UREDITEV GOSPODARSKE JAVNE INFRASTRUKTURE NA OBMOČJU POTNIŠKEGA CENTRA LJUBLJANA – 1.FAZA

VRSTA PROJEKTNE DOKUMENTACIJE	**Projektna dokumentacija za izvedbo gradnje (PZI)**
VRSTA GRADNJE	**Novogradnja in rekonstrukcija**
ŠTEVILKA PROJEKTA	**9013-1F**
INVESTITOR	**Mestna občina Ljubljana** Mestni trg 1 1000 Ljubljana
PROJEKTANTA	**Ljubljanski urbanistični zavod d. d.** Verovškova ulica 64 1000 Ljubljana **ELEA iC d.o.o.** Dunajska 21 1000 Ljubljana
ODGOVORNA OSEBA PROJEKTANTA LUZ D.D.	**dr. Jure Zavrtanik** univ. dipl. inž. arh.
ODGOVORNA OSEBA PROJEKTANTA ELEA IC D.O.O.	**Angelo Žigon** univ. dipl. inž. grad.
PODPIS IN ŽIG	**LUZ d.d.** **ELEA iC d.o.o.**
DATUM	**avgust 2025**

Ljubljanski urbanistični zavod, d. d.
Verovškova ulica 64
SI-1000 Ljubljana
Slovenija
T/ +386 1 360 24 00
F/ +386 1 360 24 01
E/ info@luz.si
www.luz.si

PRILOGA 1C

NASLOVNA STRAN NAČRTA

2/2 Načrt kanalizacije

PODATKI O GRADNJI		
naziv gradnje		**Ureditev gospodarske javne infrastrukture na območju Potniškega centra Ljubljana - 1.FAZA**
kratek opis gradnje		**Novogradnja kolektorja komunalnih vodov in rekonstrukcija gospodarske javne infrastrukture (kanalizacija, vodovod, plinovod, vročevod, elektrikoenergetski vodi, elektronska komunikacija) na območju Potniškega centra Ljubljana. Zaradi obsežnosti območja in načrtovanih ureditev je gradnja razdeljena v dve fazi, pri čemer predmetna 1. faza zajema zahodni del celotnega območja, druga pa vzhodnega.** **Predmet projekta je gradnja in rekonstrukcija objektov, vodov in naprav gospodarske javne infrastrukture brez javnih cest za zahodni del območja PCL med Dunajsko in Železno oz. Resljevo cesto.**
VRSTE GRADNJE	☑	**NOVOGRADNJA - NOVOZGRAJEN OBJEKT**
označiti vse ustrezne vrste gradnje	☐	**NOVOGRADNJA - PRIZIDAVA**
	☑	**REKONSTRUKCIJA**
	☐	**SPREMEMBA NAMEMBNOSTI**
	☐	**ODSTRANITEV CELOTNEGA OBJEKTA**
	☐	**LEGALIZACIJA**
	☐	**MANJŠA REKONSTRUKCIJA**
PODATKI O PROJEKTNI DOKUMENTACIJI		
vrsta dokumentacije		**PZI (projektna dokumentacija za izvedbo gradnje)**
številka projekta		**9013-1F**
PODATKI O NAČRTU		
strokovno področje načrta		**2 Načrt s področja gradbeništva**
naziv načrta		**2/2 Načrt kanalizacije**
številka načrta		**9013_1F/2_2**
datum izdelave		**avgust 2025**
datum spremembe		
PODATKI O PROJEKTANTU NAČRTA		
projektant načrta (naziv družbe)		**LUZ d.d.**
naslov		**Verovškova 64, Ljubljana**
odgovorna oseba projektanta načrta		**dr. Jure Zavrtanik, univ.dipl.inž.arh.**
podpis odgovorne osebe projektanta načrta		
PODATKI O IZDELOVALCU NAČRTA		
ime in priimek pooblaščenega arhitekta, pooblaščenega inženirja		**Uroš Maršič, univ.dipl.inž.grad.**
identifikacijska številka		**G-3272**
podpis pooblaščenega arhitekta, pooblaščenega inženirja		

PRILOGA 2C

IZJAVA PROJEKTANTA NAČRTA IN POOBLAŠČENEGA STOKOVNJAKA, KI JE IZDELAL NAČRT V PZI IN PID

PROJEKTANT NAČRTA	
projektant načrta (naziv družbe)	**LUZ d.d.**
naslov	**Verovškova 64, Ljubljana**
odgovorna oseba projektanta načrta	**dr. Jure Zavrtanik, univ.dipl.inž.arh.**

IN POOBLAŠČENI STROKOVNJAK, KI JE IZDELAL NAČRT	
pooblaščeni strokovnjak	**Uroš Maršič, univ.dipl.inž.grad.**

IZJAVLJAVA:

da načrt

vrsta dokumentacije	**PZI (projektna dokumentacija za izvedbo gradnje)**
strokovno področje načrta	**2 Načrt s področja gradbeništva**
naziv načrta	**2/2 Načrt kanalizacije**
številka načrta	**9013_1F/2_2**
datum izdelave	**avgust 2025**

upošteva relevantne predpise in druge normativne dokumente ter da so upoštevane ustrezne bistvene in druge zahteve.

pooblaščeni strokovnjak	**Uroš Maršič, univ.dipl.inž.grad.**
identifikacijska številka	**G-3272**
podpis pooblaščenega strokovnjaka	
odgovorna oseba projektanta načrta	**dr. Jure Zavrtanik, univ.dipl.inž.arh.**
podpis odgovorne osebe projektanta načrta	

S/1 KAZALO VSEBINE NAČRTA

SPLOŠNI DEL		
S/1	**KAZALO VSEBINE NAČRTA**	
S/2	**NASLOVNA STRAN NAČRTA** Vse vsebine so zajete v priloženi prilogi 1C pravilnika	
S/3	**IZJAVA PROJEKTANTA NAČRTA IN POOBLAŠČENEGA STROKOVNJAKA, KI JE IZDELAL NAČRT V PZI IN PID** Vse vsebine so zajete v priloženi prilogi 2C pravilnika	
TEHNIČNI DEL		
T/1	**KAZALO TEHNIČNEGA POROČILA**	
T/2	**TEHNIČNO POROČILO**	
T/3	**ZAKOLIČBENE TOČKE**	
T/4	**HIDRAVLIČNI IZRAČUN**	
T/5	**STATIČNI IZRAČUN**	
G	**GRAFIČNI PRIKAZI**	
G/1	**TEHNIČNI PRIKAZI**	
	Kazalo risb	
list	vsebina risbe	merilo
G.1	Pregledna situacija	1:5.000
G.2.1.1	Situacija fekalne kanalizacije 1	1:250
G.2.1.2	Situacija fekalne kanalizacije 2	1:250
G.2.1.3	Situacija padavinske kanalizacije 1	1:250
G.2.2.1	Situacija prispevnih površin fekalne kanalizacije	1:250
G.2.2.2	Situacija prispevnih površin padavinske kanalizacije	1:250
G.3.1	Vzdolžni profil Kanala 1	1:1000/100
G.3.2	Vzdolžni profil Kanala 2	1:1000/100
G.3.3	Vzdolžni profil Kanala 2.3	1:1000/100

G.3.4	Vzdolžni profil Kanala 3	1:1000/100
G.3.5	Vzdolžni profil Kanala 3.1	1:1000/100
G.3.6	Vzdolžni profil Kanala 3.2	1:1000/100
G.3.7	Vzdolžni profil Kanala 4	1:1000/100
G.3.8	Vzdolžni profil Kanala M1	1:1000/100
G.3.9	Vzdolžni profil Kanala M1.1	1:1000/100
G.4.1	Karakteristični prečni profil	1:20
G.5.1	Detajl cestnega požiralnika z LTŽ rešetko	1:20
G.5. 2	Detajl cestnega požiralnika z robniško rešetko	1:20
G.5. 3	Detajl vpada iz cestnega požiralnika	1:25
G.5. 4	Detajl revizijskega jaška	1:25
G.5.5	Detajl polaganja kanalizacijskih cevi	1:25
G.5.6	Detajl križanja komunalnih vodov	1:25
G.5.7	Detajl ponikovalnice	1:50
G.5. 6	Detajl lovilca olja	1:25

T/1 KAZALO TEHNIČNEGA POROČILA

1 SPLOŠNO 6
1.1 Predmet projekta 6
1.2 Zakonske podloge in izhodišča 6
2 OPIS OBSTOJEČEGA STANJA 7
3 OPIS PREDVIDENEGA POSEGA 7
3.1 Fekalna kanalizacija 7
3.1.1 Kanal 1 7
3.1.2 Kanal 2 10
3.1.3 Kanal 3 10
3.2 Padavinska kanalizacija 12
3.2.1 Kanal M1 12
4 Hidravlični izračun 14
4.1.1 Hišni priključki 17
4.1.2 Požiralniki 17
4.1.3 Lovilec olja 17
5 TEHNIČNA IZVEDBA 17
5.1 Pričetek gradnje 17
5.2 Izkopi 18
5.3 Statični izračun nosilnosti cevi 18
5.4 Izbira materiala cevi 18
5.5 Tlačni preizkus 19
5.6 Revizijski jaški 19
5.7 Zaključna dela 19
6 KRIŽANJA Z OSTALIMI KOMUNALNIMI VODI 20
7 HIDRAVLIKA IN DIMENZIONIRANJE 21
7.1 Hidravlični izračun 21
8 IZVAJANJE GRADNJE IN TEHNIČNA IZVEDBA OBJEKTOV 21
8.1 Splošna določila 21
8.2 Izkopi 22
8.2.1 Planiranje terena in jarkov 22
8.2.2 Peščena posteljica, zasipi jarkov in zasipi ob objektih 22
8.2.3 Odvoz zemlje in preostalega materiala 22
8.2.4 Cene za enoto 23

8.3 Betonska dela 23
8.3.1 Splošna določila 23
8.3.2 Beton in armiran beton za objekte 24
8.3.3 Cene na enoto 24
8.4 Tesarska dela 24
8.4.1 Splošna določila 24
8.4.2 Opaži in odri 24
8.4.3 Cena na enoto 24
8.5 Zidarska dela 25
8.5.1 Splošna določila 25
8.5.2 Cena na enoto 25
8.5.3 Cevi in stiki 25
8.5.4 Izvedba gradbenih jam pri mikrotuneliranju 25
8.6 ZAKLJUČNA DELA 26

T/2 TEHNIČNO POROČILO

1 SPLOŠNO

1.1 Predmet projekta

Predmet obdelave je rekonstrukcija območja, ki je predvidena v sklopu obsežnejše ureditve Potniškega centra Ljubljana, ki zajema novo avtobusno in železniško postajo. Obsežnejša rekonstrukcija zajema tudi ureditev vseh obstoječih cest ki obkrožajo novi potniški terminal.

Predvidena rekonstrukcija Masarykove ceste od križišča z Dunajsko cesto do križišča s Topniško ulico v skupni dolžini 1368m vključuje razširitev na štiripasovno mestno cesto, s posebnimi pasovi za vozila mestnega javnega potniškega prometa, vmesno zelenico, obojestranskim drevored, kolesarsko stezo in hodnikom za pešce kot tudi novi podvoz pod železniško progo. Avtobusna postajališča so predvidena na vozišču. Širitev je predvidena na severno stran kjer so predvidene rušitve objektov in ukinitev glavne avtobusne postaje.

Na tem območju se bo obnovila javna infrastruktura in s tem tudi kanalizacija.

V prvi fazi se bo gradila in obnavlja kanalizacija med Dunajsko cesto in Resljevo ulico.

Vse obstoječe povezave na fekalne, meteorne in mešane kanale je potrebno preveriti.

1.2 Zakonske podloge in izhodišča

V območju predvidenim za gradnjo je bila izdelana naslednja projektna dokumentacija:

- (Uradni list RS, št. 107/06, 83/08, 43/09, 78/10, 109/11 in 42/18)
- Gradbeni zakon – GZ (Uradni list RS, št. 61/17 in popr. 72/17)
- Zakon o prostorskem načrtovanju – ZPNačrt (Uradni list RS, št. 33/07; Spremembe: 70/2008-ZVO-1B, 108/2009, 80/2010-ZUPUDPP (106/2010 popr.), 43/2011-ZKZ-C, 57/2012, 57/2012-ZUPUDPP-A),
- Zakon o urejanju prostora /ZUreP-2/ (Ur. list RS, št61/2017 in 89. člen ZPNačrt),
- Zakon o varstvu okolja – ZVO-1 (Uradni list RS, št. 41/2004; Spremembe: 17/2006, 20/2006, 28/2006 Skl.US: U-I-51/06-5, 39/2006-UPB1, 49/2006-ZMetD, 66/2006 Odl.US: U-I-51/06-10, 112/2006 Odl.US: U-I-40/06-10, 33/2007-ZPNačrt, 57/2008-ZFO-1A, 70/2008, 108/2009, 48/2012, 57/2012),
- Zakon o graditvi objektov – ZGO-1 (Ur.l., št. 110/02), spremembe: Ur.l. RS, št. 97/2003 Odl.US: U-I-152/00-23, 41/2004-ZVO-1, 45/2004, 47/2004, 62/2004 Odl.US: U-I-1/03-15, 102/2004-UPB1 (14/2005 popr.), 92/2005-ZJC-B, 93/2005-ZVMS, 111/2005 Odl.US: U-I-150/04-19, 120/2006 Odl.US: U-I-286/04-46, 126/2007, 57/2009 Skl.US: U-I-165/09-8, 108/2009, 61/2010-ZRud-1 (62/2010 popr.), 20/2011 Odl.US: U-I-165/09-34, 57/2012
- Zakon o cestah – ZCes-1 (Uradni list RS, št. 109/10: Spremembe 48/2012),
- Zakon o pravilih cestnega prometa /ZPrCP/ (Ur. list RS, št. 109/10),
- Pravilnik o projektiranju cest (Uradni list RS, št. 91/05; Spremembe: 26/2006, 109/2010-ZCes-1),
- Pravilnik o cestnih priključkih na javne ceste (Uradni list RS, št. 86/2009; Spremembe: 109/2010-ZCes-1),
- Pravilnik o pogojih za graditev gradbenih ali drugih objektov, saditev drevja ter postavljanja naprav v varovalnem progovnem pasu in v varovalnem pasu ob industrijskem tiru (Uradni list SRS, št. 2/1987 in 25/1988),
- Pravilnik o projektni in tehnični dokumentaciji (Uradni list RS, št. 66/2004; Spremembe: 54/2005, 55/2008),
- Pravilnik o kolesarskih površinah (Uradni list RS, št. 36/15)
- Pravilnik o prometni signalizaciji in prometni opremi na cestah (Uradni list RS, št. 99/15, 46/17),
- Pravilnik o avtobusnih postajališčih (Uradni list RS, št. 106/11 in 36/18)

- Odlok o občinskih cestah (Ur.l. RS, št. 78/00 in spremembe)
- Predlog prometne politike Mestne občine Ljubljana, sprejet na 18. Seji Mestnega sveta MOL, 24.9.2012
- Tehnične specifikacije za javne ceste,
- Smernice za umeščanje kolesarske infrastrukture v urbanih območjih (2017),
- Odredba o seznamu potrjenih tehničnih specifikacij za javne ceste (Uradni list RS, št. 8/12, 42/12 in 99/15)
- Evropski standardi SIST EN 13108-1 do 8,
- Slovenski nacionalni dodatki SIST 1038-1 do 8,
- SIST EN 13043, 12591 in 14023,
- SIST 1035 in 1043,
- Splošni in posebni tehnični pogoji,
- TSC 06.300 / 06.410 : 2009 Smernice in tehnični pogoji za graditev asfaltnih plasti.
- Zakon o vodah Uradni list RS, št. 67/02 in spremembe
- Pri izdelavi projekta so bila upoštevana tehnična navodila za kanalizacijo (JP Vodovod – kanalizacija d.o.o., Ljubljana, EAD-116244).
- Zakonski in podzakonski predpisi, ki bodo sprejeti v času izdelave te dokumentacije.
- Geodetski načrt za pripravo projektne dokumentacije Zelene jame, št. LUZ-2025/2407, marec 2025, LUZ d.d.

2 OPIS OBSTOJEČEGA STANJA

Širše območje železniške postaje Ljubljana je infrastrukturno dobro opremljeno, saj se na obodnih cestah območja nahajajo ali se mu približujejo obstoječi vodi vseh vrst komunalne infrastrukture (vodovod, kanalizacija mešanega sistema, vročevodno omrežje, plinovodno omrežje, elektroenergetske kabelske kanalizacije s pripadajočimi elektroenergetskimi vodi, elektronsko komunikacijske kabelske kanalizacije s pripadajočimi telekomunikacijskimi vodi, po cestah in v križiščih pa poteka omrežje cestne razsvetljave in semaforizacije s pripadajočo kabelsko kanalizacijo). Po Vilharjevi cesti in zahodni strani Dunajske ceste je zgrajen kolektor komunalnih vodov, v katerem potekajo vodovod, vročevodno omrežje ter omrežje elektroenergetskih in elektronsko komunikacijskih vodov. Kolektor komunalnih vodov se nahaja tudi na severnem delu Slovenske ceste.

Čezmerni obseg prometnih tokov predvsem na Šmartinski in Masarykovi cesti ter Trgu OF povzroča stalne zastoje in terja izvedbo razširitve zmogljivosti prometnega omrežja, poleg tega pa je na širšem območju načrtovana tudi gradnja novih stavb (območje PCL, Gospodarskega razstavišča in Kolinske.

3 OPIS PREDVIDENEGA POSEGA

3.1 Fekalna kanalizacija

V prvi fazi se bo gradila in obnavlja kanalizacija med Dunajsko cesto in Resljevo ulico. Na obravnavanem območju so predvideni mešani in padavinski kanali. Mešani kanali odvajajo fekalno in padavinsko strešno odpadno vodo v obstoječi mešani kanalizacijski sistem. Padavinski kanali odvodnjavajo padavinsko vodo s cestišča, ki se preko lovilcev olj ponikajo v raščenem terenu.

Kanali ki odvajajo fekalno in strešno padavinsko vodo so:

3.1.1 Kanal 1

Kanal 1 ima funkcijo povezovalnega kolektorja od Trga OF, po Kolodvorski cesti, do križišča Kolodvorske ulice in Komenskega ulice.

Kanal 1 se začne v združitvenem objektu O1.2 in poteka proti jugu do krožišča med Kolodvorsko ulico in Komenskega ulico - do združitvenega objekta O1.1, kjer se priklopi na obstoječe omrežje.

Kanal 1 je glavni odvodni kanal komunalnih in padavinskih strešnih odpadnih vod s širšega območja južno od potniškega centra. Trasa projektiranega kanala je nadaljevanje kanala „RTV". Začetek trase se nahaja v združitvenem objektu O1.1 na severni strani parkirišča Sanatorij (južno od RTV hiše), kjer je zgrajen obstoječi jašek kanala RTV. Omenjeni jašek se nadomesti z novim AB združitvenim objektom O1.1 velikosti 4,1x5,4 m. Kota priklopa v novem združitvenem objektu je enaka obstoječi koti in znaša po podatkih katastra JP VO-KA 287,66 mnv, kota pokrova pa 296,26 mnv. V nadaljevanju poteka kanal z lokom 45° in nato severno v radiju R=1000 m v smeri Kolodvorske ulice. Zaključi se v združitvenem objektu O1.2 s koto terena 298,04 mnv, ter koto dna 289,66 mnv, ki se nahaja v parku OF. Nanj se priključita še dva kanala; kanal 2 na koti 292,22 mnv ter kanal 3 na koti 292,10 mnv. Natančen potek je razviden iz grafičnih prilog.

Kanal se izvaja z **mikro tuneliranjem**. Z metodo mikro tuneliranja se izvajajo cevovodi večjih premerov in večjih dolžin. Pri tej metodi gre za daljinsko vodene stroje, ki služijo potiskanju cevi v horizontalni smeri. Celoten postopek dela nadzoruje operater stroja iz mobilne kabine, locirane ob sami gradbeni jami. Preko računalniške konzole ter precizne nadzorne opreme mu je omogočen stalni pritok povratnih informacij o lokaciji ter orientaciji (inklinaciji) vrtalnega orodja, kakor tudi o delu hidravličnih sklopov. Operater lahko na ta način precizno upravlja ter nadzira vse faze vrtanja z MTBM opremo, direktno iz kontrolne kabine.

Cev namenjena za vgradnjo se vstavlja v samo gradbeno jamo ter s pomočjo MTBM stroja potiska v vrtino. Gre za t.i. »Pipe jacking« sistem, ki temelji na uporabi posebnih potisnih cevi. Izbira ustreznega sklopa vrtalne opreme in ustreznega postopka izdelave tunela je odvisna od premera cevi, dolžine odseka in od geoloških pogojev. S povečevanjem dolžine tunela, se povečuje tudi trenje okoli vgrajene cevi. V nevezanih zemljinah z manjšo vsebnostjo veznih frakcij (prodnata tla, peski) se za zmanjšanje trenja v vrtalno vrzel vbrizgava mešanico bentonita in vode. Za izvajanje daljših odsekov, je predvsem zaradi prevelikega trenja potrebna izgradnja vmesnih potisnih postaj, ki pripomorejo k enostavnejšemu, uspešnemu potiskanju cevi na celotnem odseku.

Sistem tehnologije gradnje mikropredorov temelji na zaprtem tokokrogu vode in daljinskem vodenju Glave. Vrtalna glava z napredovanjem reže in melje zemljino/kamnino pred seboj, ki pade v komoro. Preko dovodne linije črpamo vodo v komoro, kjer se pomeša z zdrobljenim materialom. Izvrtani material, pomešan z vodo (angl. slurry), preko sesalne linije odsesamo iz komore in ga vodimo na separacijsko enoto. Na separacijski enoti izločimo iz izplake (mulja) izvrtan material in vodo prečrpamo nazaj v glavo, Tlak na dovodni liniji v normalnih pogojih delovanja ne bo presegel 3 barov. Če presežemo to vrednost, so najverjetneje zamašene dovodne linije oziroma se je zemljina nenadzorovano nakopičila v vrtalni glavi. Na sesalni liniji glede na geološke pogoje v komori operiramo s podtlakom ali nadtlakom. V tleh 4. in 5. kategorije ter nekoherentnih zemljinah (produ) je zaželen podtlak (–1 do –0,5 bara), ker moramo očistiti zdrobljen material, ki se ne veže z vodo. V koherentnih zemljinah pa želimo čim več vode ohraniti na čelu in s tem spirati zemljino ter preprečiti zamašitev vrtalne glave, zato operiramo z nadtlakom +0,5 do +1 bara.

Pri dovajanju in odvajanju vode na čelo imamo ločene merilce pretoka. Razlike v pretoku povejo količino vode, ki vdira na čelu iz tal, oziroma izgubo dovedene vode na čelu. Napredovanje vrtalne glave in potisnih cevi se izvaja s potisno enoto kjer se postopek ponovi.

Kanal je dolg 425,95 metrov, premerov 1400mm, GPR materiala in naklona 4 do 5‰.

Potek kanala je razviden v grafiki G.2.1.2 in v vzdolžnem profilu G.3.1.

Kanal	Material	Premer	Dolžina
Kanal 1	GRP	DN 1400mm	426 m

3.1.1.1 Združitveni objekt na kanalu 1 – objekt O1.1

Nahaja se na severni strani parkirišča Sanatorij (cca. 20 m južno od RTV hiše), kjer je zgrajen obstoječi jašek kanala RTV. Naloga projektiranega objekta je povezava projektiranega kanala iz GRP DN 1400mm z obstoječim kanalom RTV iz betonske cevi DN 1400mm, z zamikom toka. Dotok v objekt je GRP cev DN 1400 mm; i=5‰, iztok iz objekta je betonska cev DN 1400mm. Kota pokrova objekta znaša 296,26 mnv, kota dna objekta znaša 287,66 mnv.

Združitveni objekt je armiranobetonski objekt C 25/30, RA 400/500-2, MAG 500/560, nepravilne oblike, širine 4,1 m in dolžine 5,4 m (notranje dimenzije). V dnu se izdela betonska mulda C 16/20, debeline 15cm, v naklonu 0,7 ‰, preko katere se izvede tudi povezava obeh cevovodov. Projektirana debelina sten in talne plošče je 30,0 cm, debelina krovne plošče pa 30,0 cm. Objekt je v celoti vkopan.
Vstop v objekt je omogočen preko odprtine v krovni plošči in vstopnega jaška kvadratne oblike ø 1200 mm z lestvijo . Vstop se prekrije z litoželeznim pokrovom ø 600 mm z zaklepom, ki se vgradi v AB venec.
Zaradi izvedbe gradbene jame za objekt O1.1 je treba:
- začasno ukiniti in odstraniti obstoječi vročevod DN 125 v Komenskega ulici. Po končanju podvrtavanja se vročevod vrne v prvotno stanje. Dela se opravlja izključno izven kurilne sezone,
- začasno prestaviti oz. prevezati kable elektronskih komunikacij in cestne razsvetljave v Komenskega ulici.
Detajlno so objekti obdelani v načrtu 2/5

3.1.1.2 Združitveni objekt na kanalu 1 – Objekt O1.2

Nahaja se v parku OF. Naloga projektiranega objekta je povezava projektiranega kanala 2 iz GRP DN 600 mm, ki poteka po ulici Trg OF desno od objekta, ter projektiranega kanala 3 iz GRP DN 600 mm, ki poteka po ulici Trg OF levo od objekta, s projektiranim kanalom 1 iz GRP DN 1400 mm po Kolodvorski ulici. Kota terena je 298,04 mnv, kota dna je 289,66 mnv, kota priklopa kanala 2 je 292,22 mnv, kota priklopa kanala 3 je 292,10 mnv.

Združitveni objekt je armiranobetonski objekt C 25/30, RA 400/500-2, MAG 500/560, nepravilne oblike, širine 3,7 m in dolžine 4.7m (notranje dimenzije). V dnu se izdela betonska mulda C 16/20, debeline 15cm, v naklonu 0,7‰, preko katere se izvede tudi povezava obeh cevovodov. Projektirana debelina sten in talne plošče je 30,0 cm, debelina krovne plošče pa 30,0 cm. Objekt je v celoti vkopan.

Vstop v objekt je omogočen preko odprtine v krovni plošči in vstopnega jaška kvadratne oblike iz betona ø 1200 mm z lestvijo. . Vstop se prekrije z litoželeznim pokrovom ø 600 mm z zaklepom, ki se vgradi v AB venec.

Zaradi izvedbe gradbene jame za objekt O1.2 je treba:
- začasno prestaviti kabelsko kanalizacijo oz. prevezati kable elektronskih komunikacij po zahodni strani spomenika generalu Maistru. Po končanju del se kabelsko kanalizacijo in kable v njih povrne v prvotno stanje.
- začasno ukiniti in odstraniti stojala sistema BicikeLJ. Po končanju podvrtavanja se stojala povrne v prvotno stanje.

Detajlno so objekti obdelani v načrtu 2/5 Načrt objekti kanalizacija

3.1.2 Kanal 2

Kanal 2 je glavni odvodni kanal komunalnih in padavinskih strešnih odpadnih vod vzhodnega dela širšega območja južno od potniškega centra. Kanal 2 poteka v sredini desnega voznega pasu ulice Trg OF in Masarykove ceste, gledano v smeri proti toku, t.j. proti Njegoševi ulici. Začne se v združitvenem objektu O 1.2, kjer se konča kanal 1.

Kanal 2 ima funkcijo odvajanja padavinske strešne vode in hišnih priključkov po Masarykovi cesti do križišča s Kolodvorsko ulico. V 1. fazi bo potekal kanal od revizijskega jaška RJ7_K2 do točke RJ1_K2, kjer se priklopi na združitveni objekt O1.2.

Kanal je dolg 169 metrov, premerov 600 mm, GPR materiala in naklona 3 ‰.

Potek kanala je razviden v grafiki G.2.1.1 in v vzdolžnem profilu G.3.2.

Kanal	Material	Premer	Dolžina
Kanal 2	GRP	DN 600mm	169 m

3.1.2.1 Kanal 2.3

Kanal 2.3 ima funkcijo odvajanja strešne padavinske vode in hišnih priključkov s severo-vzhodnega dela Trga OF.

Kanal 2.3 se začne pri revizijskem jašku RJ1_K2.3, poteka proti jugu v cestišču, prečka kolektor in se v revizijskem jašku PRJ5_K2 priklopi na Kanal 2.

Kanal je dolg 35 metrov, premera 300 mm, GPR materiala in naklona 20‰.

Potek kanala je razviden v grafiki G.2.1.1 in v vzdolžnem profilu G.3.3.

Kanal	Material	Premer	Dolžina
Kanal 2.3	GRP	DN 300mm	35 m

3.1.3 Kanal 3

Kanal 3 je glavni odvodni kanal komunalnih in padavinskih strešnih odpadnih vod zahodnega dela širšega območja južno od potniškega centra. Kanal 3 poteka v sredini desnega voznega pasu Trga OF, gledano v smeri toka, t.j. proti Njegoševi ulici. Začne se v združitvenem objektu O1.2, kjer se konča kanal 1. Trasa zavije iz objekta pod kotom 45° proti zahodu na Trg OF, kjer poteka linearno po omenjeni ulici.

Kanal 3 ima funkcijo odvajanja strešne padavinske vode in hišnih priključkov objektu ob Trgu OF, od križišča z Dunajsko cesto do križišča s Kolodvorsko ulico.

Kanal 3 se začne pri revizijskem jašku RJ11_K3 in poteka proti vzhodu v cestišču in se v točki RJ1_K3 priklopi na združitveni objekt O1.2.

Kanal je dolg 330 metrov, premerov 300 – 500 - 600mm, GPR materiala in naklona 3-7‰.

Potek kanala je razviden v grafiki G.2.1.1 in v vzdolžnem profilu G.3.4.

Kanal	Material	Premer	Dolžina
Kanal 3	GRP	DN 300mm	90 m
		DN 50 mm	184 m
		DN 600mm	56 m

3.1.3.1 Kanal 3.1

Kanal 3.1 ima funkcijo odvajanja padavinske vode in hišnih priključkov na Trgu OF od objekta Železniške postaje do križišča s Kolodvorsko ulico.

Kanal 3.1 se začne pri revizijskem jašku RJ4_K3.1 in poteka proti vzhodu cestišča in se v revizijskem jašku PRJ4_K3 priklopi na Kanal 3.

Kanal je dolg 60 metrov, premerov 300 – 400 mm, GPR materiala in naklona 5-‰.

Potek kanala je razviden v grafiki G.2.1.1 in v vzdolžnem profilu G.3.5.

Kanal	Material	Premer	Dolžina
Kanal 3.1	GRP	DN 300mm	39 m
		DN 400mm	21 m

3.1.3.2 Kanal 3.2

Kanal 3.2 ima funkcijo odvajanja padavinske vode in hišnih priključkov na severni strani Trga OF do križišča z Miklošičevo ulico.

Kanal 3.2 se začne pri revizijskem jašku PRJ1_K3.2, poteka proti jugu cestišča in se v revizijskem jašku PRJ6_K3 priklopi na Kanal 3.

Kanal je dolg 20 metrov, premera 300 mm, GPR materiala in naklona 10‰.

Potek kanala je razviden v grafiki G.2.1.1 in v vzdolžnem profilu G.3.6.

Kanal	Material	Premer	Dolžina
Kanal 3.2	GRP	DN 300mm	20 m

3.1.3.3 Kanal 4

Jaška se nahajata v križišču Slovenske in Tivolske ceste. Naloga projektiranega kanala je premostitev obstoječega padavinskega kanala 700/1050mm zaradi izgradnje komunalnega kolektorja v smeri proti vzhodu. Omenjeni komunalni kolektor se višinsko križa z obstoječim padavinskim kanalom, zato se na mestu križanja predvidi profil kanala DN 600 mm, namesto profila 700/1050.

Kanal se prične pri obstoječem jašku RJ2_K4 severno od križanja s kolektorjem in poteka južno v dolžini 6 m, kjer je predviden nov revizijski jašek RJ1_K4 na obstoječem kanalu DN 700/1050. Kota pokrova jaška RJ2_K4 znaša 297,89 mnv, kota dna znaša 293,75 mnv. Kota pokrova jaška RJ1_K4 znaša 297,90 mnv, kota dna znaša 293,74 mnv.

Kanal je dolg 6 metrov, premera 600mm, GPR materiala in naklona 7‰.

Hidravlično smo preverili dotok padavinske vode, ki se steka na obstoječ kanal s Tivolske ceste in križišča na Dunajski cesti. Izračun je pokazal, da je ob merodajni padavini povratne dobe 5 let in trajanja 15 minut s dodanimi 20 % zaradi podnebnih sprememb - 299 l/s/ha kapaciteta kanala premera 600 mm zadostuje – polnost cevi je samo 53 %.

Oznaka	**Polnitev [%]**	Max. V [m/s]	Max Q [l/s]	Min. V [m/s]	Notranji fi [mm]	i [o/oo]	L [m]	A [ha]	Ared[ha]	Ng
M17.K2.C1 (RJ1K_TIV/DUN1 - RJ2K_TIV/DUN1)	**53,1%**	1.7	206.89	1.7	600	6.8	47	0.156	0.14	0.013
M17.K2.C2 (RJ2K_TIV/DUN1 - RJ3K_TIV/DUN1)	**32.10%**	3.31	165.66	3.29	700/1050	50.7	8.67	0.02	0.018	0.013
M17.K2.C3 (RJ3K_TIV/DUN1 - RJ4K_TIV/DUN1)	**54.30%**	0.97	160.36	0.97	600	1.8	16.36	0.037	0.034	0.013
M17.K2.C4 (RJ4K_TIV/DUN1 - RJ5K_TIV/DUN1)	**44.70%**	1.35	150.47	1.35	600	4.6	6.55	0	0	0.013
M17.K2.C5 (RJ5K_TIV/DUN1 - RJ6K_TIV/DUN1)	**41.50%**	1.6	150.47	1.59	600	7.2	25.03	0.019	0.017	0.013
M17.K2.C6 (RJ6K_TIV/DUN1 - RJ7K_TIV/DUN1)	**43.00%**	1.68	76.4	1.67	400	12.8	41.33	0.071	0.064	0.013
M17.K2.C7 (RJ7K_TIV/DUN1 - RJ8K_TIV/DUN1)	**42.60%**	1.29	57.56	1.29	400	7.7	38.8	0.067	0.061	0.013
M17.K2.C8 (RJ8K_TIV/DUN1 - RJ9K_TIV/DUN1)	**37.80%**	1.18	39.67	1.18	400	8	40.17	0.072	0.065	0.013
M17.K2.C9 (RJ9K_TIV/DUN1 - RJ10K_TIV/DUN1)	**37.70%**	1.09	20.61	1.1	300	10.2	38.17	0.078	0.07	0.013

Potek kanala je razviden v grafiki G.2.1.1 in v vzdolžnem profilu G.3.7.

3.2 Padavinska kanalizacija

3.2.1 Kanal M1

Kanal M1 ima funkcijo odvajanja padavinske vode s cestišča Trga OF, zahodno od Kolodvorske ulice. S tem bomo razbremenili obstoječ kanalizacijski sistem in ponikali vodo preko lovilca olj v raščenem terenu.

Kanal M1 se začne pri revizijskem jašku RJ18_M1 na najbolj zahodnem delu Trga OF in poteka v cestišču proti vzhodu. Pri Kolodvorski ulici se usmeri v Maistrov park, kjer padavinska voda preko lovilca olj ponika v 5 ponikovalnicah. Iz ponikovalnice PON1 je narejen še varnostni preliv, ki se steka v združitveni objekt O1.2.

Kanal je dolg 415 metrov, premerov 300 - 400 – 500 – 600 - 800 mm, GPR materiala in naklona 3‰.

Potek kanala je razviden v grafiki G.2.1.3 in v vzdolžnem profilu G.3.8.

Kanal	**Material**	**Premer**	**Dolžina**
Kanal M1	GRP	DN 400mm	110 m
		DN 500mm	28 m

		DN 600mm	20 m
		DN 800mm	8 m
		DN 300mm	62 m

Za projektiranje ponikovalnic smo uporabili koeficient ponikanja iz poročila, ki je bil narejen za objekt P1 Emonika, ki leži nekoliko bolj severno - »Emonika City Centre – Poročilo o izvedenih raziskavah in določitev ponikovalne kapacitete vodnjaka«, št. projekta, 223017_HGP, april 20222, Elea IC.

Dolžina filtra za ponikanje skozi cev	L	8	m
Tlak na sredini filtrov (v osnovi polovica filtra, če gre gladina vode nad filter, še upošteva dodatna višina nad filtrom	h = L/2 (+ h1 nad filtrom)	6	m
Višina gladine nad zgornjo koto filtra	h1	2	m
Koeficient ponikanja	K_{pon}	1.06E-03	m/s
Zunanji polmer izkopa vodnjaka	r_{krit}	0.5	m
π	π	3.14	

Kapaciteta ponikanja vodnjaka	Q_{pon}	0.115	m3/s
		115	l/s

Upoštevamo formulo, za kritično hitrost, da ne pride do spiranja delcev:

$$v_{krit} = \frac{\sqrt{K_{pon}}}{15}.$$

Tako dobimo, da je primerna kapaciteta ene ponikovalnice: Q = 55 l/s. Glede na hidravlični izračun dobimo, da je največji pretok kanala M1 = 275 l/s, za kar nam zadostuje 5 ponikovalnic, globokih 8 metrov, premera 1000 mm. Med ponikovalnicami je 62 m povezovalnih GRP cevi DN 300 mm.

3.2.1.1 Kanal M1.1

Kanal M1.1 ima funkcijo odvajanja padavinske vode s cestišča Trga OF, vzhodno od Kolodvorske ulice.

Kanal M1.1 se začne pri revizijskem jašku RJ5_M1.1 na najbolj vzhodnem delu Trga OF in poteka v cestišču proti zahodu do Kolodvorske ulice. V revizijskem jašku RJ5_M1 se priklopi na kanal M1.

Kanal je dolg 150 metrov, premerov 300 – 400 mm, GPR materiala in naklona 3-20‰.

Potek kanala je razviden v grafiki G.2.1.3 in v vzdolžnem profilu G.3.9.

Kanal	Material	Premer	Dolžina
Kanal M1	GRP	DN 300mm	22 m
		DN 400mm	128 m

3.2.1.2 Rekonstrukcije obstoječih mešanih oz. fekalnih kanalov

Pri gradnji novih kanalov, kolektorja komunalnih vodov ali druge GJI se bodo ukinili odseki oz. deli obstoječe kanalizacije v križiščih Dunajska – Vilharjeva, Trg OF - Slovenska cesta, Trg OF – Miklošičeva cesta, Trg OF – Kolodvorska ulica in Trg OF – Resljeva cesta. Na vseh končnih odsekih se bo zgradil nov jašek dimenzije DN 1000 mm pri najbližjem hišnem priključku, ki se veže na obstoječo kanalizacijo.

4 Hidravlični izračun

Pri izračunu deževnega odtoka za dimenzioniranje padavinskih kanalov smo upoštevali krivuljo gospodarsko enakovrednih nalivov (GEN) za Ljubljana Bežigrad s povratno dobo 5 let in dodali 20% po poročilu o vplivu podnebnih sprememb »Podnebne spremembe 2021 - Fizikalne osnove in stanje v Sloveniji - Poročilo IPCC 2021, Povzetek za odločevalce z dodanim opisom stanja«.

Tako smo za hidravlični izračun dobili **299 l/s/ha.**

Hidravlični izračun se je izvedel s pomočjo programske opreme Sewer+, ki za izračun uporablja retenzijsko metodo. Pri izračunu deževnega odtoka za dimenzioniranje padavinskih kanalov smo upoštevali koeficient odtoka ø= 0,9 za asfaltne površine.

Prispevne površine so se upoštevale za območje cestišča med dvema retenzijskima jaškoma, na katero cev se priključujejo požiralniki. Prispevne površine so razvidne iz grafik G.2.2.1 Situacija prispevnih površin mešane kanalizacije in G.2.2.2 Situacija prispevnih površin padavinske kanalizacije.

Oznaka	Polnitev [%]	Max. V [m/s]	Max Q [l/s]	Notranji fi [mm]	i [o/oo]	L [m]	Qsušni [l/s]	A [ha]	Ared[ha]	Ng
K1 - 'Kanal1'										
M1.K1.C1 (O1.1 - 1)	31,1	1.98	462	1370	3.6	2.77	0	0	0	0.01
M1.K1.C2 (1 - 2)	29,2	2.36	462	1370	5.8	1.71	0	0	0	0.01
M1.K1.C3 (2 - 3)	31,0	2	462	1370	3.7	50.96	0	0	0	0.01
M1.K1.C4 (3 - 4)	30,9	2.01	462	1370	3.8	58.47	0	0	0	0.01
M1.K1.C5 (4 - 6)	29,7	2.01	462	1370	3.8	47.56	0	0	0	0.01
M1.K1.C6 (6 - 7)	29,7	2.23	462	1370	5	31.54	0	0	0	0.01
M1.K1.C7 (7 - 8)	29,7	2.24	462	1370	5.1	35.37	0	0	0	0.01
M1.K1.C8 (8 - 9)	29,7	2.23	462	1370	5	28.27	0	0	0	0.01
M1.K1.C9 (9 - 10)	29,7	2.23	462	1370	5	26.72	0	0	0	0.01
M1.K1.C10 (10 - 11)	29,7	2.25	462	1370	5.2	22.09	0	0	0	0.01
M1.K1.C11 (11 - 12)	29,7	2.23	462	1370	5	40.64	0	0	0	0.01
M1.K1.C12 (12 - 13)	29,7	2.23	462	1370	5	44.98	0	0	0	0.01
M1.K1.C13 (13 - O1.2)	29,7	2.47	462	1370	6.6	34.85	462	0	0	0.01
K2 - 'Kanal2'										
M1.K2.C1 (RJ1_K2 - RJ2_K2)	49.90%	1.53	205.93	588	3	24.71	0	0.02	0.018	0.01

M1.K2.C2 (RJ2_K2 - RJ3_K2)	49.50%	1.51	200.48	588	3	11.39	0	0	0	0.01
M1.K2.C3 (RJ3_K2 - RJ4_K2)	49.70%	1.5	200.48	588	2.9	53.37	0	0	0	0.01
M1.K2.C4 (RJ4_K2 - PRJ5_K2)	48.70%	1.56	200.48	588	3.2	50.81	0	0	0	0.01
M1.K2.C5 (PRJ5_K2 - RJ6_K2)	51.30%	1.34	191.18	588	2.2	11.27	0	0	0	0.01
M1.K2.C6 (RJ6_K2 - RJ7_K2)	43.20%	1.92	191.18	588	6	17.24	0	0	0	0.01
M1.K2.C7 (RJ7_K2 - RJ8_K2)	51.60%	1.32	191.18	588	2.2	34.41	0	0	0	0.01
M1.K2.C8 (RJ8_K2 - RJ9_K2)	50.90%	1.36	191.18	588	2.3	33.48	0	0.234	0.211	0.01
M1.K2.C9 (RJ9_K2 - RJ10_K2)	51.60%	1.35	128.13	477	3	40.98	0	0	0	0.01
M1.K2.C10 (RJ10_K2 - RJ11_K2)	51.50%	1.35	128.13	477	3	33.03	0	0	0	0.01
M1.K2.C11 (RJ11_K2 - RJ12_K2)	51.60%	1.35	128.13	477	3	29.37	0	0.183	0.165	0.01
M1.K2.C12 (RJ12_K2 - RJ13_K2)	54.40%	1.19	78.78	379	3	52.51	0	0	0	0.01
M1.K2.C13 (RJ13_K2 - RJ14_K2)	54.30%	1.19	78.78	379	3	65.76	0	0.143	0.129	0.01
M1.K2.C14 (RJ14_K2 - RJ15_K2)	30.70%	0.61	7.07	306	2.8	17	0	0	0	0.01
M1.K2.C15 (RJ15_K2 - RJ16_K2)	19.90%	0.38	1.33	306	3	7.41	1.33	0	0	0.01
K5 - 'Kanal2.3'										
M1.K5.C1 (PRJ5_K2 - RJ1_K2.3)	25.40%	1.33	9.3	306	20	34.16	0	0.035	0.031	0.01
K6 - 'Kanal3'										
M1.K6.C1 (RJ1K3 - RJ2K3)	50.00%	1.95	264.18	588	4.9	22.39	0	0	0	0.01
M1.K6.C2 (RJ2K3 - RJ3K3)	48.90%	2.04	264.18	588	5.5	9.13	0	0	0	0.01
M1.K6.C3 (RJ3K3 - PRJ4K3)	48.20%	2.1	264.18	588	5.9	24.44	0	0.032	0.029	0.01
M1.K6.C4 (PRJ4K3 - RJ5K3)	49.00%	2.04	175.07	477	7.3	37.11	0	0.092	0.083	0.01
M1.K6.C5 (RJ5K3 - PRJ6K3)	55.70%	1.37	150.33	477	2.9	40.8	0	0	0	0.01
M1.K6.C6 (PRJ6K3 - RJ7K3)	55.00%	1.39	148.99	477	3	26.29	0	0.056	0.051	0.01
M1.K6.C7 (RJ7K3 - RJ8K3)	52.50%	1.36	133.81	477	3	40.03	0	0	0	0.01
M1.K6.C8 (RJ8K3 - RJ9K3)	52.50%	1.36	133.81	477	3	39.99	0	0.279	0.251	0.01
M1.K6.C9 (RJ9K3 - RJ10K3)	55.00%	1.33	58.77	306	5	40	0	0.177	0.159	0.01
M1.K6.C10 (RJ10K3 - RJ11K3)	31.10%	0.92	11.11	306	6.2	49.36	0	0.041	0.037	0.01
K7 - 'Kanal3.1'										
M1.K7.C1 (PRJ4K3 - RJ1K3.1)	52.50%	1.3	80.4	379	3.7	4.48	0	0	0	0.01
M1.K7.C2 (RJ1K3.1 - RJ2K3.1)	46.70%	1.64	80.4	379	6.8	16.23	0	0.054	0.048	0.01
M1.K7.C3 (RJ2K3.1 - RJ3K3.1)	69.70%	1.06	65.91	306	3	26.8	0	0	0	0.01
M1.K7.C4 (RJ3K3.1 - RJ4K3.1)	54.20%	1.53	65.91	306	6.7	12.03	0	0.245	0.22	0.01
K8 - 'Kanal3.2'										

M1.K8.C1 (PRJ6K3 - RJ1K3.2)	12.80%	0.55	1.33	477	10.8	19.03	1.33	0	0	0.01
K9 - 'Kanal 4'										
M1.K9.C1 (RJ1K4 – RJ2K4)	53.40%	0.91	140.78	588	1	6.27	0	0.523	0.471	0.01
K11 - 'KanalM1'										
M1.K11.C1 (Preliv_M1 - PON1_M1)	100.00%	3.73	274.52	306	3	7.62	0	0	0	0.01
M1.K11.C2 (PON1_M1 - PON2_M1)	100.00%	3.73	274.52	306	3	12	0	0	0	0.01
M1.K11.C3 (PON2_M1 - PON3_M1)	100.00%	3.73	274.52	306	3	12	0	0	0	0.01
M1.K11.C4 (PON3_M1 - PON4_M1)	100.00%	3.73	274.52	306	3	12	0	0	0	0.01
M1.K11.C5 (PON4_M1 - PON5_M1)	100.00%	3.73	274.52	306	3	12.04	0	0	0	0.01
M1.K11.C6 (PON5_M1 - RJ6M1)	100.00%	3.73	274.52	306	3	6.34	0	0	0	0.01
M1.K11.C7 (RJ6M1 - LO 300/30)	42.40%	1.63	274.52	782	3	4.18	0	0	0	0.01
M1.K11.C8 (LO 300/30 - RJ8M1)	42.40%	1.63	274.52	782	3	3.89	0	0	0	0.01
M1.K11.C9 (RJ8M1 - RJ9M1)	49.60%	1.57	208.98	588	3.2	38.61	0	0.046	0.042	0.01
M1.K11.C10 (RJ9M1 - RJ10M1)	48.70%	1.53	196.55	588	3.1	32.11	0	0.075	0.067	0.01
M1.K11.C11 (RJ10M1 - RJ11M1)	48.30%	1.39	176.45	588	2.6	26.55	0	0.054	0.048	0.01
M1.K11.C12 (RJ11M1 - RJ12M1)	45.60%	1.45	162.05	588	3.1	22.47	0	0.051	0.046	0.01
M1.K11.C13 (RJ12M1 - RJ13M1)	44.60%	1.39	148.38	588	2.9	44.24	0	0.09	0.081	0.01
M1.K11.C14 (RJ13M1 - RJ14M1)	41.90%	1.34	124.3	588	3	43.31	0	0.091	0.082	0.01
M1.K11.C15 (RJ14M1 - RJ15M1)	46.90%	1.27	99.7	477	3	27.65	0	0.059	0.054	0.01
M1.K11.C16 (RJ15M1 - RJ16M1)	56.00%	1.2	83.71	379	3	28.7	0	0.072	0.065	0.01
M1.K11.C17 (RJ16M1 - RJ17M1)	50.00%	1.14	64.36	379	3	39.99	0	0.104	0.094	0.01
M1.K11.C18 (RJ17M1 - RJ18M1)	41.20%	0.98	36.29	379	3	41.33	0	0.135	0.121	0.01
K12 - 'KanalM1.1'										
M1.K12.C1 (RJ8M1 - PRJ1M1.1)	47.70%	1.28	65.54	379	4.1	47.84	0	0.037	0.033	0.01
M1.K12.C2 (PRJ1M1.1 - RJ2M1.1)	48.70%	1.04	55.64	379	2.6	23.07	0	0.037	0.033	0.01
M1.K12.C3 (RJ2M1.1 - PRJ3M1.1)	43.70%	1.08	45.74	379	3.3	29.04	0	0.064	0.058	0.01
M1.K12.C4 (PRJ3M1.1 - RJ4M1.1)	32.30%	1.4	28.44	379	10	28.04	0	0.048	0.043	0.01
M1.K12.C5 (RJ4M1.1 - RJ5M1.1)	29.00%	1.57	15.62	306	20.9	22.33	0	0.058	0.052	0.01

Cevi smo dimenzionirali tako, da je maksimalna polnitev 50%. V tej fazi smo zanemarili vpliv fekalne odpadne vode na hidravlični izračun.

Obstoječa kanalizacija mešanem in ločenem sistemu na obravnavanem območju ni predmet tega projekta. Obstoječo kanalizacijo bo potrebno v času rekonstrukcije zaščititi ter pokrove jaškov bo potrebno prilagoditi novim višinam asfalta.

4.1.1 Hišni priključki

Hišni priključki niso predmet tega projekta. Vse obstoječe priključke je treba prevezati na nove komunalne vode. Odpadne vode iz objektov se praviloma priključujejo preko skupnega jaška na enem mestu.

4.1.2 Požiralniki

Požiralniki se priključujejo na nov padavinski kanal, saj razbremenjujemo sistem in se padavinska voda ponika v zelenih površinah.

Obstoječe navezave požiralniških zvez na kanal v mešanem sistemu se ukine in zatesni.

4.1.3 Lovilec olja

Na kanalizaciji je umeščen lovilec olja.

Lovilec olj preprečuje, da bi olje, bencin, plinsko olje, maziva, kurilno olje in nekatere druge snovi odtekle v naravno okolje. Te snovi imajo namreč nižjo specifično težo od vode in to lastnost izrablja lovilec olj pri delovanju. S pomočjo gravitacije in vgrajenega koalescenčnega filtra ločuje zgoraj navedene lahke tekočine iz vode. Sestavni del lovilca olj je tudi usedalnik mulja, v katerem se iz vode izločijo trdni delci.

Lovilec olj je obvezen na javnih cestah, vseh bencinskih servisih, parkiriščih, avtopralnicah, mehaničnih delavnicah in drugod, kjer lahke tekočine uhajajo v naravo. Lovilec olj iz vode ne more izločati snovi, ki so v vodi topne in stabilne emulzije, saj je zato potrebna kemijska obdelava.

Umazana voda priteče najprej v usedalnik mulja, kjer se vodni tok upočasni in iz vode se izločijo trdni delci. Delno mehansko očiščena voda nato vstopa v lovilec olja skozi posebne polietilenske plošče (lamelni usedalnik), ki dodatno umirijo vodni tok tako, da se pospeši izločanje mulja, istočasno pa se izločijo tudi večje kapljice lahkih tekočin. Zaradi posebne konstrukcije plošč popolna zamašitev sistema ni možna.

Manjše kapljice lahkih tekočin se iz vode izločijo s pomočjo koalescenčnega filtra. Očiščena voda skozi odtok zapusti lovilec olja.

Lovilec olj naj bo vgrajen v bližini izvora onesnažene vode. Lovilci olj so praviloma vkopani, lahko so tudi prosto stoječi, vendar ni priporočljiva vgradnja v zaprtem prostoru. Vkopani lovilci olj so lahko povozni ali nepovozni, odvisno od potrebe in prostorskih možnosti. Lovilec olj mora biti dostopen zaradi vzdrževanja in praznjenja. Olje pod nobenim pogojem ne sme nekontrolirano izteči iz lovilca olj.

Izbran je tipski koalescentni lovilec olj z usedalnikom in by-passom, s pretočno sposobnostjo 300/30l/s.

5 TEHNIČNA IZVEDBA

5.1 Pričetek gradnje

Pred začetkom dela na gradbišču mora naročnik ali nadzornik projekta zagotoviti izdelavo varnostnega načrta.

Pred pričetkom gradnje je potrebno zavarovati gradbišče z ustreznimi zaščitnimi ograjami, signalizacijo in ostalim, kot je navedeno v predpisih o varstvu pri gradbenem delu. Zavarovanje je postaviti na mestih, kjer pričakujemo promet pešcev, kolesarjev, motornih vozil ter vozil z vprego.

Sočasno z zakoličbo projektiranega kanala je obvezno zakoličiti trase ostalih komunalnih vodov, ki tangirajo traso proj. kanala. Zakoličbo je potrebno izvajati v prisotnosti upravljalcev posameznih kom. vodov in upravljalca ceste. O zakoličbi je potrebno voditi zapisnik. V zapisniku je navesti tudi ime odgovorne osebe, ki bo dolžna vršiti nadzor varovanja komunalnih instalacij v času gradnje.

