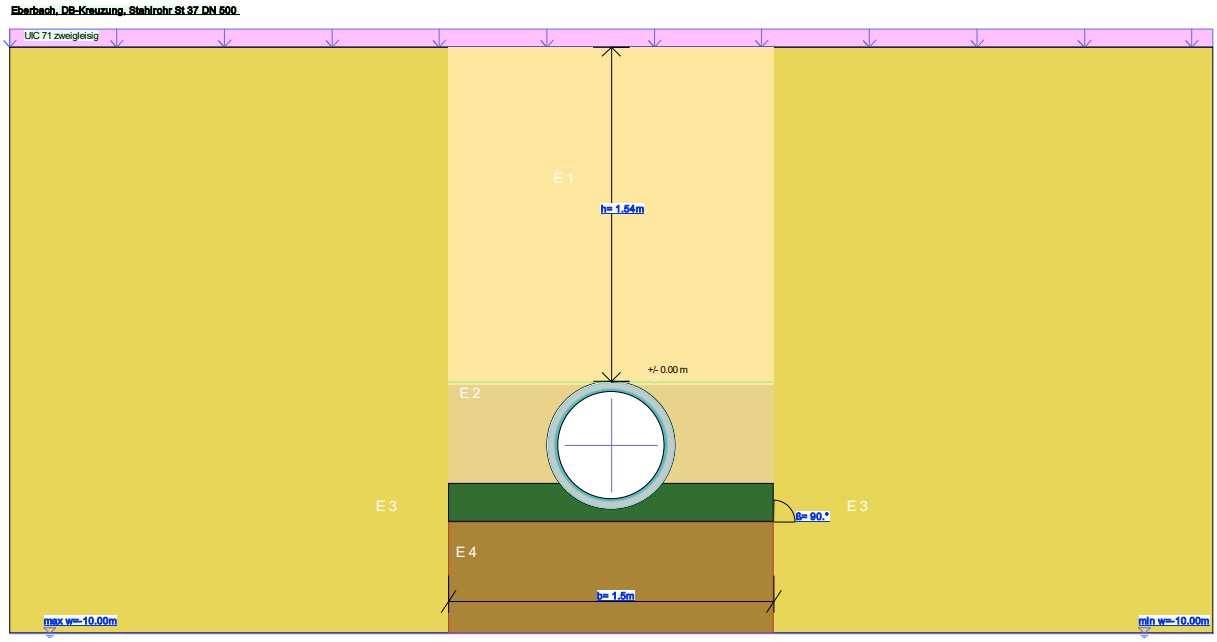
Eberbach, DB-Kreuzung, Stahlrohr St 37 DN 500

Input file: ZFSV-Boden_Stahlrohr_02.ror
Datum/Date : 26.10.2018



S T R U C T U R A L A N A L Y S I S O F B U R I E D P I P E S

according to DWA worksheet A127: Code for the structural analysis of drainage ducts and drainage tubes (RIB program *A127*)
Calculation acc. to DWA-A 127

Steel pipes DIN 1629/1626

Printout of the input:

Dimensions and material data:

Nominal diameter		DN 500
Outer diameter	da =	583.4 mm
Inner diameter	di =	493.4 mm
Wall thickness	t =	45.0 mm

Material properties:

Specific weight of pipe material	SpeWgt.R =	78.500 kN/m3
Youngs modulus of the pipe	E.R =	210000 N/mm2
Characteristic bending stress	sigma.R =	320.0 N/mm2
Partial safety factor for member resist. lateral to the pipe axis	gamm.R,rad =	1.15

Installation:
The pipes are designed for an installation according to DIN EN 1610 and ATV-DVWK-A 139:
- Foundation type 1 resp. 3 on sand/sand-gravel resp. on natural soil according to DIN EN 1610, Fig. 3 or 5, resp. ATV-DVWK-A 139, Fig. 5
  Angle of foundation 2*Alpha = 180 degrees
- Embedment condition B1:
  Fluidized soil in the embedment area
  In layers against existing natural soil resp. embankment fill compacted in layers and lateral backfill
- Backfill condition A1:
  Fluidized soil in the surcharge area
  Backfill compacted in layers against natural ground respectively embankment fill.

- Trench width used b = 1.5 m
  Angle of repose Beta = 90 Deg.