Pri projektiranju smo upoštevali obstoječ teren z vzpostavitvijo v prvotno stanje.

5.2 Izkopi

Izkop mora potekati pod nadzorom strokovne osebe. Izkop se bo izvajal delno strojno delno ročno neposredno ob obstoječih jaških. Globina izkopa bo od 1,9 do 5,98 m Po strojnem in ročnem izkopu jarka je potrebno dno enakomerno splanirati v projektiranem padcu z odstranitvijo grobih ostrih kamnov. Dno jarka je širine 1,30 m (bruto DN cevi + 100 cm). Na tako pripravljeno dno se izdela nasip za izravnavo podlage v deb. 10 cm iz peščenega materiala gr. 8 - 16 mm ter utrdi do 95% trdnosti po standardnem Proktorjevem postopku. Na nasip za izravnavo se izvede 3 - 5 cm debel nasip za poravnavo tal v katerega si cev izdela ležišče. Obsip cevi se nato izvaja v plasteh po 15 - 20 cm, na obeh straneh hkrati. Paziti je potrebno, da se cev ne premakne iz ležišča. Kot nasipni in obsipni material se uporabi peščeni material gr. 0.02 - 16 mm. Višina nasipa je 30 cm nad temenom cevi. Utrjuje se do 95% trdnosti po standardnem Proktorjevem postopku.

Po končanih delih je potrebno okolico gradbišča očistiti.

Projektirani kanali bodo iz cevi iz GRP, premera DN 300-800 mm.

Pred pričetkom gradnje kanalizacije morajo upravljavci ostalih že izvedenih internih komunalnih vodov trase le-teh označiti in sodelovati pri izkopih na mestih prečkanj.

Pri izvajanju gradbenih in montažnih del je potrebno upoštevati "Splošna navodila za izvajanje gradnje in tehnično izvedbo cevovodov ter spremljajočih objektov" ter navodila proizvajalcev opreme in obstoječo gradbeno zakonodajo.

Izkopi v območju 1A se upoštevajo od ustroja ceste navzdol, v območju 1B pa se upoštevajo vse do povrnitev ceste v prvotno stanje.

5.3 Statični izračun nosilnosti cevi

Statični izračun je podan v prilogi.

5.4 Izbira materiala cevi

Projektant predlaga vgradnjo (GRP) poliestrskih cevi togosti SN 10000, nazivnega tlaka PN 10, lahko pa se uporabijo tudi druge cevi, ki morajo ustrezati standardu SIST EN *23856:2021*, za katere je potreben dokaz deformacij. Cev mora imeti notranji zaščitni sloj cevi iz poliestra, s ciljem doseganja kontrole tesnosti, kemijske in abrazijske odpornosti ter odpornosti na obrus pri visokotlačnem čiščenju.

Poliestrske cevi imajo veliko možnost improvizacije na terenu, ter pestro paleto fazonskih kosov zaradi česar odpadejo veliki združitveni objekti, ki so dragi in zamudni za izvedbo. Prav tako omogočajo kvalitetno naknadno vgradnjo hišnih priključkov. Poleg tega so iz poliestra predvideni tudi revizijski jaški, kar pomeni, da bo pri gradnji na gradbišču en sam material, ter s tem možnost težav manjša (dobava, prehodi med materiali,...).

Vgradnja cevi se izvaja po navodilih proizvajalca cevi. Če se bodo vgrajevale druge vrste cevi morajo ustrezati standardu SIST EN *23856:2021*, ter imeti podobne karakteristike kot predvidene (vodotesnost, propustnost, hrapavost, nosilnost).

Pred uporabo mora biti vodotesnost javne kanalizacije preverjena v skladu s standardiziranimi postopki.

Kvaliteta cevi mora biti skladna tudi z zahtevo DIN 19523 ter da omogoča čiščenje z visokim tlakom od 60 – do minimalno 100 barov.

5.5 Tlačni preizkus

Tlačni preizkus je potrebno izvesti v skladu z zahtevami standarda DIN 19523, s pritiskom od min 60 – 100 barov.

5.6 Revizijski jaški

Revizijski jaški so iz poliestra ∅ 1000 mm in ∅ 1200 za kanale DN500-600 mm, z minimalno debelino stene 9mm, prekriti z reducirnim kosom DN 1000/800mm na katerega se položi AB venec s pokrovom. Temelj jaška je betoniran na mestu z betonom C16/20, debelina plošče je 20 cm. Na temelj se postavi jašek iz poliestra, okrog jaška se izvede AB venec iz C16/20. Dno je izoblikovano iz poliestra, v obliki koritnice, ki usmerja odtok odpadne vode.

Pokrov jaška iz LTŽ ∅ 600 mm; EN 124 D 400, z ventilacijskimi odprtinami, protihrupnim vložkom in zaklepom je vgrajen v armiranobetonski venec. Pokrov jaška na voznih površinah ne sme biti temeljen na obodno steno jaška, ampak na utrjeno gramozno nasutje ob jašku.

Razred nosilnosti pokrovov je odvisen od lokacije jaška. V spodnji tabeli smo podrobno razdelali razrede nosilnosti v odvisnosti od lokacije jaška.

Lokacija	**Razred nosilnosti**	**Nosilnost [kN]**
Prometne površine, ki jih lahko uporabljajo izključno pešci in kolesarji, ter podobne površine, na primer zelenice.	A	15
Pločniki, peš cone (vožnja po njih le zaradi oskrbe ali v nujnih primerih) in podobne površine, parkirišča za osebna vozila.	B	125
Velja le za nastavke in pokrove za področje robnih žlebov, ki seže od robnika maksimalno 0,5 m na vozišče in 0,2 m na pločnik, ter za stranske pasove ceste	C	250
Vozišča cest (tudi peš cone, na katerem je promet z vozili ob določenem času prepovedan (npr. ob koncu delovnega časa, drugače normalen promet z vozili))	D	400

Vsi revizijski pokrovi morajo biti opremljeni s protihrupnim vložkom, na zaklep in z ventilacijskimi odprtinami. Na površinah zelenic se pokrovi jaškov dvignejo za 10 cm nad koto terena.

5.7 Zaključna dela

Po končani gradnji kanalizacije je potrebno izvesti čiščenje kanala, pregled s TV kamero in tlačni preizkus skladno s standardom DIN 19523 s pritiskom od min 60 – 100 bar. Še pred zasutjem kanala se izvede geodetski posnetek javnega kanala (višinsko in situacijsko), vključno s posnetkom trase hišnih priključkov. Geodetski posnetek je osnova za izdelavo elaborata za vpis kanala v kataster gospodarske javne infrastrukture.

6 KRIŽANJA Z OSTALIMI KOMUNALNIMI VODI

Pred pričetkom gradnje morajo vsi upravljavci komunalnih vodov na predmetnem območju označiti trase obstoječih in predvidenih komunalnih vodov.

Trasa projektiranega meteornega kanala upošteva potek obstoječih in predvidenih komunalnih vodov.

Potek kanalizacije poteka horizontalno brez vertikalnih lomov in poteka pod drugimi komunalnimi vodi ter ima pred ostalimi vodi prednost, saj mora zagotavljati padec.

Opis križanj kanalizacije z ostalimi komunalnimi vodi:

- električni kabel, telekomunikacijski kabel, kabel javne razsvetljave:

v primeru poteka kanalizacijske cevi pod ali nad vodom, morajo biti komunalni vodi zaščiteni z zaščitno cevjo. Horizontalni odmik od obstoječih in predvidenih podzemnih napeljav naj ne bo manjši od 0,4 m

- plinovod:

v primeru poteka kanalizacijske cevi pod ali nad obstoječim oziroma projektiranim plinovodom, mora biti plinovod zaščiten z zaščitno cevjo. Horizontalni odmik od obstoječih in predvidenih podzemnih napeljav naj ne bo manjši od 0,4 m

- vodovod:
  a) v primeru poteka vodovodne cevi pod kanalizacijo, morajo biti izpolnjene naslednje zahteve:
     - vodovod mora biti vgrajen v zaščitni cevi,
     - ustji zaščitne cevi morata biti odmaknjeni od zunanje stene cevi kanalizacije, najmanj 3 m na vsako stran,
     - v primeru možnosti kontrole drenirane vode sta ustji zaščitne cevi lahko odmaknjeni od zunanje stene cevi kanalizacije, 0,8 m na vsako stran,
     - v izjemnih primerih je kanalizacija lahko zaščitena tudi drugače (PVC folija, glinen naboj), po dogovoru z upravljalcem,
     - vertikalni odmik je najmanj 0,6 m
  b) vodovod nad kanalizacijo, na območju vodoprepustnega zemljišča, morajo biti izpolnjene naslednje zahteve:
     - vodovod mora biti vgrajen v zaščitni cevi,
     - ustji zaščitne cevi morata biti odmaknjeni od zunanje stene kanalizacije, najmanj 3 m na vsako stran,
     - vertikalni odmik je najmanj 0,6 m;
  c) vodovod nad kanalizacijo, na območju vodoneprepustnega zemljišča:
     - vodovod mora biti vgrajen v zaščitni cevi (posteljici in zasipa obeh vodov niso neprepustni, zato se v primeru puščanja kanalizacije odpadna voda lahko dvigne v območje vodovoda),
     - v tem primeru vodovoda ni treba obvezno vgraditi v zaščitno cev,
     - vertikalni odmik je najmanj 0,6 m.

V primeru, da predpisanih odmikov ni mogoče doseči, se je pred vgradnjo potrebno posvetovati z upravljavci komunalnih vodov

V času gradnje je potrebno pri vseh morebitnih komunalnih vodih, ki niso vrisani v kataster in zato v projektu niso upoštevani opozoriti upravljavce le-teh, da sodelujejo pri izkopu na mestih prečkanj.

Pri ugotovljenih odstopanjih poteka obstoječih komunalnih vodov od vrisanega v načrte, ki bi ovirali gradnjo projektiranih cevovodov, se je potrebno pred montažo cevovoda posvetovati s projektantom.

7 HIDRAVLIKA IN DIMENZIONIRANJE

7.1 Hidravlični izračun

Za hidravlični izračun količine vode, ki priteka s cestišča smo upoštevali podatke s meteorološke postaje Ljubljan Bežigrad in za povratno dobo smo upoštevali 5 letno povratno dobo 15 minut – 249 l/s/ha. Temu podatki smo dodali 20 % zaradi podnebnih sprememb, kot pravi poročilo IPPC s leta 2018.

Tako je skupna količina 299 l/s/ha.

Hidravlični izračun se je izvedel s pomočjo programske opreme Sewer+, ki za izračun uporablja retenzijsko metodo. Pri izračunu deževnega odtoka s strešnih površin smo upoštevali koeficient odtoka ϕ= 0,9 za asfaltne površine.

Za ponikanje se je uporabil koeficient ponikanja s bližnjih projektov (PCL), kjer so bile narejene raziskav.

Tako je za skupen maksimalni pretok 52 l/s dovolj ponikalnica, ki je globoka od nivelete 5 metrov premera 1 meter.

DOLŽINA FILTRA ZA PONIKANJE SKOZI CEV	L	5	m
TLAK NA SREDINI FILTROV (V OSNOVI POLOVICA FILTRA, ČE GRE GLADINA VODE NAD FILTER, ŠE UPOŠTEVA DODATNA VIŠINA NAD FILTROM	h = L/2 (+ h1 nad filtrom)	4.5	m
višina gladine nad zgornjo koto filtra	h1	2	m
KOEFICIENT PONIKANJA	K_{pon}	1.06E-03	m/s
zunanji polmer izkopa vodnjaka	r_{krit}	0.5	m
π	π	3.14	

KAPACITETA PONIKANJA VODNJAKA	Q_{pon}	0.065	m3/s
		65	l/s

Vsi hidravlični odseki so prikazani v prilogi Hidravlika.

8 IZVAJANJE GRADNJE IN TEHNIČNA IZVEDBA OBJEKTOV

8.1 Splošna določila

Vsa zemeljska dela se izvajajo po načrtih in detajlih, določilih tehničnih predpisov in skladno z obveznimi standardi.

Pri delih na prometnih površinah mora biti izvajanje del v skladu s cestno-prometnimi predpisi in izdanimi soglasji.

Pred začetkom del je izvajalec dolžan popolnoma očistiti teren, odstraniti rastline in objekte ter ves material transportirati na deponijo.

Na tako očiščenem terenu, izvajalec skupaj s predstavniki investitorja posname vse višinske kote terena, zakoliči in zavaruje celotno traso cevovoda oziroma objekte, ki se gradijo. Vse kote in ostale podatke vpiše v gradbeno knjigo zaradi točnega obračuna zemeljskih del. Potrebno razpiranje oziroma

črpanje meteorne ali podtalne vode pri izkopih jarkov ali za objekte, je izvajalec del dolžan izvršiti na lastne stroške.

Pri vseh izkopih mora izvajalec del paziti, da poškoduje čim manj obdelovalnih površin in objektov, ker gre vsaka škoda, nastala iz naslova nestrokovnega in nesolidnega dela, ter po njegovi krivdi, na stroške izvajalca del.

Vsa zemeljska dela morajo biti izvršena pravilno in upoštevaje vse kote in detajle iz načrtov.

Predno se dela nadaljujejo, morajo biti vsa zemeljska dela sprejeta in potrjena s strani nadzornega organa ter zaradi obračuna, vpisana v gradbeno knjigo. Obračun vseh zemeljskih del se izvrši po dejansko izvršeni količini.

8.2 Izkopi

Vsi izkopi za objekte oziroma izkopi jarkov za polaganje cevovodov ali izkopi temeljev objekta morajo biti izvršeni pravilno po kotah in detajlih iz načrtov ter predpisanih padcev.

Izkopi pri objektih se vršijo po zunanjih merah temeljev in zidov, upoštevanje dodatno razširitev za 50 cm z vsake strani in naklon v odvisnosti od kategorije zemljišča ter načrta eventualnega razpiranja. Odstranitev vsipov in njihovega kasnejšega zasipavanja gre v breme izvajalca del.

Obračuni izkopov se vršijo 1 m^3 izkopanega materiala v raščenem stanju ne glede na kategorijo zemljišča.

8.2.1 Planiranje terena in jarkov

Planiranje terena okoli objekta, kakor tudi dna jarkov za cevovode ali temeljev objekta, mora biti izvršeno do zahtevane točnosti po popisu del.

Planiranje in čiščenje terena po končani gradnji, zasipanje jam na gradbišču po odstranitvi vsega preostalega materiala, kakor tudi izkopa začasnih jam, se obračuna v zaključnih delih.

Obračun se vrši po 1 m2 planirane površine

8.2.2 Peščena posteljica, zasipi jarkov in zasipi ob objektih

Peščena posteljica, kakor vsi zasipi jarkov za polaganje cevovoda in zasipi ob objektih, morajo biti izvršeni z materialom in na način, kakor to predvidevajo načrti oziroma opis del.

Pri zasipanju jarkov za cevovode je obvezno potrebno uporabiti nevezan material iz izkopa, če je primeren (za prvi sloj debeline cca 20 - 30 cm nad temenom cevi, frakcije 0,02 do 16 mm).

V nasprotnem primeru je potrebno zagotoviti ustrezen material za nasip, kot je upoštevano v predmetnem projektu.

Omenjeni prvi sloj zasipa nad cevovodi sme biti komprimiran le ročno.

Preostali zasipi jarkov in zasipi ob objektih se lahko izvršijo z materialom iz izkopa in s strojnim komprimiranjem v slojih, kakor to predvidevajo načrti oziroma popis del.

Izbor materiala in način izvajanja zasipa jarkov za cevovode pod prometnimi površinami, se določi po predhodnem dogovoru z nadzornim organom in v soglasju z naročnikom.

Izračun se vrši po 1 m3 opravljenega zasipa.

8.2.3 Odvoz zemlje in preostalega materiala

Ves izkopani material se transportira na začasno deponijo, ki jo določi nadzorni organ. Tu se vrši izbor materiala za naknadno uporabo oziroma za odvoz na stalno deponijo.

Na posebno zahtevo naročnika je izvajalec del dolžan izvršiti ločitev izkopanega materiala po kategorijah.

Izračun se vrši po 1 m^3 transportiranega materiala z upoštevanjem nakladanja, razkladanja in razprostiranja materiala po deponiji.

8.2.4 Cene za enoto

Cene za enoto zemeljskih del vsebujejo:

- ves porabljeni material
- vse potrebno delo
- vse transporte
- najemnino za vso potrebno mehanizacijo
- najemnino ali stroške izdelave, nameščanja in odstranjevanja vseh pomožnih odrov, platojev in opiranja za izkope v večjih globinah.

Vsa zemeljska dela, v kolikor ni drugače odločeno, se obračunavajo v raščenem stanju z upoštevanjem koeficienta razrahljivosti pri ceni za enoto.

Vozišča konstrukcija

8.3 Betonska dela

8.3.1 Splošna določila

Vsa betonska in armiranobetonska dela se izvajajo v skladu z načrti, opisi del, statičnimi izračuni ter tehničnimi predpisi in standardi.

Kvaliteta vgrajenega betona mora odgovarjati zahtevam opisa del, tehničnim predpisom in standardom glede čistoče agregata, granulacije, količine in kvalitete cementa in vode.

Cement, uporabljen za vsa dela, mora biti svež, pravilno skladiščen in zaščiten pred vodo in vlago, v skladu z navodili in predpisi za beton in armirani beton.

Agregat za pripravo betona naj bo po možnosti rečnega porekla, brez gline in mulja, zrnavosti po predpisih za predvideno marko betona.

Armatura mora biti dobro očiščena rje, blata in apna, krivljena in dimenzionirana po detajlih. Glede kvalitete mora odgovarjati veljavnim tehničnim predpisom.

Vse betonske in armiranobetonske konstrukcije morajo biti betonirane z marko betona predvideno v statičnem izračunu. V primeru, da v kakšni predračunski postavki ali statičnem izračunu MB ni določena, se izvaja z C25/30 za armirani beton oz. C8/10 za nearmirani beton.

Vgrajevanje betona v konstrukcije se mora izvajati po navodilih statika in zahtevah iz opisa del, ter v skladu s tehničnimi predpisi. Beton se vgrajuje strojno do potrebne zbitosti, tako da izpolni ves prostor med armaturo in opažem ter povsem obloži vso armaturo.

Vgrajevanje betona ni dovoljeno, dokler nadzorni organ ne pregleda vse položene armature. Pri prekinitvah betoniranja je mesta, kjer se betoniranje prekine, potrebno določiti že vnaprej. Za nadaljevanje del je stično ploskev potrebno očistiti rahlega betona, cementne kaše in prahu ter stik dobro namočiti in ga prepojiti s tanjšo plastjo mastne mešanice betona drobnejše zrnatosti.

Pri zahtevnih konstrukcijah statik določi vrstni red in način opaženja oziroma razopaženja ter mesta, kjer je betoniranje dovoljeno prekiniti.

Med betoniranjem je izvajalec dolžan vgraditi vse ostale elemente kot so podložke, čepi, škatle za prehode instalacij, kljuke potrebne za poznejšo pritrditev drugih montažnih elementov in instalacij.

V času med in po končanem betoniranju je izvajalec dolžan v skladu z začasnimi predpisi za beton in armirani beton, beton negovati in zaščititi pred vplivom nizkih oziroma visokih temperatur. Vse armiranobetonske konstrukcije, ki ostanejo vidne, se morajo v slučaju poškodbe zakrpati in zgladiti.

Obračun betonskih in armirano betonskih del se vrši za 1 m3 vgrajenega betona, obračun armature pa za 1 kg položene armature, če se obračunava posebej.

8.3.2 Beton in armiran beton za objekte

Vgrajuje se beton in armirani beton posameznih konstruktivnih elementov objektov po načrtih, opisu del, predpisih za beton in armirani beton ter upoštevanju ustreznih standardov, kot je že opisano v splošnih določilih za betonska dela.

Obračunava se 1 m^3 vgrajenega betona

8.3.3 Cene na enoto

Cene za enoto betonskih in armiranobetonskih del vsebujejo:

- ves potreben material, vključno z armaturo
- vse delo potrebno za izdelavo in vgrajevanje betona ter polaganje armature
- vse potrebne transporte
- zaščito in nego betona
- se pomožne delovne odre z dohodi, potrebne za delo pri betoniranju
- pri montažnih armiranobetonskih konstrukcijah cene vsebujejo tudi montažo

Obračun vseh betonskih in armiranobetonskih del se vrši za 1 m3 vgrajenega betona.

8.4 Tesarska dela

8.4.1 Splošna določila

Ves material, ki se uporablja za izdelavo opažev, mora biti pripravljen v odgovarjajočih merah in po kvaliteti odgovarjati ustreznim tehničnim predpisom za lesene konstrukcije in ustreznim standardom.

Opaži morajo biti izdelani točno po merah v načrtih in v vseh detajlih, z vsemi potrebnimi podporami, horizontalno in vertikalno povezavo, tako da so stabilni in sposobni prevzeti težo vgrajenega betona. Stične površine morajo biti čiste in ravne.

Opaži morajo biti izvedeni tako, da se razopaženje lahko opravi brez pretresov in poškodovanja armiranobetonskih konstrukcij oziroma opažev samih.

Obračun se vrši za napravo, postavitev in odstranitev 1 m^2 opaža.

8.4.2 Opaži in odri

Vsi opaži armiranobetonskih konstrukcij (temelji, stene, nosilci, stebri, plošče ipd...), kakor tudi vsi pomični in nepomični delovni in podporni odri, se izdelujejo po načrtih in predpisih del ter v skladu z vsemi pogoji splošnih določil.

8.4.3 Cena na enoto

Cene za enoto tesarskih del vsebujejo:

- ves potreben material
- vse potrebno delo in prenose
- vse pomožne odre, v kolikor niso predvideni v predračunu

Obračun se vrši za 1 m2 izdelanega opaža, upoštevajoč notranje površine opažev, to je vidne površine konstrukcij.

8.5 Zidarska dela

8.5.1 Splošna določila

Ves material potreben za zidanje, ometavanje in ostala zidarska dela, mora biti kvaliteten in mora odgovarjati tehničnim predpisom in ustreznim standardom.

Zidanje mora biti izvršeno po načrtih in statičnem izračunu. Delo mora biti izvršeno čisto, s pravilno vezavo opeke in dobro zalitimi stiki z malto. Vrste opeke morajo biti popolnoma ravne, vse zidane površine pa popolnoma vertikalne.

Vse ometane površine morajo biti popolnoma ravne in enakomerno obdelane.

Vsa dela za izvedbo hidroizolacij, toplotnih in zvočnih izolacij, vzidav in zazidav ter ostala zidarska dela morajo biti izvršena strokovno na način, ki je predpisan v posamezni postavki del.

Obračun se vrši za mersko enoto po posamezni postavki iz predračuna.

8.5.2 Cena na enoto

Cene za enoto tesarskih del vsebujejo:

- ves potreben material
- vse potrebno delo in prenose
- vse pomožne odre, v kolikor niso predvideni v predračunu

Obračun se vrši za 1 m^2 izdelanega opaža, upoštevajoč notranje površine opažev, to je vidne površine konstrukcij

8.5.3 Cevi in stiki

Vsa dela pri montaži cevovodov je treba izvršiti točno po popisu del oziroma po navodilih proizvajalca cevi. Cevi se polaga na peščeno posteljico. V primeru slabe nosilnosti tal je potrebno izdelati poseben statični izračun. Pri jeklenih ceveh je potrebno vse zvare testirati na priznan način

8.5.4 Izvedba gradbenih jam pri mikrotuneliranju

Način in postopek izvedbe ter zaščite gradbene jame je odvisen od geoloških pogojev, globine izkopa in tehnologije izvedbe. Jeklene zagatne stene so primerne zaradi hitrosti izvedbe in zmožnosti zagotavljanja skoraj neprepustnega stika. V večini primerov se uporabljajo za začasne izkope do globine 10 m. V ugodnih geoloških pogojih in z dodatnim razpiranjem lahko dosežemo globino izkopa do 16 m

Izvajalci mikrotuneliranja je posredoval podatke o minimalnih prostih odprtinah izkopov in prostih višinah od dna gradbene jame za manipulacije in delo s strojem za mikrotuneliranje. Predvidena prosta tlorisna površina mora biti 4.5*6.5m, prosta višina od dna gradbene jame pa 4 m. Poleg tega ocenjujemo, da glede razpoložljive opreme za izvedbo zaščite gradbenih jam izvajalci razpolagajo z zagatnicami VL604 (W1618 cm3/m) dolžine 12 m in jeklenimi profili HEA300, kvalitete pretežno 235-275 MPa.

Varovanje izkopa se bo izvedlo z uporabo jeklenih zagatnic tipa VL 604 dolžine 12 m. Zagatnice je skladno s statično analizo potrebno razpirati z jeklenimi profili HEA 300 – 235 MPa ali močnejšimi. Na dnu gradbenih jam je predvidena izvedba armirano betonskih razpornih plošč debeline 25 do 30 cm. Na vogalih gradbenih jam se izvedejo diagonalne razpore iz enakih jeklenih profilov. Vsi kontakti med jeklenimi profili so varjeni.

Pri izvedbi vkopov, nasipov in ostalih zemeljskih delih v sklopu obravnave izvedbe varovanja in izkopa gradbenih jam je obvezen stalen geotehnični nadzor, ki bo dajal navodila za ustrezne posege in morebitne dodatne ukrepe pri izvedbi del.

V tem projektu je izbrana uporaba potisnih cevi iz poliestra. Za izvedbo cevovodov po metodi mikrotuneliranja je potrebno predhodno izvesti gradbeno jamo, kamor se namesti potisna enota za potiskanje cevi v horizontalno vrtino. Dimenzije gradbene jame morajo biti take, da omogočajo namestitev potisne enote vanjo, vstavitev vrtalne glave in vsakokratno montažo potisne cevi pred potisno napravo ter prostor izdelavo oporne in čelne stene za oz. pred potisno napravo. Oporno in čelno steno se izdela iz armiranega betona in mora zagotavljati odpornost za predvidene potisne sile. Na drugem koncu odseka izvedbe mikrotuneliranja se izvede izhodna jama, ki je lahko manjših dimenzij, omogoča pa izvlek vrtalne glave po koncu izvajanja horizontalne vrtine.

Po tem projektu se bodo vstopne gradbene jame pripravile na lokacijah izvedbe objektov na kanalizaciji. Predvidena je izvedba v treh fazah:

- faza: izvedba potiskanja na odseku v smeri od objekta O1.2 proti objektu O1.1; potisna cev iz poliestra, notranji premer 1400 mm;

Velikosti gradbenih jam so določene glede na priporočila izvajalca vrtanja in so razvidna iz situacije

8.6 ZAKLJUČNA DELA

Po končani gradnji kanalizacije je potrebno vse kanale in jaške očistiti gradbenih odpadkov in nečistoč. Kanalske cevi je potrebno oprati in opraviti test vodotesnosti skladno s SIST EN 1610. Po končanih testiranjih je potrebno opraviti pregled s TV kamero in posnetek predati investitorju. Pred predajo kanalizacijskega sistema upravljalcu, je potrebno geodetsko posneti vsa izvedena dela. Geodetski posnetek mora biti geolociran v državnem koordinatnem sistemu, na njem se morajo jasno videti vsi elementi kanalizacijskega sistema (višina dna jaška, kota vtoka, kota iztoka) in vsa izvedena dela. Geodetski posnetek mora biti predan investitorju v pisni in digitalni obliki. Po opravljenem geodetskem posnetku je potrebno

T/3 ZAKOLIČBENE TOČKE

Oznaka	X	Y	Stacionaža	Kota pokrova	Kota dna	Kota vtoka	Kota iztoka	Globina jaška	Fi Jaška
Kanal1									
O1.1	461978.857	101670.87	0	296.2	287.66	287.66	287.66	8.62	1000
1	461977.563	101673.323	2.77	296.15	287.67	287.67	287.67	8.48	
2	461977.185	101674.994	4.49	296.16	287.68	287.68	287.68	8.47	
3	461988.558	101724.673	55.45	296.64	287.87	287.87	287.87	8.78	
4	462001.609	101781.673	113.93	296.63	288.09	288.09	288.09	8.54	
5	462006.063	101801.073	133.83	296.74	288.17	288.17	288.17	8.57	
6	462012.223	101828.033	161.49	296.82	288.27	288.27	288.27	8.51	
7	462021.057	101858.314	193.03	296.92	288.43	288.43	288.43	9.26	
8	462032.045	101891.935	228.4	297.11	288.61	288.61	288.61	8.85	
9	462040.957	101918.762	256.67	297.31	288.75	288.75	288.75	8.94	
10	462050.523	101943.712	283.39	297.68	288.89	288.89	288.89	8.8	
11	462058.952	101964.132	305.48	297.74	289	289	289	8.69	
12	462075.493	102001.251	346.12	298	289.2	289.2	289.2	8.49	
13	462095.621	102041.479	391.1	297.98	289.43	289.43	289.43	8.26	
O1.2	462114.535	102070.754	425.95	297.88	289.66	289.66	289.66	8.38	1000
Kanal2									
RJ1_K2	462116.76	102074.88	0	297.93	292.22	292.22	292.22	5.71	1200
RJ2_K2	462129.56	102096.019	24.71	297.83	292.29	292.29	292.29	5.54	1200
RJ3_K2	462140.83	102097.636	36.1	297.84	292.32	292.32	292.32	5.52	1200
RJ4_K2	462194.193	102098.27	89.47	297.68	292.48	292.48	292.48	5.2	1200
PRJ5_K2	462245.003	102098.855	140.28	297.66	292.64	292.64	292.64	5.02	1200
RJ6_K2	462255.747	102095.445	151.55	297.61	292.67	292.67	292.67	4.94	1200
RJ7_K2	462272.984	102095.642	168.79	297.63	292.77	292.77	292.77	4.8	1000
RJ8_K2	462307.394	102096.184	203.2	297.48	292.84	292.84	292.84	4.64	1000
RJ9_K2	462340.873	102096.742	236.69	297.3	292.92	292.92	292.92	4.38	1000
RJ10_K2	462381.845	102097.367	277.66	297.07	293.04	293.04	293.04	4.03	1000
RJ11_K2	462414.871	102097.612	310.69	296.89	293.14	293.14	293.14	3.75	1000
RJ12_K2	462444.24	102098.163	340.06	296.84	293.23	293.23	293.23	3.61	1000
RJ13_K2	462496.745	102098.475	392.57	296.85	293.38	293.39	293.39	3.47	1000
RJ14_K2	462562.508	102098.03	458.33	296.67	293.58	293.58	293.58	3.09	1000
RJ15_K2	462566.562	102114.541	475.34	296.58	293.63	293.63	293.63	2.95	1000
RJ16_K2	462570.13	102129.037	490.26	296.54	293.7	293.71	293.71	2.84	1000
Kanal2.3									
PRJ5_K2	462245.003	102098.855	0	297.66	292.64	295.09	292.64	5.02	1200
RJ1_K2.3	462262.891	102127.953	34.16	297.77	295.76	295.77	295.77	2.01	1000
Kanal3									
RJ1K3	462114.723	102074.992	0	297.98	292.1	292.1	292.1	5.88	1000
RJ2K3	462107.572	102096.205	22.39	297.91	292.21	292.21	292.21	5.7	1000
RJ3K3	462098.514	102097.323	31.51	297.97	292.26	292.26	292.26	5.71	1200
PRJ4K3	462074.075	102096.944	55.95	298.04	292.41	292.61	292.41	5.63	1200
RJ5K3	462036.974	102096.318	93.06	298.13	292.88	292.88	292.88	5.25	1000
PRJ6K3	461996.18	102095.935	133.86	298.19	293	294.41	293	5.19	1000
RJ7K3	461969.898	102095.519	160.14	298.19	294.49	294.49	294.49	3.7	1000
RJ8K3	461929.871	102095.128	200.17	298.15	294.61	294.61	294.61	3.54	1000
RJ9K3	461889.889	102094.667	240.16	298.05	294.73	294.73	294.73	3.32	1000
RJ10K3	461849.889	102094.197	280.16	297.9	294.93	294.93	294.93	2.97	1000
RJ11K3	461800.535	102093.596	329.52	297.7	295.24	295.24	295.24	2.46	1000
Kanal3.1									
PRJ4K3	462074.075	102096.944	0	298.04	292.41	293.21	292.41	5.63	1200
RJ1K3.1	462071.698	102100.735	4.48	298.08	293.22	293.23	293.23	4.86	1000
RJ2K3.1	462071.495	102116.963	20.7	297.92	293.33	293.34	293.34	4.56	1000
RJ3K3.1	462098.294	102117.281	47.5	297.81	293.42	293.42	293.42	4.35	1000
RJ4K3.1	462110.319	102117.424	59.53	297.74	293.5	293.5	293.5	4.21	1000
Kanal3.2									
PRJ6K3	461996.18	102095.935	0	298.19	293	293.09	293	5.19	1000
RJ1K3.2	461995.915	102114.961	19.03	297.98	293.29	293.3	293.3	4.69	1000
Kanal 4									

RJ1K4	461770.153	102090.278	0	297.9	293.74	293.74	293.74	4.15	1000
RJ2K4	461771.999	102096.265	6.27	297.89	293.75	293.75	293.75	4.14	1000
KanalM1									
Preliv_M1	462116.704	102072.237	0	297.85	294.68	294.68	294.68	3.17	
PON1_M1	462123.524	102068.834	7.62	297.7	294.7	294.7	294.7	3	1000
PON2_M1	462117.524	102058.441	19.62	297.69	294.74	294.74	294.74	2.95	1000
PON3_M1	462129.524	102058.441	31.62	297.77	294.77	294.78	294.78	3	1000
PON4_M1	462141.524	102058.441	43.62	297.77	294.81	294.81	294.81	2.96	1000
PON5_M1	462135.56	102068.897	55.66	297.79	294.85	294.85	294.85	2.95	1000
RJ6M1	462129.523	102066.964	62	297.75	294.87	294.87	294.87	2.89	1200
LO 300/30	462128.887	102071.098	66.18	297.74	294.88	294.88	294.88	2.86	2160
RJ8M1	462128.523	102074.972	70.07	296.46	294.89	294.9	294.9	2.57	1200
RJ9M1	462111.255	102109.506	108.68	297.8	295.02	295.02	295.02	2.78	1200
RJ10M1	462079.144	102108.968	140.8	297.89	295.12	295.12	295.12	2.77	1200
RJ11M1	462052.595	102108.674	167.35	297.92	295.19	295.19	295.19	2.73	1200
RJ12M1	462030.145	102109.69	189.82	297.98	295.26	295.26	295.26	2.72	1000
RJ13M1	461985.914	102109.013	234.06	297.98	295.39	295.39	295.39	2.59	1200
RJ14M1	461942.603	102108.73	277.37	298.13	295.52	295.52	295.52	2.61	1200
RJ15M1	461915.369	102113.503	305.02	298.14	295.6	295.6	295.6	2.54	1000
RJ16M1	461886.678	102113.003	333.71	297.92	295.69	295.69	295.69	2.21	1000
RJ17M1	461846.691	102112.286	373.71	297.58	295.81	295.81	295.81	1.77	1000
RJ18M1	461805.371	102111.545	415.03	297.43	295.93	295.93	295.93	1.5	1000
KanalM1.1									
RJ8M1	462128.523	102074.972	0	296.46	294.89	294.9	294.9	2.57	1200
RJ1M1.1	462161.171	102109.938	47.84	297.65	295.09	295.09	295.09	2.56	1000
RJ2M1.1	462184.237	102110.068	70.91	297.59	295.15	295.15	295.15	2.45	1000
RJ3M1.1	462213.275	102110.465	99.95	297.52	295.25	295.25	295.25	2.27	1000
RJ4M1.1	462241.315	102110.797	127.99	297.46	295.53	295.53	295.53	1.93	1000
RJ5M1.1	462263.643	102111.061	150.32	297.6	295.99	296	296	1.61	1000

T/4 HIDRAVLIČNI IZRAČUN

Oznaka	Polnitev [%]	Max. V [m/s]	Max Q [l/s]	Notranji	i [o/oo]	L [m]	Qsušni [l/s]	A [ha]	Ared[ha]	Ng
K1 - 'Kanal1'										
M1.K1.C1 (O1.1 - 1)	31,1	1.98	462	980	3.6	2.77	0	0	0	0.01
M1.K1.C2 (1 - 2)	29,2	2.36	462	980	5.8	1.71	0	0	0	0.01
M1.K1.C3 (2 - 3)	31,0	2	462	980	3.7	50.96	0	0	0	0.01
M1.K1.C4 (3 - 4)	30,9	2.01	462	980	3.8	58.47	0	0	0	0.01
M1.K1.C5 (4 - 6)	29,7	2.01	462	980	3.8	47.56	0	0	0	0.01
M1.K1.C6 (6 - 7)	29,7	2.23	462	980	5	31.54	0	0	0	0.01
M1.K1.C7 (7 - 8)	29,7	2.24	462	980	5.1	35.37	0	0	0	0.01
M1.K1.C8 (8 - 9)	29,7	2.23	462	980	5	28.27	0	0	0	0.01
M1.K1.C9 (9 - 10)	29,7	2.23	462	980	5	26.72	0	0	0	0.01
M1.K1.C10 (10 - 11)	29,7	2.25	462	980	5.2	22.09	0	0	0	0.01
M1.K1.C11 (11 - 12)	29,7	2.23	462	980	5	40.64	0	0	0	0.01
M1.K1.C12 (12 - 13)	29,7	2.23	462	980	5	44.98	0	0	0	0.01
M1.K1.C13 (13 - O1.2)	29,7	2.47	462	980	6.6	34.85	462	0	0	0.01
K2 - 'Kanal2'										
M1.K2.C1 (RJ1_K2 - RJ2_K2)	49.90%	1.53	205.93	588	3	24.71	0	0.02	0.018	0.01
M1.K2.C2 (RJ2_K2 - RJ3_K2)	49.50%	1.51	200.48	588	3	11.39	0	0	0	0.01
M1.K2.C3 (RJ3_K2 - RJ4_K2)	49.70%	1.5	200.48	588	2.9	53.37	0	0	0	0.01
M1.K2.C4 (RJ4_K2 - PRJ5_K2)	48.70%	1.56	200.48	588	3.2	50.81	0	0	0	0.01
M1.K2.C5 (PRJ5_K2 - RJ6_K2)	51.30%	1.34	191.18	588	2.2	11.27	0	0	0	0.01
M1.K2.C6 (RJ6_K2 - RJ7_K2)	43.20%	1.92	191.18	588	6	17.24	0	0	0	0.01
M1.K2.C7 (RJ7_K2 - RJ8_K2)	51.60%	1.32	191.18	588	2.2	34.41	0	0	0	0.01
M1.K2.C8 (RJ8_K2 - RJ9_K2)	50.90%	1.36	191.18	588	2.3	33.48	0	0.234	0.211	0.01
M1.K2.C9 (RJ9_K2 - RJ10_K2)	51.60%	1.35	128.13	477	3	40.98	0	0	0	0.01
M1.K2.C10 (RJ10_K2 - RJ11_K2)	51.50%	1.35	128.13	477	3	33.03	0	0	0	0.01
M1.K2.C11 (RJ11_K2 - RJ12_K2)	51.60%	1.35	128.13	477	3	29.37	0	0.183	0.165	0.01
M1.K2.C12 (RJ12_K2 - RJ13_K2)	54.40%	1.19	78.78	379	3	52.51	0	0	0	0.01
M1.K2.C13 (RJ13_K2 - RJ14_K2)	54.30%	1.19	78.78	379	3	65.76	0	0.143	0.129	0.01
M1.K2.C14 (RJ14_K2 - RJ15_K2)	30.70%	0.61	7.07	306	2.8	17	0	0	0	0.01
M1.K2.C15 (RJ15_K2 - RJ16_K2)	19.90%	0.38	1.33	306	3	7.41	1.33	0	0	0.01
K5 - 'Kanal2.3'										
M1.K5.C1 (PRJ5_K2 - RJ1_K2.3)	25.40%	1.33	9.3	306	20	34.16	0	0.035	0.031	0.01
K6 - 'Kanal3'										
M1.K6.C1 (RJ1K3 - RJ2K3)	50.00%	1.95	264.18	588	4.9	22.39	0	0	0	0.01
M1.K6.C2 (RJ2K3 - RJ3K3)	48.90%	2.04	264.18	588	5.5	9.13	0	0	0	0.01
M1.K6.C3 (RJ3K3 - PRJ4K3)	48.20%	2.1	264.18	588	5.9	24.44	0	0.032	0.029	0.01
M1.K6.C4 (PRJ4K3 - RJ5K3)	49.00%	2.04	175.07	477	7.3	37.11	0	0.092	0.083	0.01
M1.K6.C5 (RJ5K3 - PRJ6K3)	55.70%	1.37	150.33	477	2.9	40.8	0	0	0	0.01
M1.K6.C6 (PRJ6K3 - RJ7K3)	55.00%	1.39	148.99	477	3	26.29	0	0.056	0.051	0.01
M1.K6.C7 (RJ7K3 - RJ8K3)	52.50%	1.36	133.81	477	3	40.03	0	0	0	0.01
M1.K6.C8 (RJ8K3 - RJ9K3)	52.50%	1.36	133.81	477	3	39.99	0	0.279	0.251	0.01
M1.K6.C9 (RJ9K3 - RJ10K3)	55.00%	1.33	58.77	306	5	40	0	0.177	0.159	0.01
M1.K6.C10 (RJ10K3 - RJ11K3)	31.10%	0.92	11.11	306	6.2	49.36	0	0.041	0.037	0.01
K7 - 'Kanal3.1'										
M1.K7.C1 (PRJ4K3 - RJ1K3.1)	52.50%	1.3	80.4	379	3.7	4.48	0	0	0	0.01
M1.K7.C2 (RJ1K3.1 - RJ2K3.1)	46.70%	1.64	80.4	379	6.8	16.23	0	0.054	0.048	0.01
M1.K7.C3 (RJ2K3.1 - RJ3K3.1)	69.70%	1.06	65.91	306	3	26.8	0	0	0	0.01
M1.K7.C4 (RJ3K3.1 - RJ4K3.1)	54.20%	1.53	65.91	306	6.7	12.03	0	0.245	0.22	0.01
K8 - 'Kanal3.2'										
M1.K8.C1 (PRJ6K3 - RJ1K3.2)	12.80%	0.55	1.33	477	10.8	19.03	1.33	0	0	0.01
K9 - 'Kanal 4'										
M1.K9.C1 (ZO2 - ZO1)	53.40%	0.91	140.78	588	1	6.27	0	0.523	0.471	0.01
K11 - 'KanalM1'										
M1.K11.C1 (Preliv_M1 - PON1_M1)	100.00%	3.73	274.52	306	3	7.62	0	0	0	0.01
M1.K11.C2 (PON1_M1 - PON2_M1)	100.00%	3.73	274.52	306	3	12	0	0	0	0.01
M1.K11.C3 (PON2_M1 - PON3_M1)	100.00%	3.73	274.52	306	3	12	0	0	0	0.01
M1.K11.C4 (PON3_M1 - PON4_M1)	100.00%	3.73	274.52	306	3	12	0	0	0	0.01
M1.K11.C5 (PON4_M1 - PON5_M1)	100.00%	3.73	274.52	306	3	12.04	0	0	0	0.01
M1.K11.C6 (PON5_M1 - RJ6M1)	100.00%	3.73	274.52	306	3	6.34	0	0	0	0.01
M1.K11.C7 (RJ6M1 - LO 300/30)	42.40%	1.63	274.52	782	3	4.18	0	0	0	0.01
M1.K11.C8 (LO 300/30 - RJ8M1)	42.40%	1.63	274.52	782	3	3.89	0	0	0	0.01

M1.K11.C9 (RJ8M1 - RJ9M1)	49.60%	1.57	208.98	588	3.2	38.61	0	0.046	0.042	0.01
M1.K11.C10 (RJ9M1 - RJ10M1)	48.70%	1.53	196.55	588	3.1	32.11	0	0.075	0.067	0.01
M1.K11.C11 (RJ10M1 - RJ11M1)	48.30%	1.39	176.45	588	2.6	26.55	0	0.054	0.048	0.01
M1.K11.C12 (RJ11M1 - RJ12M1)	45.60%	1.45	162.05	588	3.1	22.47	0	0.051	0.046	0.01
M1.K11.C13 (RJ12M1 - RJ13M1)	44.60%	1.39	148.38	588	2.9	44.24	0	0.09	0.081	0.01
M1.K11.C14 (RJ13M1 - RJ14M1)	41.90%	1.34	124.3	588	3	43.31	0	0.091	0.082	0.01
M1.K11.C15 (RJ14M1 - RJ15M1)	46.90%	1.27	99.7	477	3	27.65	0	0.059	0.054	0.01
M1.K11.C16 (RJ15M1 - RJ16M1)	56.00%	1.2	83.71	379	3	28.7	0	0.072	0.065	0.01
M1.K11.C17 (RJ16M1 - RJ17M1)	50.00%	1.14	64.36	379	3	39.99	0	0.104	0.094	0.01
M1.K11.C18 (RJ17M1 - RJ18M1)	41.20%	0.98	36.29	379	3	41.33	0	0.135	0.121	0.01
K12 - 'KanalM1.1'										
M1.K12.C1 (RJ8M1 - PRJ1M1.1)	47.70%	1.28	65.54	379	4.1	47.84	0	0.037	0.033	0.01
M1.K12.C2 (PRJ1M1.1 - RJ2M1.1)	48.70%	1.04	55.64	379	2.6	23.07	0	0.037	0.033	0.01
M1.K12.C3 (RJ2M1.1 - PRJ3M1.1)	43.70%	1.08	45.74	379	3.3	29.04	0	0.064	0.058	0.01
M1.K12.C4 (PRJ3M1.1 - RJ4M1.1)	32.30%	1.4	28.44	379	10	28.04	0	0.048	0.043	0.01
M1.K12.C5 (RJ4M1.1 - RJ5M1.1)	29.00%	1.57	15.62	306	20.9	22.33	0	0.058	0.052	0.01

T/5 STATIČNI IZRAČUN

Structural analysis

Project:	9013 PCL 1F
Description:	GRP CC pipe DN300 PN1 SN 10.000
Contractor:	LUZ d.d Verovškova ulica 64 1000 Ljubljana Mr. Luka Kranjc (01) 36 02 473
Designer:	Josip Vrtarić Application Engineering Amiblu Alpe Adria d.o.o. Kralja Zvonimira 122, Zagreb, Croatia T +385 1 618 36 91 M +385 91 604 93 97 josip.vrtaric@amiblu.com www.amiblu.com
Calculation no.:	2025/89
Date:	19/08/2025

Content

1 Remarks 4

2 List of references 6

3 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 2,26 m 7

3.1 Input 7

3.1.1 Safety factors 7

3.1.2 Soil 7

3.1.3 Load 7

3.1.4 Installation 7

3.1.5 Pipe with nominal stiffness 8

3.2 Results 10

3.2.1 Intermediate results pipe 10

3.2.1.1 Material properties 10
3.2.1.2 Safety factors 10

3.2.2 Minimum trench width according to DIN EN 1610:2015-12 10

3.2.3 Intermediate results for load case 11

3.2.3.1 Silo Theory 11
3.2.3.2 Load 11
3.2.3.3 Soil deformation moduli EB 11
3.2.3.4 Soil stiffness values 11
3.2.3.5 Bedding angle, effective relative projection and friction angle 11
3.2.3.6 Characteristic values of pipe material and ring stiffness 11
3.2.3.7 Stiffness ratio 11
3.2.3.8 Coefficients 12
3.2.3.9 Concentration factors λR and λB 12
3.2.3.10 Pressure distribution at pipe circumference 12

3.2.4 Section forces 12

3.2.4.1 Section forces , short term 12
3.2.4.2 Section forces , long term 13

3.2.5 Short term load case 13

3.2.5.1 Strain proof 13
3.2.5.2 Deformation proof 14

3.2.6 Long term load case 14

3.2.6.1 Strain proof 14
3.2.6.2 Deformation proof 15
3.2.6.3 Stabilty proof radial, linear 15
3.2.6.4 stability proof, nonlinear 16
3.2.6.5 Proof of safety against failure with not predominantly static loading 16

4 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 4,4 m 17

4.1 Input 17

4.1.1 Safety factors 17

4.1.2 Soil 17

4.1.3 Load 17
4.1.4 Installation 17
4.1.5 Pipe with nominal stiffness 18
4.2 Results 20
4.2.1 Intermediate results pipe 20
4.2.1.1 Material properties 20
4.2.1.2 Safety factors 20
4.2.2 Minimum trench width according to DIN EN 1610:2015-12 20
4.2.3 Intermediate results for load case 21
4.2.3.1 Silo Theory 21
4.2.3.2 Load 21
4.2.3.3 Soil deformation moduli EB 21
4.2.3.4 Soil stiffness values 21
4.2.3.5 Bedding angle, effective relative projection and friction angle 21
4.2.3.6 Characteristic values of pipe material and ring stiffness 21
4.2.3.7 Stiffness ratio 21
4.2.3.8 Coefficients 22
4.2.3.9 Concentration factors λR and λB 22
4.2.3.10 Pressure distribution at pipe circumference 22
4.2.4 Section forces 22
4.2.4.1 Section forces , short term 22
4.2.4.2 Section forces , long term 23
4.2.5 Short term load case 23
4.2.5.1 Strain proof 23
4.2.5.2 Deformation proof 24
4.2.6 Long term load case 24
4.2.6.1 Strain proof 24
4.2.6.2 Deformation proof 25
4.2.6.3 Stabilty proof radial, linear 25
4.2.6.4 stability proof, nonlinear 26
4.2.6.5 Proof of safety against failure with not predominantly static loading 26
5 Appendix 27
5.1 - 28

1 Remarks

DISCLAIMER OF LIABILITY

As part of the technical service for the technical planning of projects of the Amiblu Group (hereinafter referred to as "Amiblu"), static calculations for decision-making regarding Amiblu/Flowtite/Hobas GFK pipe systems and products are regularly provided by Amiblu.

By using this free Amiblu' s technical verification service, you agree to the following terms and conditions:

1. No contractual relationship:
The use of the above mentioned Amiblu` s calculations does not constitute a contractual relationship between you and Amiblu and no consulting or information agreement is concluded. To this extent, there do not exist any contractual or quasi-contractual claims against Amiblu.

2. Requirements:
You acknowledge that the here mentioned calculations only apply to Amiblu/Flowtite/Hobas products.

3. Basis of the static calculation:
Amiblu bases the calculation according to your stated project and installation conditions and completes the missing data by itself if necessary, this to the best of its knowledge and based on the current state of knowledge and according to the requirements of the valid standards and regulations.
The trench width and installation conditions are based on the minimum requirements according to EN1610 without consideration of the trench sheet thickness (if in use). This usually represents the critical load case and is therefore on the safe side.

4. Installation specifications:
In all cases the following installation conditions must be observed for the installation of Amiblu products:

The pipe zone must be made of non-cohesive or slightly cohesive material with the quality and degree of compaction according to this calculation. The maximum grain size according to the Amiblu/Flowtite/Hobas installation instructions for buried pipes and shafts have to be observed.
To classify the bedding material, all the material in the pipeline zone has to pass through a sieve with a mesh size as specified in the installation instructions.

The pipe bedding must be at least 100 mm thick and have the specified support angle according to the static calculation. We recommend that the requirements for the pipe bedding according to EN 1610.

The degree of compaction of the pipe zone and backfill must meet or exceed the requirements of the static calculation. The installation conditions should be checked and documented. The pipe zone ends 300 mm above the pipe crown.

The quality and degree of compaction of the backfill, the existing soil and the pipeline zone must be checked and needs to meet the requirements of this static evaluation.

For the static calculation compliance with the applicable international standards and installation instructions for Amiblu/Flowtite/Hobas products is assumed. The installation instructions for Amiblu/Flowtite/Hobas can be downloaded from our homepages: http://www.flowtite.com or http://www.hobas.com or http://www.amiblu.com.

The installation conditions used for the static calculation should be compared by you or an expert engineer or the project planner with the actual conditions on site. Potential deviations may have an influence on the pipe installation.

5. Disclaimer:
The services provided are subject to Amiblu's General Conditions of Sale, insofar applicable.

The results of the calculation can only be obtained in practice if the assumptions correspond to the real construction conditions on site.

The static calculations were carried out reliably and carefully according to the professional opinion of Amiblu.

Amiblu accept liability for the static calculation carried out on the basis of customer specifications, such as e.g. contents from structural analysis forms, specifications for planning and execution, information on ground condition as well as installation and/or operation. Amiblu does not accept any liability for the correctness and completeness of the specific customer specifications.

The static calculations prepared by Amiblu are a service in the design or execution phase and usually become part of the project documentation. Amiblu assumes no liability for the applicability of the calculation results in case of deviations from the underlying assumptions.

Rev03 11/04/2023

2 List of references

DIN 4124 - Excavations and Trenches - Slopes, planking and strutting, breadths of working space: October 2002

EN 1610 - Construction and testing of drains and sewers: December 2015

EN 805 - Water Supply Requirements for systems and components outside of buildings: March 2000

EN 1992-2 - Eurocode 2: Eurocode 1: Actions on structures Part 2: Traffic loads on bridges (consolidated version): March. 2012

EN 1796 - Plastics piping systems for water supply with or without pressure - Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP): March 2013

EN 14364 - Plastics piping systems for drainage and sewerage with or without pressure – Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP): Mai 2013

EN 15383 - Plastics piping systems for drainage and sewerage - Glass- reinforced thermosetting plastics (GRP) based on polyester resin (UP) - Manholes and inspection chambers: March 2013

ISO 16611 Plastics piping systems for drainage and sewerage without pressure - Non-circular pipes and joints made of glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resins (UP) - Dimensions, requirements and tests: June 2017

ISO 25780 - Plastics piping systems for pressure and non-pressure water supply, irrigation, drainage or sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin — Pipes with flexible joints intended to be installed using jacking techniques: Mai 2011

Worksheet DWA-A127 - Structural verification of sewer channels and pipe lines, 3. corrected Issue: August 2000

3 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 2,26 m

Caption of this part of the calculation:	Cover 2,26 m
Kind of calculation:	Nominal stiffness
Add sketch to print:	Yes

3.1 Input

3.1.1 Safety factors

Safety class:	A (normal case)
Safety stability according to table 13:	Without predeformation (2.5 / 2.0)
Allowable deflection:	6% (standard)
Treatment of internal pressure:	In accordance with Footnote 39 in ATV-DVWK-A 127
Lower safety factors for flexural compression:	No (ATV-DVWK-A 127)
Proof for not predominantly static loading:	According to standard
Consideration of dyn pvh*:	According to standard
Consideration of Type A 'predeformation' in the deformation proof:	Yes
Treatment system stiffness VRB according to:	DWA-A 161:2014 (by material)
Pipe stiffness according to set of rules:	Yes

3.1.2 Soil

Soil group backfill:	G1		
Calculation E1:	Table 8 (A127)		
Soil group pipe zone:	G1		
Calculation E20:	Table 8 (A127)		
Soil group native soil:	G2		
Calculation E3:	Degree of compaction		
Compaction degree E3:	$D_{Pr,E3}$	98.0	%
E4 = 10 · E1:	Yes		
Application of silo theory:	Automatic		
K2 according to standard:	Yes		

3.1.3 Load

Cover depth:	h	2.26	m
Minimum groundwater level above pipe bed:	$h_{W,min}$	0.00	m
Maximum groundwater level above pipe bed:	$h_{W,max}$	0.00	m
Soil density:	γ_B	20.0	kN/m³
Additional surface load:	p_0	0.0	kN/m²
Inner pressure, short term:	$P_{I,K}$	0.00	bar
Inner pressure, long term:	$P_{I,L}$	0.00	bar
Water fill (e.g. damming channel):	Yes		
Density of medium:	γ_F	10.0	kN/m³
Input special-purpose vehicle:	No		
Traffic load:	Street HGV 30 (with road construction)		
Including horizontal loads due to traffic in the fatigue proof:	$\alpha_{qhT,dyn}$	0.00	%

3.1.4 Installation

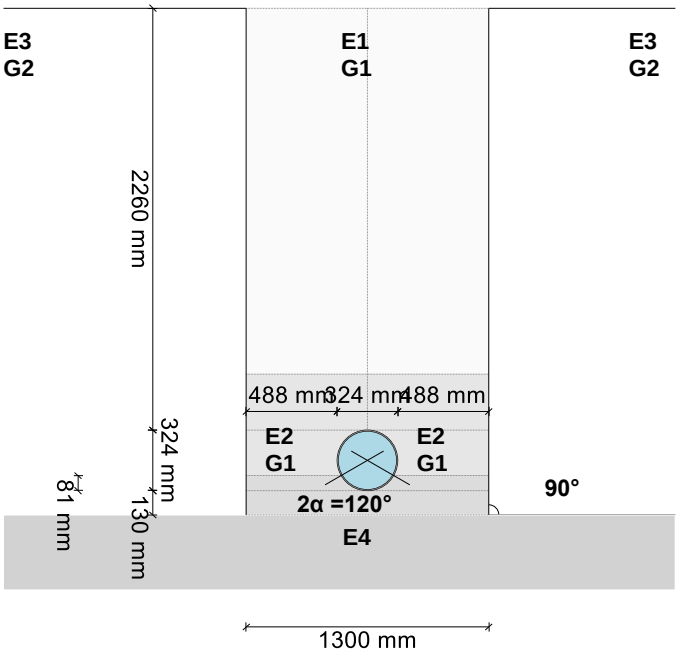
Installation:	Trench		
Trench width at pipe crown level:	b	1.30	m
Check minimum trench width:	Yes		
Automatic consideration of bedding layer:	Yes		

Slope angle:	ß	90	°
Cover condition:	A4		
Installation condition:	B1		
Type of bedding:	Loose		
Bedding angle:	120°		
Calculate bedding automatically:	Yes		
Set lower height base:	No		
Total height of base:	h_s	0.00	m

3.1.5 Pipe with nominal stiffness

Pipe chosen from datebase:	No		
Choice of input:	Do - s		
Outer diameter:	d_a	324	mm
Nominal diameter:	DN	300	mm
Wall thickness:	t	8.0	mm
Local predeformation:	$\delta_{v,I}$	0.0	%
A type predeformation:	$\delta_{v,A}$	1.0	%
Nominal stiffness:	SN	10,000	N/m²
Nominal pressure:	PN	1.0	bar
Relative failure strain according to standard:	Yes		
Creep ratio:	f_{Kriech}	2.00	[-]
Reduction factor due to temperature effect:	$A_{1,Temp}$	1.00	[-]
Reduction factor due to media attack:	$A_{2,Medium}$	1.00	[-]
Reduction factor due to dynamic loading:	$A_{3,dyn}$	1.00	[-]
Specific gravity:	γ_R	18.00	kN/m³
Poissons ratio:	v	0.30	[-]
Input of ultimate hoop tensile stress:	No		
Ultimate strain tensile strength according to standard:	Yes		
Amplitude with 2·10^6 tests is known:	Yes		
Amplitude with 2·10^6 tests:	$\Delta\sigma_{rsk,2E6}$	36.00	N/mm²
Amplitude with 1·10^8 tests is known:	Yes		
Amplitude of the pipe with 1·10^8 tests:	$\Delta\sigma_{rsk,1E8}$	24.00	N/mm²
Axial compressive strength, short term:	$f_{c,ax,K}$	90.0	N/mm²
Fiber strain for axial pressure, short term:	ε_{AxK}	1.0	%

Traffic load: Street HGV 30 (with road construction)



3.2 Results

3.2.1 Intermediate results pipe

Inner diameter:	d_i	308.0	mm
Outer diameter:	d_a	324.0	mm
Mean radius:	r_m	158.00	mm
Wall thickness:	s	8.00	mm
Ratio radius to wall thickness:	r_m/s	19.750	[-]
Curve correction factor, internal:	α_{ki}	1.017	[-]
Curve correction factor, external:	α_{ka}	0.983	[-]
Local predeformation:	$\delta_{v,l}$	0.00	%
Predeformation (ovalisation before load):	$\delta_{v,A}$	1.00	%
Radial cross section:	A_{rad}	8.00	mm²/mm
Distance of inertia:	e	4.00	mm
Moment of inertia:	I	42.67	mm^4/mm
Outer moment of resistance:	W_a	10.67	mm³/mm
Inner moment of resistance:	W_i	10.67	mm³/mm
Surface ratio:	κ_Q	1.2	[-]

3.2.1.1 Material properties

		short term	long term	
Specific gravity	γ_R	18.0	18.0	kN/m³
Poissons ratio	v	0.30	0.30	[-]
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	7,395.6	3,697.8	N/mm²
Creep ratio:		f_{creep}	2.00	[-]

Table 3 of ATV DVWK-A 127, footnote 34:
Determined from the momentary value and the creep ratio (2) with characteristic values for 2 years for the description of the long term behauvior. Also permitted for the long term verification for 50 years. Tests take place in accordance with DIN EN 1228 (momentary) and DIN EN 1225 (long term).

Characteristic value of relative fracture deformation	$\Delta d_{Bruch}/d_m$	15.0	9.0	%

$$\varepsilon_R = 4.28 \cdot s/d_m \cdot \Delta d_{Bruch}/d_m$$

Characteristic value of ultimate strain for edge fibers	ε_R	1.625	0.975	%

$$f_t = \frac{0.50 \cdot PN \cdot 4 \cdot 2 \cdot r_m}{h}$$

Characteristic value of hoop tensile strength	f_t	7.9	4.0	N/mm²
Amplitude for 2·10^6 load cycles:		$\Delta\sigma_{rsk,2E6}$	n. def	N/mm²
Amplitude at 5·10^6 load cycles:		$\Delta\sigma_{rsk,5E6}$	n. def	N/mm²
Amplitude for 1·10^8 cycles:		$\Delta\sigma_{rsk,1E8}$	n. def	N/mm²

3.2.1.2 Safety factors

Required safety coefficient, bending tensile stress	erf γ_{RBZ}	2.00	2.00	[-]
Required safety coefficient, bending compressive stress	erf γ_{RBD}	2.00	2.00	[-]
Required safety coefficient, instability (buckling)	erf γ_{stab}	2.50	2.50	[-]

3.2.2 Minimum trench width according to DIN EN 1610:2015-12

Nominal diameter:	DN	300	mm
Outer diameter:	d_a	324.0	mm
Size of the bedding layer:	a	0.13	m
Minimum width at trench sole level (incl. x) according to table 1:	$min_{b,T1}$	0.82	m
Minimum width according to table 2:	$min_{b,T2}$	0.90	m

Minimum clear width at trench sole level:	$min_{b,G}$	0.90	m
Required width at pipe crown level:	$min_{b,R}$	0.90	m
Trench width at pipe crown level:	b	1.30	m

The minimum trench width at trench sole level according DIN EN 1610 is met.

3.2.3 Intermediate results for load case

3.2.3.1 Silo Theory

Soil load coefficient κ for trench load (Silo Theory):	κ	1.000	[-]
Soil load coefficient κ0 for surface load (Silo Theory):	$κ_0$	1.000	[-]

κ0 and κ are set to 1, because E1 is larger then E3.

3.2.3.2 Load

Maximum groundwater level above pipe crown:	$h_{W,Scheitel}$	0.00	m
Vertical soil stress from soil load:	P_{Erd}	45.20	kN/m²
Vertical soil stress from soil and surface load:	P_E	45.20	kN/m²
Stress due to traffic load:	P_V	15.82	kN/m²
Included impact factor:	ϕ	1.40	[-]

3.2.3.3 Soil deformation moduli EB

Backfill elastic modulus under load:	$E_{1,σ}$	23.00	N/mm²

$$E_{3,\sigma} = \frac{40}{2} \cdot e^{-0.188(100 - D_{Pr})} \qquad 3.01$$

Native soil elastic modulus:	$E_{3,σ}$	13.73	N/mm²
Bedding elastic modulus (reduced):	$E_{2,σ}$	16.00	N/mm²
Bedding elastic modulus under load:	$E_{20,σ}$	16.00	N/mm²
Reduction factor for creep:	f_1	1.000	[-]
Reduction factor E20 (groundwater):	f_2	1.000	[-]
Reduction factor E20 (narrow trench):	$α_B$	1.000	[-]

For a ratio (trench width / outer diameter) >= 4, formula 6.03 always results in 1.0.

Bedding elastic modulus (reduced):	$E_{2,σ}$	16.00	N/mm²
Elastic modulus of soil under pipe:	$E_{4,σ}$	230.00	N/mm²

3.2.3.4 Soil stiffness values

Auxiliary value for horizontal bedding stiffness:	$Δ_f$	1.642	[-]
Correction factor for horizontal bedding stiffness:	ζ	0.998	[-]
Horizontal bedding stiffness:	S_{Bh}	9.576	N/mm²
Vertical bedding stiffness:	S_{Bv}	16.000	N/mm²

3.2.3.5 Bedding angle, effective relative projection and friction angle

Bedding angle, effective relative projection and friction angle:	2α	120	°
Height bedding from bedding angle to lower pipe ledge:	t_r	0.081	m
Calculated relative projection:	a	1.00	[-]
Effective relative projection:	a'	1.438	[-]
Internal friction angle:	φ'	30.000	°
Wall friction angle:	δ	30.000	°

3.2.3.6 Characteristic values of pipe material and ring stiffness

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Pipe stiffness	S_R	80,000	50,371	40,000	N/m²
Characteristic value of ultimate strain for edge fibers	$ε_R$	1.625	1.144	0.975	%
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	7,395.6	4,656.6	3,697.8	N/mm²

3.2.3.7 Stiffness ratio

System stiffness, weighted	$V_{RB,w}$	0.0084	0.0053	0.0042	[-]
Stiffness ratio	V_S	0.4032	0.3478	---	[-]
Coefficient for vertical deformation	c_v*	-0.012	-0.009	---	[-]

3.2.3.8 Coefficients

Ground pressure ratio (bedding)	K_2	0.400	0.400	---	[-]
Coefficient for bedding reaction pressure	K*	1.202	1.254	---	[-]
Resulting deformation coefficient	c'_h	0.0891	0.0891	---	[-]
Resulting deformation coefficient	$c'_{h,qh}$*	-0.0658	-0.0658	---	[-]
Coefficient for vertical deformation	c_v*	-0.012	-0.009	---	[-]

3.2.3.9 Concentration factors λR and λB

Maximum concentration factor	max λ	2.062	2.062	---	[-]
Coefficient for maximum concentration factor	K'	0.920	0.914	---	[-]
Concentration factor above pipe, initial value	λ_R	0.792	0.751	---	[-]
Concentration factor above pipe, under trench effect	λ_{RG}	0.792	0.751	---	[-]
Concentration factor above pipe, upper limit	λ_{fo}	3.661	3.661	---	[-]
Concentration factor above pipe, lower limit	λ_{fu}	0.244	0.244	---	[-]
Concentration factor above pipe, final value	λ_{RG}	0.792	0.751	---	[-]
Soil concentration factor	λ_B	1.069	1.083	---	[-]

3.2.3.10 Pressure distribution at pipe circumference

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Total vertical load	q_v	51.61	49.76	---	kN/m²
Lateral pressure	q_h	20.63	20.88	---	kN/m²
Bedding reaction pressure (soil load)	q^*_h	38.84	37.92	---	kN/m²
Bedding reaction pressure (water filling)	q^*_{hw}	1.51	1.60	---	kN/m²

3.2.4 Section forces

3.2.4.1 Section forces , short term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	158.00	158.00	158.00	mm
Moment due to total vertical load	M_{qv}	0.336	-0.341	0.354	kNm/m
Moment due to lateral pressure	M_{qh}	-0.129	0.129	-0.129	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-0.175	0.202	-0.175	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.007	0.008	-0.007	kNm/m
Moment due to dead weight	M_g	0.001	-0.002	0.002	kNm/m
Moment due to water filling	M_w	0.007	-0.009	0.010	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.034	-0.013	0.055	kNm/m

		crown	springline	invert	
Mean radius	r_m	158.00	158.00	158.00	mm
Normal force due to total vertical load	N_{qv}	0.220	-8.155	-0.220	kN/m
Normal force due to lateral pressure	N_{qh}	-3.260	0.000	-3.260	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-3.541	0.000	-3.541	kN/m

Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.138	0.000	-0.138	kN/m
Normal force due to dead weight	N_g	0.006	-0.036	-0.006	kN/m
Normal force due to water filling	N_w	0.156	0.054	0.343	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-6.557	-8.137	-6.821	kN/m

3.2.4.2 Section forces , long term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	158.00	158.00	158.00	mm
Moment due to total vertical load	M_{qv}	0.324	-0.329	0.342	kNm/m
Moment due to lateral pressure	M_{qh}	-0.130	0.130	-0.130	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-0.171	0.197	-0.171	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.007	0.008	-0.007	kNm/m
Moment due to dead weight	M_g	0.001	-0.002	0.002	kNm/m
Moment due to water filling	M_w	0.007	-0.009	0.010	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.024	-0.004	0.045	kNm/m

		crown	springline	invert	
Mean radius	r_m	158.00	158.00	158.00	mm
Normal force due to total vertical load	N_{qv}	0.212	-7.862	-0.212	kN/m
Normal force due to lateral pressure	N_{qh}	-3.299	0.000	-3.299	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-3.457	0.000	-3.457	kN/m
Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.146	0.000	-0.146	kN/m
Normal force due to dead weight	N_g	0.006	-0.036	-0.006	kN/m
Normal force due to water filling	N_w	0.156	0.054	0.343	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-6.528	-7.844	-6.776	kN/m

3.2.5 Short term load case

3.2.5.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh^*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh^*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:			α_{ki}	1.017	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.030	-0.028	0.053	%
Strain due to other loads	ε_{sonst}	0.003	-0.003	0.007	%

Total strain	ε	0.033	-0.031	0.060	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.63	1.63	1.63	%
Safety coefficient flexural tension:	γ_{BZ}	49.521	---	27.166	[-]
Safety coefficient flexural compression:	γ_{BD}	---	52.368	---	[-]

outside

Curve correction factor, external:			α_{ka}	0.983	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	-0.051	0.000	-0.074	%
Strain due to other loads	ε_{sonst}	-0.002	0.003	-0.006	%
Total strain	ε	-0.054	0.003	-0.081	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.63	1.63	1.63	%
Safety coefficient flexural tension:	γ_{BZ}	---	549.729	---	[-]
Safety coefficient flexural compression:	γ_{BD}	30.364	---	20.186	[-]

All calculated safety coefficients of the strain proof are sufficient.

3.2.5.2 Deformation proof

Calculation mode:			linear		
Ratio:			I/(A·rm²)	0.00021	[-]
Ratio 'I/(A·rm²)·κ~Q':			I/(A·rm²)·κ_Q	0.00026	[-]
		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	1.60	mm
Horizontal diameter change:	Δd_h	1.28	mm
Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	0.51	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	1.51	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

3.2.6 Long term load case

3.2.6.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh^*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh^*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:			α_{ki}	1.017	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.029	-0.025	0.063	%
Strain due to other loads	ε_{sonst}	0.004	-0.005	0.013	%
Total strain	ε	0.033	-0.030	0.076	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.13	1.12	1.12	%
Safety coefficient flexural tension:	γ_{BZ}	34.242	---	14.665	[-]
Safety coefficient flexural compression:	γ_{BD}	---	37.241	---	[-]

outside

Curve correction factor, external:			α_{ka}	0.983	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	-0.062	-0.017	-0.098	%
Strain due to other loads	ε_{sonst}	-0.004	0.005	-0.012	%
Total strain	ε	-0.066	-0.012	-0.109	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.14	1.11	1.13	%
Safety coefficient flexural tension:	γ_{BZ}	---	---	---	[-]
Safety coefficient flexural compression:	γ_{BD}	17.145	90.591	10.330	[-]

All calculated safety coefficients of the strain proof are sufficient.

3.2.6.2 Deformation proof

Calculation mode:			linear		
Ratio:			I/(A·rm²)	0.00021	[-]
Ratio 'I/(A·rm²)·κ~Q':			I/(A·rm²)·κ_Q	0.00026	[-]

		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	1.74	mm
Horizontal diameter change:	Δd_h	1.25	mm
Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	0.55	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	1.55	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

3.2.6.3 Stabilty proof radial, linear

Earth and traffic loads

Pipe stiffness:	$\bar{S}_R$	50,371	N/m²
Horizontal bedding stiffness:	S_{Bh}	9.576	N/mm²
System stiffness, weighted:	$V_{RB,w}$	0.0053	[-]
Reduction factor buckling load for earth/traffic loads:	κ_{v2}	0.87	[-]
Friction angle in bedding zone:	φ'_2	35.000	°
Critical vertical total load:	krit q_v	1,212.2	kN/m²
Total vertical load:	q_v	49.76	kN/m²
Safety stability, radial:	$\gamma_{Stab,rad}$	24.36	[-]
Required safety coefficient, instability (buckling):	erf γ_{stab}	2.50	[-]

The buckling proof is fulfilled.

3.2.6.4 stability proof, nonlinear

The nonlinear stability proof is not applicable because of VRB > 1.0 (rigid pipe) or relative vertical deformation < 6%.

3.2.6.5 Proof of safety against failure with not predominantly static loading

According to the standard the dynamic proof is not required (e.g. traffic load > 1,5 m).

All necessary proofs are ok.

4 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 4,4 m

Caption of this part of the calculation:	Cover 4,4 m
Kind of calculation:	Nominal stiffness
Add sketch to print:	Yes

4.1 Input

4.1.1 Safety factors

Safety class:	A (normal case)
Safety stability according to table 13:	Without predeformation (2.5 / 2.0)
Allowable deflection:	6% (standard)
Treatment of internal pressure:	In accordance with Footnote 39 in ATV-DVWK-A 127
Lower safety factors for flexural compression:	No (ATV-DVWK-A 127)
Proof for not predominantly static loading:	According to standard
Consideration of dyn pvh*:	According to standard
Consideration of Type A 'predeformation' in the deformation proof:	Yes
Treatment system stiffness VRB according to:	DWA-A 161:2014 (by material)
Pipe stiffness according to set of rules:	Yes

4.1.2 Soil

Soil group backfill:	G1		
Calculation E1:	Table 8 (A127)		
Soil group pipe zone:	G1		
Calculation E20:	Table 8 (A127)		
Soil group native soil:	G2		
Calculation E3:	Degree of compaction		
Compaction degree E3:	$D_{Pr,E3}$	98.0	%
E4 = 10 · E1:	Yes		
Application of silo theory:	Automatic		
K2 according to standard:	Yes		

4.1.3 Load

Cover depth:	h	4.40	m
Minimum groundwater level above pipe bed:	$h_{W,min}$	0.00	m
Maximum groundwater level above pipe bed:	$h_{W,max}$	0.00	m
Soil density:	γ_B	20.0	kN/m³
Additional surface load:	p_0	0.0	kN/m²
Inner pressure, short term:	$P_{I,K}$	0.00	bar
Inner pressure, long term:	$P_{I,L}$	0.00	bar
Water fill (e.g. damming channel):	Yes		
Density of medium:	γ_F	10.0	kN/m³
Input special-purpose vehicle:	No		
Traffic load:	Street HGV 30 (with road construction)		
Including horizontal loads due to traffic in the fatigue proof:	$\alpha_{qhT,dyn}$	0.00	%

4.1.4 Installation

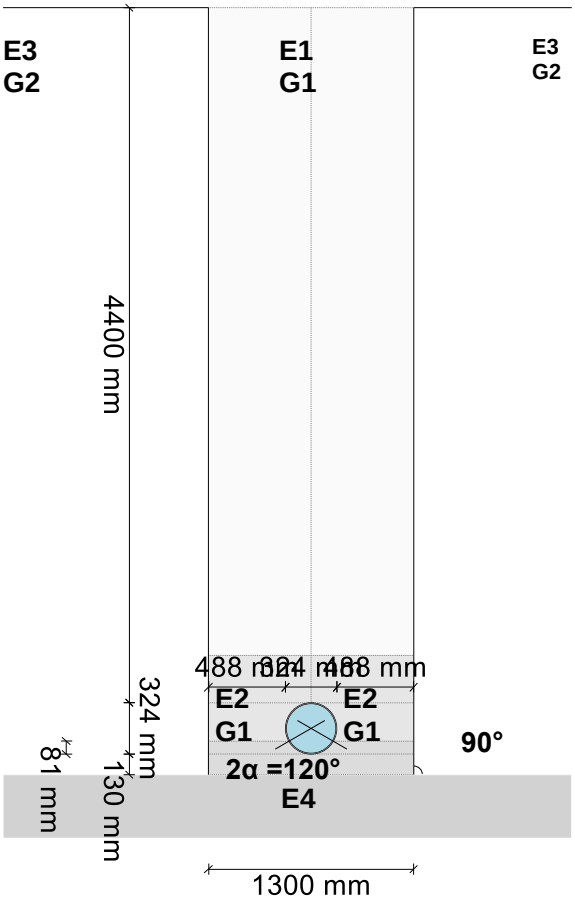
Installation:	Trench		
Trench width at pipe crown level:	b	1.30	m
Check minimum trench width:	Yes		
Automatic consideration of bedding layer:	Yes		

Slope angle:	ß	90	°
Cover condition:	A4		
Installation condition:	B1		
Type of bedding:	Loose		
Bedding angle:	120°		
Calculate bedding automatically:	Yes		
Set lower height base:	No		
Total height of base:	h_s	0.00	m

4.1.5 Pipe with nominal stiffness

Pipe chosen from datebase:	No		
Choice of input:	Do - s		
Outer diameter:	d_a	324	mm
Nominal diameter:	DN	300	mm
Wall thickness:	t	8.0	mm
Local predeformation:	$\delta_{v,I}$	0.0	%
A type predeformation:	$\delta_{v,A}$	1.0	%
Nominal stiffness:	SN	10,000	N/m²
Nominal pressure:	PN	1.0	bar
Relative failure strain according to standard:	Yes		
Creep ratio:	f_{Kriech}	2.00	[-]
Reduction factor due to temperature effect:	$A_{1,Temp}$	1.00	[-]
Reduction factor due to media attack:	$A_{2,Medium}$	1.00	[-]
Reduction factor due to dynamic loading:	$A_{3,dyn}$	1.00	[-]
Specific gravity:	γ_R	18.00	kN/m³
Poissons ratio:	v	0.30	[-]
Input of ultimate hoop tensile stress:	No		
Ultimate strain tensile strength according to standard:	Yes		
Amplitude with 2·10^6 tests is known:	Yes		
Amplitude with 2·10^6 tests:	$\Delta\sigma_{rsk,2E6}$	36.00	N/mm²
Amplitude with 1·10^8 tests is known:	Yes		
Amplitude of the pipe with 1·10^8 tests:	$\Delta\sigma_{rsk,1E8}$	24.00	N/mm²
Axial compressive strength, short term:	$f_{c,ax,K}$	90.0	N/mm²
Fiber strain for axial pressure, short term:	ε_{AxK}	1.0	%

Traffic load: Street HGV 30 (with road construction)



4.2 Results

4.2.1 Intermediate results pipe

Inner diameter:	d_i	308.0	mm
Outer diameter:	d_a	324.0	mm
Mean radius:	r_m	158.00	mm
Wall thickness:	s	8.00	mm
Ratio radius to wall thickness:	r_m/s	19.750	[-]
Curve correction factor, internal:	α_{ki}	1.017	[-]
Curve correction factor, external:	α_{ka}	0.983	[-]
Local predeformation:	$\delta_{v,l}$	0.00	%
Predeformation (ovalisation before load):	$\delta_{v,A}$	1.00	%
Radial cross section:	A_{rad}	8.00	mm²/mm
Distance of inertia:	e	4.00	mm
Moment of inertia:	I	42.67	mm^4/mm
Outer moment of resistance:	W_a	10.67	mm³/mm
Inner moment of resistance:	W_i	10.67	mm³/mm
Surface ratio:	κ_Q	1.2	[-]

4.2.1.1 Material properties

		short term	long term	
Specific gravity	γ_R	18.0	18.0	kN/m³
Poissons ratio	v	0.30	0.30	[-]
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	7,395.6	3,697.8	N/mm²
Creep ratio:		f_{creep}	2.00	[-]

Table 3 of ATV DVWK-A 127, footnote 34:
Determined from the momentary value and the creep ratio (2) with characteristic values for 2 years for the description of the long term behauvior. Also permitted for the long term verification for 50 years. Tests take place in accordance with DIN EN 1228 (momentary) and DIN EN 1225 (long term).

Characteristic value of relative fracture deformation	$\Delta d_{Bruch}/d_m$	15.0	9.0	%

$$\varepsilon_R = 4.28 \cdot s/d_m \cdot \Delta d_{Bruch}/d_m$$

Characteristic value of ultimate strain for edge fibers	ε_R	1.625	0.975	%

$$f_t = \frac{0.50 \cdot PN \cdot 4 \cdot 2 \cdot r_m}{h}$$

Characteristic value of hoop tensile strength	f_t	7.9	4.0	N/mm²
Amplitude for 2·10^6 load cycles:		$\Delta\sigma_{rsk,2E6}$	n. def	N/mm²
Amplitude at 5·10^6 load cycles:		$\Delta\sigma_{rsk,5E6}$	n. def	N/mm²
Amplitude for 1·10^8 cycles:		$\Delta\sigma_{rsk,1E8}$	n. def	N/mm²

4.2.1.2 Safety factors

Required safety coefficient, bending tensile stress	erf γ_{RBZ}	2.00	2.00	[-]
Required safety coefficient, bending compressive stress	erf γ_{RBD}	2.00	2.00	[-]
Required safety coefficient, instability (buckling)	erf γ_{stab}	2.50	2.50	[-]

4.2.2 Minimum trench width according to DIN EN 1610:2015-12

Nominal diameter:	DN	300	mm
Outer diameter:	d_a	324.0	mm
Size of the bedding layer:	a	0.13	m
Minimum width at trench sole level (incl. x) according to table 1:	$min_{b,T1}$	0.82	m
Minimum width according to table 2:	$min_{b,T2}$	1.00	m

Minimum clear width at trench sole level:	$min_{b,G}$	1.00	m
Required width at pipe crown level:	$min_{b,R}$	1.00	m
Trench width at pipe crown level:	b	1.30	m

The minimum trench width at trench sole level according DIN EN 1610 is met.

4.2.3 Intermediate results for load case

4.2.3.1 Silo Theory

Soil load coefficient κ for trench load (Silo Theory):	κ	1.000	[-]
Soil load coefficient κ0 for surface load (Silo Theory):	$κ_0$	1.000	[-]

κ0 and κ are set to 1, because E1 is larger then E3.

4.2.3.2 Load

Maximum groundwater level above pipe crown:	$h_{W,Scheitel}$	0.00	m
Vertical soil stress from soil load:	P_{Erd}	88.00	kN/m²
Vertical soil stress from soil and surface load:	P_E	88.00	kN/m²
Stress due to traffic load:	P_V	7.54	kN/m²
Included impact factor:	ϕ	1.40	[-]

4.2.3.3 Soil deformation moduli EB

Backfill elastic modulus under load:	$E_{1,σ}$	23.00	N/mm²

$$E_{3,\sigma} = \frac{40}{2} \cdot e^{-0.188(100 - D_{Pr})} \qquad 3.01$$

Native soil elastic modulus:	$E_{3,σ}$	13.73	N/mm²
Bedding elastic modulus (reduced):	$E_{2,σ}$	16.00	N/mm²
Bedding elastic modulus under load:	$E_{20,σ}$	16.00	N/mm²
Reduction factor for creep:	f_1	1.000	[-]
Reduction factor E20 (groundwater):	f_2	1.000	[-]
Reduction factor E20 (narrow trench):	$α_B$	1.000	[-]

For a ratio (trench width / outer diameter) >= 4, formula 6.03 always results in 1.0.

Bedding elastic modulus (reduced):	$E_{2,σ}$	16.00	N/mm²
Elastic modulus of soil under pipe:	$E_{4,σ}$	230.00	N/mm²

4.2.3.4 Soil stiffness values

Auxiliary value for horizontal bedding stiffness:	$Δ_f$	1.642	[-]
Correction factor for horizontal bedding stiffness:	ζ	0.998	[-]
Horizontal bedding stiffness:	S_{Bh}	9.576	N/mm²
Vertical bedding stiffness:	S_{Bv}	16.000	N/mm²

4.2.3.5 Bedding angle, effective relative projection and friction angle

Bedding angle, effective relative projection and friction angle:	2α	120	°
Height bedding from bedding angle to lower pipe ledge:	t_r	0.081	m
Calculated relative projection:	a	1.00	[-]
Effective relative projection:	a'	1.438	[-]
Internal friction angle:	φ'	30.000	°
Wall friction angle:	δ	30.000	°

4.2.3.6 Characteristic values of pipe material and ring stiffness

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Pipe stiffness	S_R	80,000	43,156	40,000	N/m²
Characteristic value of ultimate strain for edge fibers	$ε_R$	1.625	1.026	0.975	%
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	7,395.6	3,989.6	3,697.8	N/mm²

4.2.3.7 Stiffness ratio

System stiffness, weighted	$V_{RB,w}$	0.0084	0.0045	0.0042	[-]
Stiffness ratio	V_S	0.4032	0.3292	---	[-]
Coefficient for vertical deformation	c_v*	-0.012	-0.008	---	[-]

4.2.3.8 Coefficients

Ground pressure ratio (bedding)	K_2	0.400	0.400	---	[-]
Coefficient for bedding reaction pressure	K*	1.202	1.267	---	[-]
Resulting deformation coefficient	c'_h	0.0891	0.0891	---	[-]
Resulting deformation coefficient	$c'_{h,qh}$*	-0.0658	-0.0658	---	[-]
Coefficient for vertical deformation	c_v*	-0.012	-0.008	---	[-]

4.2.3.9 Concentration factors λR and λB

Maximum concentration factor	max λ	2.318	2.318	---	[-]
Coefficient for maximum concentration factor	K'	0.920	0.912	---	[-]
Concentration factor above pipe, initial value	λ_R	0.783	0.727	---	[-]
Concentration factor above pipe, under trench effect	λ_{RG}	0.783	0.727	---	[-]
Concentration factor above pipe, upper limit	λ_{fo}	3.340	3.340	---	[-]
Concentration factor above pipe, lower limit	λ_{fu}	0.127	0.127	---	[-]
Concentration factor above pipe, final value	λ_{RG}	0.783	0.727	---	[-]
Soil concentration factor	λ_B	1.072	1.091	---	[-]

4.2.3.10 Pressure distribution at pipe circumference

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Total vertical load	q_v	76.41	71.47	---	kN/m²
Lateral pressure	q_h	39.05	39.70	---	kN/m²
Bedding reaction pressure (soil load)	q^*_h	47.95	43.53	---	kN/m²
Bedding reaction pressure (water filling)	q^*_{hw}	1.51	1.60	---	kN/m²

4.2.4 Section forces

4.2.4.1 Section forces , short term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	158.00	158.00	158.00	mm
Moment due to total vertical load	M_{qv}	0.498	-0.505	0.525	kNm/m
Moment due to lateral pressure	M_{qh}	-0.244	0.244	-0.244	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-0.217	0.249	-0.217	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.007	0.008	-0.007	kNm/m
Moment due to dead weight	M_g	0.001	-0.002	0.002	kNm/m
Moment due to water filling	M_w	0.007	-0.009	0.010	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.040	-0.015	0.070	kNm/m

		crown	springline	invert	
Mean radius	r_m	158.00	158.00	158.00	mm
Normal force due to total vertical load	N_{qv}	0.326	-12.073	-0.326	kN/m
Normal force due to lateral pressure	N_{qh}	-6.169	0.000	-6.169	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-4.371	0.000	-4.371	kN/m

Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.138	0.000	-0.138	kN/m
Normal force due to dead weight	N_g	0.006	-0.036	-0.006	kN/m
Normal force due to water filling	N_w	0.156	0.054	0.343	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-10.191	-12.055	-10.667	kN/m

4.2.4.2 Section forces , long term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	158.00	158.00	158.00	mm
Moment due to total vertical load	M_{qv}	0.466	-0.473	0.491	kNm/m
Moment due to lateral pressure	M_{qh}	-0.248	0.248	-0.248	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-0.197	0.226	-0.197	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.007	0.008	-0.007	kNm/m
Moment due to dead weight	M_g	0.001	-0.002	0.002	kNm/m
Moment due to water filling	M_w	0.007	-0.009	0.010	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.023	-0.001	0.051	kNm/m

		crown	springline	invert	
Mean radius	r_m	158.00	158.00	158.00	mm
Normal force due to total vertical load	N_{qv}	0.305	-11.293	-0.305	kN/m
Normal force due to lateral pressure	N_{qh}	-6.273	0.000	-6.273	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-3.969	0.000	-3.969	kN/m
Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.146	0.000	-0.146	kN/m
Normal force due to dead weight	N_g	0.006	-0.036	-0.006	kN/m
Normal force due to water filling	N_w	0.156	0.054	0.343	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-9.922	-11.275	-10.356	kN/m

4.2.5 Short term load case

4.2.5.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh^*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh^*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:			α_{ki}	1.017	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.031	-0.037	0.064	%
Strain due to other loads	ε_{sonst}	0.003	-0.003	0.007	%

Total strain	ε	0.034	-0.040	0.072	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.63	1.63	1.63	%
Safety coefficient flexural tension:	γ_{BZ}	48.168	---	22.711	[-]
Safety coefficient flexural compression:	γ_{BD}	---	40.631	---	[-]

outside

Curve correction factor, external:			α_{ka}	0.983	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	$\varepsilon_{qv,qh,qh*}$	-0.064	-0.004	-0.098	%
Strain due to other loads	ε_{sonst}	-0.002	0.003	-0.006	%
Total strain	ε	-0.067	-0.001	-0.105	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.63	1.63	1.63	%
Safety coefficient flexural tension:	γ_{BZ}	---	---	---	[-]
Safety coefficient flexural compression:	γ_{BD}	24.441	1,161.389	15.531	[-]

All calculated safety coefficients of the strain proof are sufficient.

4.2.5.2 Deformation proof

Calculation mode:			linear		
Ratio:			I/(A·rm²)	0.00021	[-]
Ratio 'I/(A·rm²)·κ~Q':			$I/(A \cdot rm^2) \cdot \kappa_Q$	0.00026	[-]
		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	1.98	mm
Horizontal diameter change:	Δd_h	1.58	mm

Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	0.63	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	1.63	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

4.2.6 Long term load case

4.2.6.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:	α_{ki}	1.017	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.019	-0.033	0.077	%
Strain due to other loads	ε_{sonst}	0.004	-0.005	0.013	%
Total strain	ε	0.024	-0.038	0.090	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.02	1.02	1.02	%
Safety coefficient flexural tension:	γ_{BZ}	42.970	---	11.269	[-]
Safety coefficient flexural compression:	γ_{BD}	---	26.962	---	[-]

outside

Curve correction factor, external:	α_{ka}		0.983	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	-0.080	-0.038	-0.140	%
Strain due to other loads	ε_{sonst}	-0.004	0.005	-0.012	%
Total strain	ε	-0.084	-0.033	-0.151	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.02	1.02	1.02	%
Safety coefficient flexural tension:	γ_{BZ}	---	---	---	[-]
Safety coefficient flexural compression:	γ_{BD}	12.188	31.046	6.765	[-]

All calculated safety coefficients of the strain proof are sufficient.

4.2.6.2 Deformation proof

Calculation mode:			linear	
Ratio:			I/(A·rm²)	0.00021 [-]
Ratio 'I/(A·rm²)·κ~Q':			$I/(A \cdot rm^2) \cdot \kappa_Q$	0.00026 [-]

		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	2.12	mm
Horizontal diameter change:	Δd_h	1.44	mm
Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	0.67	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	1.67	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

4.2.6.3 Stabilty proof radial, linear

Earth and traffic loads

Pipe stiffness:	$\bar{S}_R$	43,156	N/m²
Horizontal bedding stiffness:	S_{Bh}	9.576	N/mm²
System stiffness, weighted:	$V_{RB,w}$	0.0045	[-]
Reduction factor buckling load for earth/traffic loads:	κ_{v2}	0.87	[-]
Friction angle in bedding zone:	φ'_2	35.000	°
Critical vertical total load:	krit q_v	1,122.8	kN/m²
Total vertical load:	q_v	71.47	kN/m²
Safety stability, radial:	$\gamma_{Stab,rad}$	15.71	[-]
Required safety coefficient, instability (buckling):	erf γ_{stab}	2.50	[-]

The buckling proof is fulfilled.

4.2.6.4 stability proof, nonlinear

The nonlinear stability proof is not applicable because of VRB > 1.0 (rigid pipe) or relative vertical deformation < 6%.

4.2.6.5 Proof of safety against failure with not predominantly static loading

According to the standard the dynamic proof is not required (e.g. traffic load > 1,5 m).

All necessary proofs are ok.

5 Appendix

Amiblu®
Sustainable Water Solutions

FLOWTITE® | HOBAS®

Input Data for structural analysis

of application buried pipes in open trench condition, calculation acc. DWA-A 127

Please send to:
Amiblu Holding GmbH
Pischeldorfer Straße 128
A-9020 Klagenfurt
T +43 463 482424
info@amiblu.com

9013 PCL 1F	
project	
LUZ d.d	Luka Krajnc
company	contact person
Verovškova ulica 64	(01) 36 02 473
street	phone/Fax:
1000	Text input.
postcode	signature:
Ljubljana	Text input.
city	date/stamp

Pipe Details:

nominal diameter DN	300	sewer pipe	☒
		sewer pressure pipe	☐
pressure class PN	PN1	pressure pipe	☐
		potable water pipe	☐
nominal stiffness SN	10000	installation in protective water area	☐
		air pipe	☐
pipe material	GRP	storage sewer	☐
		others	Text input.

Types of native soil: acc. ATV-DVWK-A 127; DIN 18196 (please subsoil expertise ad)

		Native soil	backfilling	Pipe zone
G1	Non cohesive soils (gravel, sand) (GE, GW, GI, SE, SW, SI)	☐	☒	☒
G2	Slightly cohesive soils (GU, GT, SU, ST)	☒	☐	☐
G3	Cohesive mixed soils, silt (GÜ, GŤ, SÜ, SŤ, UL, UM)	☐	☐	☐
G4	Cohesive soils, except silts (TL, TM, TA, OU, OT, OH, UA)	☐	☐	☐
Other types of soil	Text input.	☐	☐	☐

Proctor density for native soil (Proctor density 85 – 100 %): 98 %

Foundation of pipeline

- ☒ On native soil
- ☐ very hard and rocky
- ☐ Weak soil, not stable for foundation

Soil replacement: thickness Text input. m

material Text input.

Proctor density D_{Pr} Text input. %

Specification of loads:

	Min. cover depth		Max. cover depth	
Depth of earth cover h	2,26	m	4,4	m
min. Ground water h_w above pipe invert	Text input.	m	Text input.	m
max. Ground water h_w above pipe invert	Text input.	m	Text input.	m

Other surface loads Text input. kN/m²

For pressure pipes

Short term: Text input. bar, e.g. system test pressure; hydrostatic pressure, water hammer

Long term: Text input. bar, e.g. operating pressure (OP), system pressure (PN, DP)

Traffic load

☐ no traffic

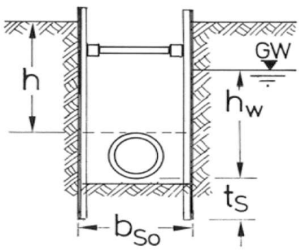
street
- ☐ HCL 60
- ☒ HCL 30
- ☐ HGV 12
- ☐ DIN EN 1991-2, TS und UDL
  - ☐ LM1-lane 3,00 m
  - ☐ LM1-lane 2,70 m
  - ☐ LM1-green field area

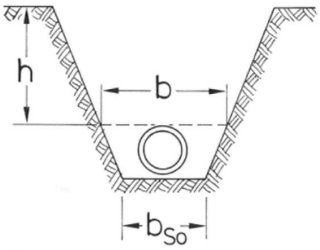
railway
- ☐ one track, UIC
- ☐ two tracks, UIC
- ☐ one track, LM 71
- ☐ two tracks, LM 71

aircraft
- ☐ BFZ 90
- ☐ BFZ 180
- ☐ BFZ 350
- ☐ BFZ 550
- ☐ BFZ 750

Other loads, e.g. special vehicle (please add load scheme with axle, wheels and wheel loads):
Text input.

Building construction:





Type of trench ☒ embankment ☐ single trench ☐ double trench [1] ☐ stepped trench [1]

[1] For special shapes add a sketch

Trench angel ☒ 90° ☐ 60° ☐ 45° ☐ Text input.

Width of trench b = 1.3 m at pipe crown

b_{So} = 1,3 m at pipe trench bottom inclusive planks

Trench planking

☐ no planks

☐ Horizontal planks, also applies to plank walls (Berlin lining)
☒ Planking with plates
☐ Vertical plank with light weight
☐ Vertical plank with boards *
☐ Vertical plank with light weight *
☐ Vertical plank with sheet piling *

bedding

☐ on native soil (acc. EN 1610)
☒ on gravel, sand
☐ on concrete [2]

[2] only as spezial construction in agreement with the pipe producer

bedding angle 2α

☐ 90° ☐ 120°
☐ 180°

* Depth of sheeting below pipe invert t_S = Text input. m

*thickness of plank (one-side) b_S = Text input. m

Cover condition for backfilling:

A1 ☐ Backfilling compacted in layers against the native soil (without proof of compaction degree); also applies to plank walls, Berlin lining

A2 ☐ Vertical pipe trench lining with boards that are not removed before backfilling. Lining boards or devices that are removed step by step during backfilling. Non-compacted backfilling/ backfilling with slurry (only suitable for soils of group G1).

A3 ☐ Vertical trench lining with sheet piling, light weight sheet connection, wooden planks, lining boards or devices that are not removed before backfilling.

A4 ☒ Backfilling compacted in layers against the native soil with proof of the required compaction degree to ZTVE-StB ; also applies to plank walls (Berlin lining). Cover condition A4 is not applicable to sails of group G4.

Bedding condition for pipe:

B1 ☒ Bedding compacted in layers against the native soil or in the embankment (without proof of compaction degree); also applies to plank walls, Berlin lining

B2 ☐ Vertical lining in the pipe zone with planks that reach down to the trench bottom and are not removed before backfilling and compaction. Lining boards or devices provided that the soil is compacted after the linings are removed.

B3 ☐ Vertical lining in the pipe zone with sheet piling or lightweight sheeting and compaction against the lining reaching down below the trench bottom. There is no safe calculation model for determining vertical lining with wooden planks, boards or devices that are not removed before backfilling and compaction the pipe zone.

B4 ☐ Bedding compacted in layers against the native soil or in the embankment with proof of the required compaction degree to ZTVE-StB. Bedding condition B4 does not apply to soils of group G4.

Structural analysis

Project:	9013 PCL 1F
Description:	GRP CC pipe DN400 PN1 SN 10.000
Contractor:	LUZ d.d Verovškova ulica 64 1000 Ljubljana Mr. Luka Kranjc (01) 36 02 473
Designer:	Josip Vrtarić Application Engineering Amiblu Alpe Adria d.o.o. Kralja Zvonimira 122, Zagreb, Croatia T +385 1 618 36 91 M +385 91 604 93 97 josip.vrtaric@amiblu.com www.amiblu.com
Calculation no.:	2025/90
Date:	19/08/2025

Content

1 Remarks 4

2 List of references 6

3 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 1,9 m 7

3.1 Input 7

3.1.1 Safety factors 7

3.1.2 Soil 7

3.1.3 Load 7

3.1.4 Installation 7

3.1.5 Pipe with nominal stiffness 8

3.2 Results 10

3.2.1 Intermediate results pipe 10

3.2.1.1 Material properties 10
3.2.1.2 Safety factors 10

3.2.2 Minimum trench width according to DIN EN 1610:2015-12 10

3.2.3 Intermediate results for load case 11

3.2.3.1 Silo Theory 11
3.2.3.2 Load 11
3.2.3.3 Soil deformation moduli EB 11
3.2.3.4 Soil stiffness values 11
3.2.3.5 Bedding angle, effective relative projection and friction angle 11
3.2.3.6 Characteristic values of pipe material and ring stiffness 11
3.2.3.7 Stiffness ratio 12
3.2.3.8 Coefficients 12
3.2.3.9 Concentration factors λR and λB 12
3.2.3.10 Pressure distribution at pipe circumference 12

3.2.4 Section forces 12

3.2.4.1 Section forces , short term 12
3.2.4.2 Section forces , long term 13

3.2.5 Short term load case 13

3.2.5.1 Strain proof 13
3.2.5.2 Deformation proof 14

3.2.6 Long term load case 14

3.2.6.1 Strain proof 14
3.2.6.2 Deformation proof 15
3.2.6.3 Stabilty proof radial, linear 15
3.2.6.4 stability proof, nonlinear 16
3.2.6.5 Proof of safety against failure with not predominantly static loading 16

4 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 5,9 m 17

4.1 Input 17

4.1.1 Safety factors 17

4.1.2 Soil 17

4.1.3 Load 17
4.1.4 Installation 17
4.1.5 Pipe with nominal stiffness 18
4.2 Results 20
4.2.1 Intermediate results pipe 20
4.2.1.1 Material properties 20
4.2.1.2 Safety factors 20
4.2.2 Minimum trench width according to DIN EN 1610:2015-12 20
4.2.3 Intermediate results for load case 21
4.2.3.1 Silo Theory 21
4.2.3.2 Load 21
4.2.3.3 Soil deformation moduli EB 21
4.2.3.4 Soil stiffness values 21
4.2.3.5 Bedding angle, effective relative projection and friction angle 21
4.2.3.6 Characteristic values of pipe material and ring stiffness 21
4.2.3.7 Stiffness ratio 22
4.2.3.8 Coefficients 22
4.2.3.9 Concentration factors λR and λB 22
4.2.3.10 Pressure distribution at pipe circumference 22
4.2.4 Section forces 22
4.2.4.1 Section forces , short term 22
4.2.4.2 Section forces , long term 23
4.2.5 Short term load case 23
4.2.5.1 Strain proof 23
4.2.5.2 Deformation proof 24
4.2.6 Long term load case 24
4.2.6.1 Strain proof 24
4.2.6.2 Deformation proof 25
4.2.6.3 Stabilty proof radial, linear 25
4.2.6.4 stability proof, nonlinear 26
4.2.6.5 Proof of safety against failure with not predominantly static loading 26
5 Appendix 27
5.1 - 28

1 Remarks

DISCLAIMER OF LIABILITY

As part of the technical service for the technical planning of projects of the Amiblu Group (hereinafter referred to as "Amiblu"), static calculations for decision-making regarding Amiblu/Flowtite/Hobas GFK pipe systems and products are regularly provided by Amiblu.

By using this free Amiblu' s technical verification service, you agree to the following terms and conditions:

1. No contractual relationship:
The use of the above mentioned Amiblu` s calculations does not constitute a contractual relationship between you and Amiblu and no consulting or information agreement is concluded. To this extent, there do not exist any contractual or quasi-contractual claims against Amiblu.

2. Requirements:
You acknowledge that the here mentioned calculations only apply to Amiblu/Flowtite/Hobas products.

3. Basis of the static calculation:
Amiblu bases the calculation according to your stated project and installation conditions and completes the missing data by itself if necessary, this to the best of its knowledge and based on the current state of knowledge and according to the requirements of the valid standards and regulations.
The trench width and installation conditions are based on the minimum requirements according to EN1610 without consideration of the trench sheet thickness (if in use). This usually represents the critical load case and is therefore on the safe side.

4. Installation specifications:
In all cases the following installation conditions must be observed for the installation of Amiblu products:

The pipe zone must be made of non-cohesive or slightly cohesive material with the quality and degree of compaction according to this calculation. The maximum grain size according to the Amiblu/Flowtite/Hobas installation instructions for buried pipes and shafts have to be observed.
To classify the bedding material, all the material in the pipeline zone has to pass through a sieve with a mesh size as specified in the installation instructions.

The pipe bedding must be at least 100 mm thick and have the specified support angle according to the static calculation. We recommend that the requirements for the pipe bedding according to EN 1610.

The degree of compaction of the pipe zone and backfill must meet or exceed the requirements of the static calculation. The installation conditions should be checked and documented. The pipe zone ends 300 mm above the pipe crown.

The quality and degree of compaction of the backfill, the existing soil and the pipeline zone must be checked and needs to meet the requirements of this static evaluation.

For the static calculation compliance with the applicable international standards and installation instructions for Amiblu/Flowtite/Hobas products is assumed. The installation instructions for Amiblu/Flowtite/Hobas can be downloaded from our homepages: http://www.flowtite.com or http://www.hobas.com or http://www.amiblu.com.

The installation conditions used for the static calculation should be compared by you or an expert engineer or the project planner with the actual conditions on site. Potential deviations may have an influence on the pipe installation.

5. Disclaimer:
The services provided are subject to Amiblu's General Conditions of Sale, insofar applicable.

The results of the calculation can only be obtained in practice if the assumptions correspond to the real construction conditions on site.

The static calculations were carried out reliably and carefully according to the professional opinion of Amiblu.

Amiblu accept liability for the static calculation carried out on the basis of customer specifications, such as e.g. contents from structural analysis forms, specifications for planning and execution, information on ground condition as well as installation and/or operation. Amiblu does not accept any liability for the correctness and completeness of the specific customer specifications.

The static calculations prepared by Amiblu are a service in the design or execution phase and usually become part of the project documentation. Amiblu assumes no liability for the applicability of the calculation results in case of deviations from the underlying assumptions.