Design load assumptions:
  Backfill height h = 1.54 m
  Relative projection a = 1.00
  Live load: LM 71 - mehrgleisig
  Ground water: not present

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Soil characteristics:

Soil zones:	Zone 1 Main filling	Zone 2 Pipe zone	Zone 3 Natural soil	Zone 4 below pipe
Installation cond.	A1	B1		
Soil classes	G5	G5	G1	
Proctor density	Dpr =100 %	Dpr =100 %	Dpr = 95 %	
Mod. of deform.	E1 = 25.0	E2 = 25.0	E3 = 23.0	E4 = 230.0
Angle of frict.	Phi' = 34.0		Phi'= 33.0	
Specific weight	Gamma = 20.0			
under buoyancy	Gamma'= 11.0			

Definition of the soil groups (see section 3.1):
Group G1: Non cohesive sand and gravel, to be compacted to Dpr 95%
Group G2: Weakly cohesive sand and gravel,to be compacted to Dpr 95%
Group G3: Cohesive soil mixtures and silt,to be compacted to Dpr 92%
Group G4: Cohesive soils (clay and loam), to be compacted to Dpr 92%

Computed results:

Soil zones:	Zone 1	Zone 2	Zone 3	Zone 4
Earth press. rel.	K1 = 0.500	K2 = 0.500		
Limit E2		E2 = 25.0		
Creep factor f1		f1 = 1.0		
Factor f2		f2 = 1.000		
Factor Alpha.B		alp.B= 1.000		
effective E	E1 = 25.0	E2 = 25.0	E3 = 23.0	E4 = 230.0
effective Phi'	phi'= 33.0			
effective Delta	del = 22.0			

A TFS infilling material is used in zone 1.
A TFS infilling material is used in zone 2.
Trench support is being pulled in the flowable state of the TFS soil.

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Analysis of a sufficient stability of the material in the flowable state:
Compliance with the minimum yield point:
tau.f >= tau.o,min
192.0 >= 192.0 N/m2
Analysis fulfilled
withtau.o,min=(4/3)*(gamma.grain-gamma.fluid)*r.grain,90
withtau.o,min=(4/3)*(27.0 - 11.0)* 9.0 = 192.0

Compressive strengths and ability to re-excavate of the fluidized soil
with stiffness increase f.z (N/mm2) between t1=7 and t2=56 days
for a compressive strength f.c,7d = 0.150 N/mm2 to t1= 7 days
f.c,56d = 0.280 N/mm2 to t2=56 days
f.c,28d = 0.240 N/mm2 to t3=28 days
withf.z = (f.c,56d-f.c,7d)/(log(t2/t1)) = 0.144

Characteristic of the ability to re-excavate:
easy; by hand

Effective relative projection a' = a*E1/E2	=	1.000	
Reduction factor trench load kappa	=	1.000	
Reduction factor surface load kappa.0	=	1.000	
Pipe stiffness SR	=	81.743	N/mm2
zeta	=	0.970	
Horizontal foundation stiffness SBh	=	14.55	N/mm2
Vertical foundation stiffness SBv	=	25.00	N/mm2
System stiffness Pipe/Soil VRB	=	5.617	
K*	=	0.000	
cv*	=	-0.083	
Stiffness proportion VS	=	39.25	
Concentration factors max.lambda	=	1.435	
lambda.R	=	1.420	
lambda.RG	=	1.220	
lambda.B	=	0.860	

External loads:
Earth loads:

- within soil above pipe pE	=	30.8	kN/m2
- vertical lambda.RG * pE = ev	=	37.6	kN/m2
- horizontal qh = eh	=	16.2	kN/m2
- found. reaction pressure (ev - eh) * K* = eh*	=	0.0	kN/m2

Live loads:

- Traffic load p	=	48.7	kN/m2
- Impact coefficient phi	=	1.62	
Impact coefficient ground phi0	=	1.67	
- structurally effective pV	=	78.7	kN/m2
- structurally effective pH	=	30.4	kN/m2

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- found. reaction pressure (pV-pH) * K* = ph* = 0.0 kN/m2
  - dynamically effective dyn.pV = 78.7 kN/m2
  - dynamically effective dyn.pH = 30.4 kN/m2
  - found. reaction pressure dyn.ph* = 0.0 kN/m2
    with alpha = 1.0