Rev03 11/04/2023

2 List of references

DIN 4124 - Excavations and Trenches - Slopes, planking and strutting, breadths of working space: October 2002

EN 1610 - Construction and testing of drains and sewers: December 2015

EN 805 - Water Supply Requirements for systems and components outside of buildings: March 2000

EN 1992-2 - Eurocode 2: Eurocode 1: Actions on structures Part 2: Traffic loads on bridges (consolidated version): March. 2012

EN 1796 - Plastics piping systems for water supply with or without pressure - Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP): March 2013

EN 14364 - Plastics piping systems for drainage and sewerage with or without pressure – Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP): Mai 2013

EN 15383 - Plastics piping systems for drainage and sewerage - Glass- reinforced thermosetting plastics (GRP) based on polyester resin (UP) - Manholes and inspection chambers: March 2013

ISO 16611 Plastics piping systems for drainage and sewerage without pressure - Non-circular pipes and joints made of glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resins (UP) - Dimensions, requirements and tests: June 2017

ISO 25780 - Plastics piping systems for pressure and non-pressure water supply, irrigation, drainage or sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin — Pipes with flexible joints intended to be installed using jacking techniques: Mai 2011

Worksheet DWA-A127 - Structural verification of sewer channels and pipe lines, 3. corrected Issue: August 2000

3 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 1,9 m

Caption of this part of the calculation:	Cover 1,9 m
Kind of calculation:	Nominal stiffness
Add sketch to print:	Yes

3.1 Input

3.1.1 Safety factors

Safety class:	A (normal case)
Safety stability according to table 13:	Without predeformation (2.5 / 2.0)
Allowable deflection:	6% (standard)
Treatment of internal pressure:	In accordance with Footnote 39 in ATV-DVWK-A 127
Lower safety factors for flexural compression:	No (ATV-DVWK-A 127)
Proof for not predominantly static loading:	According to standard
Consideration of dyn pvh*:	According to standard
Consideration of Type A 'predeformation' in the deformation proof:	Yes
Treatment system stiffness VRB according to:	DWA-A 161:2014 (by material)
Pipe stiffness according to set of rules:	Yes

3.1.2 Soil

Soil group backfill:	G1		
Calculation E1:	Table 8 (A127)		
Soil group pipe zone:	G1		
Calculation E20:	Table 8 (A127)		
Soil group native soil:	G2		
Calculation E3:	Degree of compaction		
Compaction degree E3:	$D_{Pr,E3}$	98.0	%
E4 = 10 · E1:	Yes		
Application of silo theory:	Automatic		
K2 according to standard:	Yes		

3.1.3 Load

Cover depth:	h	1.90	m
Minimum groundwater level above pipe bed:	$h_{W,min}$	0.00	m
Maximum groundwater level above pipe bed:	$h_{W,max}$	0.00	m
Soil density:	γ_B	20.0	kN/m³
Additional surface load:	p_0	0.0	kN/m²
Inner pressure, short term:	$P_{I,K}$	0.00	bar
Inner pressure, long term:	$P_{I,L}$	0.00	bar
Water fill (e.g. damming channel):	Yes		
Density of medium:	γ_F	10.0	kN/m³
Input special-purpose vehicle:	No		
Traffic load:	Street HGV 30 (with road construction)		
Including horizontal loads due to traffic in the fatigue proof:	$\alpha_{qhT,dyn}$	0.00	%

3.1.4 Installation

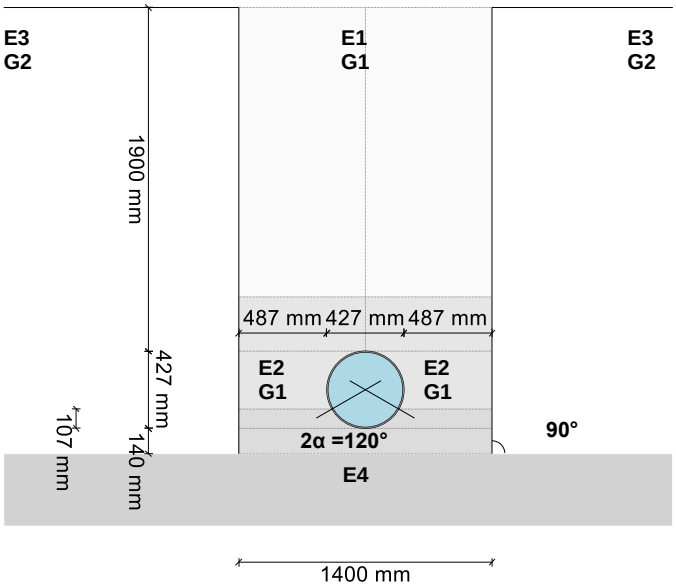
Installation:	Trench		
Trench width at pipe crown level:	b	1.40	m
Check minimum trench width:	Yes		
Automatic consideration of bedding layer:	Yes		

Slope angle:	ß	90	°
Cover condition:	A4		
Installation condition:	B1		
Type of bedding:	Loose		
Bedding angle:	120°		
Calculate bedding automatically:	Yes		
Set lower height base:	No		
Total height of base:	h_s	0.00	m

3.1.5 Pipe with nominal stiffness

Pipe chosen from datebase:	No		
Choice of input:	Do - s		
Outer diameter:	d_a	427	mm
Nominal diameter:	DN	400	mm
Wall thickness:	t	9.0	mm
Local predeformation:	$\delta_{v,I}$	0.0	%
A type predeformation:	$\delta_{v,A}$	1.0	%
Nominal stiffness:	SN	10,000	N/m²
Nominal pressure:	PN	1.0	bar
Relative failure strain according to standard:	Yes		
Creep ratio:	f_{Kriech}	2.00	[-]
Reduction factor due to temperature effect:	$A_{1,Temp}$	1.00	[-]
Reduction factor due to media attack:	$A_{2,Medium}$	1.00	[-]
Reduction factor due to dynamic loading:	$A_{3,dyn}$	1.00	[-]
Specific gravity:	γ_R	18.00	kN/m³
Poissons ratio:	v	0.30	[-]
Input of ultimate hoop tensile stress:	No		
Ultimate strain tensile strength according to standard:	Yes		
Amplitude with 2·10^6 tests is known:	Yes		
Amplitude with 2·10^6 tests:	$\Delta\sigma_{rsk,2E6}$	36.00	N/mm²
Amplitude with 1·10^8 tests is known:	Yes		
Amplitude of the pipe with 1·10^8 tests:	$\Delta\sigma_{rsk,1E8}$	24.00	N/mm²
Axial compressive strength, short term:	$f_{c,ax,K}$	90.0	N/mm²
Fiber strain for axial pressure, short term:	ε_{AxK}	1.0	%

Traffic load: Street HGV 30 (with road construction)



3.2 Results

3.2.1 Intermediate results pipe

Inner diameter:	d_i	409.0	mm
Outer diameter:	d_a	427.0	mm
Mean radius:	r_m	209.00	mm
Wall thickness:	s	9.00	mm
Ratio radius to wall thickness:	r_m/s	23.222	[-]
Curve correction factor, internal:	α_{ki}	1.014	[-]
Curve correction factor, external:	α_{ka}	0.986	[-]
Local predeformation:	$\delta_{v,l}$	0.00	%
Predeformation (ovalisation before load):	$\delta_{v,A}$	1.00	%
Radial cross section:	A_{rad}	9.00	mm²/mm
Distance of inertia:	e	4.50	mm
Moment of inertia:	I	60.75	mm^4/mm
Outer moment of resistance:	W_a	13.50	mm³/mm
Inner moment of resistance:	W_i	13.50	mm³/mm
Surface ratio:	κ_Q	1.2	[-]

3.2.1.1 Material properties

		short term	long term	
Specific gravity	γ_R	18.0	18.0	kN/m³
Poissons ratio	v	0.30	0.30	[-]
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	12,022.2	6,011.1	N/mm²
Creep ratio:	f_{creep}		2.00	[-]

Table 3 of ATV DVWK-A 127, footnote 34:
Determined from the momentary value and the creep ratio (2) with characteristic values for 2 years for the description of the long term behauvior. Also permitted for the long term verification for 50 years. Tests take place in accordance with DIN EN 1228 (momentary) and DIN EN 1225 (long term).

Characteristic value of relative fracture deformation	$\Delta d_{Bruch}/d_m$	15.0	9.0	%

$$\varepsilon_R = 4.28 \cdot s/d_m \cdot \Delta d_{Bruch}/d_m$$

Characteristic value of ultimate strain for edge fibers	ε_R	1.382	0.829	%

$$f_t = \frac{0.50 \cdot PN \cdot 4 \cdot 2 \cdot r_m}{h}$$

Characteristic value of hoop tensile strength	f_t	9.3	4.6	N/mm²
Amplitude for 2·10^6 load cycles:	$\Delta\sigma_{rsk,2E6}$		n. def	N/mm²
Amplitude at 5·10^6 load cycles:	$\Delta\sigma_{rsk,5E6}$		n. def	N/mm²
Amplitude for 1·10^8 cycles:	$\Delta\sigma_{rsk,1E8}$		n. def	N/mm²

3.2.1.2 Safety factors

Required safety coefficient, bending tensile stress	erf γ_{RBZ}	2.00	2.00	[-]
Required safety coefficient, bending compressive stress	erf γ_{RBD}	2.00	2.00	[-]
Required safety coefficient, instability (buckling)	erf γ_{stab}	2.50	2.50	[-]

3.2.2 Minimum trench width according to DIN EN 1610:2015-12

Nominal diameter:	DN	400	mm
Outer diameter:	d_a	427.0	mm
Size of the bedding layer:	a	0.14	m
Minimum width at trench sole level (incl. x) according to table 1:	$min_{b,T1}$	1.13	m
Minimum width according to table 2:	$min_{b,T2}$	0.90	m

Minimum clear width at trench sole level:	$min_{b,G}$	1.13	m
Required width at pipe crown level:	$min_{b,R}$	1.12	m
Trench width at pipe crown level:	b	1.40	m

The minimum trench width at trench sole level according DIN EN 1610 is met.

3.2.3 Intermediate results for load case

3.2.3.1 Silo Theory

Soil load coefficient κ for trench load (Silo Theory):	κ	1.000	[-]
Soil load coefficient κ0 for surface load (Silo Theory):	$κ_0$	1.000	[-]

κ0 and κ are set to 1, because E1 is larger then E3.

3.2.3.2 Load

Maximum groundwater level above pipe crown:	$h_{W,Scheitel}$	0.00	m
Vertical soil stress from soil load:	P_{Erd}	38.00	kN/m²
Vertical soil stress from soil and surface load:	P_E	38.00	kN/m²
Stress due to traffic load:	P_V	18.08	kN/m²
Included impact factor:	ϕ	1.40	[-]

3.2.3.3 Soil deformation moduli EB

Backfill elastic modulus under load:	$E_{1,σ}$	23.00	N/mm²

$$E_{3,\sigma} = \frac{40}{2} \cdot e^{-0.188(100 - D_{Pr})} \qquad 3.01$$

Native soil elastic modulus:	$E_{3,σ}$	13.73	N/mm²
Bedding elastic modulus (reduced):	$E_{2,σ}$	14.72	N/mm²
Bedding elastic modulus under load:	$E_{20,σ}$	16.00	N/mm²
Reduction factor for creep:	f_1	1.000	[-]
Reduction factor E20 (groundwater):	f_2	1.000	[-]
Reduction factor E20 (Diagram 5):	$α_{B0}$	0.667	[-]
Reduction factor E20 (narrow trench):	$α_B$	0.920	[-]
Bedding elastic modulus (reduced):	$E_{2,σ}$	14.72	N/mm²
Elastic modulus of soil under pipe:	$E_{4,σ}$	230.00	N/mm²

3.2.3.4 Soil stiffness values

Auxiliary value for horizontal bedding stiffness:	$Δ_f$	1.401	[-]
Correction factor for horizontal bedding stiffness:	ζ	0.989	[-]
Horizontal bedding stiffness:	S_{Bh}	8.730	N/mm²
Vertical bedding stiffness:	S_{Bv}	14.718	N/mm²

3.2.3.5 Bedding angle, effective relative projection and friction angle

Bedding angle, effective relative projection and friction angle:	2α	120	°
Height bedding from bedding angle to lower pipe ledge:	t_r	0.107	m
Calculated relative projection:	a	1.00	[-]
Effective relative projection:	a'	1.563	[-]
Internal friction angle:	φ'	30.000	°
Wall friction angle:	δ	30.000	°

3.2.3.6 Characteristic values of pipe material and ring stiffness

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Pipe stiffness	S_R	80,000	52,898	40,000	N/m²
Characteristic value of ultimate strain for edge fibers	$ε_R$	1.382	1.008	0.829	%
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	12,022.2	7,949.3	6,011.1	N/mm²

3.2.3.7 Stiffness ratio

System stiffness, weighted	$V_{RB,w}$	0.0092	0.0061	0.0046	[-]
Stiffness ratio	V_S	0.4108	0.3614	---	[-]
Coefficient for vertical deformation	c_v*	-0.013	-0.010	---	[-]

3.2.3.8 Coefficients

Ground pressure ratio (bedding)	K_2	0.400	0.400	---	[-]
Coefficient for bedding reaction pressure	K*	1.189	1.240	---	[-]
Resulting deformation coefficient	c'_h	0.0891	0.0891	---	[-]
Resulting deformation coefficient	$c'_{h,qh}$*	-0.0658	-0.0658	---	[-]
Coefficient for vertical deformation	c_v*	-0.013	-0.010	---	[-]

3.2.3.9 Concentration factors λR and λB

Maximum concentration factor	max λ	1.944	1.944	---	[-]
Coefficient for maximum concentration factor	K'	0.921	0.916	---	[-]
Concentration factor above pipe, initial value	λ_R	0.807	0.771	---	[-]
Concentration factor above pipe, under trench effect	λ_{RG}	0.854	0.826	---	[-]
Concentration factor above pipe, upper limit	λ_{fo}	3.715	3.715	---	[-]
Concentration factor above pipe, lower limit	λ_{fu}	0.359	0.359	---	[-]
Concentration factor above pipe, final value	λ_{RG}	0.854	0.826	---	[-]
Soil concentration factor	λ_B	1.064	1.076	---	[-]

3.2.3.10 Pressure distribution at pipe circumference

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Total vertical load	q_v	50.53	49.49	---	kN/m²
Lateral pressure	q_h	17.88	18.07	---	kN/m²
Bedding reaction pressure (soil load)	q^*_h	40.18	40.42	---	kN/m²
Bedding reaction pressure (water filling)	q^*_{hw}	2.00	2.13	---	kN/m²

3.2.4 Section forces

3.2.4.1 Section forces , short term

Rerounding factor (reduction moments): r 1.000 [-]

		crown	springline	invert	
Mean radius	r_m	209.00	209.00	209.00	mm
Moment due to total vertical load	M_{qv}	0.576	-0.585	0.607	kNm/m
Moment due to lateral pressure	M_{qh}	-0.195	0.195	-0.195	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-0.318	0.365	-0.318	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.016	0.018	-0.016	kNm/m
Moment due to dead weight	M_g	0.003	-0.003	0.004	kNm/m
Moment due to water filling	M_w	0.017	-0.020	0.024	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.067	-0.030	0.106	kNm/m

		crown	springline	invert	
Mean radius	r_m	209.00	209.00	209.00	mm
Normal force due to total vertical load	N_{qv}	0.285	-10.560	-0.285	kN/m
Normal force due to lateral pressure	N_{qh}	-3.738	0.000	-3.738	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-4.846	0.000	-4.846	kN/m

Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.241	0.000	-0.241	kN/m
Normal force due to dead weight	N_g	0.008	-0.053	-0.008	kN/m
Normal force due to water filling	N_w	0.273	0.094	0.601	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-8.258	-10.519	-8.517	kN/m

3.2.4.2 Section forces , long term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	209.00	209.00	209.00	mm
Moment due to total vertical load	M_{qv}	0.564	-0.573	0.594	kNm/m
Moment due to lateral pressure	M_{qh}	-0.197	0.197	-0.197	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-0.320	0.367	-0.320	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.017	0.019	-0.017	kNm/m
Moment due to dead weight	M_g	0.003	-0.003	0.004	kNm/m
Moment due to water filling	M_w	0.017	-0.020	0.024	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.051	-0.012	0.088	kNm/m

		crown	springline	invert	
Mean radius	r_m	209.00	209.00	209.00	mm
Normal force due to total vertical load	N_{qv}	0.279	-10.343	-0.279	kN/m
Normal force due to lateral pressure	N_{qh}	-3.776	0.000	-3.776	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-4.874	0.000	-4.874	kN/m
Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.256	0.000	-0.256	kN/m
Normal force due to dead weight	N_g	0.008	-0.053	-0.008	kN/m
Normal force due to water filling	N_w	0.273	0.094	0.601	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-8.346	-10.302	-8.594	kN/m

3.2.5 Short term load case

3.2.5.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh^*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh^*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:			α_{ki}	1.014	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.032	-0.025	0.051	%
Strain due to other loads	ε_{sonst}	0.003	-0.003	0.008	%

Total strain	ε	0.034	-0.028	0.058	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.38	1.38	1.38	%
Safety coefficient flexural tension:	γ_{BZ}	40.136	---	23.783	[-]
Safety coefficient flexural compression:	γ_{BD}	---	49.027	---	[-]

outside

Curve correction factor, external:			α_{ka}	0.986	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	-0.046	0.005	-0.065	%
Strain due to other loads	ε_{sonst}	-0.003	0.003	-0.007	%
Total strain	ε	-0.049	0.008	-0.072	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.38	1.38	1.38	%
Safety coefficient flexural tension:	γ_{BZ}	---	168.013	---	[-]
Safety coefficient flexural compression:	γ_{BD}	28.493	---	19.199	[-]

All calculated safety coefficients of the strain proof are sufficient.

3.2.5.2 Deformation proof

Calculation mode:			linear		
Ratio:			I/(A·rm²)	0.00015	[-]
Ratio 'I/(A·rm²)·κ~Q':			$I/(A \cdot rm^2) \cdot \kappa_Q$	0.00019	[-]
		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	2.35	mm
Horizontal diameter change:	Δd_h	1.92	mm

Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	0.56	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	1.56	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

3.2.6 Long term load case

3.2.6.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh^*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh^*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:	α_{ki}	1.014	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.033	-0.022	0.061	%
Strain due to other loads	ε_{sonst}	0.004	-0.005	0.014	%
Total strain	ε	0.037	-0.027	0.075	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	0.99	0.98	0.98	%
Safety coefficient flexural tension:	γ_{BZ}	26.717	---	13.128	[-]
Safety coefficient flexural compression:	γ_{BD}	---	36.256	---	[-]

outside

Curve correction factor, external:			α_{ka}	0.986	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	-0.055	-0.007	-0.084	%
Strain due to other loads	ε_{sonst}	-0.004	0.005	-0.012	%
Total strain	ε	-0.059	-0.002	-0.096	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.00	0.95	0.99	%
Safety coefficient flexural tension:	γ_{BZ}	---	---	---	[-]
Safety coefficient flexural compression:	γ_{BD}	16.906	469.177	10.308	[-]

All calculated safety coefficients of the strain proof are sufficient.

3.2.6.2 Deformation proof

Calculation mode:			linear		
Ratio:			I/(A·rm²)	0.00015	[-]
Ratio 'I/(A·rm²)·κ~Q':			I/(A·rm²)·κ_Q	0.00019	[-]

		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	2.59	mm
Horizontal diameter change:	Δd_h	1.94	mm
Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	0.62	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	1.62	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

3.2.6.3 Stabilty proof radial, linear

Earth and traffic loads

Pipe stiffness:	$\bar{S}_R$	52,898	N/m²
Horizontal bedding stiffness:	S_{Bh}	8.730	N/mm²
System stiffness, weighted:	$V_{RB,w}$	0.0061	[-]
Reduction factor buckling load for earth/traffic loads:	κ_{v2}	0.87	[-]
Friction angle in bedding zone:	φ'_2	35.000	°
Critical vertical total load:	krit q_v	1,185.3	kN/m²
Total vertical load:	q_v	49.49	kN/m²
Safety stability, radial:	$\gamma_{Stab,rad}$	23.95	[-]
Required safety coefficient, instability (buckling):	erf γ_{stab}	2.50	[-]

The buckling proof is fulfilled.

3.2.6.4 stability proof, nonlinear

The nonlinear stability proof is not applicable because of VRB > 1.0 (rigid pipe) or relative vertical deformation < 6%.

3.2.6.5 Proof of safety against failure with not predominantly static loading

According to the standard the dynamic proof is not required (e.g. traffic load > 1,5 m).

All necessary proofs are ok.

4 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 5,9 m

Caption of this part of the calculation:	Cover 5,9 m
Kind of calculation:	Nominal stiffness
Add sketch to print:	Yes

4.1 Input

4.1.1 Safety factors

Safety class:	A (normal case)
Safety stability according to table 13:	Without predeformation (2.5 / 2.0)
Allowable deflection:	6% (standard)
Treatment of internal pressure:	In accordance with Footnote 39 in ATV-DVWK-A 127
Lower safety factors for flexural compression:	No (ATV-DVWK-A 127)
Proof for not predominantly static loading:	According to standard
Consideration of dyn pvh*:	According to standard
Consideration of Type A 'predeformation' in the deformation proof:	Yes
Treatment system stiffness VRB according to:	DWA-A 161:2014 (by material)
Pipe stiffness according to set of rules:	Yes

4.1.2 Soil

Soil group backfill:	G1		
Calculation E1:	Table 8 (A127)		
Soil group pipe zone:	G1		
Calculation E20:	Table 8 (A127)		
Soil group native soil:	G2		
Calculation E3:	Degree of compaction		
Compaction degree E3:	$D_{Pr,E3}$	98.0	%
E4 = 10 · E1:	Yes		
Application of silo theory:	Automatic		
K2 according to standard:	Yes		

4.1.3 Load

Cover depth:	h	5.90	m
Minimum groundwater level above pipe bed:	$h_{W,min}$	0.00	m
Maximum groundwater level above pipe bed:	$h_{W,max}$	0.00	m
Soil density:	γ_B	20.0	kN/m³
Additional surface load:	p_0	0.0	kN/m²
Inner pressure, short term:	$P_{I,K}$	0.00	bar
Inner pressure, long term:	$P_{I,L}$	0.00	bar
Water fill (e.g. damming channel):	Yes		
Density of medium:	γ_F	10.0	kN/m³
Input special-purpose vehicle:	No		
Traffic load:	Street HGV 30 (with road construction)		
Including horizontal loads due to traffic in the fatigue proof:	$\alpha_{qhT,dyn}$	0.00	%

4.1.4 Installation

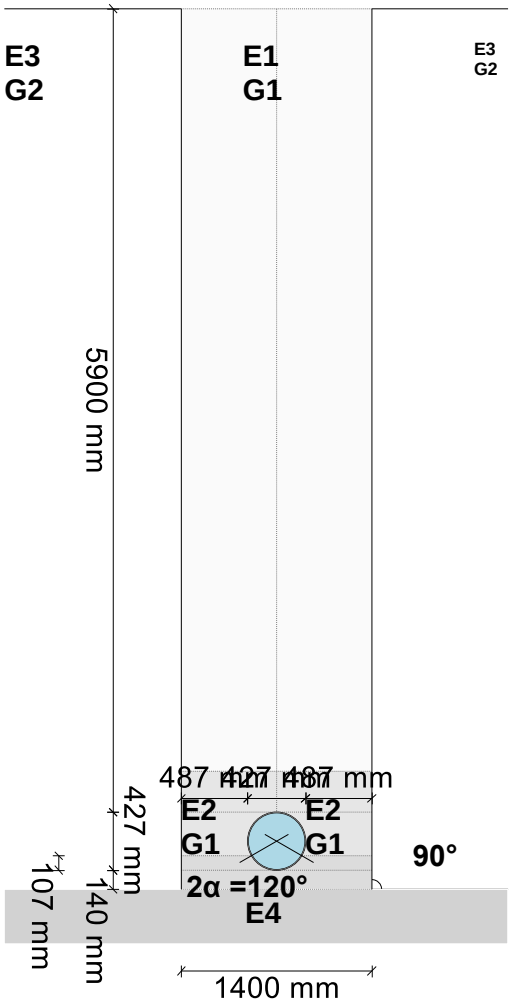
Installation:	Trench		
Trench width at pipe crown level:	b	1.40	m
Check minimum trench width:	Yes		
Automatic consideration of bedding layer:	Yes		

Slope angle:	ß	90	°
Cover condition:	A4		
Installation condition:	B1		
Type of bedding:	Loose		
Bedding angle:	120°		
Calculate bedding automatically:	Yes		
Set lower height base:	No		
Total height of base:	h_s	0.00	m

4.1.5 Pipe with nominal stiffness

Pipe chosen from datebase:	No		
Choice of input:	Do - s		
Outer diameter:	d_a	427	mm
Nominal diameter:	DN	400	mm
Wall thickness:	t	9.0	mm
Local predeformation:	$\delta_{v,I}$	0.0	%
A type predeformation:	$\delta_{v,A}$	1.0	%
Nominal stiffness:	SN	10,000	N/m²
Nominal pressure:	PN	1.0	bar
Relative failure strain according to standard:	Yes		
Creep ratio:	f_{Kriech}	2.00	[-]
Reduction factor due to temperature effect:	$A_{1,Temp}$	1.00	[-]
Reduction factor due to media attack:	$A_{2,Medium}$	1.00	[-]
Reduction factor due to dynamic loading:	$A_{3,dyn}$	1.00	[-]
Specific gravity:	γ_R	18.00	kN/m³
Poissons ratio:	v	0.30	[-]
Input of ultimate hoop tensile stress:	No		
Ultimate strain tensile strength according to standard:	Yes		
Amplitude with 2·10^6 tests is known:	Yes		
Amplitude with 2·10^6 tests:	$\Delta\sigma_{rsk,2E6}$	36.00	N/mm²
Amplitude with 1·10^8 tests is known:	Yes		
Amplitude of the pipe with 1·10^8 tests:	$\Delta\sigma_{rsk,1E8}$	24.00	N/mm²
Axial compressive strength, short term:	$f_{c,ax,K}$	90.0	N/mm²
Fiber strain for axial pressure, short term:	ε_{AxK}	1.0	%

Traffic load: Street HGV 30 (with road construction)



4.2 Results

4.2.1 Intermediate results pipe

Inner diameter:	d_i	409.0	mm
Outer diameter:	d_a	427.0	mm
Mean radius:	r_m	209.00	mm
Wall thickness:	s	9.00	mm
Ratio radius to wall thickness:	r_m/s	23.222	[-]
Curve correction factor, internal:	α_{ki}	1.014	[-]
Curve correction factor, external:	α_{ka}	0.986	[-]
Local predeformation:	$\delta_{v,l}$	0.00	%
Predeformation (ovalisation before load):	$\delta_{v,A}$	1.00	%
Radial cross section:	A_{rad}	9.00	mm²/mm
Distance of inertia:	e	4.50	mm
Moment of inertia:	I	60.75	mm^4/mm
Outer moment of resistance:	W_a	13.50	mm³/mm
Inner moment of resistance:	W_i	13.50	mm³/mm
Surface ratio:	κ_Q	1.2	[-]

4.2.1.1 Material properties

		short term	long term	
Specific gravity	γ_R	18.0	18.0	kN/m³
Poissons ratio	v	0.30	0.30	[-]
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	12,022.2	6,011.1	N/mm²
Creep ratio:		f_{creep}	2.00	[-]

Table 3 of ATV DVWK-A 127, footnote 34:
Determined from the momentary value and the creep ratio (2) with characteristic values for 2 years for the description of the long term behauvior. Also permitted for the long term verification for 50 years. Tests take place in accordance with DIN EN 1228 (momentary) and DIN EN 1225 (long term).

Characteristic value of relative fracture deformation	$\Delta d_{Bruch}/d_m$	15.0	9.0	%

$$\varepsilon_R = 4.28 \cdot s/d_m \cdot \Delta d_{Bruch}/d_m$$

Characteristic value of ultimate strain for edge fibers	ε_R	1.382	0.829	%

$$f_t = \frac{0.50 \cdot PN \cdot 4 \cdot 2 \cdot r_m}{h}$$

Characteristic value of hoop tensile strength	f_t	9.3	4.6	N/mm²
Amplitude for 2·10^6 load cycles:		$\Delta\sigma_{rsk,2E6}$	n. def	N/mm²
Amplitude at 5·10^6 load cycles:		$\Delta\sigma_{rsk,5E6}$	n. def	N/mm²
Amplitude for 1·10^8 cycles:		$\Delta\sigma_{rsk,1E8}$	n. def	N/mm²

4.2.1.2 Safety factors

Required safety coefficient, bending tensile stress	erf γ_{RBZ}	2.00	2.00	[-]
Required safety coefficient, bending compressive stress	erf γ_{RBD}	2.00	2.00	[-]
Required safety coefficient, instability (buckling)	erf γ_{stab}	2.50	2.50	[-]

4.2.2 Minimum trench width according to DIN EN 1610:2015-12

Nominal diameter:	DN	400	mm
Outer diameter:	d_a	427.0	mm
Size of the bedding layer:	a	0.14	m
Minimum width at trench sole level (incl. x) according to table 1:	$min_{b,T1}$	1.13	m
Minimum width according to table 2:	$min_{b,T2}$	1.00	m

Minimum clear width at trench sole level:	$min_{b,G}$	1.13	m
Required width at pipe crown level:	$min_{b,R}$	1.12	m
Trench width at pipe crown level:	b	1.40	m

The minimum trench width at trench sole level according DIN EN 1610 is met.

4.2.3 Intermediate results for load case

4.2.3.1 Silo Theory

Soil load coefficient κ for trench load (Silo Theory):	κ	1.000	[-]
Soil load coefficient κ0 for surface load (Silo Theory):	$κ_0$	1.000	[-]

κ0 and κ are set to 1, because E1 is larger then E3.

4.2.3.2 Load

Maximum groundwater level above pipe crown:	$h_{W,Scheitel}$	0.00	m
Vertical soil stress from soil load:	P_{Erd}	118.00	kN/m²
Vertical soil stress from soil and surface load:	P_E	118.00	kN/m²
Stress due to traffic load:	P_V	4.78	kN/m²
Included impact factor:	ϕ	1.40	[-]

4.2.3.3 Soil deformation moduli EB

Backfill elastic modulus under load:	$E_{1,σ}$	23.00	N/mm²

$$E_{3,\sigma} = \frac{40}{2} \cdot e^{-0.188(100 - D_{Pr})} \qquad 3.01$$

Native soil elastic modulus:	$E_{3,σ}$	13.73	N/mm²
Bedding elastic modulus (reduced):	$E_{2,σ}$	14.72	N/mm²
Bedding elastic modulus under load:	$E_{20,σ}$	16.00	N/mm²
Reduction factor for creep:	f_1	1.000	[-]
Reduction factor E20 (groundwater):	f_2	1.000	[-]
Reduction factor E20 (Diagram 5):	$α_{B0}$	0.667	[-]
Reduction factor E20 (narrow trench):	$α_B$	0.920	[-]
Bedding elastic modulus (reduced):	$E_{2,σ}$	14.72	N/mm²
Elastic modulus of soil under pipe:	$E_{4,σ}$	230.00	N/mm²

4.2.3.4 Soil stiffness values

Auxiliary value for horizontal bedding stiffness:	$Δ_f$	1.401	[-]
Correction factor for horizontal bedding stiffness:	ζ	0.989	[-]
Horizontal bedding stiffness:	S_{Bh}	8.730	N/mm²
Vertical bedding stiffness:	S_{Bv}	14.718	N/mm²

4.2.3.5 Bedding angle, effective relative projection and friction angle

Bedding angle, effective relative projection and friction angle:	2α	120	°
Height bedding from bedding angle to lower pipe ledge:	t_r	0.107	m
Calculated relative projection:	a	1.00	[-]
Effective relative projection:	a'	1.563	[-]
Internal friction angle:	φ'	30.000	°
Wall friction angle:	δ	30.000	°

4.2.3.6 Characteristic values of pipe material and ring stiffness

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Pipe stiffness	S_R	80,000	41,558	40,000	N/m²
Characteristic value of ultimate strain for edge fibers	$ε_R$	1.382	0.851	0.829	%
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	12,022.2	6,245.3	6,011.1	N/mm²

4.2.3.7 Stiffness ratio

System stiffness, weighted	$V_{RB,w}$	0.0092	0.0048	0.0046	[-]
Stiffness ratio	V_S	0.4108	0.3328	---	[-]
Coefficient for vertical deformation	c_v*	-0.013	-0.008	---	[-]

4.2.3.8 Coefficients

Ground pressure ratio (bedding)	K_2	0.400	0.400	---	[-]
Coefficient for bedding reaction pressure	K*	1.189	1.263	---	[-]
Resulting deformation coefficient	c'_h	0.0891	0.0891	---	[-]
Resulting deformation coefficient	$c'_{h,qh}$*	-0.0658	-0.0658	---	[-]
Coefficient for vertical deformation	c_v*	-0.013	-0.008	---	[-]

4.2.3.9 Concentration factors λR and λB

Maximum concentration factor	max λ	2.443	2.443	---	[-]
Coefficient for maximum concentration factor	K'	0.921	0.913	---	[-]
Concentration factor above pipe, initial value	λ_R	0.790	0.730	---	[-]
Concentration factor above pipe, under trench effect	λ_{RG}	0.840	0.795	---	[-]
Concentration factor above pipe, upper limit	λ_{fo}	3.115	3.115	---	[-]
Concentration factor above pipe, lower limit	λ_{fu}	0.125	0.125	---	[-]
Concentration factor above pipe, final value	λ_{RG}	0.840	0.795	---	[-]
Soil concentration factor	λ_B	1.070	1.090	---	[-]

4.2.3.10 Pressure distribution at pipe circumference

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Total vertical load	q_v	103.92	98.58	---	kN/m²
Lateral pressure	q_h	52.22	53.16	---	kN/m²
Bedding reaction pressure (soil load)	q^*_h	65.50	61.72	---	kN/m²
Bedding reaction pressure (water filling)	q^*_{hw}	2.00	2.13	---	kN/m²

4.2.4 Section forces

4.2.4.1 Section forces , short term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	209.00	209.00	209.00	mm
Moment due to total vertical load	M_{qv}	1.185	-1.203	1.248	kNm/m
Moment due to lateral pressure	M_{qh}	-0.570	0.570	-0.570	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-0.518	0.595	-0.518	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.016	0.018	-0.016	kNm/m
Moment due to dead weight	M_g	0.003	-0.003	0.004	kNm/m
Moment due to water filling	M_w	0.017	-0.020	0.024	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.101	-0.043	0.172	kNm/m
		crown	springline	invert	
Mean radius	r_m	209.00	209.00	209.00	mm
Normal force due to total vertical load	N_{qv}	0.586	-21.720	-0.586	kN/m
Normal force due to lateral pressure	N_{qh}	-10.914	0.000	-10.914	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-7.898	0.000	-7.898	kN/m

Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.241	0.000	-0.241	kN/m
Normal force due to dead weight	N_g	0.008	-0.053	-0.008	kN/m
Normal force due to water filling	N_w	0.273	0.094	0.601	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-18.185	-21.679	-19.047	kN/m

4.2.4.2 Section forces , long term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	209.00	209.00	209.00	mm
Moment due to total vertical load	M_{qv}	1.124	-1.141	1.184	kNm/m
Moment due to lateral pressure	M_{qh}	-0.580	0.580	-0.580	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-0.488	0.561	-0.488	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.017	0.019	-0.017	kNm/m
Moment due to dead weight	M_g	0.003	-0.003	0.004	kNm/m
Moment due to water filling	M_w	0.017	-0.020	0.024	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.059	-0.004	0.126	kNm/m

		crown	springline	invert	
Mean radius	r_m	209.00	209.00	209.00	mm
Normal force due to total vertical load	N_{qv}	0.556	-20.603	-0.556	kN/m
Normal force due to lateral pressure	N_{qh}	-11.110	0.000	-11.110	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-7.443	0.000	-7.443	kN/m
Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.256	0.000	-0.256	kN/m
Normal force due to dead weight	N_g	0.008	-0.053	-0.008	kN/m
Normal force due to water filling	N_w	0.273	0.094	0.601	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-17.972	-20.562	-18.774	kN/m

4.2.5 Short term load case

4.2.5.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh^*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh^*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:			α_{ki}	1.014	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.044	-0.044	0.082	%
Strain due to other loads	ε_{sonst}	0.003	-0.003	0.008	%

Total strain	ε	0.046	-0.047	0.090	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.38	1.38	1.38	%
Safety coefficient flexural tension:	γ_{BZ}	29.844	---	15.385	[-]
Safety coefficient flexural compression:	γ_{BD}	---	29.578	---	[-]

outside

Curve correction factor, external:			α_{ka}	0.986	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	$\varepsilon_{qv,qh,qh*}$	-0.076	0.003	-0.115	%
Strain due to other loads	ε_{sonst}	-0.003	0.003	-0.007	%
Total strain	ε	-0.078	0.006	-0.122	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.38	1.38	1.38	%
Safety coefficient flexural tension:	γ_{BZ}	---	234.078	---	[-]
Safety coefficient flexural compression:	γ_{BD}	17.689	---	11.329	[-]

All calculated safety coefficients of the strain proof are sufficient.

4.2.5.2 Deformation proof

Calculation mode:			linear		
Ratio:			I/(A·rm²)	0.00015	[-]
Ratio 'I/(A·rm²)·κ~Q':			$I/(A \cdot rm^2) \cdot \kappa_Q$	0.00019	[-]
		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	3.86	mm
Horizontal diameter change:	Δd_h	3.14	mm

Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	0.92	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	1.92	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

4.2.6 Long term load case

4.2.6.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:	α_{ki}	1.014	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.035	-0.036	0.105	%
Strain due to other loads	ε_{sonst}	0.004	-0.005	0.014	%
Total strain	ε	0.039	-0.041	0.119	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	0.85	0.85	0.85	%
Safety coefficient flexural tension:	γ_{BZ}	21.945	---	7.129	[-]
Safety coefficient flexural compression:	γ_{BD}	---	20.605	---	[-]

outside

Curve correction factor, external:	α_{ka}		0.986	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	-0.097	-0.037	-0.169	%
Strain due to other loads	ε_{sonst}	-0.004	0.005	-0.012	%
Total strain	ε	-0.101	-0.032	-0.181	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	0.85	0.85	0.85	%
Safety coefficient flexural tension:	γ_{BZ}	---	---	---	[-]
Safety coefficient flexural compression:	γ_{BD}	8.449	26.426	4.682	[-]

All calculated safety coefficients of the strain proof are sufficient.

4.2.6.2 Deformation proof

Calculation mode:			linear	
Ratio:			I/(A·rm²)	0.00015 [-]
Ratio 'I/(A·rm²)·κ~Q':			I/(A·rm²)·κ_Q	0.00019 [-]

		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	4.27	mm
Horizontal diameter change:	Δd_h	2.96	mm
Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	1.02	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	2.02	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

4.2.6.3 Stabilty proof radial, linear

Earth and traffic loads

Pipe stiffness:	$\bar{S}_R$	41,558	N/m²
Horizontal bedding stiffness:	S_{Bh}	8.730	N/mm²
System stiffness, weighted:	$V_{RB,w}$	0.0048	[-]
Reduction factor buckling load for earth/traffic loads:	κ_{v2}	0.87	[-]
Friction angle in bedding zone:	φ'_2	35.000	°
Critical vertical total load:	krit q_v	1,051.8	kN/m²
Total vertical load:	q_v	98.58	kN/m²
Safety stability, radial:	$\gamma_{Stab,rad}$	10.67	[-]
Required safety coefficient, instability (buckling):	erf γ_{stab}	2.50	[-]

The buckling proof is fulfilled.

4.2.6.4 stability proof, nonlinear

The nonlinear stability proof is not applicable because of VRB > 1.0 (rigid pipe) or relative vertical deformation < 6%.

4.2.6.5 Proof of safety against failure with not predominantly static loading

According to the standard the dynamic proof is not required (e.g. traffic load > 1,5 m).

All necessary proofs are ok.

5 Appendix

Amiblu®
Sustainable Water Solutions

FLOWTITE® | HOBAS®

Input Data for structural analysis

of application buried pipes in open trench condition, calculation acc. DWA-A 127

Please send to:
Amiblu Holding GmbH
Pischeldorfer Straße 128
A-9020 Klagenfurt
T +43 463 482424
info@amiblu.com

9013 PCL 1F	
project	
LUZ d.d	Luka Krajnc
company	contact person
Verovškova ulica 64	(01) 36 02 473
street	phone/Fax:
1000	Text input.
postcode	signature:
Ljubljana	Text input.
city	date/stamp

Pipe Details:

nominal diameter DN	400
pressure class PN	PN1
nominal stiffness SN	10000
pipe material	GRP

sewer pipe	☒
sewer pressure pipe	☐
pressure pipe	☐
potable water pipe	☐
installation in protective water area	☐
air pipe	☐
storage sewer	☐
others	Text input.

Types of native soil: acc. ATV-DVWK-A 127; DIN 18196 (please subsoil expertise ad)

		Native soil	backfilling	Pipe zone
G1	Non cohesive soils (gravel, sand) (GE, GW, GI, SE, SW, SI)	☐	☒	☒
G2	Slightly cohesive soils (GU, GT, SU, ST)	☒	☐	☐
G3	Cohesive mixed soils, silt (GÜ, GŤ, SÜ, SŤ, UL, UM)	☐	☐	☐
G4	Cohesive soils, except silts (TL, TM, TA, OU, OT, OH, UA)	☐	☐	☐
Other types of soil	Text input.	☐	☐	☐

Proctor density for native soil (Proctor density 85 – 100 %): 98 %

Foundation of pipeline
- ☒ On native soil
- ☐ very hard and rocky
- ☐ Weak soil, not stable for foundation

Soil replacement: thickness Text input. m
material Text input.
Proctor density D_{Pr} Text input. %

Specification of loads:

	Min. cover depth		Max. cover depth	
Depth of earth cover h	1,9	m	5,9	m
min. Ground water h_w above pipe invert	Text input.	m	Text input.	m
max. Ground water h_w above pipe invert	Text input.	m	Text input.	m

Other surface loads Text input. kN/m²

For pressure pipes
Short term: Text input. bar, e.g. system test pressure; hydrostatic pressure, water hammer
Long term: Text input. bar, e.g. operating pressure (OP), system pressure (PN, DP)

Traffic load
☐ no traffic

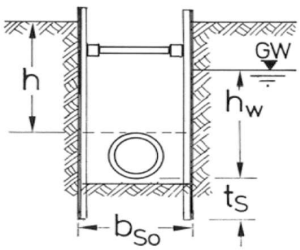
street
- ☐ HCL 60
- ☒ HCL 30
- ☐ HGV 12
- ☐ DIN EN 1991-2, TS und UDL
  - ☐ LM1-lane 3,00 m
  - ☐ LM1-lane 2,70 m
  - ☐ LM1-green field area

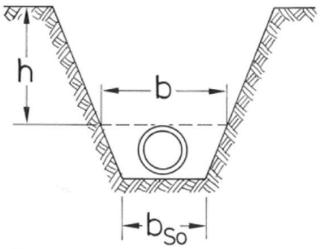
railway
- ☐ one track, UIC
- ☐ two tracks, UIC
- ☐ one track, LM 71
- ☐ two tracks, LM 71

aircraft
- ☐ BFZ 90
- ☐ BFZ 180
- ☐ BFZ 350
- ☐ BFZ 550
- ☐ BFZ 750

Other loads, e.g. special vehicle (please add load scheme with axle, wheels and wheel loads):
Text input.

Building construction:





Type of trench ☒ embankment ☐ single trench ☐ double trench [1] ☐ stepped trench [1]
[1] For special shapes add a sketch

Trench angel ☒ 90° ☐ 60° ☐ 45° ☐ Text input.

Width of trench b = 1.4 m at pipe crown

b_{So} = 1,4 m at pipe trench bottom inclusive planks

Trench planking

☐ no planks

☐ Horizontal planks, also applies to plank walls (Berlin lining)
☒ Planking with plates
☐ Vertical plank with light weight
☐ Vertical plank with boards *
☐ Vertical plank with light weight *
☐ Vertical plank with sheet piling *

bedding

☐ on native soil (acc. EN 1610)
☒ on gravel, sand
☐ on concrete [2]

[2] only as spezial construction in agreement with the pipe producer

bedding angle 2α

☐ 90° ☐ 120°
☐ 180°

* Depth of sheeting below pipe invert t_S = Text input. m

*thickness of plank (one-side) b_S = Text input. m

Cover condition for backfilling:

A1 ☐ Backfilling compacted in layers against the native soil (without proof of compaction degree); also applies to plank walls, Berlin lining

A2 ☐ Vertical pipe trench lining with boards that are not removed before backfilling. Lining boards or devices that are removed step by step during backfilling. Non-compacted backfilling/ backfilling with slurry (only suitable for soils of group G1).

A3 ☐ Vertical trench lining with sheet piling, light weight sheet connection, wooden planks, lining boards or devices that are not removed before backfilling.

A4 ☒ Backfilling compacted in layers against the native soil with proof of the required compaction degree to ZTVE-StB ; also applies to plank walls (Berlin lining). Cover condition A4 is not applicable to sails of group G4.

Bedding condition for pipe:

B1 ☒ Bedding compacted in layers against the native soil or in the embankment (without proof of compaction degree); also applies to plank walls, Berlin lining

B2 ☐ Vertical lining in the pipe zone with planks that reach down to the trench bottom and are not removed before backfilling and compaction. Lining boards or devices provided that the soil is compacted after the linings are removed.

B3 ☐ Vertical lining in the pipe zone with sheet piling or lightweight sheeting and compaction against the lining reaching down below the trench bottom. There is no safe calculation model for determining vertical lining with wooden planks, boards or devices that are not removed before backfilling and compaction the pipe zone.

B4 ☐ Bedding compacted in layers against the native soil or in the embankment with proof of the required compaction degree to ZTVE-StB. Bedding condition B4 does not apply to soils of group G4.

Structural analysis

Project:	9013 PCL 1F
Description:	GRP CC pipe DN500 PN1 SN 10.000
Contractor:	LUZ d.d Verovškova ulica 64 1000 Ljubljana Mr. Luka Kranjc (01) 36 02 473
Designer:	Josip Vrtarić Application Engineering Amiblu Alpe Adria d.o.o. Kralja Zvonimira 122, Zagreb, Croatia T +385 1 618 36 91 M +385 91 604 93 97 josip.vrtaric@amiblu.com www.amiblu.com
Calculation no.:	2025/91
Date:	19/08/2025

Content

1 Remarks 4

2 List of references 6

3 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 3,7 m 7

3.1 Input 7

3.1.1 Safety factors 7

3.1.2 Soil 7

3.1.3 Load 7

3.1.4 Installation 7

3.1.5 Pipe with nominal stiffness 8

3.2 Results 10

3.2.1 Intermediate results pipe 10

3.2.1.1 Material properties 10
3.2.1.2 Safety factors 10

3.2.2 Minimum trench width according to DIN EN 1610:2015-12 10

3.2.3 Intermediate results for load case 11

3.2.3.1 Silo Theory 11
3.2.3.2 Load 11
3.2.3.3 Soil deformation moduli EB 11
3.2.3.4 Soil stiffness values 11
3.2.3.5 Bedding angle, effective relative projection and friction angle 11
3.2.3.6 Characteristic values of pipe material and ring stiffness 11
3.2.3.7 Stiffness ratio 12
3.2.3.8 Coefficients 12
3.2.3.9 Concentration factors λR and λB 12
3.2.3.10 Pressure distribution at pipe circumference 12

3.2.4 Section forces 12

3.2.4.1 Section forces , short term 12
3.2.4.2 Section forces , long term 13

3.2.5 Short term load case 13

3.2.5.1 Strain proof 13
3.2.5.2 Deformation proof 14

3.2.6 Long term load case 14

3.2.6.1 Strain proof 14
3.2.6.2 Deformation proof 15
3.2.6.3 Stabilty proof radial, linear 15
3.2.6.4 stability proof, nonlinear 16
3.2.6.5 Proof of safety against failure with not predominantly static loading 16

4 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 5,74 m 17

4.1 Input 17

4.1.1 Safety factors 17

4.1.2 Soil 17

4.1.3 Load 17
4.1.4 Installation 17
4.1.5 Pipe with nominal stiffness 18
4.2 Results 20
4.2.1 Intermediate results pipe 20
4.2.1.1 Material properties 20
4.2.1.2 Safety factors 20
4.2.2 Minimum trench width according to DIN EN 1610:2015-12 20
4.2.3 Intermediate results for load case 21
4.2.3.1 Silo Theory 21
4.2.3.2 Load 21
4.2.3.3 Soil deformation moduli EB 21
4.2.3.4 Soil stiffness values 21
4.2.3.5 Bedding angle, effective relative projection and friction angle 21
4.2.3.6 Characteristic values of pipe material and ring stiffness 21
4.2.3.7 Stiffness ratio 22
4.2.3.8 Coefficients 22
4.2.3.9 Concentration factors λR and λB 22
4.2.3.10 Pressure distribution at pipe circumference 22
4.2.4 Section forces 22
4.2.4.1 Section forces , short term 22
4.2.4.2 Section forces , long term 23
4.2.5 Short term load case 23
4.2.5.1 Strain proof 23
4.2.5.2 Deformation proof 24
4.2.6 Long term load case 24
4.2.6.1 Strain proof 24
4.2.6.2 Deformation proof 25
4.2.6.3 Stabilty proof radial, linear 25
4.2.6.4 stability proof, nonlinear 26
4.2.6.5 Proof of safety against failure with not predominantly static loading 26
5 Appendix 27
5.1 - 28

1 Remarks

DISCLAIMER OF LIABILITY

As part of the technical service for the technical planning of projects of the Amiblu Group (hereinafter referred to as "Amiblu"), static calculations for decision-making regarding Amiblu/Flowtite/Hobas GFK pipe systems and products are regularly provided by Amiblu.

By using this free Amiblu' s technical verification service, you agree to the following terms and conditions:

1. No contractual relationship:
The use of the above mentioned Amiblu` s calculations does not constitute a contractual relationship between you and Amiblu and no consulting or information agreement is concluded. To this extent, there do not exist any contractual or quasi-contractual claims against Amiblu.

2. Requirements:
You acknowledge that the here mentioned calculations only apply to Amiblu/Flowtite/Hobas products.

3. Basis of the static calculation:
Amiblu bases the calculation according to your stated project and installation conditions and completes the missing data by itself if necessary, this to the best of its knowledge and based on the current state of knowledge and according to the requirements of the valid standards and regulations.
The trench width and installation conditions are based on the minimum requirements according to EN1610 without consideration of the trench sheet thickness (if in use). This usually represents the critical load case and is therefore on the safe side.

4. Installation specifications:
In all cases the following installation conditions must be observed for the installation of Amiblu products:

The pipe zone must be made of non-cohesive or slightly cohesive material with the quality and degree of compaction according to this calculation. The maximum grain size according to the Amiblu/Flowtite/Hobas installation instructions for buried pipes and shafts have to be observed.
To classify the bedding material, all the material in the pipeline zone has to pass through a sieve with a mesh size as specified in the installation instructions.

The pipe bedding must be at least 100 mm thick and have the specified support angle according to the static calculation. We recommend that the requirements for the pipe bedding according to EN 1610.

The degree of compaction of the pipe zone and backfill must meet or exceed the requirements of the static calculation. The installation conditions should be checked and documented. The pipe zone ends 300 mm above the pipe crown.

The quality and degree of compaction of the backfill, the existing soil and the pipeline zone must be checked and needs to meet the requirements of this static evaluation.

For the static calculation compliance with the applicable international standards and installation instructions for Amiblu/Flowtite/Hobas products is assumed. The installation instructions for Amiblu/Flowtite/Hobas can be downloaded from our homepages: http://www.flowtite.com or http://www.hobas.com or http://www.amiblu.com.

The installation conditions used for the static calculation should be compared by you or an expert engineer or the project planner with the actual conditions on site. Potential deviations may have an influence on the pipe installation.

5. Disclaimer:
The services provided are subject to Amiblu's General Conditions of Sale, insofar applicable.

The results of the calculation can only be obtained in practice if the assumptions correspond to the real construction conditions on site.

The static calculations were carried out reliably and carefully according to the professional opinion of Amiblu.

Amiblu accept liability for the static calculation carried out on the basis of customer specifications, such as e.g. contents from structural analysis forms, specifications for planning and execution, information on ground condition as well as installation and/or operation. Amiblu does not accept any liability for the correctness and completeness of the specific customer specifications.

The static calculations prepared by Amiblu are a service in the design or execution phase and usually become part of the project documentation. Amiblu assumes no liability for the applicability of the calculation results in case of deviations from the underlying assumptions.

Rev03 11/04/2023

2 List of references

DIN 4124 - Excavations and Trenches - Slopes, planking and strutting, breadths of working space: October 2002

EN 1610 - Construction and testing of drains and sewers: December 2015

EN 805 - Water Supply Requirements for systems and components outside of buildings: March 2000

EN 1992-2 - Eurocode 2: Eurocode 1: Actions on structures Part 2: Traffic loads on bridges (consolidated version): March. 2012

EN 1796 - Plastics piping systems for water supply with or without pressure - Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP): March 2013

EN 14364 - Plastics piping systems for drainage and sewerage with or without pressure – Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP): Mai 2013

EN 15383 - Plastics piping systems for drainage and sewerage - Glass- reinforced thermosetting plastics (GRP) based on polyester resin (UP) - Manholes and inspection chambers: March 2013

ISO 16611 Plastics piping systems for drainage and sewerage without pressure - Non-circular pipes and joints made of glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resins (UP) - Dimensions, requirements and tests: June 2017

ISO 25780 - Plastics piping systems for pressure and non-pressure water supply, irrigation, drainage or sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin — Pipes with flexible joints intended to be installed using jacking techniques: Mai 2011

Worksheet DWA-A127 - Structural verification of sewer channels and pipe lines, 3. corrected Issue: August 2000

3 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 3,7 m

Caption of this part of the calculation:	Cover 3,7 m
Kind of calculation:	Nominal stiffness
Add sketch to print:	Yes

3.1 Input

3.1.1 Safety factors

Safety class:	A (normal case)
Safety stability according to table 13:	Without predeformation (2.5 / 2.0)
Allowable deflection:	6% (standard)
Treatment of internal pressure:	In accordance with Footnote 39 in ATV-DVWK-A 127
Lower safety factors for flexural compression:	No (ATV-DVWK-A 127)
Proof for not predominantly static loading:	According to standard
Consideration of dyn pvh*:	According to standard
Consideration of Type A 'predeformation' in the deformation proof:	Yes
Treatment system stiffness VRB according to:	DWA-A 161:2014 (by material)
Pipe stiffness according to set of rules:	Yes

3.1.2 Soil

Soil group backfill:	G1		
Calculation E1:	Table 8 (A127)		
Soil group pipe zone:	G1		
Calculation E20:	Table 8 (A127)		
Soil group native soil:	G2		
Calculation E3:	Degree of compaction		
Compaction degree E3:	$D_{Pr,E3}$	98.0	%
E4 = 10 · E1:	Yes		
Application of silo theory:	Automatic		
K2 according to standard:	Yes		

3.1.3 Load

Cover depth:	h	3.70	m
Minimum groundwater level above pipe bed:	$h_{W,min}$	0.00	m
Maximum groundwater level above pipe bed:	$h_{W,max}$	0.00	m
Soil density:	γ_B	20.0	kN/m³
Additional surface load:	p_0	0.0	kN/m²
Inner pressure, short term:	$P_{I,K}$	0.00	bar
Inner pressure, long term:	$P_{I,L}$	0.00	bar
Water fill (e.g. damming channel):	Yes		
Density of medium:	γ_F	10.0	kN/m³
Input special-purpose vehicle:	No		
Traffic load:	Street HGV 30 (with road construction)		
Including horizontal loads due to traffic in the fatigue proof:	$\alpha_{qhT,dyn}$	0.00	%

3.1.4 Installation

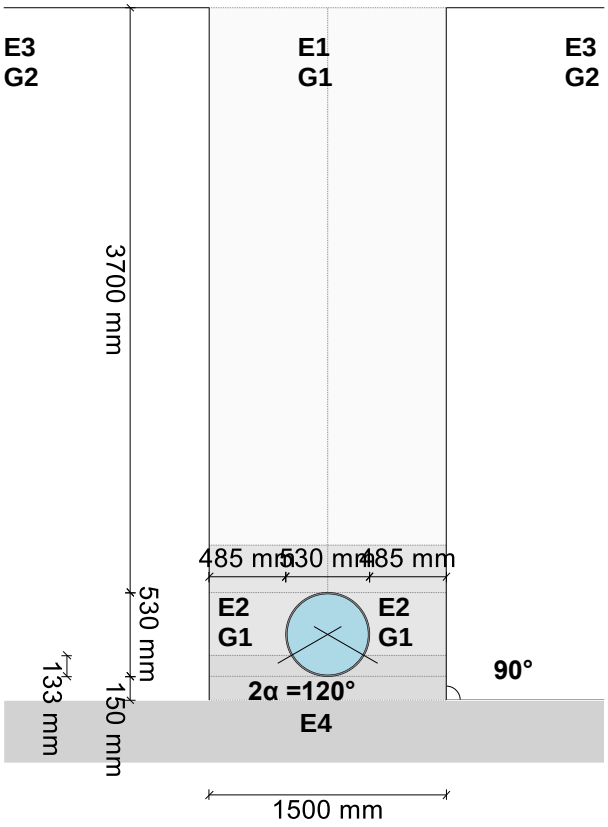
Installation:	Trench		
Trench width at pipe crown level:	b	1.50	m
Check minimum trench width:	Yes		
Automatic consideration of bedding layer:	Yes		

Slope angle:	ß	90	°
Cover condition:	A4		
Installation condition:	B1		
Type of bedding:	Loose		
Bedding angle:	120°		
Calculate bedding automatically:	Yes		
Set lower height base:	No		
Total height of base:	h_s	0.00	m

3.1.5 Pipe with nominal stiffness

Pipe chosen from datebase:	No		
Choice of input:	Do - s		
Outer diameter:	d_a	530	mm
Nominal diameter:	DN	500	mm
Wall thickness:	t	11.0	mm
Local predeformation:	$\delta_{v,I}$	0.0	%
A type predeformation:	$\delta_{v,A}$	1.0	%
Nominal stiffness:	SN	10,000	N/m²
Nominal pressure:	PN	1.0	bar
Relative failure strain according to standard:	Yes		
Creep ratio:	f_{Kriech}	2.00	[-]
Reduction factor due to temperature effect:	$A_{1,Temp}$	1.00	[-]
Reduction factor due to media attack:	$A_{2,Medium}$	1.00	[-]
Reduction factor due to dynamic loading:	$A_{3,dyn}$	1.00	[-]
Specific gravity:	γ_R	18.00	kN/m³
Poissons ratio:	v	0.30	[-]
Input of ultimate hoop tensile stress:	No		
Ultimate strain tensile strength according to standard:	Yes		
Amplitude with 2·10^6 tests is known:	Yes		
Amplitude with 2·10^6 tests:	$\Delta\sigma_{rsk,2E6}$	36.00	N/mm²
Amplitude with 1·10^8 tests is known:	Yes		
Amplitude of the pipe with 1·10^8 tests:	$\Delta\sigma_{rsk,1E8}$	24.00	N/mm²
Axial compressive strength, short term:	$f_{c,ax,K}$	90.0	N/mm²
Fiber strain for axial pressure, short term:	ε_{AxK}	1.0	%

Traffic load: Street HGV 30 (with road construction)



3.2 Results

3.2.1 Intermediate results pipe

Inner diameter:	d_i	508.0	mm
Outer diameter:	d_a	530.0	mm
Mean radius:	r_m	259.50	mm
Wall thickness:	s	11.00	mm
Ratio radius to wall thickness:	r_m/s	23.591	[-]
Curve correction factor, internal:	α_{ki}	1.014	[-]
Curve correction factor, external:	α_{ka}	0.986	[-]
Local predeformation:	$\delta_{v,I}$	0.00	%
Predeformation (ovalisation before load):	$\delta_{v,A}$	1.00	%
Radial cross section:	A_{rad}	11.00	mm²/mm
Distance of inertia:	e	5.50	mm
Moment of inertia:	I	110.92	mm^4/mm
Outer moment of resistance:	W_a	20.17	mm³/mm
Inner moment of resistance:	W_i	20.17	mm³/mm
Surface ratio:	κ_Q	1.2	[-]

3.2.1.1 Material properties

		short term	long term	
Specific gravity	γ_R	18.0	18.0	kN/m³
Poissons ratio	v	0.30	0.30	[-]
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	12,603.9	6,302.0	N/mm²
Creep ratio:		f_{creep}	2.00	[-]

Table 3 of ATV DVWK-A 127, footnote 34:
Determined from the momentary value and the creep ratio (2) with characteristic values for 2 years for the description of the long term behauvior. Also permitted for the long term verification for 50 years. Tests take place in accordance with DIN EN 1228 (momentary) and DIN EN 1225 (long term).

Characteristic value of relative fracture deformation	$\Delta d_{Bruch}/d_m$	15.0	9.0	%

$$\varepsilon_R = 4.28 \cdot s/d_m \cdot \Delta d_{Bruch}/d_m$$

Characteristic value of ultimate strain for edge fibers	ε_R	1.361	0.816	%

$$f_t = \frac{0.50 \cdot PN \cdot 4 \cdot 2 \cdot r_m}{h}$$

Characteristic value of hoop tensile strength	f_t	9.4	4.7	N/mm²
Amplitude for 2·10^6 load cycles:		$\Delta\sigma_{rsk,2E6}$	n. def	N/mm²
Amplitude at 5·10^6 load cycles:		$\Delta\sigma_{rsk,5E6}$	n. def	N/mm²
Amplitude for 1·10^8 cycles:		$\Delta\sigma_{rsk,1E8}$	n. def	N/mm²

3.2.1.2 Safety factors

Required safety coefficient, bending tensile stress	erf γ_{RBZ}	2.00	2.00	[-]
Required safety coefficient, bending compressive stress	erf γ_{RBD}	2.00	2.00	[-]
Required safety coefficient, instability (buckling)	erf γ_{stab}	2.50	2.50	[-]

3.2.2 Minimum trench width according to DIN EN 1610:2015-12

Nominal diameter:	DN	500	mm
Outer diameter:	d_a	530.0	mm
Size of the bedding layer:	a	0.15	m
Minimum width at trench sole level (incl. x) according to table 1:	$min_{b,T1}$	1.23	m
Minimum width according to table 2:	$min_{b,T2}$	1.00	m

Minimum clear width at trench sole level:	$min_{b,G}$	1.23	m
Required width at pipe crown level:	$min_{b,R}$	1.23	m
Trench width at pipe crown level:	b	1.50	m

The minimum trench width at trench sole level according DIN EN 1610 is met.

3.2.3 Intermediate results for load case

3.2.3.1 Silo Theory

Soil load coefficient κ for trench load (Silo Theory):	κ	1.000	[-]
Soil load coefficient κ0 for surface load (Silo Theory):	$κ_0$	1.000	[-]

κ0 and κ are set to 1, because E1 is larger then E3.

3.2.3.2 Load

Maximum groundwater level above pipe crown:	$h_{W,Scheitel}$	0.00	m
Vertical soil stress from soil load:	P_{Erd}	74.00	kN/m²
Vertical soil stress from soil and surface load:	P_E	74.00	kN/m²
Stress due to traffic load:	P_V	9.53	kN/m²
Included impact factor:	ϕ	1.40	[-]

3.2.3.3 Soil deformation moduli EB

Backfill elastic modulus under load:	$E_{1,σ}$	23.00	N/mm²

$$E_{3,\sigma} = \frac{40}{2} \cdot e^{-0.188(100 - D_{Pr})} \qquad 3.01$$

Native soil elastic modulus:	$E_{3,σ}$	13.73	N/mm²
Bedding elastic modulus (reduced):	$E_{2,σ}$	13.92	N/mm²
Bedding elastic modulus under load:	$E_{20,σ}$	16.00	N/mm²
Reduction factor for creep:	f_1	1.000	[-]
Reduction factor E20 (groundwater):	f_2	1.000	[-]
Reduction factor E20 (Diagram 5):	$α_{B0}$	0.667	[-]
Reduction factor E20 (narrow trench):	$α_B$	0.870	[-]
Bedding elastic modulus (reduced):	$E_{2,σ}$	13.92	N/mm²
Elastic modulus of soil under pipe:	$E_{4,σ}$	230.00	N/mm²

3.2.3.4 Soil stiffness values

Auxiliary value for horizontal bedding stiffness:	$Δ_f$	1.220	[-]
Correction factor for horizontal bedding stiffness:	ζ	0.996	[-]
Horizontal bedding stiffness:	S_{Bh}	8.322	N/mm²
Vertical bedding stiffness:	S_{Bv}	13.920	N/mm²

3.2.3.5 Bedding angle, effective relative projection and friction angle

Bedding angle, effective relative projection and friction angle:	2α	120	°
Height bedding from bedding angle to lower pipe ledge:	t_r	0.133	m
Calculated relative projection:	a	1.00	[-]
Effective relative projection:	a'	1.652	[-]
Internal friction angle:	φ'	30.000	°
Wall friction angle:	δ	30.000	°

3.2.3.6 Characteristic values of pipe material and ring stiffness

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Pipe stiffness	S_R	80,000	44,565	40,000	N/m²
Characteristic value of ultimate strain for edge fibers	$ε_R$	1.361	0.879	0.816	%
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	12,603.9	7,021.2	6,302.0	N/mm²

3.2.3.7 Stiffness ratio

System stiffness, weighted	$V_{RB,w}$	0.0096	0.0054	0.0048	[-]
Stiffness ratio	V_S	0.4200	0.3495	---	[-]
Coefficient for vertical deformation	c_v*	-0.014	-0.009	---	[-]

3.2.3.8 Coefficients

Ground pressure ratio (bedding)	K_2	0.400	0.400	---	[-]
Coefficient for bedding reaction pressure	K*	1.181	1.252	---	[-]
Resulting deformation coefficient	c'_h	0.0891	0.0891	---	[-]
Resulting deformation coefficient	$c'_{h,qh}$*	-0.0658	-0.0658	---	[-]
Coefficient for vertical deformation	c_v*	-0.014	-0.009	---	[-]

3.2.3.9 Concentration factors λR and λB

Maximum concentration factor	max λ	2.227	2.227	---	[-]
Coefficient for maximum concentration factor	K'	0.921	0.914	---	[-]
Concentration factor above pipe, initial value	λ_R	0.805	0.752	---	[-]
Concentration factor above pipe, under trench effect	λ_{RG}	0.881	0.849	---	[-]
Concentration factor above pipe, upper limit	λ_{fo}	3.445	3.445	---	[-]
Concentration factor above pipe, lower limit	λ_{fu}	0.244	0.244	---	[-]
Concentration factor above pipe, final value	λ_{RG}	0.881	0.849	---	[-]
Soil concentration factor	λ_B	1.065	1.083	---	[-]

3.2.3.10 Pressure distribution at pipe circumference

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Total vertical load	q_v	74.75	72.36	---	kN/m²
Lateral pressure	q_h	33.64	34.16	---	kN/m²
Bedding reaction pressure (soil load)	q^*_h	51.15	50.61	---	kN/m²
Bedding reaction pressure (water filling)	q^*_{hw}	2.46	2.63	---	kN/m²

3.2.4 Section forces

3.2.4.1 Section forces , short term

Rerounding factor (reduction moments): r 1.000 [-]

		crown	springline	invert	
Mean radius	r_m	259.50	259.50	259.50	mm
Moment due to total vertical load	M_{qv}	1.314	-1.334	1.384	kNm/m
Moment due to lateral pressure	M_{qh}	-0.566	0.566	-0.566	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-0.623	0.716	-0.623	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.030	0.035	-0.030	kNm/m
Moment due to dead weight	M_g	0.005	-0.006	0.007	kNm/m
Moment due to water filling	M_w	0.033	-0.038	0.045	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.132	-0.061	0.217	kNm/m

		crown	springline	invert	
Mean radius	r_m	259.50	259.50	259.50	mm
Normal force due to total vertical load	N_{qv}	0.524	-19.397	-0.524	kN/m
Normal force due to lateral pressure	N_{qh}	-8.730	0.000	-8.730	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-7.659	0.000	-7.659	kN/m

Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.369	0.000	-0.369	kN/m
Normal force due to dead weight	N_g	0.013	-0.081	-0.013	kN/m
Normal force due to water filling	N_w	0.421	0.145	0.926	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-15.801	-19.333	-16.369	kN/m

3.2.4.2 Section forces , long term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	259.50	259.50	259.50	mm
Moment due to total vertical load	M_{qv}	1.272	-1.291	1.340	kNm/m
Moment due to lateral pressure	M_{qh}	-0.575	0.575	-0.575	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-0.617	0.709	-0.617	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.032	0.037	-0.032	kNm/m
Moment due to dead weight	M_g	0.005	-0.006	0.007	kNm/m
Moment due to water filling	M_w	0.033	-0.038	0.045	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.086	-0.015	0.168	kNm/m

		crown	springline	invert	
Mean radius	r_m	259.50	259.50	259.50	mm
Normal force due to total vertical load	N_{qv}	0.507	-18.777	-0.507	kN/m
Normal force due to lateral pressure	N_{qh}	-8.865	0.000	-8.865	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-7.578	0.000	-7.578	kN/m
Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.394	0.000	-0.394	kN/m
Normal force due to dead weight	N_g	0.013	-0.081	-0.013	kN/m
Normal force due to water filling	N_w	0.421	0.145	0.926	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-15.897	-18.713	-16.432	kN/m

3.2.5 Short term load case

3.2.5.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh^*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh^*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:			α_{ki}	1.014	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.038	-0.034	0.065	%
Strain due to other loads	ε_{sonst}	0.003	-0.004	0.009	%

Total strain	ε	0.041	-0.038	0.075	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.36	1.36	1.36	%
Safety coefficient flexural tension:	γ_{BZ}	32.927	---	18.227	[-]
Safety coefficient flexural compression:	γ_{BD}	---	35.613	---	[-]

outside

Curve correction factor, external:			α_{ka}	0.986	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	-0.060	0.006	-0.088	%
Strain due to other loads	ε_{sonst}	-0.003	0.004	-0.008	%
Total strain	ε	-0.063	0.010	-0.096	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.36	1.36	1.36	%
Safety coefficient flexural tension:	γ_{BZ}	---	141.096	---	[-]
Safety coefficient flexural compression:	γ_{BD}	21.719	---	14.195	[-]

All calculated safety coefficients of the strain proof are sufficient.

3.2.5.2 Deformation proof

Calculation mode:			linear		
Ratio:			I/(A·rm²)	0.00015	[-]
Ratio 'I/(A·rm²)·κ~Q':			$I/(A \cdot rm^2) \cdot \kappa_Q$	0.00018	[-]
		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	3.88	mm
Horizontal diameter change:	Δd_h	3.19	mm

Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	0.75	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	1.75	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

3.2.6 Long term load case

3.2.6.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh^*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh^*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:	α_{ki}	1.014	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.036	-0.029	0.084	%
Strain due to other loads	ε_{sonst}	0.005	-0.006	0.017	%
Total strain	ε	0.041	-0.035	0.101	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	0.87	0.87	0.87	%
Safety coefficient flexural tension:	γ_{BZ}	21.023	---	8.609	[-]
Safety coefficient flexural compression:	γ_{BD}	---	24.619	---	[-]

outside

Curve correction factor, external:			α_{ka}	0.986	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	-0.076	-0.019	-0.125	%
Strain due to other loads	ε_{sonst}	-0.005	0.006	-0.015	%
Total strain	ε	-0.081	-0.013	-0.140	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	0.88	0.87	0.87	%
Safety coefficient flexural tension:	γ_{BZ}	---	---	---	[-]
Safety coefficient flexural compression:	γ_{BD}	10.820	64.357	6.235	[-]

All calculated safety coefficients of the strain proof are sufficient.

3.2.6.2 Deformation proof

Calculation mode:			linear		
Ratio:			I/(A·rm²)	0.00015	[-]
Ratio 'I/(A·rm²)·κ~Q':			I/(A·rm²)·κ_Q	0.00018	[-]

		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	4.39	mm
Horizontal diameter change:	Δd_h	3.16	mm
Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	0.85	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	1.85	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

3.2.6.3 Stabilty proof radial, linear

Earth and traffic loads

Pipe stiffness:	$\bar{S}_R$	44,565	N/m²
Horizontal bedding stiffness:	S_{Bh}	8.322	N/mm²
System stiffness, weighted:	$V_{RB,w}$	0.0054	[-]
Reduction factor buckling load for earth/traffic loads:	κ_{v2}	0.87	[-]
Friction angle in bedding zone:	φ'_2	35.000	°
Critical vertical total load:	krit q_v	1,062.8	kN/m²
Total vertical load:	q_v	72.36	kN/m²
Safety stability, radial:	$\gamma_{Stab,rad}$	14.69	[-]
Required safety coefficient, instability (buckling):	erf γ_{stab}	2.50	[-]

The buckling proof is fulfilled.

3.2.6.4 stability proof, nonlinear

The nonlinear stability proof is not applicable because of VRB > 1.0 (rigid pipe) or relative vertical deformation < 6%.

3.2.6.5 Proof of safety against failure with not predominantly static loading

According to the standard the dynamic proof is not required (e.g. traffic load > 1,5 m).

All necessary proofs are ok.

4 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 5,74 m

Caption of this part of the calculation:	Cover 5,74 m
Kind of calculation:	Nominal stiffness
Add sketch to print:	Yes

4.1 Input

4.1.1 Safety factors

Safety class:	A (normal case)
Safety stability according to table 13:	Without predeformation (2.5 / 2.0)
Allowable deflection:	6% (standard)
Treatment of internal pressure:	In accordance with Footnote 39 in ATV-DVWK-A 127
Lower safety factors for flexural compression:	No (ATV-DVWK-A 127)
Proof for not predominantly static loading:	According to standard
Consideration of dyn pvh*:	According to standard
Consideration of Type A 'predeformation' in the deformation proof:	Yes
Treatment system stiffness VRB according to:	DWA-A 161:2014 (by material)
Pipe stiffness according to set of rules:	Yes

4.1.2 Soil

Soil group backfill:	G1		
Calculation E1:	Table 8 (A127)		
Soil group pipe zone:	G1		
Calculation E20:	Table 8 (A127)		
Soil group native soil:	G2		
Calculation E3:	Degree of compaction		
Compaction degree E3:	$D_{Pr,E3}$	98.0	%
E4 = 10 · E1:	Yes		
Application of silo theory:	Automatic		
K2 according to standard:	Yes		

4.1.3 Load

Cover depth:	h	5.74	m
Minimum groundwater level above pipe bed:	$h_{W,min}$	0.00	m
Maximum groundwater level above pipe bed:	$h_{W,max}$	0.00	m
Soil density:	γ_B	20.0	kN/m³
Additional surface load:	p_0	0.0	kN/m²
Inner pressure, short term:	$P_{I,K}$	0.00	bar
Inner pressure, long term:	$P_{I,L}$	0.00	bar
Water fill (e.g. damming channel):	Yes		
Density of medium:	γ_F	10.0	kN/m³
Input special-purpose vehicle:	No		
Traffic load:	Street HGV 30 (with road construction)		
Including horizontal loads due to traffic in the fatigue proof:	$\alpha_{qhT,dyn}$	0.00	%

4.1.4 Installation

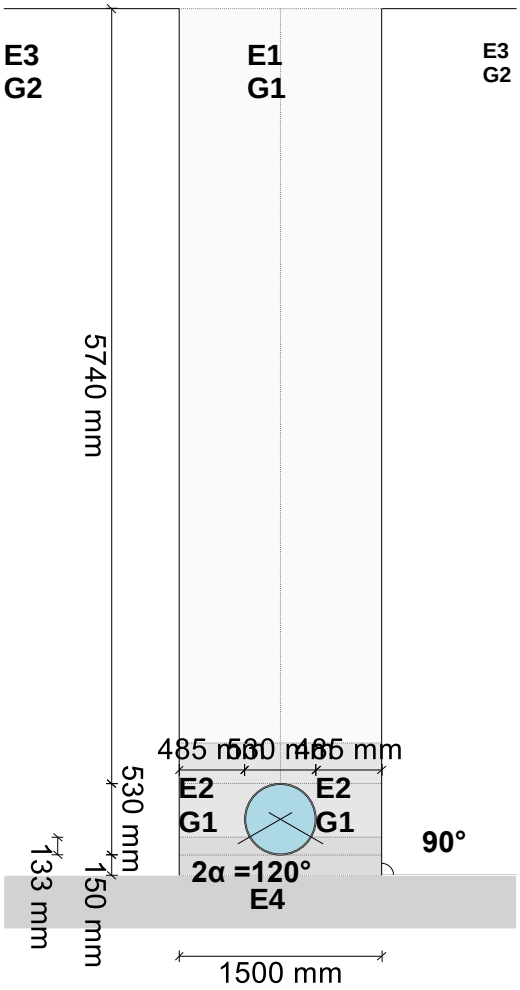
Installation:	Trench		
Trench width at pipe crown level:	b	1.50	m
Check minimum trench width:	Yes		
Automatic consideration of bedding layer:	Yes		

Slope angle:	ß	90	°
Cover condition:	A4		
Installation condition:	B1		
Type of bedding:	Loose		
Bedding angle:	120°		
Calculate bedding automatically:	Yes		
Set lower height base:	No		
Total height of base:	h_s	0.00	m

4.1.5 Pipe with nominal stiffness

Pipe chosen from datebase:	No		
Choice of input:	Do - s		
Outer diameter:	d_a	530	mm
Nominal diameter:	DN	500	mm
Wall thickness:	t	11.0	mm
Local predeformation:	$\delta_{v,I}$	0.0	%
A type predeformation:	$\delta_{v,A}$	1.0	%
Nominal stiffness:	SN	10,000	N/m²
Nominal pressure:	PN	1.0	bar
Relative failure strain according to standard:	Yes		
Creep ratio:	f_{Kriech}	2.00	[-]
Reduction factor due to temperature effect:	$A_{1,Temp}$	1.00	[-]
Reduction factor due to media attack:	$A_{2,Medium}$	1.00	[-]
Reduction factor due to dynamic loading:	$A_{3,dyn}$	1.00	[-]
Specific gravity:	γ_R	18.00	kN/m³
Poissons ratio:	v	0.30	[-]
Input of ultimate hoop tensile stress:	No		
Ultimate strain tensile strength according to standard:	Yes		
Amplitude with 2·10^6 tests is known:	Yes		
Amplitude with 2·10^6 tests:	$\Delta\sigma_{rsk,2E6}$	36.00	N/mm²
Amplitude with 1·10^8 tests is known:	Yes		
Amplitude of the pipe with 1·10^8 tests:	$\Delta\sigma_{rsk,1E8}$	24.00	N/mm²
Axial compressive strength, short term:	$f_{c,ax,K}$	90.0	N/mm²
Fiber strain for axial pressure, short term:	ε_{AxK}	1.0	%

Traffic load: Street HGV 30 (with road construction)



4.2 Results

4.2.1 Intermediate results pipe

Inner diameter:	d_i	508.0	mm
Outer diameter:	d_a	530.0	mm
Mean radius:	r_m	259.50	mm
Wall thickness:	s	11.00	mm
Ratio radius to wall thickness:	r_m/s	23.591	[-]
Curve correction factor, internal:	α_{ki}	1.014	[-]
Curve correction factor, external:	α_{ka}	0.986	[-]
Local predeformation:	$\delta_{v,I}$	0.00	%
Predeformation (ovalisation before load):	$\delta_{v,A}$	1.00	%
Radial cross section:	A_{rad}	11.00	mm²/mm
Distance of inertia:	e	5.50	mm
Moment of inertia:	I	110.92	mm^4/mm
Outer moment of resistance:	W_a	20.17	mm³/mm
Inner moment of resistance:	W_i	20.17	mm³/mm
Surface ratio:	κ_Q	1.2	[-]

4.2.1.1 Material properties

		short term	long term	
Specific gravity	γ_R	18.0	18.0	kN/m³
Poissons ratio	v	0.30	0.30	[-]
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	12,603.9	6,302.0	N/mm²
Creep ratio:		f_{creep}	2.00	[-]

Table 3 of ATV DVWK-A 127, footnote 34:
Determined from the momentary value and the creep ratio (2) with characteristic values for 2 years for the description of the long term behauvior. Also permitted for the long term verification for 50 years. Tests take place in accordance with DIN EN 1228 (momentary) and DIN EN 1225 (long term).

Characteristic value of relative fracture deformation	$\Delta d_{Bruch}/d_m$	15.0	9.0	%

$$\varepsilon_R = 4.28 \cdot s/d_m \cdot \Delta d_{Bruch}/d_m$$

Characteristic value of ultimate strain for edge fibers	ε_R	1.361	0.816	%

$$f_t = \frac{0.50 \cdot PN \cdot 4 \cdot 2 \cdot r_m}{h}$$

Characteristic value of hoop tensile strength	f_t	9.4	4.7	N/mm²
Amplitude for 2·10^6 load cycles:		$\Delta\sigma_{rsk,2E6}$	n. def	N/mm²
Amplitude at 5·10^6 load cycles:		$\Delta\sigma_{rsk,5E6}$	n. def	N/mm²
Amplitude for 1·10^8 cycles:		$\Delta\sigma_{rsk,1E8}$	n. def	N/mm²

4.2.1.2 Safety factors

Required safety coefficient, bending tensile stress	erf γ_{RBZ}	2.00	2.00	[-]
Required safety coefficient, bending compressive stress	erf γ_{RBD}	2.00	2.00	[-]
Required safety coefficient, instability (buckling)	erf γ_{stab}	2.50	2.50	[-]

4.2.2 Minimum trench width according to DIN EN 1610:2015-12

Nominal diameter:	DN	500	mm
Outer diameter:	d_a	530.0	mm
Size of the bedding layer:	a	0.15	m
Minimum width at trench sole level (incl. x) according to table 1:	$min_{b,T1}$	1.23	m
Minimum width according to table 2:	$min_{b,T2}$	1.00	m

Minimum clear width at trench sole level:	$min_{b,G}$	1.23	m
Required width at pipe crown level:	$min_{b,R}$	1.23	m
Trench width at pipe crown level:	b	1.50	m

The minimum trench width at trench sole level according DIN EN 1610 is met.

4.2.3 Intermediate results for load case

4.2.3.1 Silo Theory

Soil load coefficient κ for trench load (Silo Theory):	κ	1.000	[-]
Soil load coefficient κ0 for surface load (Silo Theory):	$κ_0$	1.000	[-]

κ0 and κ are set to 1, because E1 is larger then E3.

4.2.3.2 Load

Maximum groundwater level above pipe crown:	$h_{W,Scheitel}$	0.00	m
Vertical soil stress from soil load:	P_{Erd}	114.80	kN/m²
Vertical soil stress from soil and surface load:	P_E	114.80	kN/m²
Stress due to traffic load:	P_V	5.00	kN/m²
Included impact factor:	ϕ	1.40	[-]

4.2.3.3 Soil deformation moduli EB

Backfill elastic modulus under load:	$E_{1,σ}$	23.00	N/mm²

$$E_{3,\sigma} = \frac{40}{2} \cdot e^{-0.188(100 - D_{Pr})} \qquad 3.01$$

Native soil elastic modulus:	$E_{3,σ}$	13.73	N/mm²
Bedding elastic modulus (reduced):	$E_{2,σ}$	13.92	N/mm²
Bedding elastic modulus under load:	$E_{20,σ}$	16.00	N/mm²
Reduction factor for creep:	f_1	1.000	[-]
Reduction factor E20 (groundwater):	f_2	1.000	[-]
Reduction factor E20 (Diagram 5):	$α_{B0}$	0.667	[-]
Reduction factor E20 (narrow trench):	$α_B$	0.870	[-]
Bedding elastic modulus (reduced):	$E_{2,σ}$	13.92	N/mm²
Elastic modulus of soil under pipe:	$E_{4,σ}$	230.00	N/mm²

4.2.3.4 Soil stiffness values

Auxiliary value for horizontal bedding stiffness:	$Δ_f$	1.220	[-]
Correction factor for horizontal bedding stiffness:	ζ	0.996	[-]
Horizontal bedding stiffness:	S_{Bh}	8.322	N/mm²
Vertical bedding stiffness:	S_{Bv}	13.920	N/mm²

4.2.3.5 Bedding angle, effective relative projection and friction angle

Bedding angle, effective relative projection and friction angle:	2α	120	°
Height bedding from bedding angle to lower pipe ledge:	t_r	0.133	m
Calculated relative projection:	a	1.00	[-]
Effective relative projection:	a'	1.652	[-]
Internal friction angle:	φ'	30.000	°
Wall friction angle:	δ	30.000	°

4.2.3.6 Characteristic values of pipe material and ring stiffness

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Pipe stiffness	S_R	80,000	41,671	40,000	N/m²
Characteristic value of ultimate strain for edge fibers	$ε_R$	1.361	0.839	0.816	%
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	12,603.9	6,565.2	6,302.0	N/mm²

4.2.3.7 Stiffness ratio

System stiffness, weighted	$V_{RB,w}$	0.0096	0.0050	0.0048	[-]
Stiffness ratio	V_S	0.4200	0.3415	---	[-]
Coefficient for vertical deformation	c_v*	-0.014	-0.009	---	[-]

4.2.3.8 Coefficients

Ground pressure ratio (bedding)	K_2	0.400	0.400	---	[-]
Coefficient for bedding reaction pressure	K*	1.181	1.258	---	[-]
Resulting deformation coefficient	c'_h	0.0891	0.0891	---	[-]
Resulting deformation coefficient	$c'_{h,qh}$*	-0.0658	-0.0658	---	[-]
Coefficient for vertical deformation	c_v*	-0.014	-0.009	---	[-]

4.2.3.9 Concentration factors λR and λB

Maximum concentration factor	max λ	2.430	2.430	---	[-]
Coefficient for maximum concentration factor	K'	0.921	0.914	---	[-]
Concentration factor above pipe, initial value	λ_R	0.800	0.740	---	[-]
Concentration factor above pipe, under trench effect	λ_{RG}	0.878	0.841	---	[-]
Concentration factor above pipe, upper limit	λ_{fo}	3.139	3.139	---	[-]
Concentration factor above pipe, lower limit	λ_{fu}	0.160	0.160	---	[-]
Concentration factor above pipe, final value	λ_{RG}	0.878	0.841	---	[-]
Soil concentration factor	λ_B	1.067	1.087	---	[-]

4.2.3.10 Pressure distribution at pipe circumference

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Total vertical load	q_v	105.76	101.58	---	kN/m²
Lateral pressure	q_h	51.11	52.02	---	kN/m²
Bedding reaction pressure (soil load)	q^*_h	68.50	66.61	---	kN/m²
Bedding reaction pressure (water filling)	q^*_{hw}	2.46	2.63	---	kN/m²

4.2.4 Section forces

4.2.4.1 Section forces , short term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	259.50	259.50	259.50	mm
Moment due to total vertical load	M_{qv}	1.859	-1.887	1.959	kNm/m
Moment due to lateral pressure	M_{qh}	-0.860	0.860	-0.860	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-0.835	0.960	-0.835	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.030	0.035	-0.030	kNm/m
Moment due to dead weight	M_g	0.005	-0.006	0.007	kNm/m
Moment due to water filling	M_w	0.033	-0.038	0.045	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.172	-0.077	0.286	kNm/m
		crown	springline	invert	
Mean radius	r_m	259.50	259.50	259.50	mm
Normal force due to total vertical load	N_{qv}	0.741	-27.446	-0.741	kN/m
Normal force due to lateral pressure	N_{qh}	-13.263	0.000	-13.263	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-10.257	0.000	-10.257	kN/m

Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.369	0.000	-0.369	kN/m
Normal force due to dead weight	N_g	0.013	-0.081	-0.013	kN/m
Normal force due to water filling	N_w	0.421	0.145	0.926	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-22.714	-27.382	-23.717	kN/m

4.2.4.2 Section forces , long term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	259.50	259.50	259.50	mm
Moment due to total vertical load	M_{qv}	1.785	-1.813	1.881	kNm/m
Moment due to lateral pressure	M_{qh}	-0.876	0.876	-0.876	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-0.812	0.933	-0.812	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.032	0.037	-0.032	kNm/m
Moment due to dead weight	M_g	0.005	-0.006	0.007	kNm/m
Moment due to water filling	M_w	0.033	-0.038	0.045	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.104	-0.011	0.214	kNm/m

		crown	springline	invert	
Mean radius	r_m	259.50	259.50	259.50	mm
Normal force due to total vertical load	N_{qv}	0.712	-26.359	-0.712	kN/m
Normal force due to lateral pressure	N_{qh}	-13.500	0.000	-13.500	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-9.974	0.000	-9.974	kN/m
Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.394	0.000	-0.394	kN/m
Normal force due to dead weight	N_g	0.013	-0.081	-0.013	kN/m
Normal force due to water filling	N_w	0.421	0.145	0.926	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-22.723	-26.295	-23.667	kN/m

4.2.5 Short term load case

4.2.5.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh^*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh^*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:			α_{ki}	1.014	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.049	-0.047	0.088	%
Strain due to other loads	ε_{sonst}	0.003	-0.004	0.009	%

Total strain	ε	0.052	-0.051	0.097	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.36	1.36	1.36	%
Safety coefficient flexural tension:	γ_{BZ}	26.101	---	14.055	[-]
Safety coefficient flexural compression:	γ_{BD}	---	26.916	---	[-]

outside

Curve correction factor, external:			α_{ka}	0.986	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	-0.080	0.006	-0.120	%
Strain due to other loads	ε_{sonst}	-0.003	0.004	-0.008	%
Total strain	ε	-0.083	0.010	-0.128	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.36	1.36	1.36	%
Safety coefficient flexural tension:	γ_{BZ}	---	133.457	---	[-]
Safety coefficient flexural compression:	γ_{BD}	16.396	---	10.643	[-]

All calculated safety coefficients of the strain proof are sufficient.

4.2.5.2 Deformation proof

Calculation mode:			linear		
Ratio:			I/(A·rm²)	0.00015	[-]
Ratio 'I/(A·rm²)·κ~Q':			$I/(A \cdot rm^2) \cdot \kappa_Q$	0.00018	[-]
		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_V	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	5.21	mm
Horizontal diameter change:	Δd_h	4.27	mm

Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	1.00	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	2.00	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

4.2.6 Long term load case

4.2.6.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh^*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh^*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:	α_{ki}	1.014	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.043	-0.039	0.115	%
Strain due to other loads	ε_{sonst}	0.005	-0.006	0.017	%
Total strain	ε	0.048	-0.045	0.131	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	0.84	0.84	0.84	%
Safety coefficient flexural tension:	γ_{BZ}	17.373	---	6.361	[-]
Safety coefficient flexural compression:	γ_{BD}	---	18.496	---	[-]

outside

Curve correction factor, external:	α_{ka}		0.986	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	-0.104	-0.034	-0.177	%
Strain due to other loads	ε_{sonst}	-0.005	0.006	-0.015	%
Total strain	ε	-0.109	-0.028	-0.192	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	0.84	0.84	0.84	%
Safety coefficient flexural tension:	γ_{BZ}	---	---	---	[-]
Safety coefficient flexural compression:	γ_{BD}	7.699	30.023	4.353	[-]

All calculated safety coefficients of the strain proof are sufficient.

4.2.6.2 Deformation proof

Calculation mode:			linear	
Ratio:			$I/(A \cdot rm^2)$	0.00015 [-]
Ratio 'I/(A·rm²)·κ~Q':			$I/(A \cdot rm^2) \cdot \kappa_Q$	0.00018 [-]

		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	5.90	mm
Horizontal diameter change:	Δd_h	4.15	mm
Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	1.14	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	2.14	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

4.2.6.3 Stabilty proof radial, linear

Earth and traffic loads

Pipe stiffness:	$\bar{S}_R$	41,671	N/m²
Horizontal bedding stiffness:	S_{Bh}	8.322	N/mm²
System stiffness, weighted:	$V_{RB,w}$	0.0050	[-]
Reduction factor buckling load for earth/traffic loads:	κ_{v2}	0.87	[-]
Friction angle in bedding zone:	φ'_2	35.000	°
Critical vertical total load:	krit q_v	1,028.0	kN/m²
Total vertical load:	q_v	101.58	kN/m²
Safety stability, radial:	$\gamma_{Stab,rad}$	10.12	[-]
Required safety coefficient, instability (buckling):	erf γ_{stab}	2.50	[-]

The buckling proof is fulfilled.

4.2.6.4 stability proof, nonlinear

The nonlinear stability proof is not applicable because of VRB > 1.0 (rigid pipe) or relative vertical deformation < 6%.

4.2.6.5 Proof of safety against failure with not predominantly static loading

According to the standard the dynamic proof is not required (e.g. traffic load > 1,5 m).

All necessary proofs are ok.

5 Appendix

Input Data for structural analysis

of application buried pipes in open trench condition, calculation acc. DWA-A 127

Please send to:
Amiblu Holding GmbH
Pischeldorfer Straße 128
A-9020 Klagenfurt
T +43 463 482424
info@amiblu.com

9013 PCL 1F	
project	
LUZ d.d	Luka Krajnc
company	contact person
Verovškova ulica 64	(01) 36 02 473
street	phone/Fax:
1000	Text input.
postcode	signature:
Ljubljana	Text input.
city	date/stamp

Pipe Details:

nominal diameter DN	500
pressure class PN	PN1
nominal stiffness SN	10000
pipe material	GRP

sewer pipe	☒
sewer pressure pipe	☐
pressure pipe	☐
potable water pipe	☐
installation in protective water area	☐
air pipe	☐
storage sewer	☐
others	Text input.

Types of native soil: acc. ATV-DVWK-A 127; DIN 18196 (please subsoil expertise ad)

		Native soil	backfilling	Pipe zone
G1	Non cohesive soils (gravel, sand) (GE, GW, GI, SE, SW, SI)	☐	☒	☒
G2	Slightly cohesive soils (GU, GT, SU, ST)	☒	☐	☐
G3	Cohesive mixed soils, silt (GÜ, GŤ, SÜ, SŤ, UL, UM)	☐	☐	☐
G4	Cohesive soils, except silts (TL, TM, TA, OU, OT, OH, UA)	☐	☐	☐
Other types of soil	Text input.	☐	☐	☐

Proctor density for native soil (Proctor density 85 – 100 %): 98 %

Foundation of pipeline
- ☒ On native soil
- ☐ very hard and rocky
- ☐ Weak soil, not stable for foundation

Soil replacement: thickness Text input. m
material Text input.
Proctor density D_{Pr} Text input. %

Specification of loads:

	Min. cover depth		Max. cover depth	
Depth of earth cover h	3,7	m	5,74	m
min. Ground water h_w above pipe invert	Text input.	m	Text input.	m
max. Ground water h_w above pipe invert	Text input.	m	Text input.	m

Other surface loads Text input. kN/m²

For pressure pipes
Short term: Text input. bar, e.g. system test pressure; hydrostatic pressure, water hammer
Long term: Text input. bar, e.g. operating pressure (OP), system pressure (PN, DP)

Traffic load
☐ no traffic

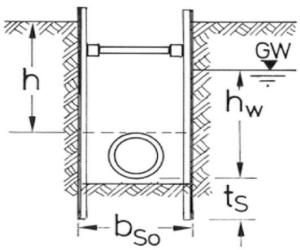
street
- ☐ HCL 60
- ☒ HCL 30
- ☐ HGV 12
- ☐ DIN EN 1991-2, TS und UDL
  - ☐ LM1-lane 3,00 m
  - ☐ LM1-lane 2,70 m
  - ☐ LM1-green field area

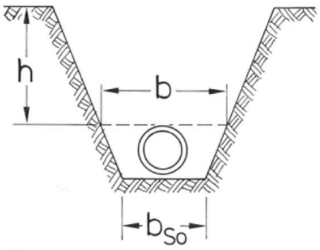
railway
- ☐ one track, UIC
- ☐ two tracks, UIC
- ☐ one track, LM 71
- ☐ two tracks, LM 71

aircraft
- ☐ BFZ 90
- ☐ BFZ 180
- ☐ BFZ 350
- ☐ BFZ 550
- ☐ BFZ 750

Other loads, e.g. special vehicle (please add load scheme with axle, wheels and wheel loads):
Text input.

Building construction:





Type of trench ☒ embankment ☐ single trench ☐ double trench [1] ☐ stepped trench [1]
[1] For special shapes add a sketch

Trench angel ☒ 90° ☐ 60° ☐ 45° ☐ Text input.

Width of trench b = 1.5 m at pipe crown

b_{So} = 1,5 m at pipe trench bottom inclusive planks

Trench planking

☐ no planks

☐ Horizontal planks, also applies to plank walls (Berlin lining)
☒ Planking with plates
☐ Vertical plank with light weight
☐ Vertical plank with boards *
☐ Vertical plank with light weight *
☐ Vertical plank with sheet piling *

bedding

☐ on native soil (acc. EN 1610)
☒ on gravel, sand
☐ on concrete [2]

[2] only as spezial construction in agreement with the pipe producer

bedding angle 2α

☐ 90° ☐ 120°
☐ 180°

* Depth of sheeting below pipe invert t_S = Text input. m

*thickness of plank (one-side) b_S = Text input. m

Cover condition for backfilling:

A1 ☐ Backfilling compacted in layers against the native soil (without proof of compaction degree); also applies to plank walls, Berlin lining

A2 ☐ Vertical pipe trench lining with boards that are not removed before backfilling. Lining boards or devices that are removed step by step during backfilling. Non-compacted backfilling/ backfilling with slurry (only suitable for soils of group G1).

A3 ☐ Vertical trench lining with sheet piling, light weight sheet connection, wooden planks, lining boards or devices that are not removed before backfilling.

A4 ☒ Backfilling compacted in layers against the native soil with proof of the required compaction degree to ZTVE-StB ; also applies to plank walls (Berlin lining). Cover condition A4 is not applicable to sails of group G4.

Bedding condition for pipe:

B1 ☒ Bedding compacted in layers against the native soil or in the embankment (without proof of compaction degree); also applies to plank walls, Berlin lining

B2 ☐ Vertical lining in the pipe zone with planks that reach down to the trench bottom and are not removed before backfilling and compaction. Lining boards or devices provided that the soil is compacted after the linings are removed.

B3 ☐ Vertical lining in the pipe zone with sheet piling or lightweight sheeting and compaction against the lining reaching down below the trench bottom. There is no safe calculation model for determining vertical lining with wooden planks, boards or devices that are not removed before backfilling and compaction the pipe zone.

B4 ☐ Bedding compacted in layers against the native soil or in the embankment with proof of the required compaction degree to ZTVE-StB. Bedding condition B4 does not apply to soils of group G4.

Structural analysis

Project:	9013 PCL 1F
Description:	GRP CC pipe DN600 PN1 SN 10.000
Contractor:	LUZ d.d Verovškova ulica 64 1000 Ljubljana Mr. Luka Kranjc (01) 36 02 473
Designer:	Josip Vrtarić Application Engineering Amiblu Alpe Adria d.o.o. Kralja Zvonimira 122, Zagreb, Croatia T +385 1 618 36 91 M +385 91 604 93 97 josip.vrtaric@amiblu.com www.amiblu.com
Calculation no.:	2025/92
Date:	19/08/2025

Content

1 Remarks 4

2 List of references 6

3 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 3,15 m 7

3.1 Input 7

3.1.1 Safety factors 7

3.1.2 Soil 7

3.1.3 Load 7

3.1.4 Installation 7

3.1.5 Pipe with nominal stiffness 8

3.2 Results 10

3.2.1 Intermediate results pipe 10

3.2.1.1 Material properties 10
3.2.1.2 Safety factors 10

3.2.2 Minimum trench width according to DIN EN 1610:2015-12 10

3.2.3 Intermediate results for load case 11

3.2.3.1 Silo Theory 11
3.2.3.2 Load 11
3.2.3.3 Soil deformation moduli EB 11
3.2.3.4 Soil stiffness values 11
3.2.3.5 Bedding angle, effective relative projection and friction angle 11
3.2.3.6 Characteristic values of pipe material and ring stiffness 11
3.2.3.7 Stiffness ratio 12
3.2.3.8 Coefficients 12
3.2.3.9 Concentration factors λR and λB 12
3.2.3.10 Pressure distribution at pipe circumference 12

3.2.4 Section forces 12

3.2.4.1 Section forces , short term 12
3.2.4.2 Section forces , long term 13

3.2.5 Short term load case 13

3.2.5.1 Strain proof 13
3.2.5.2 Deformation proof 14

3.2.6 Long term load case 14

3.2.6.1 Strain proof 14
3.2.6.2 Deformation proof 15
3.2.6.3 Stabilty proof radial, linear 15
3.2.6.4 stability proof, nonlinear 16
3.2.6.5 Proof of safety against failure with not predominantly static loading 16

4 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 5,98 m 17

4.1 Input 17

4.1.1 Safety factors 17

4.1.2 Soil 17

4.1.3 Load 17
4.1.4 Installation 17
4.1.5 Pipe with nominal stiffness 18
4.2 Results 20
4.2.1 Intermediate results pipe 20
4.2.1.1 Material properties 20
4.2.1.2 Safety factors 20
4.2.2 Minimum trench width according to DIN EN 1610:2015-12 20
4.2.3 Intermediate results for load case 21
4.2.3.1 Silo Theory 21
4.2.3.2 Load 21
4.2.3.3 Soil deformation moduli EB 21
4.2.3.4 Soil stiffness values 21
4.2.3.5 Bedding angle, effective relative projection and friction angle 21
4.2.3.6 Characteristic values of pipe material and ring stiffness 21
4.2.3.7 Stiffness ratio 22
4.2.3.8 Coefficients 22
4.2.3.9 Concentration factors λR and λB 22
4.2.3.10 Pressure distribution at pipe circumference 22
4.2.4 Section forces 22
4.2.4.1 Section forces , short term 22
4.2.4.2 Section forces , long term 23
4.2.5 Short term load case 23
4.2.5.1 Strain proof 23
4.2.5.2 Deformation proof 24
4.2.6 Long term load case 24
4.2.6.1 Strain proof 24
4.2.6.2 Deformation proof 25
4.2.6.3 Stabilty proof radial, linear 25
4.2.6.4 stability proof, nonlinear 26
4.2.6.5 Proof of safety against failure with not predominantly static loading 26
5 Appendix 27
5.1 - 28

1 Remarks

DISCLAIMER OF LIABILITY

As part of the technical service for the technical planning of projects of the Amiblu Group (hereinafter referred to as "Amiblu"), static calculations for decision-making regarding Amiblu/Flowtite/Hobas GFK pipe systems and products are regularly provided by Amiblu.

By using this free Amiblu' s technical verification service, you agree to the following terms and conditions:

1. No contractual relationship:
The use of the above mentioned Amiblu` s calculations does not constitute a contractual relationship between you and Amiblu and no consulting or information agreement is concluded. To this extent, there do not exist any contractual or quasi-contractual claims against Amiblu.

2. Requirements:
You acknowledge that the here mentioned calculations only apply to Amiblu/Flowtite/Hobas products.

3. Basis of the static calculation:
Amiblu bases the calculation according to your stated project and installation conditions and completes the missing data by itself if necessary, this to the best of its knowledge and based on the current state of knowledge and according to the requirements of the valid standards and regulations.
The trench width and installation conditions are based on the minimum requirements according to EN1610 without consideration of the trench sheet thickness (if in use). This usually represents the critical load case and is therefore on the safe side.

4. Installation specifications:
In all cases the following installation conditions must be observed for the installation of Amiblu products:

The pipe zone must be made of non-cohesive or slightly cohesive material with the quality and degree of compaction according to this calculation. The maximum grain size according to the Amiblu/Flowtite/Hobas installation instructions for buried pipes and shafts have to be observed.
To classify the bedding material, all the material in the pipeline zone has to pass through a sieve with a mesh size as specified in the installation instructions.

The pipe bedding must be at least 100 mm thick and have the specified support angle according to the static calculation. We recommend that the requirements for the pipe bedding according to EN 1610.

The degree of compaction of the pipe zone and backfill must meet or exceed the requirements of the static calculation. The installation conditions should be checked and documented. The pipe zone ends 300 mm above the pipe crown.

The quality and degree of compaction of the backfill, the existing soil and the pipeline zone must be checked and needs to meet the requirements of this static evaluation.

For the static calculation compliance with the applicable international standards and installation instructions for Amiblu/Flowtite/Hobas products is assumed. The installation instructions for Amiblu/Flowtite/Hobas can be downloaded from our homepages: http://www.flowtite.com or http://www.hobas.com or http://www.amiblu.com.

The installation conditions used for the static calculation should be compared by you or an expert engineer or the project planner with the actual conditions on site. Potential deviations may have an influence on the pipe installation.

5. Disclaimer:
The services provided are subject to Amiblu's General Conditions of Sale, insofar applicable.

The results of the calculation can only be obtained in practice if the assumptions correspond to the real construction conditions on site.

The static calculations were carried out reliably and carefully according to the professional opinion of Amiblu.

Amiblu accept liability for the static calculation carried out on the basis of customer specifications, such as e.g. contents from structural analysis forms, specifications for planning and execution, information on ground condition as well as installation and/or operation. Amiblu does not accept any liability for the correctness and completeness of the specific customer specifications.

The static calculations prepared by Amiblu are a service in the design or execution phase and usually become part of the project documentation. Amiblu assumes no liability for the applicability of the calculation results in case of deviations from the underlying assumptions.

Rev03 11/04/2023

2 List of references

DIN 4124 - Excavations and Trenches - Slopes, planking and strutting, breadths of working space: October 2002

EN 1610 - Construction and testing of drains and sewers: December 2015

EN 805 - Water Supply Requirements for systems and components outside of buildings: March 2000

EN 1992-2 - Eurocode 2: Eurocode 1: Actions on structures Part 2: Traffic loads on bridges (consolidated version): March. 2012

EN 1796 - Plastics piping systems for water supply with or without pressure - Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP): March 2013

EN 14364 - Plastics piping systems for drainage and sewerage with or without pressure – Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP): Mai 2013

EN 15383 - Plastics piping systems for drainage and sewerage - Glass- reinforced thermosetting plastics (GRP) based on polyester resin (UP) - Manholes and inspection chambers: March 2013

ISO 16611 Plastics piping systems for drainage and sewerage without pressure - Non-circular pipes and joints made of glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resins (UP) - Dimensions, requirements and tests: June 2017

ISO 25780 - Plastics piping systems for pressure and non-pressure water supply, irrigation, drainage or sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin — Pipes with flexible joints intended to be installed using jacking techniques: Mai 2011

Worksheet DWA-A127 - Structural verification of sewer channels and pipe lines, 3. corrected Issue: August 2000

3 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 3,15 m

Caption of this part of the calculation:	Cover 3,15 m
Kind of calculation:	Nominal stiffness
Add sketch to print:	Yes

3.1 Input

3.1.1 Safety factors

Safety class:	A (normal case)
Safety stability according to table 13:	Without predeformation (2.5 / 2.0)
Allowable deflection:	6% (standard)
Treatment of internal pressure:	In accordance with Footnote 39 in ATV-DVWK-A 127
Lower safety factors for flexural compression:	No (ATV-DVWK-A 127)
Proof for not predominantly static loading:	According to standard
Consideration of dyn pvh*:	According to standard
Consideration of Type A 'predeformation' in the deformation proof:	Yes
Treatment system stiffness VRB according to:	DWA-A 161:2014 (by material)
Pipe stiffness according to set of rules:	Yes

3.1.2 Soil

Soil group backfill:	G1		
Calculation E1:	Table 8 (A127)		
Soil group pipe zone:	G1		
Calculation E20:	Table 8 (A127)		
Soil group native soil:	G2		
Calculation E3:	Degree of compaction		
Compaction degree E3:	$D_{Pr,E3}$	98.0	%
E4 = 10 · E1:	Yes		
Application of silo theory:	Automatic		
K2 according to standard:	Yes		

3.1.3 Load

Cover depth:	h	3.15	m
Minimum groundwater level above pipe bed:	$h_{W,min}$	0.00	m
Maximum groundwater level above pipe bed:	$h_{W,max}$	0.00	m
Soil density:	γ_B	20.0	kN/m³
Additional surface load:	p_0	0.0	kN/m²
Inner pressure, short term:	$P_{I,K}$	0.00	bar
Inner pressure, long term:	$P_{I,L}$	0.00	bar
Water fill (e.g. damming channel):	Yes		
Density of medium:	γ_F	10.0	kN/m³
Input special-purpose vehicle:	No		
Traffic load:	Street HGV 30 (with road construction)		
Including horizontal loads due to traffic in the fatigue proof:	$\alpha_{qhT,dyn}$	0.00	%

3.1.4 Installation

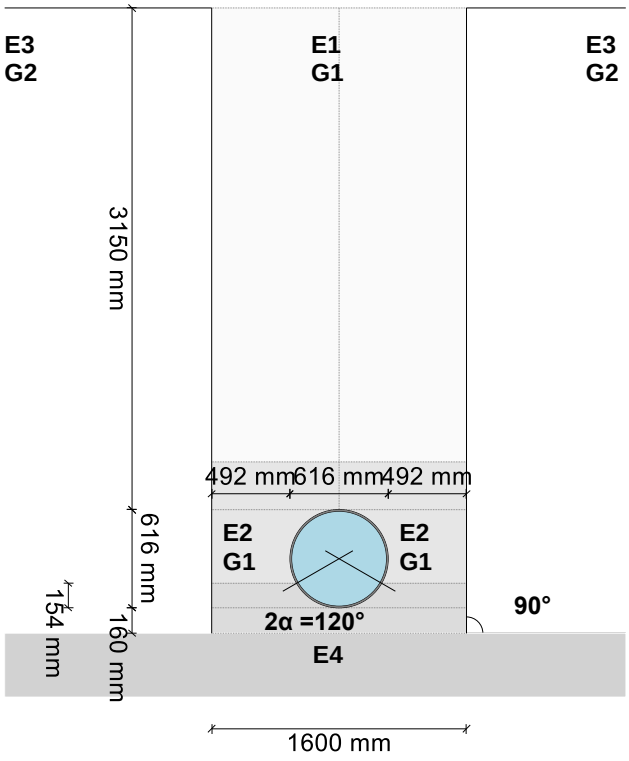
Installation:	Trench		
Trench width at pipe crown level:	b	1.60	m
Check minimum trench width:	Yes		
Automatic consideration of bedding layer:	Yes		

Slope angle:	ß	90	°
Cover condition:	A4		
Installation condition:	B1		
Type of bedding:	Loose		
Bedding angle:	120°		
Calculate bedding automatically:	Yes		
Set lower height base:	No		
Total height of base:	h_s	0.00	m

3.1.5 Pipe with nominal stiffness

Pipe chosen from datebase:	No		
Choice of input:	Do - s		
Outer diameter:	d_a	616	mm
Nominal diameter:	DN	600	mm
Wall thickness:	t	13.0	mm
Local predeformation:	$\delta_{v,I}$	0.0	%
A type predeformation:	$\delta_{v,A}$	1.0	%
Nominal stiffness:	SN	10,000	N/m²
Nominal pressure:	PN	1.0	bar
Relative failure strain according to standard:	Yes		
Creep ratio:	f_{Kriech}	2.00	[-]
Reduction factor due to temperature effect:	$A_{1,Temp}$	1.00	[-]
Reduction factor due to media attack:	$A_{2,Medium}$	1.00	[-]
Reduction factor due to dynamic loading:	$A_{3,dyn}$	1.00	[-]
Specific gravity:	γ_R	18.00	kN/m³
Poissons ratio:	v	0.30	[-]
Input of ultimate hoop tensile stress:	No		
Ultimate strain tensile strength according to standard:	Yes		
Amplitude with 2·10^6 tests is known:	Yes		
Amplitude with 2·10^6 tests:	$\Delta\sigma_{rsk,2E6}$	36.00	N/mm²
Amplitude with 1·10^8 tests is known:	Yes		
Amplitude of the pipe with 1·10^8 tests:	$\Delta\sigma_{rsk,1E8}$	24.00	N/mm²
Axial compressive strength, short term:	$f_{c,ax,K}$	90.0	N/mm²
Fiber strain for axial pressure, short term:	ε_{AxK}	1.0	%

Traffic load: Street HGV 30 (with road construction)



3.2 Results

3.2.1 Intermediate results pipe

Inner diameter:	d_i	590.0	mm
Outer diameter:	d_a	616.0	mm
Mean radius:	r_m	301.50	mm
Wall thickness:	s	13.00	mm
Ratio radius to wall thickness:	r_m/s	23.192	[-]
Curve correction factor, internal:	α_{ki}	1.014	[-]
Curve correction factor, external:	α_{ka}	0.986	[-]
Local predeformation:	$\delta_{v,I}$	0.00	%
Predeformation (ovalisation before load):	$\delta_{v,A}$	1.00	%
Radial cross section:	A_{rad}	13.00	mm²/mm
Distance of inertia:	e	6.50	mm
Moment of inertia:	I	183.08	mm^4/mm
Outer moment of resistance:	W_a	28.17	mm³/mm
Inner moment of resistance:	W_i	28.17	mm³/mm
Surface ratio:	κ_Q	1.2	[-]

3.2.1.1 Material properties

		short term	long term	
Specific gravity	γ_R	18.0	18.0	kN/m³
Poissons ratio	v	0.30	0.30	[-]
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	11,975.8	5,987.9	N/mm²
Creep ratio:	f_{creep}		2.00	[-]

Table 3 of ATV DVWK-A 127, footnote 34:
Determined from the momentary value and the creep ratio (2) with characteristic values for 2 years for the description of the long term behauvior. Also permitted for the long term verification for 50 years. Tests take place in accordance with DIN EN 1228 (momentary) and DIN EN 1225 (long term).