Maximum total loads qv = 116.2 kN/m2
qh = 46.6 kN/m2
qh* = 0.0 kN/m2

Sections:	Springline	Pipe crown	Pipe base
Cross-section values:			
Area (cm2/m):	450.000	450.000	450.000
Moment of resistance (cm3/m):	337.500	337.500	337.500
Correction factor inn.alpha.K =	1.056	1.056	1.056
Correction factor out.alpha.K =	0.944	0.944	0.944
Internal forces acc. to chapter 9.1 (associated values acc. to table T3)			
Bending moments M (kNm/m):			
M.g (Dead load) =	-0.101	0.088	0.113
M.w (Water fill/ground water) =	-0.038	0.034	0.043
M.ev (Earth load vertical) =	-0.681	0.681	0.681
M.eh (Earth load horizontal) =	0.293	-0.293	-0.293
M.pV (Live load vertical) =	-1.425	1.425	1.425
M.pH (traffic horizontal):	0.551	-0.551	-0.551
Sum of M (total load) =	-1.401	1.384	1.418
Moments due to predominantly non-static live loads:			
M.pV (dyn) =	-1.425	1.425	1.425
M.pH (dyn) =	0.551	-0.551	-0.551
M.Gk (Sum of permanent loads) =	-0.527	0.510	0.544
M.Qk (Sum of variable loads) =	-0.874	0.874	0.874
M.Gd = gamma.G*M.Gk = 1.35*M.Gk =	-0.711	0.688	0.734
M.Qd = gamma.Q*M.Qk = 1.35*M.Qk =	-1.180	1.180	1.180
M.Ed = M.Gd + M.Qd =	-1.891	1.868	1.914

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Normal forces N (kN/m):				
N.g (Dead load)	=	-1.494	0.159	-0.159
N.w (Water fill/ground water)	=	0.156	0.422	1.027
N.ev (Earth load vertical)	=	-10.117	0.000	0.000
N.eh (Earth load horizontal)	=	0.000	-4.351	-4.351
N.pV (Live load vertical)	=	-21.177	0.000	0.000
N.pH (traffic horizontal):		0.000	-8.193	-8.193
Sum of N (total load)	=	-32.632	-11.962	-11.676

Normal forces due to predominantly non-static live loads:			
N.pV (dyn) =	-21.177	0.000	0.000
N.pH (dyn) =	0.000	-8.193	-8.193
N.Gk (Sum of permanent loads) =	-11.455	-3.770	-3.483
N.Qk (Sum of variable loads) =	-21.177	-8.193	-8.193
N.Gd = gamma.G*N.Gk = 1.35*N.Gk =	-15.464	-5.089	-4.702
N.Qd = gamma.Q*N.Qk = 1.35*N.Qk =	-28.589	-11.060	-11.060
N.Ed = N.Gd + N.Qd =	-44.053	-16.149	-15.762

Stress analysis (charac.) acc. to section 9.2 (N/mm2)			
sigma.M inside = M*alfa.I/W !	-4.2 !	4.1 !	4.2
sigma.M outside = M*alfa.A/W !	4.2 !	-4.1 !	-4.2
sigma.N = N/A !	-0.7 !	-0.3 !	-0.3
exis sigma inside from N+M !	-4.9 !	3.8 !	3.9
exis sigma outside from N+M !	3.4 !	-4.4 !	-4.5

Stress analysis (design) acc. to section 9.2 (N/mm2)			
sigma.M inside = M*alfa.I/W !	-5.6 !	5.5 !	5.7
sigma.M outside = M*alfa.A/W !	5.6 !	-5.5 !	-5.7
sigma.N = N/A !	-1.0 !	-0.4 !	-0.4
exis sigma inside from N+M !	-6.6 !	5.2 !	5.3
exis sigma outside from N+M !	4.6 !	-5.9 !	-6.0
adm. beta.BZR = !	320.0 !	320.0 !	320.0
adm. beta.BZR,d= !	278.3 !	278.3 !	278.3
adm. beta.D = !	360.0 !	360.0 !	360.0
adm. beta.D,d = !	313.0 !	313.0 !	313.0
Factors of safety:			
existing gamma = !	47.56 !	53.11 !	51.99
required gamma = !	1.00 !	1.00 !	1.00

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Proof of operational strength acc. to ATV-A161, section 7.6.2

The pipe has sufficient bending stiffness.
Deformation analysis and proof of stability are not required.