Characteristic value of relative fracture deformation	$\Delta d_{Bruch}/d_m$	15.0	9.0	%

$\varepsilon_R = 4.28 \cdot s/d_m \cdot \Delta d_{Bruch}/d_m$

Characteristic value of ultimate strain for edge fibers	ε_R	1.384	0.830	%

$$f_t = \frac{0.50 \cdot PN \cdot 4 \cdot 2 \cdot r_m}{h}$$

Characteristic value of hoop tensile strength	f_t	9.3	4.6	N/mm²
Amplitude for 2·10^6 load cycles:	$\Delta\sigma_{rsk,2E6}$		n. def	N/mm²
Amplitude at 5·10^6 load cycles:	$\Delta\sigma_{rsk,5E6}$		n. def	N/mm²
Amplitude for 1·10^8 cycles:	$\Delta\sigma_{rsk,1E8}$		n. def	N/mm²

3.2.1.2 Safety factors

Required safety coefficient, bending tensile stress	erf γ_{RBZ}	2.00	2.00	[-]
Required safety coefficient, bending compressive stress	erf γ_{RBD}	2.00	2.00	[-]
Required safety coefficient, instability (buckling)	erf γ_{stab}	2.50	2.50	[-]

3.2.2 Minimum trench width according to DIN EN 1610:2015-12

Nominal diameter:	DN	600	mm
Outer diameter:	d_a	616.0	mm
Size of the bedding layer:	a	0.16	m
Minimum width at trench sole level (incl. x) according to table 1:	$min_{b,T1}$	1.32	m
Minimum width according to table 2:	$min_{b,T2}$	0.90	m

Minimum clear width at trench sole level:	$min_{b,G}$	1.32	m
Required width at pipe crown level:	$min_{b,R}$	1.31	m
Trench width at pipe crown level:	b	1.60	m

The minimum trench width at trench sole level according DIN EN 1610 is met.

3.2.3 Intermediate results for load case

3.2.3.1 Silo Theory

Soil load coefficient κ for trench load (Silo Theory):	κ	1.000	[-]
Soil load coefficient κ0 for surface load (Silo Theory):	$κ_0$	1.000	[-]

κ0 and κ are set to 1, because E1 is larger then E3.

3.2.3.2 Load

Maximum groundwater level above pipe crown:	$h_{W,Scheitel}$	0.00	m
Vertical soil stress from soil load:	P_{Erd}	63.00	kN/m²
Vertical soil stress from soil and surface load:	P_E	63.00	kN/m²
Stress due to traffic load:	P_V	11.54	kN/m²
Included impact factor:	ϕ	1.40	[-]

3.2.3.3 Soil deformation moduli EB

Backfill elastic modulus under load:	$E_{1,σ}$	23.00	N/mm²

$$E_{3,\sigma} = \frac{40}{2} \cdot e^{-0.188(100 - D_{Pr})} \qquad 3.01$$

Native soil elastic modulus:	$E_{3,σ}$	13.73	N/mm²
Bedding elastic modulus (reduced):	$E_{2,σ}$	13.51	N/mm²
Bedding elastic modulus under load:	$E_{20,σ}$	16.00	N/mm²
Reduction factor for creep:	f_1	1.000	[-]
Reduction factor E20 (groundwater):	f_2	1.000	[-]
Reduction factor E20 (Diagram 5):	$α_{B0}$	0.667	[-]
Reduction factor E20 (narrow trench):	$α_B$	0.844	[-]
Bedding elastic modulus (reduced):	$E_{2,σ}$	13.51	N/mm²
Elastic modulus of soil under pipe:	$E_{4,σ}$	230.00	N/mm²

3.2.3.4 Soil stiffness values

Auxiliary value for horizontal bedding stiffness:	$Δ_f$	1.114	[-]
Correction factor for horizontal bedding stiffness:	ζ	1.005	[-]
Horizontal bedding stiffness:	S_{Bh}	8.148	N/mm²
Vertical bedding stiffness:	S_{Bv}	13.506	N/mm²

3.2.3.5 Bedding angle, effective relative projection and friction angle

Bedding angle, effective relative projection and friction angle:	2α	120	°
Height bedding from bedding angle to lower pipe ledge:	t_r	0.154	m
Calculated relative projection:	a	1.00	[-]
Effective relative projection:	a'	1.703	[-]
Internal friction angle:	φ'	30.000	°
Wall friction angle:	δ	30.000	°

3.2.3.6 Characteristic values of pipe material and ring stiffness

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Pipe stiffness	S_R	80,000	46,194	40,000	N/m²
Characteristic value of ultimate strain for edge fibers	$ε_R$	1.384	0.916	0.830	%
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	11,975.8	6,915.1	5,987.9	N/mm²

3.2.3.7 Stiffness ratio

System stiffness, weighted	$V_{RB,w}$	0.0098	0.0057	0.0049	[-]
Stiffness ratio	V_S	0.4264	0.3596	---	[-]
Coefficient for vertical deformation	c_v*	-0.014	-0.010	---	[-]

3.2.3.8 Coefficients

Ground pressure ratio (bedding)	K_2	0.400	0.400	---	[-]
Coefficient for bedding reaction pressure	K*	1.178	1.247	---	[-]
Resulting deformation coefficient	c'_h	0.0891	0.0891	---	[-]
Resulting deformation coefficient	$c'_{h,qh}$*	-0.0658	-0.0658	---	[-]
Coefficient for vertical deformation	c_v*	-0.014	-0.010	---	[-]

3.2.3.9 Concentration factors λR and λB

Maximum concentration factor	max λ	2.104	2.104	---	[-]
Coefficient for maximum concentration factor	K'	0.921	0.915	---	[-]
Concentration factor above pipe, initial value	λ_R	0.816	0.766	---	[-]
Concentration factor above pipe, under trench effect	λ_{RG}	0.902	0.876	---	[-]
Concentration factor above pipe, upper limit	λ_{fo}	3.528	3.528	---	[-]
Concentration factor above pipe, lower limit	λ_{fu}	0.321	0.321	---	[-]
Concentration factor above pipe, final value	λ_{RG}	0.902	0.876	---	[-]
Soil concentration factor	λ_B	1.061	1.078	---	[-]

3.2.3.10 Pressure distribution at pipe circumference

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Total vertical load	q_v	68.36	66.70	---	kN/m²
Lateral pressure	q_h	29.21	29.63	---	kN/m²
Bedding reaction pressure (soil load)	q^*_h	48.37	48.63	---	kN/m²
Bedding reaction pressure (water filling)	q^*_{hw}	2.85	3.05	---	kN/m²

3.2.4 Section forces

3.2.4.1 Section forces , short term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	301.50	301.50	301.50	mm
Moment due to total vertical load	M_{qv}	1.622	-1.647	1.709	kNm/m
Moment due to lateral pressure	M_{qh}	-0.664	0.664	-0.664	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-0.796	0.915	-0.796	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.047	0.054	-0.047	kNm/m
Moment due to dead weight	M_g	0.008	-0.009	0.011	kNm/m
Moment due to water filling	M_w	0.052	-0.060	0.071	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.175	-0.084	0.285	kNm/m
		crown	springline	invert	
Mean radius	r_m	301.50	301.50	301.50	mm
Normal force due to total vertical load	N_{qv}	0.557	-20.611	-0.557	kN/m
Normal force due to lateral pressure	N_{qh}	-8.807	0.000	-8.807	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-8.415	0.000	-8.415	kN/m

Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.497	0.000	-0.497	kN/m
Normal force due to dead weight	N_g	0.018	-0.111	-0.018	kN/m
Normal force due to water filling	N_w	0.568	0.195	1.250	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-16.577	-20.527	-17.043	kN/m

3.2.4.2 Section forces , long term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	301.50	301.50	301.50	mm
Moment due to total vertical load	M_{qv}	1.583	-1.607	1.667	kNm/m
Moment due to lateral pressure	M_{qh}	-0.673	0.673	-0.673	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-0.800	0.919	-0.800	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.050	0.058	-0.050	kNm/m
Moment due to dead weight	M_g	0.008	-0.009	0.011	kNm/m
Moment due to water filling	M_w	0.052	-0.060	0.071	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.119	-0.026	0.226	kNm/m

		crown	springline	invert	
Mean radius	r_m	301.50	301.50	301.50	mm
Normal force due to total vertical load	N_{qv}	0.543	-20.111	-0.543	kN/m
Normal force due to lateral pressure	N_{qh}	-8.932	0.000	-8.932	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-8.460	0.000	-8.460	kN/m
Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.531	0.000	-0.531	kN/m
Normal force due to dead weight	N_g	0.018	-0.111	-0.018	kN/m
Normal force due to water filling	N_w	0.568	0.195	1.250	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-16.794	-20.027	-17.234	kN/m

3.2.5 Short term load case

3.2.5.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh^*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh^*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:			α_{ki}	1.014	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.038	-0.034	0.064	%
Strain due to other loads	ε_{sonst}	0.004	-0.005	0.011	%

Total strain	ε	0.042	-0.038	0.075	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.38	1.38	1.38	%
Safety coefficient flexural tension:	γ_{BZ}	32.870	---	18.546	[-]
Safety coefficient flexural compression:	γ_{BD}	---	35.991	---	[-]

outside

Curve correction factor, external:			α_{ka}	0.986	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	$\varepsilon_{qv,qh,qh*}$	-0.058	0.007	-0.084	%
Strain due to other loads	ε_{sonst}	-0.004	0.005	-0.010	%
Total strain	ε	-0.062	0.011	-0.094	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.38	1.38	1.38	%
Safety coefficient flexural tension:	γ_{BZ}	---	121.726	---	[-]
Safety coefficient flexural compression:	γ_{BD}	22.357	---	14.709	[-]

All calculated safety coefficients of the strain proof are sufficient.

3.2.5.2 Deformation proof

Calculation mode:			linear		
Ratio:			I/(A·rm²)	0.00015	[-]
Ratio 'I/(A·rm²)·κ~Q':			$I/(A \cdot rm^2) \cdot \kappa_Q$	0.00019	[-]
		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	4.34	mm
Horizontal diameter change:	Δd_h	3.58	mm

Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	0.72	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	1.72	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

3.2.6 Long term load case

3.2.6.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:	α_{ki}	1.014	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.038	-0.030	0.081	%
Strain due to other loads	ε_{sonst}	0.006	-0.007	0.020	%
Total strain	ε	0.044	-0.037	0.101	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	0.91	0.90	0.90	%
Safety coefficient flexural tension:	γ_{BZ}	20.497	---	8.891	[-]
Safety coefficient flexural compression:	γ_{BD}	---	24.501	---	[-]

outside

Curve correction factor, external:			α_{ka}	0.986	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	-0.074	-0.015	-0.118	%
Strain due to other loads	ε_{sonst}	-0.006	0.007	-0.018	%
Total strain	ε	-0.080	-0.008	-0.136	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	0.91	0.89	0.91	%
Safety coefficient flexural tension:	γ_{BZ}	---	---	---	[-]
Safety coefficient flexural compression:	γ_{BD}	11.420	109.489	6.662	[-]

All calculated safety coefficients of the strain proof are sufficient.

3.2.6.2 Deformation proof

Calculation mode:			linear		
Ratio:			I/(A·rm²)	0.00015	[-]
Ratio 'I/(A·rm²)·κ~Q':			I/(A·rm²)·κ_Q	0.00019	[-]

		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	4.92	mm
Horizontal diameter change:	Δd_h	3.60	mm
Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	0.82	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	1.82	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

3.2.6.3 Stabilty proof radial, linear

Earth and traffic loads

Pipe stiffness:	$\bar{S}_R$	46,194	N/m²
Horizontal bedding stiffness:	S_{Bh}	8.148	N/mm²
System stiffness, weighted:	$V_{RB,w}$	0.0057	[-]
Reduction factor buckling load for earth/traffic loads:	κ_{v2}	0.87	[-]
Friction angle in bedding zone:	φ'_2	35.000	°
Critical vertical total load:	krit q_v	1,070.4	kN/m²
Total vertical load:	q_v	66.70	kN/m²
Safety stability, radial:	$\gamma_{Stab,rad}$	16.05	[-]
Required safety coefficient, instability (buckling):	erf γ_{stab}	2.50	[-]

The buckling proof is fulfilled.

3.2.6.4 stability proof, nonlinear

The nonlinear stability proof is not applicable because of VRB > 1.0 (rigid pipe) or relative vertical deformation < 6%.

3.2.6.5 Proof of safety against failure with not predominantly static loading

According to the standard the dynamic proof is not required (e.g. traffic load > 1,5 m).

All necessary proofs are ok.

4 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 5,98 m

Caption of this part of the calculation:	Cover 5,98 m
Kind of calculation:	Nominal stiffness
Add sketch to print:	Yes

4.1 Input

4.1.1 Safety factors

Safety class:	A (normal case)
Safety stability according to table 13:	Without predeformation (2.5 / 2.0)
Allowable deflection:	6% (standard)
Treatment of internal pressure:	In accordance with Footnote 39 in ATV-DVWK-A 127
Lower safety factors for flexural compression:	No (ATV-DVWK-A 127)
Proof for not predominantly static loading:	According to standard
Consideration of dyn pvh*:	According to standard
Consideration of Type A 'predeformation' in the deformation proof:	Yes
Treatment system stiffness VRB according to:	DWA-A 161:2014 (by material)
Pipe stiffness according to set of rules:	Yes

4.1.2 Soil

Soil group backfill:	G1		
Calculation E1:	Table 8 (A127)		
Soil group pipe zone:	G1		
Calculation E20:	Table 8 (A127)		
Soil group native soil:	G2		
Calculation E3:	Degree of compaction		
Compaction degree E3:	$D_{Pr,E3}$	98.0	%
E4 = 10 · E1:	Yes		
Application of silo theory:	Automatic		
K2 according to standard:	Yes		

4.1.3 Load

Cover depth:	h	5.98	m
Minimum groundwater level above pipe bed:	$h_{W,min}$	0.00	m
Maximum groundwater level above pipe bed:	$h_{W,max}$	0.00	m
Soil density:	γ_B	20.0	kN/m³
Additional surface load:	p_0	0.0	kN/m²
Inner pressure, short term:	$P_{I,K}$	0.00	bar
Inner pressure, long term:	$P_{I,L}$	0.00	bar
Water fill (e.g. damming channel):	Yes		
Density of medium:	γ_F	10.0	kN/m³
Input special-purpose vehicle:	No		
Traffic load:	Street HGV 30 (with road construction)		
Including horizontal loads due to traffic in the fatigue proof:	$\alpha_{qhT,dyn}$	0.00	%

4.1.4 Installation

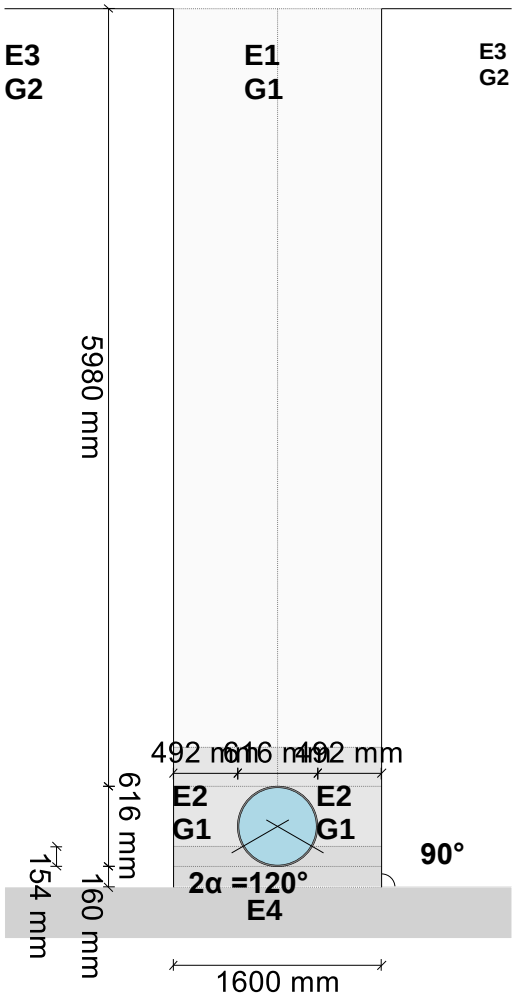
Installation:	Trench		
Trench width at pipe crown level:	b	1.60	m
Check minimum trench width:	Yes		
Automatic consideration of bedding layer:	Yes		

Slope angle:	ß	90	°
Cover condition:	A4		
Installation condition:	B1		
Type of bedding:	Loose		
Bedding angle:	120°		
Calculate bedding automatically:	Yes		
Set lower height base:	No		
Total height of base:	h_s	0.00	m

4.1.5 Pipe with nominal stiffness

Pipe chosen from datebase:	No		
Choice of input:	Do - s		
Outer diameter:	d_a	616	mm
Nominal diameter:	DN	600	mm
Wall thickness:	t	13.0	mm
Local predeformation:	$\delta_{v,I}$	0.0	%
A type predeformation:	$\delta_{v,A}$	1.0	%
Nominal stiffness:	SN	10,000	N/m²
Nominal pressure:	PN	1.0	bar
Relative failure strain according to standard:	Yes		
Creep ratio:	f_{Kriech}	2.00	[-]
Reduction factor due to temperature effect:	$A_{1,Temp}$	1.00	[-]
Reduction factor due to media attack:	$A_{2,Medium}$	1.00	[-]
Reduction factor due to dynamic loading:	$A_{3,dyn}$	1.00	[-]
Specific gravity:	γ_R	18.00	kN/m³
Poissons ratio:	v	0.30	[-]
Input of ultimate hoop tensile stress:	No		
Ultimate strain tensile strength according to standard:	Yes		
Amplitude with 2·10^6 tests is known:	Yes		
Amplitude with 2·10^6 tests:	$\Delta\sigma_{rsk,2E6}$	36.00	N/mm²
Amplitude with 1·10^8 tests is known:	Yes		
Amplitude of the pipe with 1·10^8 tests:	$\Delta\sigma_{rsk,1E8}$	24.00	N/mm²
Axial compressive strength, short term:	$f_{c,ax,K}$	90.0	N/mm²
Fiber strain for axial pressure, short term:	ε_{AxK}	1.0	%

Traffic load: Street HGV 30 (with road construction)



4.2 Results

4.2.1 Intermediate results pipe

Inner diameter:	d_i	590.0	mm
Outer diameter:	d_a	616.0	mm
Mean radius:	r_m	301.50	mm
Wall thickness:	s	13.00	mm
Ratio radius to wall thickness:	r_m/s	23.192	[-]
Curve correction factor, internal:	α_{ki}	1.014	[-]
Curve correction factor, external:	α_{ka}	0.986	[-]
Local predeformation:	$\delta_{v,I}$	0.00	%
Predeformation (ovalisation before load):	$\delta_{v,A}$	1.00	%
Radial cross section:	A_{rad}	13.00	mm²/mm
Distance of inertia:	e	6.50	mm
Moment of inertia:	I	183.08	mm^4/mm
Outer moment of resistance:	W_a	28.17	mm³/mm
Inner moment of resistance:	W_i	28.17	mm³/mm
Surface ratio:	κ_Q	1.2	[-]

4.2.1.1 Material properties

		short term	long term	
Specific gravity	γ_R	18.0	18.0	kN/m³
Poissons ratio	v	0.30	0.30	[-]
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	11,975.8	5,987.9	N/mm²
Creep ratio:		f_{creep}	2.00	[-]

Table 3 of ATV DVWK-A 127, footnote 34:
Determined from the momentary value and the creep ratio (2) with characteristic values for 2 years for the description of the long term behauvior. Also permitted for the long term verification for 50 years. Tests take place in accordance with DIN EN 1228 (momentary) and DIN EN 1225 (long term).

Characteristic value of relative fracture deformation	$\Delta d_{Bruch}/d_m$	15.0	9.0	%

$$\varepsilon_R = 4.28 \cdot s/d_m \cdot \Delta d_{Bruch}/d_m$$

Characteristic value of ultimate strain for edge fibers	ε_R	1.384	0.830	%

$$f_t = \frac{0.50 \cdot PN \cdot 4 \cdot 2 \cdot r_m}{h}$$

Characteristic value of hoop tensile strength	f_t	9.3	4.6	N/mm²
Amplitude for 2·10^6 load cycles:		$\Delta\sigma_{rsk,2E6}$	n. def	N/mm²
Amplitude at 5·10^6 load cycles:		$\Delta\sigma_{rsk,5E6}$	n. def	N/mm²
Amplitude for 1·10^8 cycles:		$\Delta\sigma_{rsk,1E8}$	n. def	N/mm²

4.2.1.2 Safety factors

Required safety coefficient, bending tensile stress	erf γ_{RBZ}	2.00	2.00	[-]
Required safety coefficient, bending compressive stress	erf γ_{RBD}	2.00	2.00	[-]
Required safety coefficient, instability (buckling)	erf γ_{stab}	2.50	2.50	[-]

4.2.2 Minimum trench width according to DIN EN 1610:2015-12

Nominal diameter:	DN	600	mm
Outer diameter:	d_a	616.0	mm
Size of the bedding layer:	a	0.16	m
Minimum width at trench sole level (incl. x) according to table 1:	$min_{b,T1}$	1.32	m
Minimum width according to table 2:	$min_{b,T2}$	1.00	m

Minimum clear width at trench sole level:	$min_{b,G}$	1.32	m
Required width at pipe crown level:	$min_{b,R}$	1.31	m
Trench width at pipe crown level:	b	1.60	m

The minimum trench width at trench sole level according DIN EN 1610 is met.

4.2.3 Intermediate results for load case

4.2.3.1 Silo Theory

Soil load coefficient κ for trench load (Silo Theory):	κ	1.000	[-]
Soil load coefficient κ0 for surface load (Silo Theory):	$κ_0$	1.000	[-]

κ0 and κ are set to 1, because E1 is larger then E3.

4.2.3.2 Load

Maximum groundwater level above pipe crown:	$h_{W,Scheitel}$	0.00	m
Vertical soil stress from soil load:	P_{Erd}	119.60	kN/m²
Vertical soil stress from soil and surface load:	P_E	119.60	kN/m²
Stress due to traffic load:	P_V	4.68	kN/m²
Included impact factor:	ϕ	1.40	[-]

4.2.3.3 Soil deformation moduli EB

Backfill elastic modulus under load:	$E_{1,σ}$	23.00	N/mm²

$$E_{3,\sigma} = \frac{40}{2} \cdot e^{-0.188(100 - D_{Pr})} \qquad 3.01$$

Native soil elastic modulus:	$E_{3,σ}$	13.73	N/mm²
Bedding elastic modulus (reduced):	$E_{2,σ}$	13.51	N/mm²
Bedding elastic modulus under load:	$E_{20,σ}$	16.00	N/mm²
Reduction factor for creep:	f_1	1.000	[-]
Reduction factor E20 (groundwater):	f_2	1.000	[-]
Reduction factor E20 (Diagram 5):	$α_{B0}$	0.667	[-]
Reduction factor E20 (narrow trench):	$α_B$	0.844	[-]
Bedding elastic modulus (reduced):	$E_{2,σ}$	13.51	N/mm²
Elastic modulus of soil under pipe:	$E_{4,σ}$	230.00	N/mm²

4.2.3.4 Soil stiffness values

Auxiliary value for horizontal bedding stiffness:	$Δ_f$	1.114	[-]
Correction factor for horizontal bedding stiffness:	ζ	1.005	[-]
Horizontal bedding stiffness:	S_{Bh}	8.148	N/mm²
Vertical bedding stiffness:	S_{Bv}	13.506	N/mm²

4.2.3.5 Bedding angle, effective relative projection and friction angle

Bedding angle, effective relative projection and friction angle:	2α	120	°
Height bedding from bedding angle to lower pipe ledge:	t_r	0.154	m
Calculated relative projection:	a	1.00	[-]
Effective relative projection:	a'	1.703	[-]
Internal friction angle:	φ'	30.000	°
Wall friction angle:	δ	30.000	°

4.2.3.6 Characteristic values of pipe material and ring stiffness

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Pipe stiffness	S_R	80,000	41,506	40,000	N/m²
Characteristic value of ultimate strain for edge fibers	$ε_R$	1.384	0.851	0.830	%
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	11,975.8	6,213.3	5,987.9	N/mm²

4.2.3.7 Stiffness ratio

System stiffness, weighted	$V_{RB,w}$	0.0098	0.0051	0.0049	[-]
Stiffness ratio	V_S	0.4264	0.3467	---	[-]
Coefficient for vertical deformation	c_v*	-0.014	-0.009	---	[-]

4.2.3.8 Coefficients

Ground pressure ratio (bedding)	K_2	0.400	0.400	---	[-]
Coefficient for bedding reaction pressure	K*	1.178	1.257	---	[-]
Resulting deformation coefficient	c'_h	0.0891	0.0891	---	[-]
Resulting deformation coefficient	$c'_{h,qh}$*	-0.0658	-0.0658	---	[-]
Coefficient for vertical deformation	c_v*	-0.014	-0.009	---	[-]

4.2.3.9 Concentration factors λR and λB

Maximum concentration factor	max λ	2.425	2.425	---	[-]
Coefficient for maximum concentration factor	K'	0.921	0.914	---	[-]
Concentration factor above pipe, initial value	λ_R	0.806	0.745	---	[-]
Concentration factor above pipe, under trench effect	λ_{RG}	0.897	0.864	---	[-]
Concentration factor above pipe, upper limit	λ_{fo}	3.103	3.103	---	[-]
Concentration factor above pipe, lower limit	λ_{fu}	0.178	0.178	---	[-]
Concentration factor above pipe, final value	λ_{RG}	0.897	0.864	---	[-]
Soil concentration factor	λ_B	1.065	1.085	---	[-]

4.2.3.10 Pressure distribution at pipe circumference

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Total vertical load	q_v	111.91	108.05	---	kN/m²
Lateral pressure	q_h	53.40	54.37	---	kN/m²
Bedding reaction pressure (soil load)	q^*_h	73.04	71.92	---	kN/m²
Bedding reaction pressure (water filling)	q^*_{hw}	2.85	3.05	---	kN/m²

4.2.4 Section forces

4.2.4.1 Section forces , short term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	301.50	301.50	301.50	mm
Moment due to total vertical load	M_{qv}	2.655	-2.696	2.798	kNm/m
Moment due to lateral pressure	M_{qh}	-1.214	1.214	-1.214	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-1.202	1.381	-1.202	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.047	0.054	-0.047	kNm/m
Moment due to dead weight	M_g	0.008	-0.009	0.011	kNm/m
Moment due to water filling	M_w	0.052	-0.060	0.071	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.253	-0.117	0.418	kNm/m
		crown	springline	invert	
Mean radius	r_m	301.50	301.50	301.50	mm
Normal force due to total vertical load	N_{qv}	0.911	-33.742	-0.911	kN/m
Normal force due to lateral pressure	N_{qh}	-16.100	0.000	-16.100	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-12.707	0.000	-12.707	kN/m

Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.497	0.000	-0.497	kN/m
Normal force due to dead weight	N_g	0.018	-0.111	-0.018	kN/m
Normal force due to water filling	N_w	0.568	0.195	1.250	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-27.806	-33.657	-28.982	kN/m

4.2.4.2 Section forces , long term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	301.50	301.50	301.50	mm
Moment due to total vertical load	M_{qv}	2.564	-2.603	2.701	kNm/m
Moment due to lateral pressure	M_{qh}	-1.236	1.236	-1.236	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-1.183	1.360	-1.183	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.050	0.058	-0.050	kNm/m
Moment due to dead weight	M_g	0.008	-0.009	0.011	kNm/m
Moment due to water filling	M_w	0.052	-0.060	0.071	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.155	-0.019	0.314	kNm/m

		crown	springline	invert	
Mean radius	r_m	301.50	301.50	301.50	mm
Normal force due to total vertical load	N_{qv}	0.880	-32.578	-0.880	kN/m
Normal force due to lateral pressure	N_{qh}	-16.392	0.000	-16.392	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-12.512	0.000	-12.512	kN/m
Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.531	0.000	-0.531	kN/m
Normal force due to dead weight	N_g	0.018	-0.111	-0.018	kN/m
Normal force due to water filling	N_w	0.568	0.195	1.250	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-27.969	-32.493	-29.082	kN/m

4.2.5 Short term load case

4.2.5.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh^*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh^*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:			α_{ki}	1.014	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.054	-0.052	0.096	%
Strain due to other loads	ε_{sonst}	0.004	-0.005	0.011	%

Total strain	ε	0.058	-0.057	0.107	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.38	1.38	1.38	%
Safety coefficient flexural tension:	γ_{BZ}	23.761	---	12.938	[-]
Safety coefficient flexural compression:	γ_{BD}	---	24.368	---	[-]

outside

Curve correction factor, external:			α_{ka}	0.986	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	-0.088	0.008	-0.131	%
Strain due to other loads	ε_{sonst}	-0.004	0.005	-0.010	%
Total strain	ε	-0.092	0.013	-0.141	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.38	1.38	1.38	%
Safety coefficient flexural tension:	γ_{BZ}	---	110.150	---	[-]
Safety coefficient flexural compression:	γ_{BD}	15.075	---	9.840	[-]

All calculated safety coefficients of the strain proof are sufficient.

4.2.5.2 Deformation proof

Calculation mode:			linear		
Ratio:			I/(A·rm²)	0.00015	[-]
Ratio 'I/(A·rm²)·κ~Q':			$I/(A \cdot rm^2) \cdot \kappa_Q$	0.00019	[-]
		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:			Δd_v	6.56	mm
Horizontal diameter change:			Δd_h	5.41	mm
Relative vertical deformation (due to loads, elastic, Type B):			$\delta_{v,B}$	1.09	%
Predeformation (e. g. due to manufacturing, plastic, Type A):			$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):			$\delta_{v,Ges}$	2.09	%
Allowable deflection:			zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

4.2.6 Long term load case

4.2.6.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh^*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh^*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:			α_{ki}	1.014	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.049	-0.045	0.127	%
Strain due to other loads	ε_{sonst}	0.006	-0.007	0.020	%
Total strain	ε	0.055	-0.052	0.147	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	0.85	0.85	0.85	%
Safety coefficient flexural tension:	γ_{BZ}	15.363	---	5.775	[-]
Safety coefficient flexural compression:	γ_{BD}	---	16.391	---	[-]

outside

Curve correction factor, external:			α_{ka}	0.986	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	-0.116	-0.036	-0.196	%
Strain due to other loads	ε_{sonst}	-0.006	0.007	-0.018	%
Total strain	ε	-0.122	-0.029	-0.214	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	0.85	0.85	0.85	%
Safety coefficient flexural tension:	γ_{BZ}	---	---	---	[-]
Safety coefficient flexural compression:	γ_{BD}	6.972	29.232	3.976	[-]

All calculated safety coefficients of the strain proof are sufficient.

4.2.6.2 Deformation proof

Calculation mode:			linear		
Ratio:			I/(A·rm²)	0.00015	[-]
Ratio 'I/(A·rm²)·κ~Q':			I/(A·rm²)·κ_Q	0.00019	[-]

		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	7.52	mm
Horizontal diameter change:	Δd_h	5.32	mm
Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	1.25	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	2.25	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

4.2.6.3 Stabilty proof radial, linear

Earth and traffic loads

Pipe stiffness:	$\bar{S}_R$	41,506	N/m²
Horizontal bedding stiffness:	S_{Bh}	8.148	N/mm²
System stiffness, weighted:	$V_{RB,w}$	0.0051	[-]
Reduction factor buckling load for earth/traffic loads:	κ_{v2}	0.87	[-]
Friction angle in bedding zone:	φ'_2	35.000	°
Critical vertical total load:	krit q_v	1,015.2	kN/m²
Total vertical load:	q_v	108.05	kN/m²
Safety stability, radial:	$\gamma_{Stab,rad}$	9.39	[-]
Required safety coefficient, instability (buckling):	erf γ_{stab}	2.50	[-]

The buckling proof is fulfilled.

4.2.6.4 stability proof, nonlinear

The nonlinear stability proof is not applicable because of VRB > 1.0 (rigid pipe) or relative vertical deformation < 6%.

4.2.6.5 Proof of safety against failure with not predominantly static loading

According to the standard the dynamic proof is not required (e.g. traffic load > 1,5 m).

All necessary proofs are ok.

5 Appendix

Amiblu®
Sustainable Water Solutions

FLOWTITE® | HOBAS®

Input Data for structural analysis

of application buried pipes in open trench condition, calculation acc. DWA-A 127

Please send to:
Amiblu Holding GmbH
Pischeldorfer Straße 128
A-9020 Klagenfurt
T +43 463 482424
info@amiblu.com

9013 PCL 1F	
project	
LUZ d.d	Luka Krajnc
company	contact person
Verovškova ulica 64	(01) 36 02 473
street	phone/Fax:
1000	Text input.
postcode	signature:
Ljubljana	Text input.
city	date/stamp

Pipe Details:

nominal diameter DN	600
pressure class PN	PN1
nominal stiffness SN	10000
pipe material	GRP

sewer pipe	☒
sewer pressure pipe	☐
pressure pipe	☐
potable water pipe	☐
installation in protective water area	☐
air pipe	☐
storage sewer	☐
others	Text input.

Types of native soil: acc. ATV-DVWK-A 127; DIN 18196 (please subsoil expertise ad)

		Native soil	backfilling	Pipe zone
G1	Non cohesive soils (gravel, sand) (GE, GW, GI, SE, SW, SI)	☐	☒	☒
G2	Slightly cohesive soils (GU, GT, SU, ST)	☒	☐	☐
G3	Cohesive mixed soils, silt (GÜ, GŤ, SÜ, SŤ, UL, UM)	☐	☐	☐
G4	Cohesive soils, except silts (TL, TM, TA, OU, OT, OH, UA)	☐	☐	☐
Other types of soil	Text input.	☐	☐	☐

Proctor density for native soil (Proctor density 85 – 100 %): 98 %

Foundation of pipeline
- ☒ On native soil
- ☐ very hard and rocky
- ☐ Weak soil, not stable for foundation

Soil replacement: thickness Text input. m
material Text input.
Proctor density D_{Pr} Text input. %

Specification of loads:

	Min. cover depth		Max. cover depth	
Depth of earth cover h	3,15	m	5,98	m
min. Ground water h_w above pipe invert	Text input.	m	Text input.	m
max. Ground water h_w above pipe invert	Text input.	m	Text input.	m

Other surface loads Text input. kN/m²

For pressure pipes
Short term: Text input. bar, e.g. system test pressure; hydrostatic pressure, water hammer
Long term: Text input. bar, e.g. operating pressure (OP), system pressure (PN, DP)

Traffic load
☐ no traffic

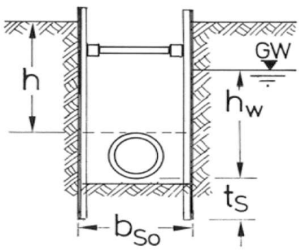
street
- ☐ HCL 60
- ☒ HCL 30
- ☐ HGV 12
- ☐ DIN EN 1991-2, TS und UDL
  - ☐ LM1-lane 3,00 m
  - ☐ LM1-lane 2,70 m
  - ☐ LM1-green field area

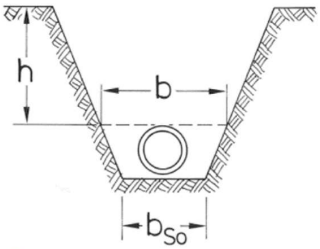
railway
- ☐ one track, UIC
- ☐ two tracks, UIC
- ☐ one track, LM 71
- ☐ two tracks, LM 71

aircraft
- ☐ BFZ 90
- ☐ BFZ 180
- ☐ BFZ 350
- ☐ BFZ 550
- ☐ BFZ 750

Other loads, e.g. special vehicle (please add load scheme with axle, wheels and wheel loads):
Text input.

Building construction:





Type of trench: ☒ embankment ☐ single trench ☐ double trench [1] ☐ stepped trench [1]
[1] For special shapes add a sketch

Trench angel: ☒ 90° ☐ 60° ☐ 45° ☐ Text input.

Width of trench b = 1.6 m at pipe crown

b_{So} = 1,6 m at pipe trench bottom inclusive planks

Trench planking

☐ no planks

☐ Horizontal planks, also applies to plank walls (Berlin lining)
☒ Planking with plates
☐ Vertical plank with light weight
☐ Vertical plank with boards *
☐ Vertical plank with light weight *
☐ Vertical plank with sheet piling *

bedding

☐ on native soil (acc. EN 1610)
☒ on gravel, sand
☐ on concrete [2]

[2] only as spezial construction in agreement with the pipe producer

bedding angle 2α

☐ 90° ☐ 120°
☐ 180°

* Depth of sheeting below pipe invert t_S = Text input. m

*thickness of plank (one-side) b_S = Text input. m

Cover condition for backfilling:

A1 ☐ Backfilling compacted in layers against the native soil (without proof of compaction degree); also applies to plank walls, Berlin lining

A2 ☐ Vertical pipe trench lining with boards that are not removed before backfilling. Lining boards or devices that are removed step by step during backfilling. Non-compacted backfilling/ backfilling with slurry (only suitable for soils of group G1).

A3 ☐ Vertical trench lining with sheet piling, light weight sheet connection, wooden planks, lining boards or devices that are not removed before backfilling.

A4 ☒ Backfilling compacted in layers against the native soil with proof of the required compaction degree to ZTVE-StB ; also applies to plank walls (Berlin lining). Cover condition A4 is not applicable to sails of group G4.

Bedding condition for pipe:

B1 ☒ Bedding compacted in layers against the native soil or in the embankment (without proof of compaction degree); also applies to plank walls, Berlin lining

B2 ☐ Vertical lining in the pipe zone with planks that reach down to the trench bottom and are not removed before backfilling and compaction. Lining boards or devices provided that the soil is compacted after the linings are removed.

B3 ☐ Vertical lining in the pipe zone with sheet piling or lightweight sheeting and compaction against the lining reaching down below the trench bottom. There is no safe calculation model for determining vertical lining with wooden planks, boards or devices that are not removed before backfilling and compaction the pipe zone.

B4 ☐ Bedding compacted in layers against the native soil or in the embankment with proof of the required compaction degree to ZTVE-StB. Bedding condition B4 does not apply to soils of group G4.

Structural analysis

Project:	9013 PCL 1F
Description:	GRP CC pipe DN800 PN1 SN 10.000
Contractor:	LUZ d.d Verovškova ulica 64 1000 Ljubljana Mr. Luka Kranjc (01) 36 02 473
Designer:	Josip Vrtarić Application Engineering Amiblu Alpe Adria d.o.o. Kralja Zvonimira 122, Zagreb, Croatia T +385 1 618 36 91 M +385 91 604 93 97 josip.vrtaric@amiblu.com www.amiblu.com
Calculation no.:	2025/93
Date:	19/08/2025

Content

1 Remarks 4

2 List of references 6

3 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 3,17 m 7

3.1 Input 7

3.1.1 Safety factors 7

3.1.2 Soil 7

3.1.3 Load 7

3.1.4 Installation 7

3.1.5 Pipe with nominal stiffness 8

3.2 Results 10

3.2.1 Intermediate results pipe 10

3.2.1.1 Material properties 10
3.2.1.2 Safety factors 10

3.2.2 Minimum trench width according to DIN EN 1610:2015-12 10

3.2.3 Intermediate results for load case 11

3.2.3.1 Silo Theory 11
3.2.3.2 Load 11
3.2.3.3 Soil deformation moduli EB 11
3.2.3.4 Soil stiffness values 11
3.2.3.5 Bedding angle, effective relative projection and friction angle 11
3.2.3.6 Characteristic values of pipe material and ring stiffness 11
3.2.3.7 Stiffness ratio 12
3.2.3.8 Coefficients 12
3.2.3.9 Concentration factors λR and λB 12
3.2.3.10 Pressure distribution at pipe circumference 12

3.2.4 Section forces 12

3.2.4.1 Section forces , short term 12
3.2.4.2 Section forces , long term 13

3.2.5 Short term load case 13

3.2.5.1 Strain proof 13
3.2.5.2 Deformation proof 14

3.2.6 Long term load case 14

3.2.6.1 Strain proof 14
3.2.6.2 Deformation proof 15
3.2.6.3 Stabilty proof radial, linear 15
3.2.6.4 stability proof, nonlinear 16
3.2.6.5 Proof of safety against failure with not predominantly static loading 16

4 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 3.19 m 17

4.1 Input 17

4.1.1 Safety factors 17

4.1.2 Soil 17

4.1.3 Load 17
4.1.4 Installation 17
4.1.5 Pipe with nominal stiffness 18
4.2 Results 20
4.2.1 Intermediate results pipe 20
4.2.1.1 Material properties 20
4.2.1.2 Safety factors 20
4.2.2 Minimum trench width according to DIN EN 1610:2015-12 20
4.2.3 Intermediate results for load case 21
4.2.3.1 Silo Theory 21
4.2.3.2 Load 21
4.2.3.3 Soil deformation moduli EB 21
4.2.3.4 Soil stiffness values 21
4.2.3.5 Bedding angle, effective relative projection and friction angle 21
4.2.3.6 Characteristic values of pipe material and ring stiffness 21
4.2.3.7 Stiffness ratio 22
4.2.3.8 Coefficients 22
4.2.3.9 Concentration factors λR and λB 22
4.2.3.10 Pressure distribution at pipe circumference 22
4.2.4 Section forces 22
4.2.4.1 Section forces , short term 22
4.2.4.2 Section forces , long term 23
4.2.5 Short term load case 23
4.2.5.1 Strain proof 23
4.2.5.2 Deformation proof 24
4.2.6 Long term load case 24
4.2.6.1 Strain proof 24
4.2.6.2 Deformation proof 25
4.2.6.3 Stabilty proof radial, linear 25
4.2.6.4 stability proof, nonlinear 26
4.2.6.5 Proof of safety against failure with not predominantly static loading 26
5 Appendix 27
5.1 - 28

1 Remarks

DISCLAIMER OF LIABILITY

As part of the technical service for the technical planning of projects of the Amiblu Group (hereinafter referred to as "Amiblu"), static calculations for decision-making regarding Amiblu/Flowtite/Hobas GFK pipe systems and products are regularly provided by Amiblu.

By using this free Amiblu' s technical verification service, you agree to the following terms and conditions:

1. No contractual relationship:
The use of the above mentioned Amiblu` s calculations does not constitute a contractual relationship between you and Amiblu and no consulting or information agreement is concluded. To this extent, there do not exist any contractual or quasi-contractual claims against Amiblu.

2. Requirements:
You acknowledge that the here mentioned calculations only apply to Amiblu/Flowtite/Hobas products.

3. Basis of the static calculation:
Amiblu bases the calculation according to your stated project and installation conditions and completes the missing data by itself if necessary, this to the best of its knowledge and based on the current state of knowledge and according to the requirements of the valid standards and regulations.
The trench width and installation conditions are based on the minimum requirements according to EN1610 without consideration of the trench sheet thickness (if in use). This usually represents the critical load case and is therefore on the safe side.

4. Installation specifications:
In all cases the following installation conditions must be observed for the installation of Amiblu products:

The pipe zone must be made of non-cohesive or slightly cohesive material with the quality and degree of compaction according to this calculation. The maximum grain size according to the Amiblu/Flowtite/Hobas installation instructions for buried pipes and shafts have to be observed.
To classify the bedding material, all the material in the pipeline zone has to pass through a sieve with a mesh size as specified in the installation instructions.

The pipe bedding must be at least 100 mm thick and have the specified support angle according to the static calculation. We recommend that the requirements for the pipe bedding according to EN 1610.

The degree of compaction of the pipe zone and backfill must meet or exceed the requirements of the static calculation. The installation conditions should be checked and documented. The pipe zone ends 300 mm above the pipe crown.

The quality and degree of compaction of the backfill, the existing soil and the pipeline zone must be checked and needs to meet the requirements of this static evaluation.

For the static calculation compliance with the applicable international standards and installation instructions for Amiblu/Flowtite/Hobas products is assumed. The installation instructions for Amiblu/Flowtite/Hobas can be downloaded from our homepages: http://www.flowtite.com or http://www.hobas.com or http://www.amiblu.com.

The installation conditions used for the static calculation should be compared by you or an expert engineer or the project planner with the actual conditions on site. Potential deviations may have an influence on the pipe installation.

5. Disclaimer:
The services provided are subject to Amiblu's General Conditions of Sale, insofar applicable.

The results of the calculation can only be obtained in practice if the assumptions correspond to the real construction conditions on site.

The static calculations were carried out reliably and carefully according to the professional opinion of Amiblu.

Amiblu accept liability for the static calculation carried out on the basis of customer specifications, such as e.g. contents from structural analysis forms, specifications for planning and execution, information on ground condition as well as installation and/or operation. Amiblu does not accept any liability for the correctness and completeness of the specific customer specifications.

The static calculations prepared by Amiblu are a service in the design or execution phase and usually become part of the project documentation. Amiblu assumes no liability for the applicability of the calculation results in case of deviations from the underlying assumptions.

Rev03 11/04/2023

2 List of references

DIN 4124 - Excavations and Trenches - Slopes, planking and strutting, breadths of working space: October 2002

EN 1610 - Construction and testing of drains and sewers: December 2015

EN 805 - Water Supply Requirements for systems and components outside of buildings: March 2000

EN 1992-2 - Eurocode 2: Eurocode 1: Actions on structures Part 2: Traffic loads on bridges (consolidated version): March. 2012

EN 1796 - Plastics piping systems for water supply with or without pressure - Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP): March 2013

EN 14364 - Plastics piping systems for drainage and sewerage with or without pressure – Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP): Mai 2013

EN 15383 - Plastics piping systems for drainage and sewerage - Glass- reinforced thermosetting plastics (GRP) based on polyester resin (UP) - Manholes and inspection chambers: March 2013

ISO 16611 Plastics piping systems for drainage and sewerage without pressure - Non-circular pipes and joints made of glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resins (UP) - Dimensions, requirements and tests: June 2017

ISO 25780 - Plastics piping systems for pressure and non-pressure water supply, irrigation, drainage or sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin — Pipes with flexible joints intended to be installed using jacking techniques: Mai 2011

Worksheet DWA-A127 - Structural verification of sewer channels and pipe lines, 3. corrected Issue: August 2000

3 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 3,17 m

Caption of this part of the calculation:	Cover 3,17 m
Kind of calculation:	Nominal stiffness
Add sketch to print:	Yes

3.1 Input

3.1.1 Safety factors

Safety class:	A (normal case)
Safety stability according to table 13:	Without predeformation (2.5 / 2.0)
Allowable deflection:	6% (standard)
Treatment of internal pressure:	In accordance with Footnote 39 in ATV-DVWK-A 127
Lower safety factors for flexural compression:	No (ATV-DVWK-A 127)
Proof for not predominantly static loading:	According to standard
Consideration of dyn pvh*:	According to standard
Consideration of Type A 'predeformation' in the deformation proof:	Yes
Treatment system stiffness VRB according to:	DWA-A 161:2014 (by material)
Pipe stiffness according to set of rules:	Yes

3.1.2 Soil

Soil group backfill:	G1		
Calculation E1:	Table 8 (A127)		
Soil group pipe zone:	G1		
Calculation E20:	Table 8 (A127)		
Soil group native soil:	G2		
Calculation E3:	Degree of compaction		
Compaction degree E3:	$D_{Pr,E3}$	98.0	%
E4 = 10 · E1:	Yes		
Application of silo theory:	Automatic		
K2 according to standard:	Yes		

3.1.3 Load

Cover depth:	h	3.17	m
Minimum groundwater level above pipe bed:	$h_{W,min}$	0.00	m
Maximum groundwater level above pipe bed:	$h_{W,max}$	0.00	m
Soil density:	γ_B	20.0	kN/m³
Additional surface load:	p_0	0.0	kN/m²
Inner pressure, short term:	$P_{I,K}$	0.00	bar
Inner pressure, long term:	$P_{I,L}$	0.00	bar
Water fill (e.g. damming channel):	Yes		
Density of medium:	γ_F	10.0	kN/m³
Input special-purpose vehicle:	No		
Traffic load:	Street HGV 30 (with road construction)		
Including horizontal loads due to traffic in the fatigue proof:	$\alpha_{qhT,dyn}$	0.00	%

3.1.4 Installation

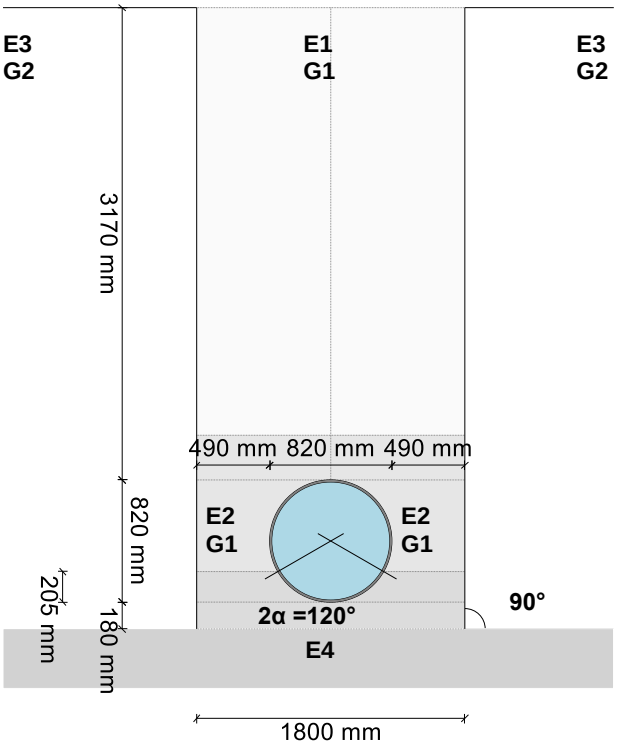
Installation:	Trench		
Trench width at pipe crown level:	b	1.80	m
Check minimum trench width:	Yes		
Automatic consideration of bedding layer:	Yes		

Slope angle:	ß	90	°
Cover condition:	A4		
Installation condition:	B1		
Type of bedding:	Loose		
Bedding angle:	120°		
Calculate bedding automatically:	Yes		
Set lower height base:	No		
Total height of base:	h_s	0.00	m

3.1.5 Pipe with nominal stiffness

Pipe chosen from datebase:	No		
Choice of input:	Do - s		
Outer diameter:	d_a	820	mm
Nominal diameter:	DN	800	mm
Wall thickness:	t	17.0	mm
Local predeformation:	$\delta_{v,I}$	0.0	%
A type predeformation:	$\delta_{v,A}$	1.0	%
Nominal stiffness:	SN	10,000	N/m²
Nominal pressure:	PN	1.0	bar
Relative failure strain according to standard:	Yes		
Creep ratio:	f_{Kriech}	2.00	[-]
Reduction factor due to temperature effect:	$A_{1,Temp}$	1.00	[-]
Reduction factor due to media attack:	$A_{2,Medium}$	1.00	[-]
Reduction factor due to dynamic loading:	$A_{3,dyn}$	1.00	[-]
Specific gravity:	γ_R	18.00	kN/m³
Poissons ratio:	v	0.30	[-]
Input of ultimate hoop tensile stress:	No		
Ultimate strain tensile strength according to standard:	Yes		
Amplitude with 2·10^6 tests is known:	Yes		
Amplitude with 2·10^6 tests:	$\Delta\sigma_{rsk,2E6}$	36.00	N/mm²
Amplitude with 1·10^8 tests is known:	Yes		
Amplitude of the pipe with 1·10^8 tests:	$\Delta\sigma_{rsk,1E8}$	24.00	N/mm²
Axial compressive strength, short term:	$f_{c,ax,K}$	90.0	N/mm²
Fiber strain for axial pressure, short term:	ε_{AxK}	1.0	%

Traffic load: Street HGV 30 (with road construction)



3.2 Results

3.2.1 Intermediate results pipe

Inner diameter:	d_i	786.0	mm
Outer diameter:	d_a	820.0	mm
Mean radius:	r_m	401.50	mm
Wall thickness:	s	17.00	mm
Ratio radius to wall thickness:	r_m/s	23.618	[-]
Curve correction factor, internal:	α_{ki}	1.014	[-]
Curve correction factor, external:	α_{ka}	0.986	[-]
Local predeformation:	$\delta_{v,I}$	0.00	%
Predeformation (ovalisation before load):	$\delta_{v,A}$	1.00	%
Radial cross section:	A_{rad}	17.00	mm²/mm
Distance of inertia:	e	8.50	mm
Moment of inertia:	I	409.42	mm^4/mm
Outer moment of resistance:	W_a	48.17	mm³/mm
Inner moment of resistance:	W_i	48.17	mm³/mm
Surface ratio:	κ_Q	1.2	[-]

3.2.1.1 Material properties

		short term	long term	
Specific gravity	γ_R	18.0	18.0	kN/m³
Poissons ratio	v	0.30	0.30	[-]
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	12,646.8	6,323.4	N/mm²
Creep ratio:		f_{creep}	2.00	[-]

Table 3 of ATV DVWK-A 127, footnote 34:
Determined from the momentary value and the creep ratio (2) with characteristic values for 2 years for the description of the long term behauvior. Also permitted for the long term verification for 50 years. Tests take place in accordance with DIN EN 1228 (momentary) and DIN EN 1225 (long term).

Characteristic value of relative fracture deformation	$\Delta d_{Bruch}/d_m$	15.0	9.0	%

$$\varepsilon_R = 4.28 \cdot s/d_m \cdot \Delta d_{Bruch}/d_m$$

Characteristic value of ultimate strain for edge fibers	ε_R	1.359	0.815	%

$$f_t = \frac{0.50 \cdot PN \cdot 4 \cdot 2 \cdot r_m}{h}$$

Characteristic value of hoop tensile strength	f_t	9.4	4.7	N/mm²
Amplitude for 2·10^6 load cycles:		$\Delta\sigma_{rsk,2E6}$	n. def	N/mm²
Amplitude at 5·10^6 load cycles:		$\Delta\sigma_{rsk,5E6}$	n. def	N/mm²
Amplitude for 1·10^8 cycles:		$\Delta\sigma_{rsk,1E8}$	n. def	N/mm²

3.2.1.2 Safety factors

Required safety coefficient, bending tensile stress	erf γ_{RBZ}	2.00	2.00	[-]
Required safety coefficient, bending compressive stress	erf γ_{RBD}	2.00	2.00	[-]
Required safety coefficient, instability (buckling)	erf γ_{stab}	2.50	2.50	[-]

3.2.2 Minimum trench width according to DIN EN 1610:2015-12

Nominal diameter:	DN	800	mm
Outer diameter:	d_a	820.0	mm
Size of the bedding layer:	a	0.18	m
Minimum width at trench sole level (incl. x) according to table 1:	$min_{b,T1}$	1.67	m
Minimum width according to table 2:	$min_{b,T2}$	0.90	m

Minimum clear width at trench sole level:	$min_{b,G}$	1.67	m
Required width at pipe crown level:	$min_{b,R}$	1.67	m
Trench width at pipe crown level:	b	1.80	m

The minimum trench width at trench sole level according DIN EN 1610 is met.

3.2.3 Intermediate results for load case

3.2.3.1 Silo Theory

Soil load coefficient κ for trench load (Silo Theory):	κ	1.000	[-]
Soil load coefficient κ0 for surface load (Silo Theory):	$κ_0$	1.000	[-]

κ0 and κ are set to 1, because E1 is larger then E3.

3.2.3.2 Load

Maximum groundwater level above pipe crown:	$h_{W,Scheitel}$	0.00	m
Vertical soil stress from soil load:	P_{Erd}	63.40	kN/m²
Vertical soil stress from soil and surface load:	P_E	63.40	kN/m²
Stress due to traffic load:	P_V	11.46	kN/m²
Included impact factor:	ϕ	1.40	[-]

3.2.3.3 Soil deformation moduli EB

Backfill elastic modulus under load:	$E_{1,σ}$	23.00	N/mm²

$$E_{3,\sigma} = \frac{40}{2} \cdot e^{-0.188(100 - D_{Pr})} \qquad 3.01$$

Native soil elastic modulus:	$E_{3,σ}$	13.73	N/mm²
Bedding elastic modulus (reduced):	$E_{2,σ}$	12.79	N/mm²
Bedding elastic modulus under load:	$E_{20,σ}$	16.00	N/mm²
Reduction factor for creep:	f_1	1.000	[-]
Reduction factor E20 (groundwater):	f_2	1.000	[-]
Reduction factor E20 (Diagram 5):	$α_{B0}$	0.667	[-]
Reduction factor E20 (narrow trench):	$α_B$	0.799	[-]
Bedding elastic modulus (reduced):	$E_{2,σ}$	12.79	N/mm²
Elastic modulus of soil under pipe:	$E_{4,σ}$	230.00	N/mm²

3.2.3.4 Soil stiffness values

Auxiliary value for horizontal bedding stiffness:	$Δ_f$	0.905	[-]
Correction factor for horizontal bedding stiffness:	ζ	1.032	[-]
Horizontal bedding stiffness:	S_{Bh}	7.923	N/mm²
Vertical bedding stiffness:	S_{Bv}	12.791	N/mm²

3.2.3.5 Bedding angle, effective relative projection and friction angle

Bedding angle, effective relative projection and friction angle:	2α	120	°
Height bedding from bedding angle to lower pipe ledge:	t_r	0.205	m
Calculated relative projection:	a	1.00	[-]
Effective relative projection:	a'	1.798	[-]
Internal friction angle:	φ'	30.000	°
Wall friction angle:	δ	30.000	°

3.2.3.6 Characteristic values of pipe material and ring stiffness

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Pipe stiffness	S_R	80,000	46,124	40,000	N/m²
Characteristic value of ultimate strain for edge fibers	$ε_R$	1.359	0.899	0.815	%
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	12,646.8	7,291.5	6,323.4	N/mm²

3.2.3.7 Stiffness ratio

System stiffness, weighted	$V_{RB,w}$	0.0101	0.0058	0.0050	[-]
Stiffness ratio	V_S	0.4415	0.3724	---	[-]
Coefficient for vertical deformation	c_v*	-0.014	-0.010	---	[-]

3.2.3.8 Coefficients

Ground pressure ratio (bedding)	K_2	0.400	0.400	---	[-]
Coefficient for bedding reaction pressure	K*	1.174	1.244	---	[-]
Resulting deformation coefficient	c'_h	0.0891	0.0891	---	[-]
Resulting deformation coefficient	$c'_{h,qh}$*	-0.0658	-0.0658	---	[-]
Coefficient for vertical deformation	c_v*	-0.014	-0.010	---	[-]

3.2.3.9 Concentration factors λR and λB

Maximum concentration factor	max λ	2.012	2.012	---	[-]
Coefficient for maximum concentration factor	K'	0.922	0.916	---	[-]
Concentration factor above pipe, initial value	λ_R	0.832	0.782	---	[-]
Concentration factor above pipe, under trench effect	λ_{RG}	0.933	0.913	---	[-]
Concentration factor above pipe, upper limit	λ_{fo}	3.525	3.525	---	[-]
Concentration factor above pipe, lower limit	λ_{fu}	0.400	0.400	---	[-]
Concentration factor above pipe, final value	λ_{RG}	0.933	0.913	---	[-]
Soil concentration factor	λ_B	1.056	1.073	---	[-]

3.2.3.10 Pressure distribution at pipe circumference

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Total vertical load	q_v	70.63	69.37	---	kN/m²
Lateral pressure	q_h	30.06	30.48	---	kN/m²
Bedding reaction pressure (soil load)	q^*_h	49.92	50.84	---	kN/m²
Bedding reaction pressure (water filling)	q^*_{hw}	3.79	4.06	---	kN/m²

3.2.4 Section forces

3.2.4.1 Section forces , short term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	401.50	401.50	401.50	mm
Moment due to total vertical load	M_{qv}	2.972	-3.017	3.131	kNm/m
Moment due to lateral pressure	M_{qh}	-1.211	1.211	-1.211	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-1.457	1.674	-1.457	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.111	0.127	-0.111	kNm/m
Moment due to dead weight	M_g	0.019	-0.022	0.026	kNm/m
Moment due to water filling	M_w	0.123	-0.142	0.168	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.335	-0.169	0.546	kNm/m

		crown	springline	invert	
Mean radius	r_m	401.50	401.50	401.50	mm
Normal force due to total vertical load	N_{qv}	0.766	-28.357	-0.766	kN/m
Normal force due to lateral pressure	N_{qh}	-12.068	0.000	-12.068	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-11.566	0.000	-11.566	kN/m

Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.878	0.000	-0.878	kN/m
Normal force due to dead weight	N_g	0.031	-0.193	-0.031	kN/m
Normal force due to water filling	N_w	1.008	0.347	2.217	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-22.708	-28.203	-23.091	kN/m

3.2.4.2 Section forces , long term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	401.50	401.50	401.50	mm
Moment due to total vertical load	M_{qv}	2.918	-2.963	3.075	kNm/m
Moment due to lateral pressure	M_{qh}	-1.228	1.228	-1.228	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-1.484	1.705	-1.484	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.118	0.136	-0.118	kNm/m
Moment due to dead weight	M_g	0.019	-0.022	0.026	kNm/m
Moment due to water filling	M_w	0.123	-0.142	0.168	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.230	-0.058	0.439	kNm/m

		crown	springline	invert	
Mean radius	r_m	401.50	401.50	401.50	mm
Normal force due to total vertical load	N_{qv}	0.752	-27.850	-0.752	kN/m
Normal force due to lateral pressure	N_{qh}	-12.237	0.000	-12.237	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-11.779	0.000	-11.779	kN/m
Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.940	0.000	-0.940	kN/m
Normal force due to dead weight	N_g	0.031	-0.193	-0.031	kN/m
Normal force due to water filling	N_w	1.008	0.347	2.217	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-23.167	-27.697	-23.523	kN/m

3.2.5 Short term load case

3.2.5.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh^*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh^*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:			α_{ki}	1.014	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.040	-0.035	0.066	%
Strain due to other loads	ε_{sonst}	0.005	-0.006	0.014	%

Total strain	ε	0.045	-0.041	0.080	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.36	1.36	1.36	%
Safety coefficient flexural tension:	γ_{BZ}	30.091	---	16.945	[-]
Safety coefficient flexural compression:	γ_{BD}	---	32.969	---	[-]

outside

Curve correction factor, external:			α_{ka}	0.986	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	-0.060	0.008	-0.086	%
Strain due to other loads	ε_{sonst}	-0.005	0.006	-0.013	%
Total strain	ε	-0.065	0.014	-0.099	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.36	1.36	1.36	%
Safety coefficient flexural tension:	γ_{BZ}	---	95.666	---	[-]
Safety coefficient flexural compression:	γ_{BD}	20.994	---	13.707	[-]

All calculated safety coefficients of the strain proof are sufficient.

3.2.5.2 Deformation proof

Calculation mode:			linear		
Ratio:			I/(A·rm²)	0.00015	[-]
Ratio 'I/(A·rm²)·κ~Q':			$I/(A \cdot rm^2) \cdot \kappa_Q$	0.00018	[-]
		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	6.10	mm
Horizontal diameter change:	Δd_h	5.06	mm

Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	0.76	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	1.76	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

3.2.6 Long term load case

3.2.6.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh^*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh^*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:			α_{ki}	1.014	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.041	-0.031	0.085	%
Strain due to other loads	ε_{sonst}	0.008	-0.009	0.026	%
Total strain	ε	0.049	-0.040	0.111	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	0.89	0.88	0.88	%
Safety coefficient flexural tension:	γ_{BZ}	18.192	---	7.925	[-]
Safety coefficient flexural compression:	γ_{BD}	---	21.871	---	[-]

outside

Curve correction factor, external:			α_{ka}	0.986	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	-0.077	-0.014	-0.122	%
Strain due to other loads	ε_{sonst}	-0.007	0.009	-0.023	%
Total strain	ε	-0.084	-0.005	-0.145	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	0.89	0.87	0.89	%
Safety coefficient flexural tension:	γ_{BZ}	---	---	---	[-]
Safety coefficient flexural compression:	γ_{BD}	10.593	179.698	6.108	[-]

All calculated safety coefficients of the strain proof are sufficient.

3.2.6.2 Deformation proof

Calculation mode:			linear		
Ratio:			I/(A·rm²)	0.00015	[-]
Ratio 'I/(A·rm²)·κ~Q':			I/(A·rm²)·κ_Q	0.00018	[-]

		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]
Vertical diameter change:			Δd_v	6.99	mm
Horizontal diameter change:			Δd_h	5.15	mm
Relative vertical deformation (due to loads, elastic, Type B):			$\delta_{v,B}$	0.87	%
Predeformation (e. g. due to manufacturing, plastic, Type A):			$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):			$\delta_{v,Ges}$	1.87	%
Allowable deflection:			zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

3.2.6.3 Stabilty proof radial, linear

Earth and traffic loads

Pipe stiffness:	$\bar{S}_R$	46,124	N/m²
Horizontal bedding stiffness:	S_{Bh}	7.923	N/mm²
System stiffness, weighted:	$V_{RB,w}$	0.0058	[-]
Reduction factor buckling load for earth/traffic loads:	κ_{v2}	0.87	[-]
Friction angle in bedding zone:	φ'_2	35.000	°
Critical vertical total load:	krit q_v	1,054.6	kN/m²
Total vertical load:	q_v	69.37	kN/m²
Safety stability, radial:	$\gamma_{Stab,rad}$	15.20	[-]
Required safety coefficient, instability (buckling):	erf γ_{stab}	2.50	[-]

The buckling proof is fulfilled.

3.2.6.4 stability proof, nonlinear

The nonlinear stability proof is not applicable because of VRB > 1.0 (rigid pipe) or relative vertical deformation < 6%.

3.2.6.5 Proof of safety against failure with not predominantly static loading

According to the standard the dynamic proof is not required (e.g. traffic load > 1,5 m).

All necessary proofs are ok.

4 Statics according to ATV-DVWK-A 127, 3rd edition: Cover 3.19 m

Caption of this part of the calculation:	Cover 3.19 m
Kind of calculation:	Nominal stiffness
Add sketch to print:	Yes

4.1 Input

4.1.1 Safety factors

Safety class:	A (normal case)
Safety stability according to table 13:	Without predeformation (2.5 / 2.0)
Allowable deflection:	6% (standard)
Treatment of internal pressure:	In accordance with Footnote 39 in ATV-DVWK-A 127
Lower safety factors for flexural compression:	No (ATV-DVWK-A 127)
Proof for not predominantly static loading:	According to standard
Consideration of dyn pvh*:	According to standard
Consideration of Type A 'predeformation' in the deformation proof:	Yes
Treatment system stiffness VRB according to:	DWA-A 161:2014 (by material)
Pipe stiffness according to set of rules:	Yes

4.1.2 Soil

Soil group backfill:	G1		
Calculation E1:	Table 8 (A127)		
Soil group pipe zone:	G1		
Calculation E20:	Table 8 (A127)		
Soil group native soil:	G2		
Calculation E3:	Degree of compaction		
Compaction degree E3:	$D_{Pr,E3}$	98.0	%
E4 = 10 · E1:	Yes		
Application of silo theory:	Automatic		
K2 according to standard:	Yes		

4.1.3 Load

Cover depth:	h	3.19	m
Minimum groundwater level above pipe bed:	$h_{W,min}$	0.00	m
Maximum groundwater level above pipe bed:	$h_{W,max}$	0.00	m
Soil density:	γ_B	20.0	kN/m³
Additional surface load:	p_0	0.0	kN/m²
Inner pressure, short term:	$P_{I,K}$	0.00	bar
Inner pressure, long term:	$P_{I,L}$	0.00	bar
Water fill (e.g. damming channel):	Yes		
Density of medium:	γ_F	10.0	kN/m³
Input special-purpose vehicle:	No		
Traffic load:	Street HGV 30 (with road construction)		
Including horizontal loads due to traffic in the fatigue proof:	$\alpha_{qhT,dyn}$	0.00	%

4.1.4 Installation

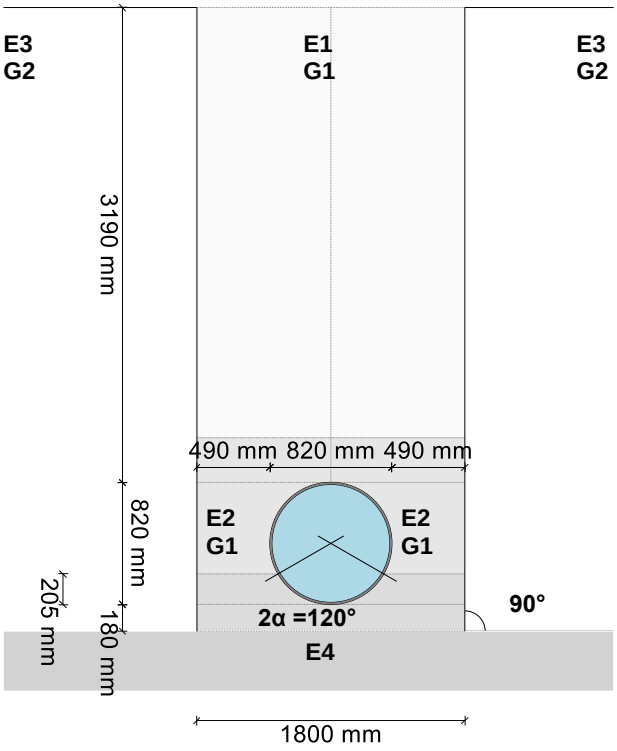
Installation:	Trench		
Trench width at pipe crown level:	b	1.80	m
Check minimum trench width:	Yes		
Automatic consideration of bedding layer:	Yes		

Slope angle:	ß	90	°
Cover condition:	A4		
Installation condition:	B1		
Type of bedding:	Loose		
Bedding angle:	120°		
Calculate bedding automatically:	Yes		
Set lower height base:	No		
Total height of base:	h_s	0.00	m

4.1.5 Pipe with nominal stiffness

Pipe chosen from datebase:	No		
Choice of input:	Do - s		
Outer diameter:	d_a	820	mm
Nominal diameter:	DN	800	mm
Wall thickness:	t	17.0	mm
Local predeformation:	$\delta_{v,I}$	0.0	%
A type predeformation:	$\delta_{v,A}$	1.0	%
Nominal stiffness:	SN	10,000	N/m²
Nominal pressure:	PN	1.0	bar
Relative failure strain according to standard:	Yes		
Creep ratio:	f_{Kriech}	2.00	[-]
Reduction factor due to temperature effect:	$A_{1,Temp}$	1.00	[-]
Reduction factor due to media attack:	$A_{2,Medium}$	1.00	[-]
Reduction factor due to dynamic loading:	$A_{3,dyn}$	1.00	[-]
Specific gravity:	γ_R	18.00	kN/m³
Poissons ratio:	v	0.30	[-]
Input of ultimate hoop tensile stress:	No		
Ultimate strain tensile strength according to standard:	Yes		
Amplitude with 2·10^6 tests is known:	Yes		
Amplitude with 2·10^6 tests:	$\Delta\sigma_{rsk,2E6}$	36.00	N/mm²
Amplitude with 1·10^8 tests is known:	Yes		
Amplitude of the pipe with 1·10^8 tests:	$\Delta\sigma_{rsk,1E8}$	24.00	N/mm²
Axial compressive strength, short term:	$f_{c,ax,K}$	90.0	N/mm²
Fiber strain for axial pressure, short term:	ε_{AxK}	1.0	%

Traffic load: Street HGV 30 (with road construction)



4.2 Results

4.2.1 Intermediate results pipe

Inner diameter:	d_i	786.0	mm
Outer diameter:	d_a	820.0	mm
Mean radius:	r_m	401.50	mm
Wall thickness:	s	17.00	mm
Ratio radius to wall thickness:	r_m/s	23.618	[-]
Curve correction factor, internal:	α_{ki}	1.014	[-]
Curve correction factor, external:	α_{ka}	0.986	[-]
Local predeformation:	$\delta_{v,I}$	0.00	%
Predeformation (ovalisation before load):	$\delta_{v,A}$	1.00	%
Radial cross section:	A_{rad}	17.00	mm²/mm
Distance of inertia:	e	8.50	mm
Moment of inertia:	I	409.42	mm^4/mm
Outer moment of resistance:	W_a	48.17	mm³/mm
Inner moment of resistance:	W_i	48.17	mm³/mm
Surface ratio:	κ_Q	1.2	[-]

4.2.1.1 Material properties

		short term	long term	
Specific gravity	γ_R	18.0	18.0	kN/m³
Poissons ratio	v	0.30	0.30	[-]
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	12,646.8	6,323.4	N/mm²
Creep ratio:		f_{creep}	2.00	[-]

Table 3 of ATV DVWK-A 127, footnote 34:
Determined from the momentary value and the creep ratio (2) with characteristic values for 2 years for the description of the long term behauvior. Also permitted for the long term verification for 50 years. Tests take place in accordance with DIN EN 1228 (momentary) and DIN EN 1225 (long term).

Characteristic value of relative fracture deformation	$\Delta d_{Bruch}/d_m$	15.0	9.0	%

$$\varepsilon_R = 4.28 \cdot s/d_m \cdot \Delta d_{Bruch}/d_m$$

Characteristic value of ultimate strain for edge fibers	ε_R	1.359	0.815	%

$$f_t = \frac{0.50 \cdot PN \cdot 4 \cdot 2 \cdot r_m}{h}$$

Characteristic value of hoop tensile strength	f_t	9.4	4.7	N/mm²
Amplitude for 2·10^6 load cycles:		$\Delta\sigma_{rsk,2E6}$	n. def	N/mm²
Amplitude at 5·10^6 load cycles:		$\Delta\sigma_{rsk,5E6}$	n. def	N/mm²
Amplitude for 1·10^8 cycles:		$\Delta\sigma_{rsk,1E8}$	n. def	N/mm²

4.2.1.2 Safety factors

Required safety coefficient, bending tensile stress	erf γ_{RBZ}	2.00	2.00	[-]
Required safety coefficient, bending compressive stress	erf γ_{RBD}	2.00	2.00	[-]
Required safety coefficient, instability (buckling)	erf γ_{stab}	2.50	2.50	[-]

4.2.2 Minimum trench width according to DIN EN 1610:2015-12

Nominal diameter:	DN	800	mm
Outer diameter:	d_a	820.0	mm
Size of the bedding layer:	a	0.18	m
Minimum width at trench sole level (incl. x) according to table 1:	$min_{b,T1}$	1.67	m
Minimum width according to table 2:	$min_{b,T2}$	1.00	m

Minimum clear width at trench sole level:	$min_{b,G}$	1.67	m
Required width at pipe crown level:	$min_{b,R}$	1.67	m
Trench width at pipe crown level:	b	1.80	m

The minimum trench width at trench sole level according DIN EN 1610 is met.

4.2.3 Intermediate results for load case

4.2.3.1 Silo Theory

Soil load coefficient κ for trench load (Silo Theory):	κ	1.000	[-]
Soil load coefficient κ0 for surface load (Silo Theory):	$κ_0$	1.000	[-]

κ0 and κ are set to 1, because E1 is larger then E3.

4.2.3.2 Load

Maximum groundwater level above pipe crown:	$h_{W,Scheitel}$	0.00	m
Vertical soil stress from soil load:	P_{Erd}	63.80	kN/m²
Vertical soil stress from soil and surface load:	P_E	63.80	kN/m²
Stress due to traffic load:	P_V	11.38	kN/m²
Included impact factor:	ϕ	1.40	[-]

4.2.3.3 Soil deformation moduli EB

Backfill elastic modulus under load:	$E_{1,σ}$	23.00	N/mm²

$$E_{3,\sigma} = \frac{40}{2} \cdot e^{-0.188(100 - D_{Pr})} \qquad 3.01$$

Native soil elastic modulus:	$E_{3,σ}$	13.73	N/mm²
Bedding elastic modulus (reduced):	$E_{2,σ}$	12.79	N/mm²
Bedding elastic modulus under load:	$E_{20,σ}$	16.00	N/mm²
Reduction factor for creep:	f_1	1.000	[-]
Reduction factor E20 (groundwater):	f_2	1.000	[-]
Reduction factor E20 (Diagram 5):	$α_{B0}$	0.667	[-]
Reduction factor E20 (narrow trench):	$α_B$	0.799	[-]
Bedding elastic modulus (reduced):	$E_{2,σ}$	12.79	N/mm²
Elastic modulus of soil under pipe:	$E_{4,σ}$	230.00	N/mm²

4.2.3.4 Soil stiffness values

Auxiliary value for horizontal bedding stiffness:	$Δ_f$	0.905	[-]
Correction factor for horizontal bedding stiffness:	ζ	1.032	[-]
Horizontal bedding stiffness:	S_{Bh}	7.923	N/mm²
Vertical bedding stiffness:	S_{Bv}	12.791	N/mm²

4.2.3.5 Bedding angle, effective relative projection and friction angle

Bedding angle, effective relative projection and friction angle:	2α	120	°
Height bedding from bedding angle to lower pipe ledge:	t_r	0.205	m
Calculated relative projection:	a	1.00	[-]
Effective relative projection:	a'	1.798	[-]
Internal friction angle:	φ'	30.000	°
Wall friction angle:	δ	30.000	°

4.2.3.6 Characteristic values of pipe material and ring stiffness

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Pipe stiffness	S_R	80,000	46,055	40,000	N/m²
Characteristic value of ultimate strain for edge fibers	$ε_R$	1.359	0.898	0.815	%
Characteristic value of Young's modulus in ring direction	$E_{R,rad}$	12,646.8	7,280.6	6,323.4	N/mm²

4.2.3.7 Stiffness ratio

System stiffness, weighted	$V_{RB,w}$	0.0101	0.0058	0.0050	[-]
Stiffness ratio	V_S	0.4415	0.3723	---	[-]
Coefficient for vertical deformation	c_v*	-0.014	-0.010	---	[-]

4.2.3.8 Coefficients

Ground pressure ratio (bedding)	K_2	0.400	0.400	---	[-]
Coefficient for bedding reaction pressure	K*	1.174	1.244	---	[-]
Resulting deformation coefficient	c'_h	0.0891	0.0891	---	[-]
Resulting deformation coefficient	$c'_{h,qh}$*	-0.0658	-0.0658	---	[-]
Coefficient for vertical deformation	c_v*	-0.014	-0.010	---	[-]

4.2.3.9 Concentration factors λR and λB

Maximum concentration factor	max λ	2.015	2.015	---	[-]
Coefficient for maximum concentration factor	K'	0.922	0.916	---	[-]
Concentration factor above pipe, initial value	λ_R	0.832	0.782	---	[-]
Concentration factor above pipe, under trench effect	λ_{RG}	0.933	0.913	---	[-]
Concentration factor above pipe, upper limit	λ_{fo}	3.522	3.522	---	[-]
Concentration factor above pipe, lower limit	λ_{fu}	0.398	0.398	---	[-]
Concentration factor above pipe, final value	λ_{RG}	0.933	0.913	---	[-]
Soil concentration factor	λ_B	1.056	1.073	---	[-]

4.2.3.10 Pressure distribution at pipe circumference

		short term All loads	long term Soil loads Traffic load	long term other Loads	
Total vertical load	q_v	70.92	69.64	---	kN/m²
Lateral pressure	q_h	30.23	30.65	---	kN/m²
Bedding reaction pressure (soil load)	q^*_h	50.08	50.99	---	kN/m²
Bedding reaction pressure (water filling)	q^*_{hw}	3.79	4.06	---	kN/m²

4.2.4 Section forces

4.2.4.1 Section forces , short term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	401.50	401.50	401.50	mm
Moment due to total vertical load	M_{qv}	2.984	-3.029	3.144	kNm/m
Moment due to lateral pressure	M_{qh}	-1.218	1.218	-1.218	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-1.461	1.679	-1.461	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.111	0.127	-0.111	kNm/m
Moment due to dead weight	M_g	0.019	-0.022	0.026	kNm/m
Moment due to water filling	M_w	0.123	-0.142	0.168	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.336	-0.169	0.548	kNm/m
		crown	springline	invert	
Mean radius	r_m	401.50	401.50	401.50	mm
Normal force due to total vertical load	N_{qv}	0.769	-28.473	-0.769	kN/m
Normal force due to lateral pressure	N_{qh}	-12.136	0.000	-12.136	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-11.601	0.000	-11.601	kN/m

Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.878	0.000	-0.878	kN/m
Normal force due to dead weight	N_g	0.031	-0.193	-0.031	kN/m
Normal force due to water filling	N_w	1.008	0.347	2.217	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-22.808	-28.319	-23.198	kN/m

4.2.4.2 Section forces , long term

Rerounding factor (reduction moments):			r	1.000	[-]
		crown	springline	invert	
Mean radius	r_m	401.50	401.50	401.50	mm
Moment due to total vertical load	M_{qv}	2.930	-2.975	3.087	kNm/m
Moment due to lateral pressure	M_{qh}	-1.235	1.235	-1.235	kNm/m
Moment due to horizontal bedding reaction pressure	M^*_{qh}	-1.488	1.710	-1.488	kNm/m
Moment due to horizontal bedding reaction pressure (water filling)	M^*_{qw}	-0.118	0.136	-0.118	kNm/m
Moment due to dead weight	M_g	0.019	-0.022	0.026	kNm/m
Moment due to water filling	M_w	0.123	-0.142	0.168	kNm/m
Moment due to water pressure/internal pressure	M_{pw}	0.000	0.000	0.000	kNm/m
Total moments	ΣM	0.230	-0.058	0.440	kNm/m

		crown	springline	invert	
Mean radius	r_m	401.50	401.50	401.50	mm
Normal force due to total vertical load	N_{qv}	0.755	-27.962	-0.755	kN/m
Normal force due to lateral pressure	N_{qh}	-12.307	0.000	-12.307	kN/m
Normal force due to horizontal bedding reaction pressure	N^*_{qh}	-11.813	0.000	-11.813	kN/m
Normal force due to horizontal bedding reaction pressure (water filling)	N^*_{qw}	-0.940	0.000	-0.940	kN/m
Normal force due to dead weight	N_g	0.031	-0.193	-0.031	kN/m
Normal force due to water filling	N_w	1.008	0.347	2.217	kN/m
Normal force due to water pressure/internal pressure	N_{pw}	0.000	0.000	0.000	kN/m
Total normal forces	ΣN	-23.268	-27.808	-23.630	kN/m

4.2.5 Short term load case

4.2.5.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh^*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh^*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:			α_{ki}	1.014	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.040	-0.035	0.066	%
Strain due to other loads	ε_{sonst}	0.005	-0.006	0.014	%

Total strain	ε	0.045	-0.041	0.080	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.36	1.36	1.36	%
Safety coefficient flexural tension:	γ_{BZ}	30.028	---	16.903	[-]
Safety coefficient flexural compression:	γ_{BD}	---	32.876	---	[-]

outside

Curve correction factor, external:			α_{ka}	0.986	[-]
		crown	springline	invert	
Strain due to earth- and trafficloads	$\varepsilon_{qv,qh,qh*}$	-0.060	0.008	-0.087	%
Strain due to other loads	ε_{sonst}	-0.005	0.006	-0.013	%
Total strain	ε	-0.065	0.014	-0.099	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	1.36	1.36	1.36	%
Safety coefficient flexural tension:	γ_{BZ}	---	95.620	---	[-]
Safety coefficient flexural compression:	γ_{BD}	20.934	---	13.666	[-]

All calculated safety coefficients of the strain proof are sufficient.

4.2.5.2 Deformation proof

Calculation mode:			linear		
Ratio:			I/(A·rm²)	0.00015	[-]
Ratio 'I/(A·rm²)·κ~Q':			$I/(A \cdot rm^2) \cdot \kappa_Q$	0.00018	[-]
		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	6.12	mm
Horizontal diameter change:	Δd_h	5.08	mm

Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	0.76	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	1.76	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

4.2.6 Long term load case

4.2.6.1 Strain proof

$$\varepsilon_{R,res} = \frac{|\varepsilon_{qv,qh,qh*}| \cdot \bar{\varepsilon}_R + |\varepsilon_{sonst}| \cdot \varepsilon_{R,L}}{|\varepsilon_{qv,qh,qh*}| + |\varepsilon_{sonst}|} \qquad (9.01d)$$

Required safety coefficient, bending tensile stress:			erf γ_{RBZ}	2.00	[-]
Required safety coefficient, bending compressive stress:			erf γ_{RBD}	2.00	[-]
Flexural tensile strength to be considered	$f_{t,fl,res}$	---	---	---	N/mm²
Flexural compressive strength to be considered	$f_{c,rad,res}$	---	---	---	N/mm²

Inside

Curve correction factor, internal:	α_{ki}	1.014	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	0.041	-0.031	0.085	%
Strain due to other loads	ε_{sonst}	0.008	-0.009	0.026	%
Total strain	ε	0.049	-0.040	0.111	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	0.89	0.88	0.88	%
Safety coefficient flexural tension:	γ_{BZ}	18.150	---	7.897	[-]
Safety coefficient flexural compression:	γ_{BD}	---	21.804	---	[-]

outside

Curve correction factor, external:		α_{ka}	0.986	[-]

		crown	springline	invert	
Strain due to earth- and trafficloads	ε_{qv,qh,qh^*}	-0.077	-0.014	-0.122	%
Strain due to other loads	ε_{sonst}	-0.007	0.009	-0.023	%
Total strain	ε	-0.085	-0.005	-0.146	%
Ultimate outer fiber strain to be considered	$\varepsilon_{R,res}$	0.89	0.87	0.89	%
Safety coefficient flexural tension:	γ_{BZ}	---	---	---	[-]
Safety coefficient flexural compression:	γ_{BD}	10.548	174.051	6.080	[-]

All calculated safety coefficients of the strain proof are sufficient.

4.2.6.2 Deformation proof

Calculation mode:		linear		
Ratio:		I/(A·rm²)	0.00015	[-]
Ratio 'I/(A·rm²)·κ~Q':		$I/(A \cdot rm^2) \cdot \kappa_Q$	0.00018	[-]

		q_v	q_h	q_h^*	
Deflection coefficient for bending moments	c_v	-0.0893	0.0833	0.0640	[-]

The modifictaion of the coefficients for the moments according to ATV-DVWK-A 127 table 10a is not used, because formula 6.19a and formula 6.19b < 0.001

Resulting deformation coefficient	c'_v	-0.0893	0.0833	0.0640	[-]
Resulting deformation coefficient	c'_h	0.0891	-0.0833	-0.0658	[-]

Vertical diameter change:	Δd_v	7.01	mm
Horizontal diameter change:	Δd_h	5.17	mm
Relative vertical deformation (due to loads, elastic, Type B):	$\delta_{v,B}$	0.87	%
Predeformation (e. g. due to manufacturing, plastic, Type A):	$\delta_{v,A}$	1.00	%
Total vertical deformation (Type A + Type B):	$\delta_{v,Ges}$	1.87	%
Allowable deflection:	zul δ_v	6.00	%

The deflection determined is less than the permissible deflection.

4.2.6.3 Stabilty proof radial, linear

Earth and traffic loads

Pipe stiffness:	$\bar{S}_R$	46,055	N/m²
Horizontal bedding stiffness:	S_{Bh}	7.923	N/mm²
System stiffness, weighted:	$V_{RB,w}$	0.0058	[-]
Reduction factor buckling load for earth/traffic loads:	κ_{v2}	0.87	[-]
Friction angle in bedding zone:	φ'_2	35.000	°
Critical vertical total load:	krit q_v	1,053.8	kN/m²
Total vertical load:	q_v	69.64	kN/m²
Safety stability, radial:	$\gamma_{Stab,rad}$	15.13	[-]
Required safety coefficient, instability (buckling):	erf γ_{stab}	2.50	[-]

The buckling proof is fulfilled.

4.2.6.4 stability proof, nonlinear

The nonlinear stability proof is not applicable because of VRB > 1.0 (rigid pipe) or relative vertical deformation < 6%.

4.2.6.5 Proof of safety against failure with not predominantly static loading

According to the standard the dynamic proof is not required (e.g. traffic load > 1,5 m).

All necessary proofs are ok.

5 Appendix

Amiblu®
Sustainable Water Solutions

FLOWTITE® | HOBAS®

Input Data for structural analysis

of application buried pipes in open trench condition, calculation acc. DWA-A 127

Please send to:
Amiblu Holding GmbH
Pischeldorfer Straße 128
A-9020 Klagenfurt
T +43 463 482424
info@amiblu.com

9013 PCL 1F	
project	
LUZ d.d	Luka Krajnc
company	contact person
Verovškova ulica 64	(01) 36 02 473
street	phone/Fax:
1000	Text input.
postcode	signature:
Ljubljana	Text input.
city	date/stamp

Pipe Details:

nominal diameter DN	800	sewer pipe	☒
		sewer pressure pipe	☐
pressure class PN	PN1	pressure pipe	☐
		potable water pipe	☐
nominal stiffness SN	10000	installation in protective water area	☐
		air pipe	☐
pipe material	GRP	storage sewer	☐
		others	Text input.

Types of native soil: acc. ATV-DVWK-A 127; DIN 18196 (please subsoil expertise ad)

		Native soil	backfilling	Pipe zone
G1	Non cohesive soils (gravel, sand) (GE, GW, GI, SE, SW, SI)	☐	☒	☒
G2	Slightly cohesive soils (GU, GT, SU, ST)	☒	☐	☐
G3	Cohesive mixed soils, silt (GÜ, GŤ, SÜ, SŤ, UL, UM)	☐	☐	☐
G4	Cohesive soils, except silts (TL, TM, TA, OU, OT, OH, UA)	☐	☐	☐
Other types of soil	Text input.	☐	☐	☐

Proctor density for native soil (Proctor density 85 – 100 %): 98 %

Foundation of pipeline

- ☒ On native soil
- ☐ very hard and rocky
- ☐ Weak soil, not stable for foundation

Soil replacement: thickness Text input. m

material Text input.

Proctor density D_{Pr} Text input. %

Specification of loads:

	Min. cover depth		Max. cover depth	
Depth of earth cover h	3,17	m	3,19	m
min. Ground water h_w above pipe invert	Text input.	m	Text input.	m
max. Ground water h_w above pipe invert	Text input.	m	Text input.	m

Other surface loads Text input. kN/m²

For pressure pipes

Short term: Text input. bar, e.g. system test pressure; hydrostatic pressure, water hammer

Long term: Text input. bar, e.g. operating pressure (OP), system pressure (PN, DP)

Traffic load

☐ no traffic

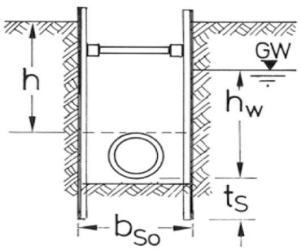
street
- ☐ HCL 60
- ☒ HCL 30
- ☐ HGV 12
- ☐ DIN EN 1991-2, TS und UDL
  - ☐ LM1-lane 3,00 m
  - ☐ LM1-lane 2,70 m
  - ☐ LM1-green field area

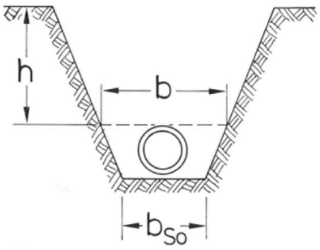
railway
- ☐ one track, UIC
- ☐ two tracks, UIC
- ☐ one track, LM 71
- ☐ two tracks, LM 71

aircraft
- ☐ BFZ 90
- ☐ BFZ 180
- ☐ BFZ 350
- ☐ BFZ 550
- ☐ BFZ 750

Other loads, e.g. special vehicle (please add load scheme with axle, wheels and wheel loads):
Text input.

Building construction:





Type of trench ☒ embankment ☐ single trench ☐ double trench [1] ☐ stepped trench [1]

[1] For special shapes add a sketch

Trench angel ☒ 90° ☐ 60° ☐ 45° ☐ Text input.

Width of trench b = 1.8 m at pipe crown

b_{So} = 1,8 m at pipe trench bottom inclusive planks

Trench planking

☐ no planks

☐ Horizontal planks, also applies to plank walls (Berlin lining)
☒ Planking with plates
☐ Vertical plank with light weight
☐ Vertical plank with boards *
☐ Vertical plank with light weight *
☐ Vertical plank with sheet piling *

bedding

☐ on native soil (acc. EN 1610)
☒ on gravel, sand
☐ on concrete [2]

[2] only as spezial construction in agreement with the pipe producer

bedding angle 2α

☐ 90° ☐ 120°
☐ 180°

* Depth of sheeting below pipe invert t_S = Text input. m

*thickness of plank (one-side) b_S = Text input. m

Cover condition for backfilling:

A1 ☐ Backfilling compacted in layers against the native soil (without proof of compaction degree); also applies to plank walls, Berlin lining

A2 ☐ Vertical pipe trench lining with boards that are not removed before backfilling. Lining boards or devices that are removed step by step during backfilling. Non-compacted backfilling/ backfilling with slurry (only suitable for soils of group G1).

A3 ☐ Vertical trench lining with sheet piling, light weight sheet connection, wooden planks, lining boards or devices that are not removed before backfilling.

A4 ☒ Backfilling compacted in layers against the native soil with proof of the required compaction degree to ZTVE-StB ; also applies to plank walls (Berlin lining). Cover condition A4 is not applicable to sails of group G4.

Bedding condition for pipe:

B1 ☒ Bedding compacted in layers against the native soil or in the embankment (without proof of compaction degree); also applies to plank walls, Berlin lining

B2 ☐ Vertical lining in the pipe zone with planks that reach down to the trench bottom and are not removed before backfilling and compaction. Lining boards or devices provided that the soil is compacted after the linings are removed.

B3 ☐ Vertical lining in the pipe zone with sheet piling or lightweight sheeting and compaction against the lining reaching down below the trench bottom. There is no safe calculation model for determining vertical lining with wooden planks, boards or devices that are not removed before backfilling and compaction the pipe zone.

B4 ☐ Bedding compacted in layers against the native soil or in the embankment with proof of the required compaction degree to ZTVE-StB. Bedding condition B4 does not apply to soils of group G4.

Input Data sheet for structural analysis

For case of application jacking process;
calculation acc. DWA-A 161

please send to:

Amiantit Germany GmbH
Am Fuchsloch 19
D-04720 Döbeln
T +49 3431 71820
germany@amiblu.com

Hobas Rohre GmbH
Gewerbepark 1
D-17039 Trollenhagen
T +49 395 45280
germany@amiblu.com

Amiblu Holding GmbH
Pischeldorfer Straße 128
A-9020 Klagenfurt
T +43 463 482424
austria@amiblu.com

HOBAS Engineering +Rohre AG
Birsigstraße 2
4054 Basel
T +41 61 2013120
switzerland@amiblu.com

PCL	
project name	
LUZ d.d	Luka Krajnc
company	contact person
Verovškova 64	+386 (0) 1 36 02 473
street	phone/fax
1000	luka.krajnc@luz.si
postcode	mail
Ljubljana	
city	date/stamp/signature

details to the jacking pipe:

pipe material	GRP (UP-GF)		pressure class PN		bar
outer diameter OD	1400	mm	wall thickness e		mm
pipe unit length l	286	m	jacking force plan.		KN

details to the jacking section:

jacking length compl. ____ m longest single jacking section ____ m

jacking route ☐ straight ☑ one curve ☐ several curves

curve radius curve 1 1000 m curve 2 ____ m curve 3 ____ m

planned transition between curves ☐ yes ☐ no

intermediate jacking station ☐ yes ☐ no

details to the jacking process:

jacking process					
OD drill head		mm			
lubrication during jacking operation	☐ no	☐ yes	lubricant pressure		bar
permanent grouting of the annular gap	☐ no	☐ yes	grout pressure		bar

Issues for static calculation for jacking method acc. DWA-A 125 / DVGW GW 304:

☐ Shield with support liquid and ground slurry; continuous support of annular gap for the whole jacking section starting from shield with documentation

☐ Other jacking methods;continuous support of annular gap for the whole jacking section starting from shield with documentation

☐ overcut ≤ 1,0cm (relating to the radius), without continuous support of annular gap for the whole jacking section

☐ overcut > 1,0cm (relating to the radius), without continuous support of annular gap for the whole jacking section

details to the loads:

Depth of earth cover (above pipe crown)	min. $h_ü$ =	8,4	m	max. $h_ü$ =	8,7	m	
Ground water table (above pipe bottom)	min. $h_ü$ =		m	max. $h_ü$ =		m	
Inner pressure	Installation condition		bar	operating condition		bar	
Water filling	Installation condition		bar	operating condition		bar	

Traffic load

☑ LM 1 ☐ LM 71 – single track* ☐ LM71 – multiple track*

☐ DAC/BFZ ☐ no traffic

* please attach an cross-section

add. **area loads** on surface (e.g. buildings) KN/m²

details to the soil conditions at pipe level and above:

Soil tyoe around jacking pipe ☐ G1 – non-cohesive ☐ G2 – slightly-cohesive

Compaction Level D ☐ loose ☐ medium dense ☐ dense ☐ very dense

☐ G3 – cohesive mixed soil ☐ G4 – cohesive soil

consistence I_C ☐ slurry ☐ soft ☐ stiff ☐ semisolid

solid rock ☐ weathered ☐ solid

deviating soil properties from DWA-A 161/DVGW GW312

specific weight _____ KN/m³

inner friction φ _____ °

modulus of deformation _____ N/mm²

Soil type above jacking pipe ☐ G1 – non-cohesive ☐ G2 – slightly-cohesive

Compaction Level D ☐ loose ☐ medium dense ☐ dense ☐ very dense

☐ G3 – cohesive mixed soil ☐ G4 – cohesive soil

consistence I_C ☐ slurry ☐ soft ☐ stiff ☐ semisolid

solid rock ☐ weathered ☐ solid

deviating soil properties from DWA-A 161/DVGW GW312

specific weight _____ KN/m³

inner friction φ _____ °

modulus of deformation _____ N/mm²

other details:

T/6 POPIS DEL

KANALIZACIJA PCL 1 FAZA

Št. postavke	Opis	Enota	Količina	Cena v EUR	Vrednost brez DDV
1.	**Kanali skupno**				
1.	**PRIPRAVLJALNA DELA**				
1.	Zakoličenje osi kanalizacije, z zavarovanjem osi in oznako revizijskih jaškov in vsa druga geodetska dela v času gradnje, ki so potrebna za nemoteno izvajanje del (smeri, višine, vmesne, začasne in končne zakoličbe...)	m1	1256		0.00 €
2.	Postavitev gradbenih profilov na vzpostavljeno os trase cevovoda, ter določitev nivoja za merjenje globine izkopa in polaganje cevovoda.	kom	52		0.00 €
3.	Priprava gradbišča, odstranitev eventuelnih ovir in utrditev delovnega platoja. Po končanih delih se gradbišče pospravi in vzpostavi v prvotno stanje.	m1	1256		0.00 €
4.	Vzdrževanje vseh prekopanih javnih površin v času od rušitve cestišča do vzpostavitve v prvotno stanje, ki zajema polivanje-protiprašna zaščito, dosip udarnih jam, izdelava nasipov za dostope do objektov, utrjevanje in planiranje vključno z dobavo materiala in delom.	m1	1256		0.00 €
5.	Nepredvidena dela vpisana v gradbeni dnevnik in potrejan s strani odgovornega nadzornika.	5%			0.00 €
1.	**PRIPRAVLJALNA DELA SKUPAJ**				**0.00 €**
2.	**ZEMELJSKA DELA**				
1.	Zavarovanje gradbene jame z razpiranjem z jeklenimi opaži -sistem z vodili (SBH, KRINGS ali podobno) . Globina jarka do 6,0m. Vključno z vsemi pomožnimi materiali, deli in transporti. (jeklene opaže se uporabi povsod).	m2	2512		0.00 €
2.	Strojni izkop jarka, skladno z določili geomehanskega poročila, globine 0-4 m, v terenu III. kat. z nakladanjem na kamion in odvozom na začasno gradbeno deponijo do 2km, s stroškom začasne deponije.	m3	4060		0.00 €
3.	Strojni izkop jarka, skladno z določili geomehanskega poročila, globine 0-4 m, v terenu III. kat. z nakladanjem na kamion in odvozom na trajno gradbeno deponijo, vključno s stroški deponije.	m3	4394		0.00 €
4.	Vertikalni strojni izkop gradbene jame globine 4-6m, v terenu V. kat. z nakladanjem na kamion in odvozom na trajno gradbeno deponijo, vključno s stroški deponije.	m3	948		0.00 €
5.	Vertikalni strojni izkop gradbene jame globine do 15 m, za ponikalnice v terenu V. kat. z nakladanjem na kamion in odvozom na trajno gradbeno deponijo, vključno s stroški deponije.	m3	30		0.00 €
6.	2128 - Ročni izkop jarka globine 0 - 4 m, z nakladanjem na kamion in odvozom na trajno gradbeno deponijo do 2 km, vključno s stroški deponije.	m3	934		0.00 €
7.	2202 - Ročno planiranje dna jarka s točnostjo +/- 3 cm po projektiranem padcu.	m2	2279		0.00 €
8.	2203 - Dobava in vgraditev peščenega materiala granulacije 8 do 16 mm za peščeno ležišče cevi (POSTELJICA) s sprotno višinsko kontrolo do predpisane kote dna cevi (10cm + D/10) z komprimacijo do stopnje 97% SPP (standardni Proctorjev preizkus), vključno z nabavo in transportom materiala.	m3	456		0.00 €
9.	2204 - Dobava in vgraditev peščenega materiala granulacije 8 do 16 mm s komprimacijo, v coni cevovoda v debelini 30 cm nad temenom, s komprimacijo v plasteh po 20 cm, zbitost 95% po proctorju, vključno z nabavo in transportom materiala.	m3	4101		0.00 €
10.	2207 - Nabava, dobava in vgraditev geotekstila za ločilno plast in ovijanje obsipa cevi, natezna trdnost 14 do 16 kN/m2, gostote minimalno 300 g/m2. V ceni so zajeti preklopi in ves potreben pritrdilni material.	m2	2606		0.00 €
11.	2208 - Zasipavanje jarka z izkopanim materialom, s komprimiranjem v slojih po 30 cm, do 95 % zgoščenosti po standardnem Proctorjevem postopku, vključno z dovozom z začasne deponije.	m3	1518		0.00 €
12.	2209 - Zasip jarka z dovozom novega gramoznega zasipnega materiala z utrjevanjem v slojih po 30 cm do 95 % trdnosti po standardnem Proctorjevem postopku; vključno z nabavo in dobavo zasipnega materiala.	m3	1518		0.00 €

13.	Kompletna izvedba podvrtavanja z vgradnjo potisnih poliesterskih cevi po tehnologiji "mikrotuneling". Vrste in plasti zemljine na lokaciji so opisane v geološkem poročilu. Zemljino, ki se odstrani kot posledico vrtanja cevi, je treba odstraniti in odpeljati na končno deponijo, ki jo preskrbi izvajalec. Potisno silo in silo krmiljenja kot tudi pozicijo vrtalne glave (MTBM stroj) je treba stalno nadzorovati in beležiti. Vse podatke o MTBM stroju, ki se beležijo in posredujejo na krmilno ploščo, je treba registrirati v skladu s programom o zagotavljanju kakovosti (po zahtevah naročnika) in vsak dan predstaviti ali zagotoviti nadzornemu osebju naročnika na gradbišču v elektronski obliki. Cev mora biti popolnoma prazna in vodotesna; Cena na enoto mora vsebovati vsa dodatna in naknadna dela in storitve, potrebne za uvrtavanje. To vključuje vse zahteve iz razpisnih pogojev, dobavo in montažo vseh strojev in opreme, potrebne za hidravlično uvrtavanje, namestitev in odstranitev TBM stroja, oskrbo z elektriko in vodo, dobavo, namestitev, obratovanje, vzdrževanje in odstranitev separacijske enote, ko se kot nosilna tekočina uporablja bentonit, kot tudi preverjena statika tunela za predmetno cev.V ceni so zajeti vsi stroški za vmesne postaje. Izvajalec določi vrsto in količino vmesnih postaj za narivanje poliesterske potisne cevi in pri tem mora upoštevati, montažo, obratovanje in vrsto ter nadzor prehoda tlaka med posameznimi cevmi in cevnimi nastavki za mazanje bentonita. Izmera po dolžinskem metru vgrajene cevi. V ceni upoštevati tudi morebitni strošek za čas izpada	m	426		0.00 €
14.	Doplačilo k zgornji poziciji za izvedbo podvrtavanja "mikrotuneling" v mehki kamnini (lapor, peščenjak, konglomerat - enosna tlačna trdnost qu = od 1 do 6 Mpa - ocena)	m	100		0.00 €
15.	Premik garniture za mikrotuneliranje	kos	1		0.00 €
16.	Izvedba nalivalnega testa za ponikalnice	kom	1		0.00 €
17.	Nepredvidena dela vpisana v gradbeni dnevnik in potrejan s strani odgovornega nadzornika.	5%			0.00 €
2.	**ZEMELJSKA DELA SKUPAJ**				**0.00 €**