For steel pipes below railtracks the operational strength must be verified according to DS 804 of DB. The proof can be established in simplified form as follows. (Stresses in N/mm2)

Sections:	Springline	Pipe crown	Pipe base
phi * max sigma.p = M.p,dyn*alpha.K/W+N.p,dyn/A =	2.0	2.6	2.6
delta sigma,Be = phi * max sigma.p/psi =	1.5	1.9	1.9
min sigma.o,Be = sigma.g,stat = M.g,stat*alpha.K/W+N.g,stat/A =	1.2	1.5	1.6
Notch group chi,Be	0.4550	0.4446	0.4624
zul. delta sigma,Be aus Tab.11 (ATV A 161) =	32.1	32.3	31.9
Endurance strength analysis |delta sigma,Be| <= adm.delta sigma,Be	fulfilled	fulfilled	fulfilled
gamma	21.969	17.112	16.921

Analysis of the effective uplift force of fluidized soils
For the state during, respectively, right after the installation of the TFS soil an analysis of the safety against uplift of the pipe in the suspension supported trench is carried out according to DWA-A127 chapter 5.5 with the effect. uplift force per m pipe length according to the following formula.

F.A = (pi* da*da/4)*(gamma.pipe - gamma.susp) + 3*pi*da*(tau.f-tau.o,min)

with outside pipe diameter da	=	0.58	(m)
with pipe dead load gamma.Pipe	=	78.50	(kN/m3)
relative to the pipe cross-section area;			
with unit weight of the TFS material gamma.Susp	=	15.00	(kN/m3)
Dead load of the empty pipe relating to 1 m length	=	5.97	(kN/m)
Uplift force from the soil suspension	=	4.01	(kN/m)
for a suppressed pipe volume	=	0.27	(m3)
Yield stress contribution to the uplift	=	0.00	(kN/m)
about the outer pipe diameter	=	1.83	(m)
effective uplift force F.A	=	1.97	(kN/m)

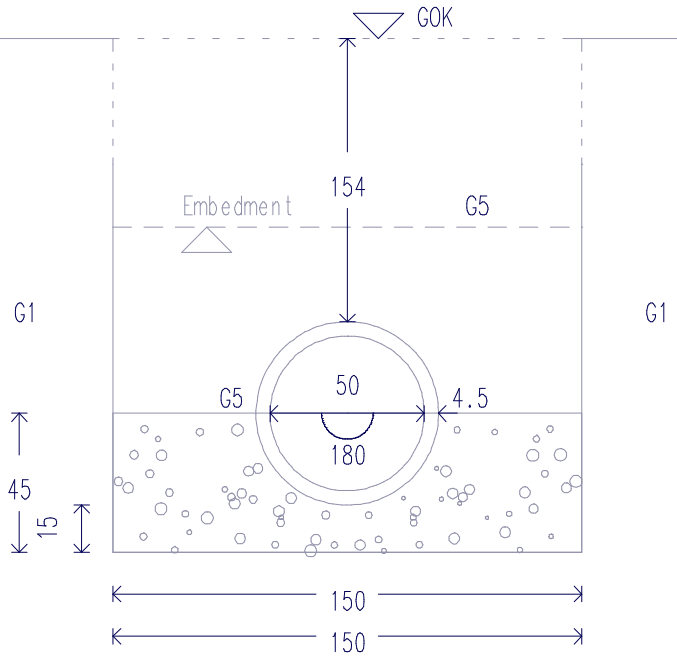
F.A > 0: The pipe is not at risk for an uplift right after the installation of the TFS infilling material!

Program RTpipe: End of calculation ZFSV-Boden_Stahlrohr_02.ror

RIB program DWA A127 18.0 Analysis of Buried Pipes

Steel pipe with/without ZM-lining DIN 1629/1626
DN500

Traffic load LM 71 - mehrgleisig



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Support acc. to EN 1610/ATV-A139

The soil groups mean:
Group G1: Non-cohesive sand and gravel
Group G2: Slightly cohesive sand and gravel
Group G3: Cohesive mixed soils and silt
Group G4: Cohesive soils (clay and loam)

Interstice particular compacting

Sand / gravel support180

Backfilling layered placing + compacting to Proctor density in %:
Earth covering = 100
Bedding = 100

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