3.	**CEVI**				
1.	Nabava, dobava in montaža kanalizacijskih cevi DN 300 mm iz armiranega poliestra (GRP) izdelane po SIST EN 14364: 2013, nazivne togosti SN 10.000 N/m2, kompletno z potrebnimi spojkami. Cev ima na eni strani montirano spojko iz poliestra z EPDM tesnilom. Spoj (tesnilo) mora biti zaradi zagotovitve kvalitete spoja preizkušen skupaj s cevmi (certifikat). Notranji zaščitni sloj cevi iz čistega poliestra, brez polnila in ojačitve, mora imeti minimalno debelino 1,0 mm s ciljem doseganja tesnosti, kemijske in abrazijske obstojnosti in odpornosti na obrus pri visokotlačnem čiščenju. Vključen je tudi prevoz in prenos kanalizacijskih cevi iz deponije do mesta vgradnje.	m1	336		0.00 €
2.	Nabava, dobava in montaža kanalizacijskih cevi DN 400 mm iz armiranega poliestra (GRP) izdelane po SIST EN 14364: 2013, nazivne togosti SN 10.000 N/m2, kompletno z potrebnimi spojkami. Cev ima na eni strani montirano spojko iz poliestra z EPDM tesnilom. Spoj (tesnilo) mora biti zaradi zagotovitve kvalitete spoja preizkušen skupaj s cevmi (certifikat). Notranji zaščitni sloj cevi iz čistega poliestra, brez polnila in ojačitve, mora imeti minimalno debelino 1,0 mm s ciljem doseganja tesnosti, kemijske in abrazijske obstojnosti in odpornosti na obrus pri visokotlačnem čiščenju. Vključen je prevoz in prenos kanalizacijskih cevi iz deponije do mesta vgradnje.	m1	259		0.00 €
3.	Nabava, dobava in montaža kanalizacijskih cevi DN 500 mm iz armiranega poliestra (GRP) izdelane po SIST EN 14364: 2013, nazivne togosti SN 10.000 N/m2, kompletno z potrebnimi spojkami. Cev ima na eni strani montirano spojko iz poliestra z EPDM tesnilom. Spoj (tesnilo) mora biti zaradi zagotovitve kvalitete spoja preizkušen skupaj s cevmi (certifikat). Notranji zaščitni sloj cevi iz čistega poliestra, brez polnila in ojačitve, mora imeti minimalno debelino 1,0 mm s ciljem doseganja tesnosti, kemijske in abrazijske obstojnosti in odpornosti na obrus pri visokotlačnem čiščenju. Vključen je prevoz in prenos kanalizacijskih cevi iz deponije do mesta vgradnje.	m1	213		0.00 €
4.	Nabava, dobava in montaža kanalizacijskih cevi DN 600 mm iz armiranega poliestra (GRP) izdelane po SIST EN 14364: 2013, nazivne togosti SN 10.000 N/m2, kompletno z potrebnimi spojkami. Cev ima na eni strani montirano spojko iz poliestra z EPDM tesnilom. Spoj (tesnilo) mora biti zaradi zagotovitve kvalitete spoja preizkušen skupaj s cevmi (certifikat). Notranji zaščitni sloj cevi iz čistega poliestra, brez polnila in ojačitve, mora imeti minimalno debelino 1,0 mm s ciljem doseganja tesnosti, kemijske in abrazijske obstojnosti in odpornosti na obrus pri visokotlačnem čiščenju. Vključen je tudi prevoz in prenos kanalizacijskih cevi iz deponije do mesta vgradnje.	m1	440		0.00 €
5.	Nabava, dobava in montaža kanalizacijskih cevi DN 800 mm iz armiranega poliestra (GRP) izdelane po SIST EN 14364: 2013, nazivne togosti SN 10.000 N/m2, kompletno z potrebnimi spojkami. Cev ima na eni strani montirano spojko iz poliestra z EPDM tesnm. Spoj (tesnilo) mora biti zaradi zagotovitve kvalitete spoja preizkušen skupaj s cevmi (certifikat). Notranji zaščitni sloj cevi iz čistega poliestra, brez polnila in ojačitve, mora imeti minimalno debelino 1,0 mm s ciljem doseganja tesnosti, kemijske in abrazijske obstojnosti in odpornosti na obrus pri visokotlačnem čiščenju. Vključen je tudi prevoz in prenos kanalizacijskih cevi iz deponije do mesta vgradnje.	m1	8		0.00 €
6.	Dobava, transport in deponiranje na gradbišču, potisne poliesterske cevi; Kanalizacijska cev zunanjega premera 1499 mm; nazivne togosti SN 64000 N/m2 in nazivnega tlaka PN 01 bar, izdelane iz poliestrske smole ojačane s steklenimi vlakni v skladu s SIST EN ISO 23856: 2022 po tehnološkem postopku centrifugiranja CC-GRP (kakor npr. Amiblu Hobas). Cev, dolžine 2,92 m +25/-10 mm, ima na eni strani montirano spojko iz poliestra z EPDM tesnilom. Notranji zaščitni sloj cevi iz čistega poliestra, brez polnila in ojačitve, mora imeti minimalno debelino 1,0 mm s ciljem doseganja kontrole tesnosti, kemijske in abrazijske obstojnosti in odpornosti na obrus pri visokotlačnem čiščenju. Po potrebi, se lahko cevi opremijo s 3 priključki iz nerjavečega jekla premera 1" za vbrizgavanje bentonita	m1	426		0.00 €
7.	Ponikovalnica, premera 1000 mm ,globoka 5 metrov	kos	5		0.00 €
8.	Nepredvidena dela vpisana v gradbeni dnevnik in potrejan s strani odgovornega nadzornika.	5%			0.00 €
3.	**CEVI SKUPAJ**				**0.00 €**
4.	**JAŠKI**				
1.	Nabava, dobava in montaža revizijskih jaškov iz armiranega poliestra po SIST EN 14 364: 2013, komplet z izdelano muldo. Premer jaška 1000mm, globina do 4 m. Minimalna debelina sten revizijskega jaška je 8mm. V ceni je vključena tudi izdelava AB temeljne plošče jaška debeline 20cm, iz betona C25/30	kos	25		0.00 €
2.	Nabava, dobava in montaža revizijskih jaškov iz armiranega poliestra po SIST EN 14 364: 2013, komplet z izdelano muldo. Premer jaška 1200mm, globina do 6 m. Minimalna debelina sten revizijskega jaška je 8mm. V ceni je vključena tudi izdelava AB temeljne plošče jaška debeline 20cm, iz betona C25/30	kos	27		0.00 €
3.	Nabava, dobava in montaža revizijskega jaška za hišni priključek iz polietilena. Premer jaška 800mm, globina 1 - 2m. Kompletno z vsemi pripadajočimi in pomožnimi deli.	kos	12		0.00 €

4.	Dobava in vgradnja LTŽ pokrova fi 600mm, skladno s SIST EN 124-1:2015 nosilnosti D 400 kN. Pokrov izveden na zaklep z odprtinami za zračenje. Tip Norinco, PAM ali enakovredno. Skupaj z razbremenilno AB ploščo za montažo na cev DN 1200 mm, ter vsemi potrebnimi deli in materiali. Vključno z AB vencem za vgradnjo LTŽ pokrova ter dobavo in vgrajevanjem betona C16/20 in vso potrebno armaturo za betoniranje pete revizijskih jaškov.	kos	57		0.00 €
5.	Prevezava obstoječih priključkov na projektirani kanal. V ceni upoštevati ponoven izkop zemljine do priključka, varovanje gradbene jame, nakladanjem in odvoz na stalno deponijo s sstroški deponijo, prevezavo obstoječega priključka, rušenje obstoječe cevi na mestu priključka in zapolnitev kanala na mestu rušenje z pustim betonom C12/15 (cca 0,5m3), planiranjem in utrjevanjem dna jarka, posteljico, obbetoniranje cevi ter zasipom do kote terena. Odcep na cevi izvesti s prefabriciranim sedlastim nastavkom ali fazonskimkosom iz enakih cevi kot je javna kanalizacija. V ceni upoštevati vsa pripadajoča in pomožna dela.	kos	12		0.00 €
6.	Strojno in ročno rušenje obstoječih kanalizacijskih povezav in križanj s obstoječimi vodi (odvodnjavanje), nakladanje in odvoz na stalno deponijo, vključno z deponijsko takso. Vzpostavitev prvotnega stanja.	KOS	10		0.00 €
7.	Betonski koalescentni separator lahkih tekočin s povečanim by-passom, nazivnega pretoka 30 l/s, celotnega pretoka 300 l/s, z usedalnikom 3000 lit,priključne cevi DN 500, EN 858, z begu D400 pokrovom	kos	1		0.00 €
8.	Nepredvidena dela vpisana v gradbeni dnevnik in potrejan s strani odgovornega nadzornika.	5%			0.00 €
4.	**JAŠKI SKUPAJ**				**0.00 €**
5.	**VOZLIŠČNA KONSTRUKCIJA**				
1.	Rezanje asfaltne plasti s talno diamantno žago, globine do 15 cm.	m	1,691.40		0.00 €
2.	Rušenje asfaltnih plasti debeline do 15 cm z nakladanjem, vključno z odvozom materiala na stalno gradbeno deponijo in plačilom deponijskih taks.	m2	1,434.80		0.00 €
3	Dobava in vgraditev geotekstilije za ločilno plast (po načrtu), natezna trdnost nad 14 do 16 kN/m2	m2	1,434.80		0.00 €
4	Izdelava nasipa iz zrnate kamnine 3. kategorije z dobavo iz kamnoloma (kamnita greda pod cesto deb. 30 cm granulacije 0/64), vgrajevanje v plasteh do debeline 0,3 m, s komprimiranjem do predpisane zgoščenosti Ev2=80Mpa. Vključno z vsemi dodatnimi in zaščitnimi deli in preizkusom nosilnosti z merilno ploščo. Obračun po izkazu kubatur.	m3	573.92		0.00 €
5	Izdelava nevezane nosilne plasti drobljenca iz kamnine v debelini 21 do 30 cm (TD 0/32 debeline 30 cm pod cesto). Dobava na mesto vgradnje in izdelava nosilne plasti z enakomerno zrnatim drobljencem zrnavosti 0-32mm, s sprotno komprimacijo do zahtevane zbitosti. Drobljenec služi tudi za izdelavo bankin. Zaključna plast mora dosegati modul nosilnosti Ev2 =120 Mpa. V ceni so zajete tudi meritve zbitosti in nosilnosti s togo krožno ploščo. PO IZKAZU KUBATUR	m3	430.44		0.00 €
6	Nabava, dobava in izdelava nosilne plasti bituminizirane zmesi AC 32 base B 50/70 A2, v debelini 11 cm. V ceni je zajeta izdelava v projektiranih padcih in naklonih, ter vsa dodatna in zaščitna dela. Cestišče.	m2	1,434.80		0.00 €
7	Nabava, dobava in izdelava vezne plasti bituminizirane zmesi AC 22 bin PmB 45/80-65 A1/A2, v debelini 7 cm. V ceni je zajeta izdelava v projektiranih padcih in naklonih, ter vsa dodatna in zaščitna dela. Cestišče.	m2	1,434.80		0.00 €
8	Nabava, dobava in izdelava obrabno zaporne asfaltne plasti SMA 11 surf PmB 45/80-65 A1/A2 v debelini 4 cm. V ceni je zajeta izdelava v projektiranih padcih in naklonih, ter vsa dodatna in zaščitna dela. Cestišče.	m2	1,434.80		0.00 €
9	Čiščenje utrjene/odrezkane površine/podlage pred pobrizgom z bitumenskim vezivom.	m2	1,434.80		0.00 €
10	Pobrizg s polimerno bitumensko emulzijo 0,31 do 0,50 kg/m2	m2	1,434.80		0.00 €
5	**VOZLIŠČNA KONSTRUKCIJA SKUPAJ**				**0.00 €**
6.	**PREGLEDI IN KRIŽANJA**				
1.	Pregled in čiščenje kanala pred izvedbo preizkusa tesnosti.	m	1682		0.00 €
2.	6102 - Preizkus tesnosti kanala po standardu SIST EN 1610 ali DIN 4033 - gravitacijski kanal. Vključno z vsemi dodatnimi in zaščitnimi deli.	m	1682		0.00 €

3.	6105 - Pregled in snemanje s TV kamero vseh gravitacijskih kanalizacijskih cevi, jaškov in vseh cevnih odsekov. Snemanje kanala po standardu SIST EN 13508-2:2003 in skladno z nemškimi smernicami ATV-M 143-2.	m	1682		0.00 €
4.	6203 - Izvedba križanja z obstoječimi komunalnimi vodi	kos	50		0.00 €
5	Preureditev in prilogoditev obstoječe gospodarske jacvne infrastrukture na območju Čufarjeve in Kolodvorske ulice: - odstranitev in ponovna vzpostavitev vročevoda na Čufarjevi ulici DN 300 in DN 400 mm - vgradnja končnih jaškov na 2 kanala DN 500 mm in prečrpavanje odpadne vode za čas gradnje iz kanalov DN 500 mm po Čufarjevi in Kolodvorski cesti na kanal južno od gradbiđšča na Kolodvorski ulici - začasna prevezava obstoječih elektronsko komunikacijskih kablov in kablov cestne razsvetljave na območju Kolodvorske in Čufarjeve ulice	kos	1		0.00 €
6	Nepredvidena dela vpisana v gradbeni dnevnik in potrejan s strani odgovornega nadzornika.	5%			0.00 €
6.	**PREGLEDI IN KRIŽANJA SKUPAJ**				**0.00 €**
7.	**TUJE STORITVE**				
1.	Projektantski nadzor v katerem so vključeni vsi odgovorni projektanti na projektu. Obračun po dejanskih stroških in po potrditvi s strani odgovornega nadzornika	ur	250		0.00 €
2.	Geotehnični nadzor, prevzem gradbene jame in temeljnih tal. Obračun po dejanskih stroških in po potrditvi s strani odgovornega nadzornika.	ur	100		0.00 €
3.	Izdelava elaborata zapore ceste za vse faze gradnje in pridobitev dovoljenja za zaporo ceste.	kos	1		0.00 €
4.	Izdelava PID projektne dokumentacije (v šestih (6) izvodih in en (1) izvod v elektronski verziji - Acad, DWG). V ceni so zajeti vsi načrti, ki so bili izdelani tudi na nivoju projekta PZI.	kos	1		0.00 €
5.	Izdeleva geodetskega snemanja terena po končanju del skupaj s potekom obstoječih komunalnih vodov. V posnetku je potrebno zajeti celoten potek obnovljenih površin, zasaditve in potek obstoječih in novih komunalnih naprav. Geodetski posnetek mora biti opremljen s certifikatom. Del geodetskega posnetka je tudi foto aero snemanje območja gradbišča (brezpilotno letalo ali alterntivno). Topografski posnetki terena morajo biti geolocirani v državnem koordinatnem sistemu, ločljivost točke aero-foto snemanja mora znašati 5 cm na terenu. Geodetski posnetek se investitorju preda v 4-ih pisnih izvodih in v digitalni obliki (DWG, TIFF, JPG)	kos	1		0.00 €
6.	Izdelava eleborata za vpis izvedenega stanja v kataster GJI.	kpl	1		0.00 €
7.	Izdelava dokazila zanesljivosti objekta DZO, vključno z navodili za obratovanje in vzdrževanje objekta skladno z gradbenim zakonom.	kpl	1		0.00 €
8.	Nepredvidena dela vpisana v gradbeni dnevnik in potrejan s strani odgovornega nadzornika.	5%			0.00 €
7.	**TUJE STORITVE SKUPAJ**				**0.00 €**

G GRAFIČNI PRIKAZI

G/1	TEHNIČNI PRIKAZI	
	Kazalo risb	
list	vsebina risbe	merilo
G.1	Pregledna situacija	1:5.000
G.2.1.1	Situacija fekalne kanalizacije 1	1:250
G.2.1.2	Situacija fekalne kanalizacije 2	1:250
G.2.1.3	Situacija padavinske kanalizacije 1	1:250
G.2.2.1	Situacija prispevnih površin fekalne kanalizacije	1:250
G.2.2.2	Situacija prispevnih površin padavinske kanalizacije	1:250
G.3.1	Vzdolžni profil Kanala 1	1:1000/100
G.3.2	Vzdolžni profil Kanala 2	1:1000/100
G.3.3	Vzdolžni profil Kanala 2.3	1:1000/100
G.3.4	Vzdolžni profil Kanala 3	1:1000/100
G.3.5	Vzdolžni profil Kanala 3.1	1:1000/100
G.3.6	Vzdolžni profil Kanala 3.2	1:1000/100
G.3.7	Vzdolžni profil Kanala 4	1:1000/100
G.3.8	Vzdolžni profil Kanala M1	1:1000/100
G.3.9	Vzdolžni profil Kanala M1.1	1:1000/100
G.4.1	Karakteristični prečni profil	1:20
G.5.1	Detajl cestnega požiralnika z LTŽ rešetko	1:20
G.5. 2	Detajl cestnega požiralnika z robniško rešetko	1:20
G.5. 3	Detajl vpada iz cestnega požiralnika	1:25
G.5. 4	Detajl revizijskega jaška	1:25
G.5.5	Detajl polaganja kanalizacijskih cevi	1:25
G.5.6	Detajl križanja komunalnih vodov	1:25

G.5.7	Detajl ponikovalnice	1:50
G.5.8	Detajl lovilca olja	1:25



Legenda

- padavinska_kanalizacija
- mesana_kanalizacija

PROJEKTANT

LJUBLJANSKI URBANISTIČNI ZAVOD, d. d.
Verovškova ulica 64, 1000 Ljubljana
+386 1 36 02 400
info@luz.si

ELEA iC d.o.o.
Dunajska c. 21, 1000 Ljubljana
+386 1 47 41 000
info@elea.si

OBJEKT	Ureditev GJI na območju potniškega centra Ljubljana - 1. faza
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
ODGOVORNI VODJA PROJEKTA 1	Uroš Maršič, univ.dipl.inž.grad. G-3272
ODGOVORNI VODJA PROJEKTA 2	Andrej Pogačnik, univ.dipl.inž.grad.
SODELAVCI	Marko Fatur, univ.dipl.inž. grad. - odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod.in kom.inž. Špela Blažič, univ.dipl.inž.vod.in kom.inž.
VRSTA PROJEKTNE DOKUMENTACIJE	PZI
VRSTA PRIKAZA	Tehnični prikaz
VSEBINA RISBE	Pregledna karta
DATUM	avgust 2025
OPOMBE	

ŠT. PROJEKTA:	9013-1F
ŠT. NAČRTA:	9013_1F/2_2
MERILO:	1:5.000
ŠT. RISBE:	G.1

LJ Center

0m 10m 20m 50m
M 1:500

EMONIKA P1

MEJA OBDELAVE
K2.1: DUNAJSKA CESTA
Navezava na obst. stanje
km 0.0+20.00

KPP 2.1

FAZA 1A FAZA 1B

KPP 2.2

Kanal 4

INTERVENCIJA / DOSTAVA

Višinska in situativna navezava na obstoječe stanje

Kanal 3.2

Masarykova cesta
LG 211240
odsek 211244
V_{pr} 50 km/h, L_o= 500 m
Skupna dolžina ureditve:
L_s=865.51 m

FAZA 1

Kanal 3

KPP 2.1

KPP 2.2

MIKLOŠIČEVA CESTA

K2.2: MIKLOŠIČEVA CESTA in EMONIKA P1
Desno, km 0.2+3.95
Levo, km 0.2+3.95

FAZA 1A FAZA 1B

AVTOBUSNA POSTAJA LJUBLJANA
JUŽNI TERMINAL

KPP 2.3

ŽELEZNIŠKA POSTAJA LJUBLJANA

Kanal 3.1

Kanal 2.3

RESLJEVA CESTA

K2.3: RESLJEVA CESTA
Desno, km 0.4+81.00

Masarykova cesta
LG 211240
odsek 211244
V_{pr} 50 km/h, L_o= 500 m
Skupna dolžina ureditve:
L_s=865.51 m

Masarykova cesta
LG 211240
odsek 211244
V_{pr} 50 km/h, L_o= 584.18 m
Skupna dolžina ureditve:
L_s=865.51 m

LEGENDA:
- MEJA POSEGA
- NOVI ASFALT
- NOVI ASFALT, KOLESARSKA STEZA
- ZELENICA
- PADAVINSKA KANALIZACIJA
- MEŠANA KANALIZACIJA
- POŽIRALNIŠKA ZVEZA
- KOLEKTOR
- PODATKI PRISPEVNIH POVRŠIN

SITUACIJA FEKALNE KANALIZACIJE 1

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA IC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

OBJEKT	Ureditev gospodarske javne infrastrukture na območju - I FAZA Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

VRSTA DOKUMENTACIJE	PZI
VRSTA PRIKAZA	TEHNIČNI PRIKAZ
VSEBINA RISBE	SITUACIJA FEKALNE KANALIZACIJE
DATUM	avgust 2025

ŠT. PROJEKTA:	9013_IF
ŠT. NAČRTA:	9013/2_2
MERILO:	1:500
ŠT. RISBE:	G.2.1.1

2025 x:\projekti\9013_9013_jpd_pzi_5_pzi_f112_2_nacrt kanalizacija\grafika\9013_pd_sit_pzi_fk.dwg

0.50m²

LJ Center

0m 10m 20m 50m
M 1:500

Kolodvorska ulica

Kanal 1- MIKROTUNELIRANJE

AC Obroč

KPP 2.2

KPP 2.3

Mala ulica

Dalmatinova ulica

Tavčarjeva ulica

Čufarjeva ulica

Komenskega ulica

LEGENDA:

- MEJA POSEGA
- NOVI ASFALT
- NOVI ASFALT, KOLESARSKA STEZA
- ZELENICA
- PADAVINSKA KANALIZACIJA
- MEŠANA KANALIZACIJA
- POŽIRALNIŠKA ZVEZA
- KOLEKTOR
- PODATKI PRISPEVNIH POVRŠIN

SITUACIJA FEKALNE KANALIZACIJE 2

PROJEKTANT / JV	LUZ, d.d. Verovškova ulica 64, 1001 Ljubljana Telefon +386(0)1 360 24 00 www.luz.si • info@luz.si	ELEA IC d.o.o. Dunajska cesta 21, Ljubljana Telefon +386(0)1 474 10 00 www.elea.si • info@elea.si
OBJEKT	Ureditev gospodarske javne infrastrukture na območju - I FAZA Potniškega centra Ljubljana	
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana	
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272	
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272	
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž	

VRSTA DOKUMENTACIJE	PZI	ŠT. PROJEKTA:	9013_IF
VRSTA PRIKAZA	TEHNIČNI PRIKAZ	ŠT. NAČRTA:	9013_1F/2_2
VSEBINA RISBE	SITUACIJA FEKLANE KANALIZACIJE 2	MERILO:	1:500
DATUM	avgust 2025	ŠT. RISBE:	G.2.1.2

© 2025 x:\projekti\9013_9013_ipd_pcl_5_pzi_f1\2_2_nacrt kanalizacija\grafika\9013_pcl_sit_pzi_fk.dwg

0.50m²

LJ Center

0m 10m 20m 50m
M 1:500

MEJA OBDELAVE
K2.1: DUNAJSKA CESTA
Navezava na obst. stanje
km 0.0+20.00

Višinska in situativna navezava na obstoječe stanje

EMONIKA P1

KPP 2.1

KPP 2.2

FAZA 1A

FAZA 1B

Masarykova cesta
LG 211240
odsek 211244
V_{pr} 50 km/h, L_o= 500 m
Skupna dolžina ureditve:
L_s=865.51 m

FAZA 1

Kanal M1

MIKLOŠIČEVA CESTA

K2.2: MIKLOŠIČEVA CESTA in EMONIKA P1
Desno, km 0.2+3.95
Levo, km 0.2+3.95

AVTOBUSNA POSTAJA LJUBLJANA
JUŽNI TERMINAL

ŽELEZNIŠKA POSTAJA LJUBLJANA

KPP 2.3

Kanal M1.1

I. FAZA II. FAZA

RESLJEVA CESTA

K2.3: RESLJEVA CESTA
Desno, km 0.4+81.00

Masarykova cesta
LG 211240
odsek 211244
V_{pr} 50 km/h, L_o= 584.18 m
Skupna dolžina ureditve:
L_s=865.51 m

LEGENDA:
- MEJA POSEGA
- NOVI ASFALT
- NOVI ASFALT, KOLESARSKA STEZA
- ZELENICA
- PADAVINSKA KANALIZACIJA
- MEŠANA KANALIZACIJA
- POŽIRALNIŠKA ZVEZA
- KOLEKTOR
- PODATKI PRIŠPEVNIH POVRŠIN

SITUACIJA PADAVINSKE KANALIZACIJE 1

PROJEKTANT / JV
LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA IC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

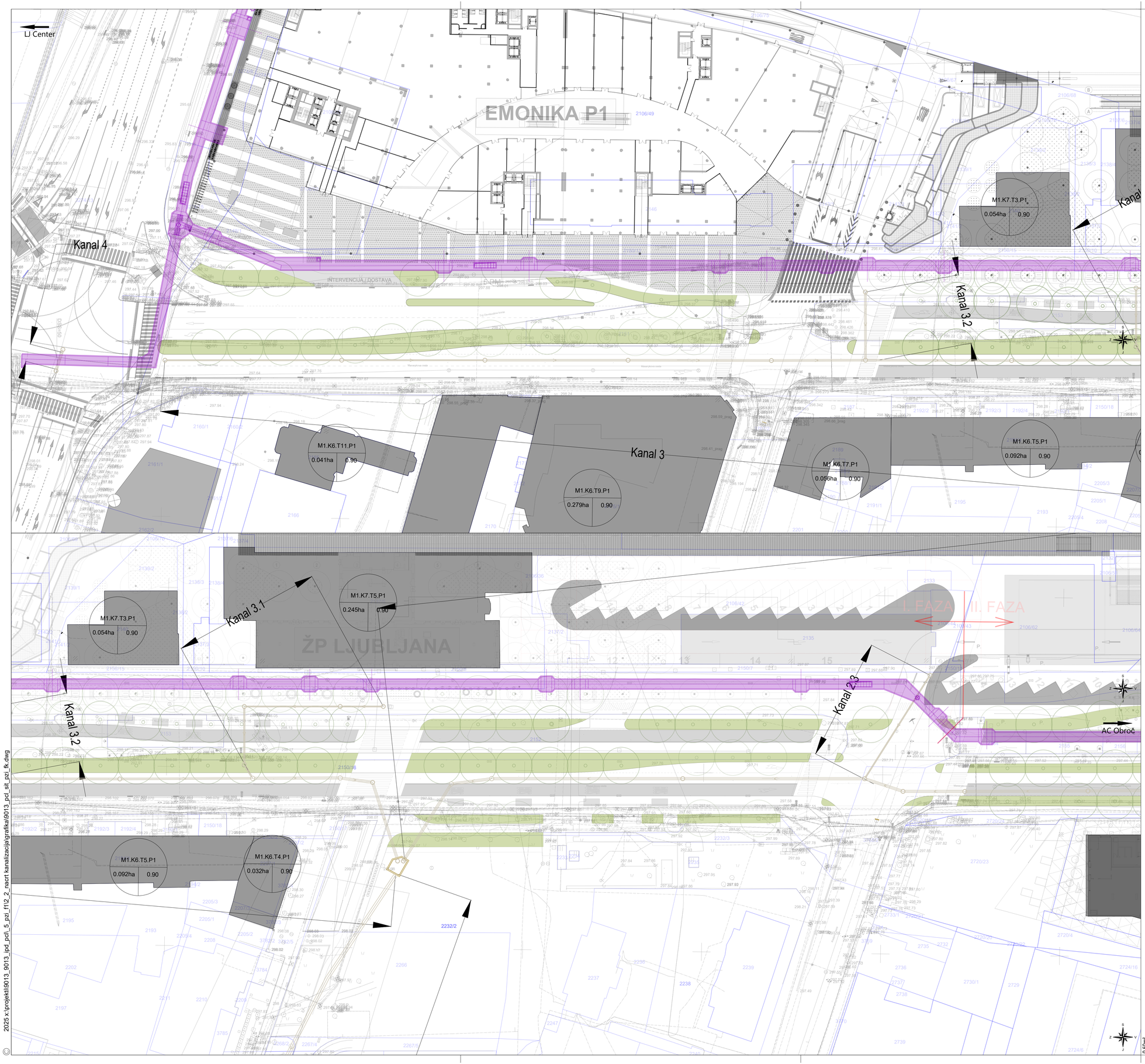
OBJEKT	Ureditev gospodarske javne infrastrukture na območju - I FAZA Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

VRSTA DOKUMENTACIJE	PZI
VRSTA PRIKAZA	TEHNIČNI PRIKAZ
VSEBINA RISBE	SITUACIJA PADAVINSKE KANALIZACIJE 1
DATUM	avgust 2025

ŠT. PROJEKTA:	9013_IF
ŠT. NAČRTA:	9013_1F/2_2
MERILO:	1:500
ŠT. RISBE:	G.2.1.3

© 2025 x:\projekti\9013_9013_ipd_pdl_5_pzi_f1\2_2_nacrt kanalizacija\grafike\9013_pdl_sit_pzi_fk.dwg

0.50m²



0m 10m 20m 50m
M 1:500

LEGENDA:

- MEJA POSEGA
- NOVI ASFALT
- NOVI ASFALT, KOLESARSKA STEZA
- ZELENICA
- PADAVINSKA KANALIZACIJA
- MEŠANA KANALIZACIJA
- POŽIRALNIŠKA ZVEZA
- KOLEKTOR
- PODATKI PRISPEVNIH POVRŠIN

SITUACIJA PRISPEVNIH POVRŠIN
FEKALNE KANALIZACIJE

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA IC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

OBJEKT	Ureditev gospodarske javne infrastrukture na območju - I FAZA Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

VRSTA DOKUMENTACIJE	PZI
VRSTA PRIKAZA	TEHNIČNI PRIKAZ
VSEBINA RISBE	SITUACIJA PRISPEVNIH POVRŠIN
DATUM	avgust 2025

ŠT. PROJEKTA:	9013_1F
ŠT. NAČRTA:	9013_1F/2_2
MERILO:	1:500
ŠT. RISBE:	G.2.2.1

© 2025 x:\projekti\9013_9013_ipd_pzi_5_pzi_f1\2_2_nacrt kanalizacija\grafika\9013_pzi_sit_pzi_fk.dwg

LJ Center

0m 10m 20m 50m
M 1:500

Kanal 2.1

Kanal 2.2

Kanal 5

NADVIŠANJE 50 cm

montažna odprtina z AB pokrovi

vstopni jašek

D7-R8-MJ5

D.P1

D.P2

D.P3

D26-MJ6

AC Obroč

Kanal 1- MIKROTUNELIRANJE

Kolodvorska ulica

Šmarinska cesta

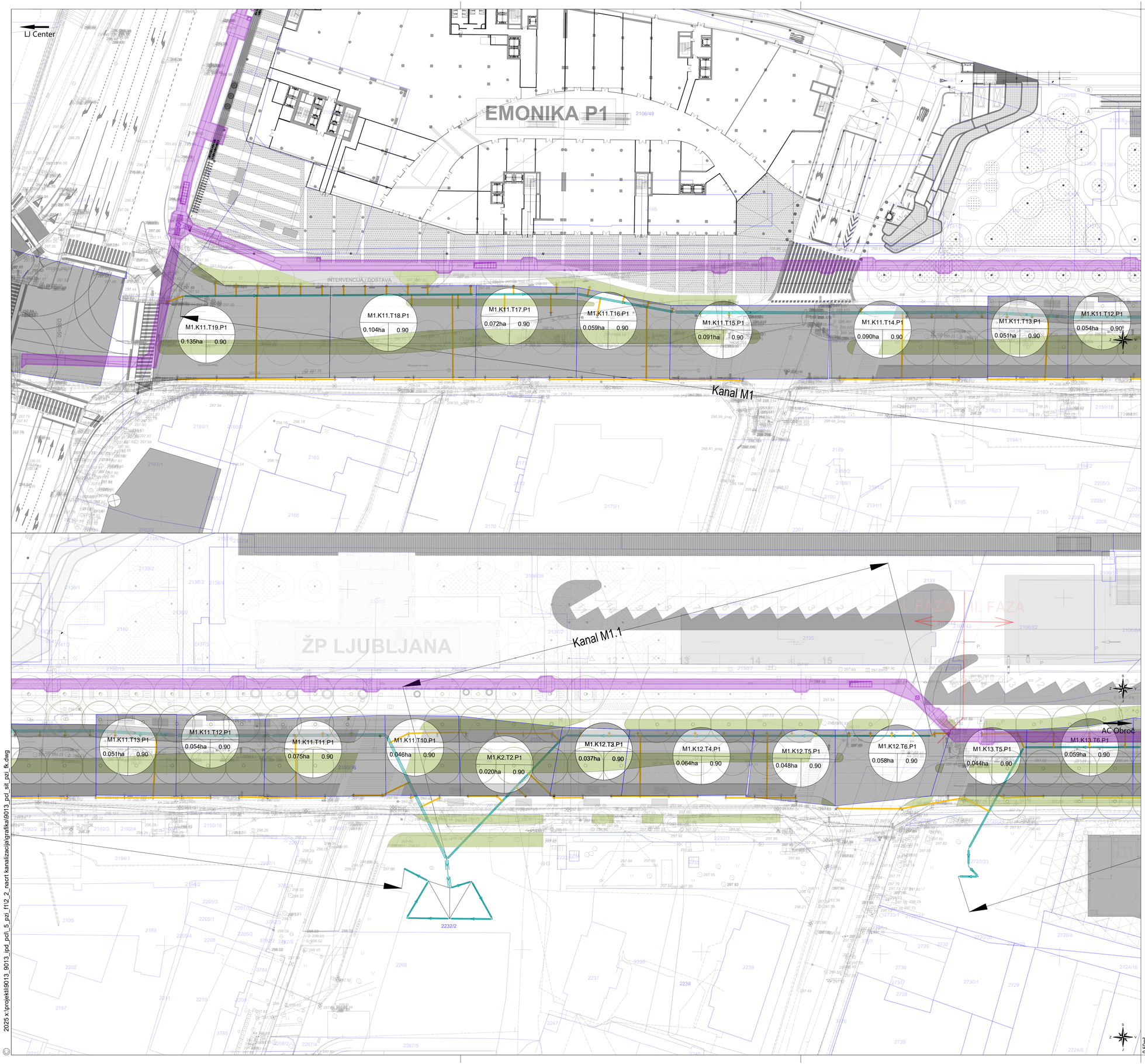
LEGENDA:

SITUACIJA KANALIZACIJE

PROJEKTANT / JV	LUZ, d.d. Verovškova ulica 64, 1001 Ljubljana Telefon +386(0)1 360 24 00 www.luz.si • info@luz.si	ELEA iC d.o.o. Dunajska cesta 21, Ljubljana Telefon +386(0)1 474 10 00 www.elea.si • info@elea.si
OBJEKT	Ureditev gospodarske javne infrastrukture na območju Potniškega centra Ljubljana	
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana	
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272	
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272	
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž	

VRSTA DOKUMENTACIJE	IZP	ŠT. PROJEKTA:	9013_1F
VRSTA PRIKAZA	TEHNIČNI PRIKAZ	ŠT. NAČRTA:	9013_1F/2_2
VSEBINA RISBE	SITUACIJA KANALIZACIJE	MERILO:	1:500
DATUM	Maj 2023	ŠT. RISBE:	G.2.2.2

© 2025 x:\projekti\9013_9013_ipd_5_pzi_f1\2_2_nacrt kanalizacija\grafika\9013_pd_sit_pzi_fk.dwg



0m 10m 20m 50m
M 1:500

LEGENDA:
- MEJA POSEGA
- NOVI ASFALT
- NOVI ASFALT, KOLESARSKA STEZA
- ZELENICA
- PADAVINSKA KANALIZACIJA
- MEŠANA KANALIZACIJA
- POŽIRALNIŠKA ZVEZA
- KOLEKTOR
- PODATKI PRISPEVNIH POVRŠIN

SITUACIJA PRISPEVNIH POVRŠIN
PADAVINSKE KANALIZACIJE

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA IC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

OBJEKT	Ureditev gospodarske javne infrastrukture na območju - I FAZA Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

VRSTA DOKUMENTACIJE	PZI	ŠT. PROJEKTA:	9013_1F
VRSTA PRIKAZA	TEHNIČNI PRIKAZ	ŠT. NAČRTA:	9013_1F/2_2
VSEBINA RISBE	SITUACIJA PRISPEVNIH POVRŠIN	MERILO:	1:500
DATUM	avgust 2025	ŠT. RISBE:	G.2.2.3

2025 x:\projekti\9013_9013_ipd_pzi_5_pzi_f1\2_2_nacrt kanalizacija\grafika\9013_pzi_sit_pzi_fk.dwg



NAZIV	01.1	2	3	4	5	6	7	8	9	10	11	12	13	01.2
STACIONAŽA	0.00 4.49		55.45	113.93	133.83	161.49	193.03	228.40	256.67	283.39	305.48	346.12	391.10	425.95
KOTA TERENA	296.20 296.11		296.64	296.63	296.74	296.82	296.92	297.11	297.31	297.68	297.74	298.00	297.98	297.88
KOTA IZTOKA, VTOKA	287.69 287.68		287.87	288.09	288.17	288.27	288.43	288.61	288.75	288.89	289.00	289.20	289.43	289.66
GLOBINA IZKOPA	8.71 8.63		8.95	8.72	8.74	8.72	8.67	8.68	8.73	8.97	8.92	8.97	8.72	8.39
NAKLON	3.8	3.7	3.8	3.8		5.0	5.1	5.0	5.0	5.2	5.0	5.0	6.6	
DOLŽINA	2.71	50.96	58.47	19.90	27.65	31.54	35.37	28.27	26.72	22.09	40.64	44.98	34.85	
CEV, PROFIL/DOLŽINA	GRP PN1 SN10000 DN1400 , L=425.95 m													
STACIONAŽA OBJEKTOV	0.00 4.49		55.45	113.93	133.83	161.49	193.03	228.40	256.67	283.39	305.48	346.12	391.10	425.95

VZDOLŽNI PROFIL KANALA1

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

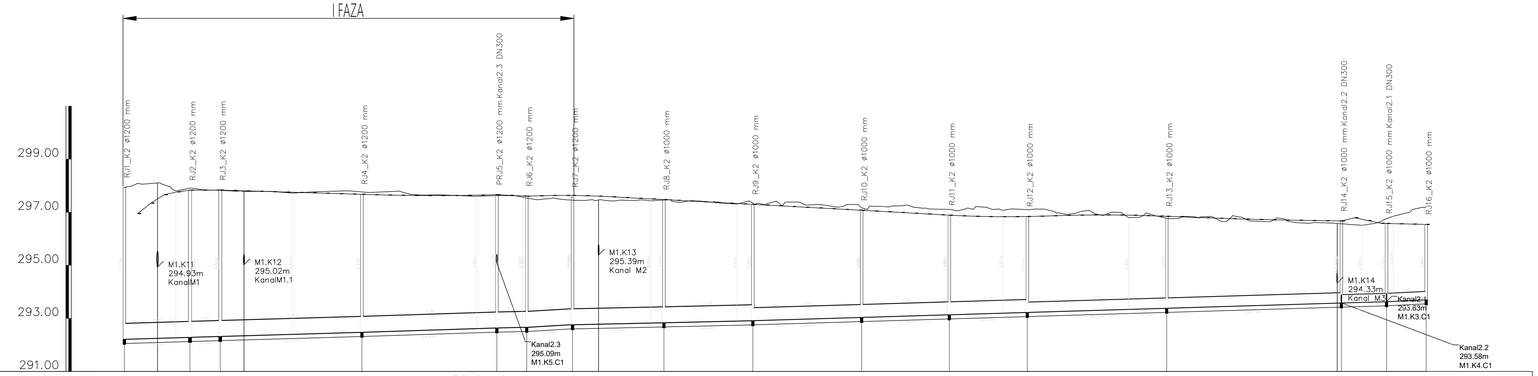
ELEA iC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

OBJEKT	Ureditev gospodarske javne infrastrukture na območju - I FAZA Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

VRSTA DOKUMENTACIJE	PZI	ŠT. PROJEKTA:	9013_1F
VRSTA PRIKAZA	TEHNIČNI PRIKAZ	ŠT. NAČRTA:	9013_1F/2_2
VSEBINA RISBE	VZDOLŽNI PROFIL KANALA 1	MERILO:	1:1000/100
DATUM	avgust 2025	ŠT. RISBE:	G.3.1

© 2025 x:\projekti\9013_9013_ipd_pzi_5_pzi_f1\2_2_nart kanalizacija\grafika\9013_pzi_vzd_pzi_fk.dwg

0.29m²



NAZIV		RJ1_K2		RJ2_K2		RJ3_K2		RJ4_K2		PRJ5_K2		RJ6_K2		RJ7_K2																
STACIONAŽA	0.00		24.71		36.10		89.47		140.28		151.55		168.79		203.20		236.69		277.66		310.69		340.06		392.57		458.33		475.34		490.26
KOTA TERENA	297.93		297.91		297.83		297.76		297.63		297.53		297.45		297.46		297.34		297.17		297.11		297.10		296.77		296.57		296.76		297.19
KOTA IZTOKA, VTOKA	292.22		292.29		292.32		292.48		292.64		292.67		292.77		292.84		292.92		293.04		293.14		293.23		293.39		293.58		293.63		293.71
GLOBINA IZKOPA	5.88		5.78		5.66		5.45		5.15		5.03		4.85		4.79		4.59		4.29		4.13		4.03		3.54		3.14		3.28		3.64
NAKLON			3.0		3.0		2.9		3.2		2.2		6.0		2.2		2.3		3.0		3.0		3.0		3.0		3.0		2.8		5.0
DOLŽINA			24.71		11.39		53.37		50.81		11.27		17.24		34.41		33.48		40.98		33.03		29.37		52.51		65.76		17.00		14.93
CEV, PROFIL/DOLŽINA		GRP PN1 SN10000 DN600 , L=236.69 m																GRP PN1 SN10000 DN500 , L=103.38 m						GRP PN1 SN10000 DN400 , L=118.27 m				GRP PN1 SN10000 DN300 , L=31.93 m			
STACIONAŽA OBJEKTOV	0.00	12.49	24.71	36.10	45.05	89.47		140.28		151.55		168.79	178.59	203.20		236.69		277.66		310.69		340.06		392.57		456.28 458.33		475.34		490.26

VZDOLŽNI PROFIL KANALA2

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA iC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

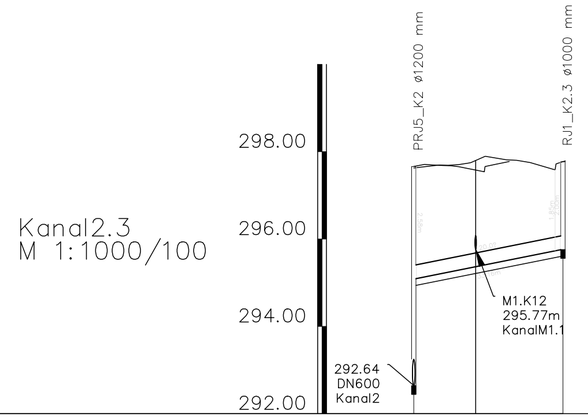
OBJEKT	Ureditev gospodarske javne infrastrukture na območju - I FAZA Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

VRSTA DOKUMENTACIJE	PZI
VRSTA PRIKAZA	TEHNIČNI PRIKAZ
VSEBINA RISBE	VZDOLŽNI PROFIL KANALA 2
DATUM	avgust 2025

ŠT. PROJEKTA:	9013_1F
ŠT. NAČRTA:	9013_1F/2_2
MERILO:	1:1000/100
ŠT. RISBE:	G.3.2

© 2025 x:\projekti\9013_9013_ipd_pzi_5_pzi_f1\2_2_nacrt kanalizacija\grafika\9013_pzi_vzd_pzi_fk_mk.dwg

0.29m²



NAZIV	PRJ5_K2 – Kanal2 RJ1_K2.3			
STACIONAŽA	0.00		34.16	
KOTA TERENA	297.63		297.77	
KOTA IZTOKA, VTOKA	292.64	295.09	295.77	
GLOBINA IZKOPA	5.14	2.70	2.16	
NAKLON	20.0			
DOLŽINA	34.16			
CEV, PROFIL/DOLŽINA	GRP PN1 SN10000 DN300 , L=34.16 m			
STACIONAŽA OBJEKTOV	0.00	14.17	34.16	

VZDOLŽNI PROFIL KANALA 2.3

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA IC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

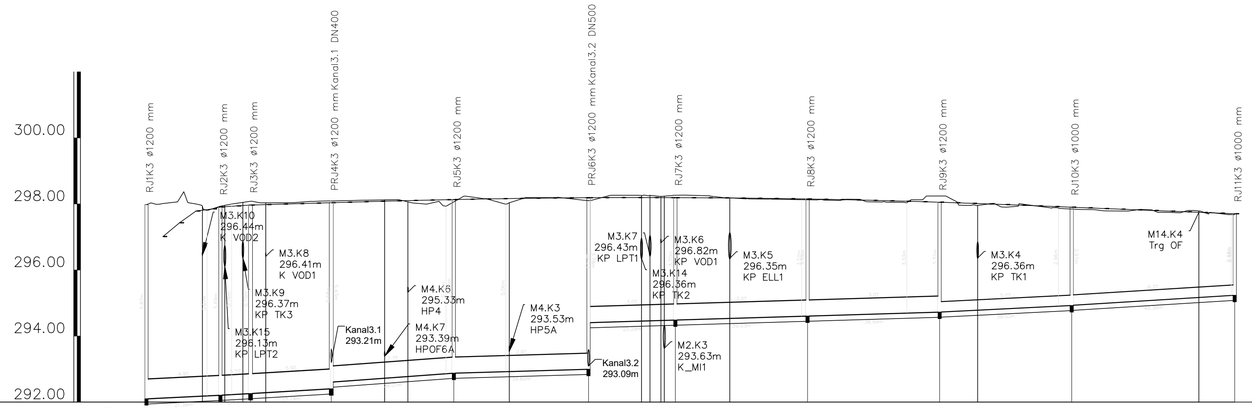
OBJEKT	Ureditev gospodarske javne infrastrukture na območju - I FAZA Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

VRSTA DOKUMENTACIJE	PZI
VRSTA PRIKAZA	TEHNIČNI PRIKAZ
VSEBINA RISBE	VZDOLŽNI PROFIL KANALA 2.3
DATUM	avgust 2025

ŠT. PROJEKTA:	9013_1F
ŠT. NAČRTA:	9013_1F/2_2
MERILO:	1:1000/100
ŠT. RISBE:	G.3.3

© 2025 x:\projekti\9013_9013_ipd_pcl_5_pzi_f112_2_nacrt kanalizacija\grafika\9013_pcl_vzd_pzi_fk_mk.dwg

0.18m²



NAZIV		RJ1K3	RJ2K3	RJ3K3	PRJ4K3	RJ5K3	PRJ6K3	RJ7K3	RJ8K3	RJ9K3	RJ10K3	RJ11K3
STACIONAŽA	0.00		22.39	31.51	55.95	93.06	133.86	160.14	200.17	240.16	280.16	329.52
KOTA TERENA	297.98		297.93	298.08	298.09	298.06	298.10	298.26	298.13	298.24	297.85	297.67
KOTA IZTOKA, VTOKA	292.10		292.21	292.26	292.41	292.88	293.00	294.49	294.61	294.73	294.93	295.24
	292.61						294.41				294.93	
GLOBINA IZKOPA	6.04		5.88	5.98	5.84	5.34	5.26	3.94	3.68	3.67	3.07	2.59
	5.64						3.85			3.67	3.07	
NAKLON			4.9	5.5	5.9	7.3	2.9	3.0	3.0	3.0	5.0	6.2
DOLŽINA			22.39	9.13	24.44	37.11	40.80	26.29	40.03	39.99	40.00	49.36
CEV, PROFIL/DOLŽINA		GRP PN1 SN10000 DN600 , L=55.95 m				GRP PN1 SN10000 DN500 , L=184.20 m					GRP PN1 SN10000 DN300 , L=89.36 m	
STACIONAŽA OBJEKTOV	0.00		16.93	22.39	23.31	29.20	36.12	55.95	72.12	79.17	93.06	109.87
												133.86
												149.89
												152.46
												158.88
												160.14
									176.63	200.17	240.16	251.68
											280.16	318.66
												329.52

VZDOLŽNI PROFIL KANALA 3

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA IC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

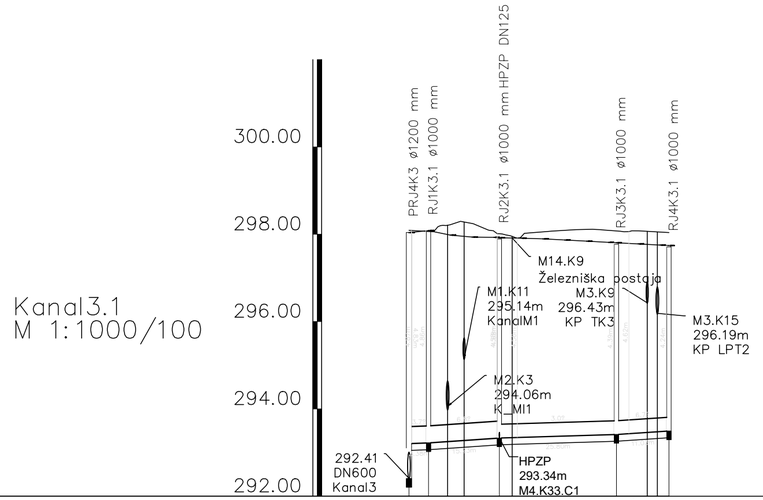
OBJEKT	Ureditev gospodarske javne infrastrukture na območju - I FAZA Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

VRSTA DOKUMENTACIJE	PZI
VRSTA PRIKAZA	TEHNIČNI PRIKAZ
VSEBINA RISBE	VZDOLŽNI PROFIL KANALA 3
DATUM	avgust 2025

ŠT. PROJEKTA:	9013_1F
ŠT. NAČRTA:	9013_1F/2_2
MERILO:	1:1000/100
ŠT. RISBE:	G.3.4

0.23m²

© 2025 x:\projekti\9013_9013_ipd_pcl_5_pzi_f112_2_nacrt kanalizacija\grafika\9013_pcl_vzd_pzi_fk_mk.dwg



NAZIV	PRJ4K3 – Kanal3		RJ1K3.1	RJ2K3.1	RJ3K3.1	RJ4K3.1	
STACIONAŽA	0.00	4.48		20.70	47.50	59.53	
KOTA TERENA	298.09	298.06		298.01	298.08	298.04	
KOTA IZTOKA, VTOKA	292.41	293.23		293.34	293.42	293.50	
GLOBINA IZKOPA	5.84	5.01		4.84	4.82	4.70	
NAKLON		3.7	6.8		3.0	6.7	
DOLŽINA		4.48	16.23		26.80	12.03	
CEV, PROFIL/DOLŽINA	GRP PN1 SN10000 GRP PN1 SN10000 DN300 , L= 38.83 m						
STACIONAŽA OBJEKTOV	0.00	4.48	8.85	12.63	20.70	23.63	47.50	54.55	56.87	59.53

VZDOLŽNI PROFIL KANALA 3.1

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA IC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

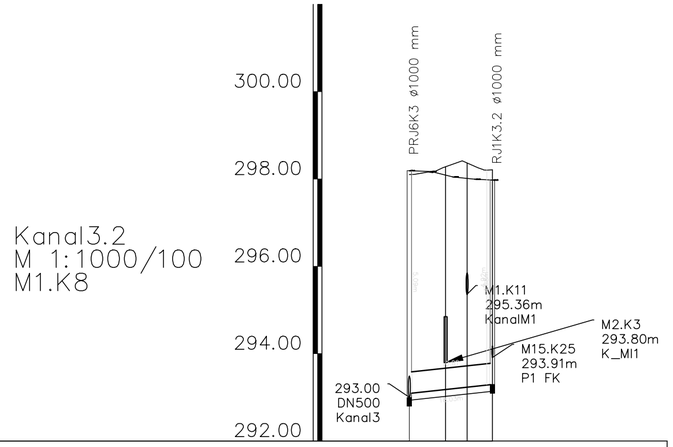
OBJEKT	Ureditev gospodarske javne infrastrukture na območju - I FAZA Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

VRSTA DOKUMENTACIJE	PZI
VRSTA PRIKAZA	TEHNIČNI PRIKAZ
VSEBINA RISBE	VZDOLŽNI PROFIL KANALA 3.1
DATUM	avgust 2025

ŠT. PROJEKTA:	9013_1F
ŠT. NAČRTA:	9013_1F/2_2
MERILO:	1:1000/100
ŠT. RISBE:	G.3.5

© 2025 x:\projekti\9013_9013_ipd_pcl_5_pzi_f1\2_2_nacrt kanalizacija\grafika\9013_pcl_vzd_pzi_fk.dwg

0.18m²



NAZIV	PRJ6K3 – Kanal3.2			
STACIONAŽA	0.00		19.03	
KOTA TERENA	298.10		298.21	
KOTA IZTOKA, VTOKA	293.00	293.09	293.30	
GLOBINA IZKOPA	5.26	5.17	5.07	
NAKLON		10.8		
DOLŽINA		19.03		
CEV, PROFIL/DOLŽINA	GRP PN1 SN10000 DN300 , L=19.03 m			
STACIONAŽA OBJEKTOV	0.00	8.30	13.23	19.03

0.18m²

VZDOLŽNI PROFIL KANALA 3.2

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

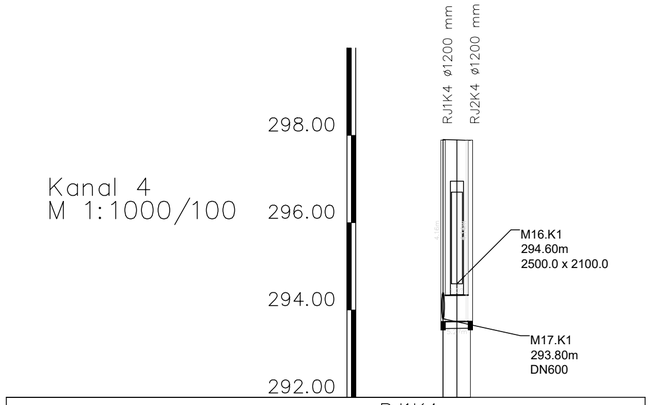
ELEA IC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

OBJEKT	Ureditev gospodarske javne infrastrukture na območju - I FAZA Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

VRSTA DOKUMENTACIJE	PZI
VRSTA PRIKAZA	TEHNIČNI PRIKAZ
VSEBINA RISBE	VZDOLŽNI PROFIL KANALA 3.2
DATUM	avgust 2025

ŠT. PROJEKTA:	9013_1F
ŠT. NAČRTA:	9013_1F/2_2
MERILO:	1:1000/100
ŠT. RISBE:	G.3.6

© 2025 x:\projekti\9013_9013_ipd_pcl_5_pzi_f1\2_2_nacrt kanalizacija\grafika\9013_pcl_vzd_pzi_fk.dwg



NAZIV	RJ1K4	RJ2K4
STACIONAŽA	0.00	6.27
KOTA TERENA	297.90	297.89
KOTA IZTOKA, VTOKA	293.74	293.75
GLOBINA IZKOPA	4.33	4.30
NAKLON	1.0	
DOLŽINA	6.27	
CEV, PROFIL/DOLŽINA	GRP PN1 SN10000 DN600 , L=6.27 m	
STACIONAŽA OBJEKTOV	0.00 3.13	6.27

VZDOLŽNI PROFIL KANALA 4

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA IC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

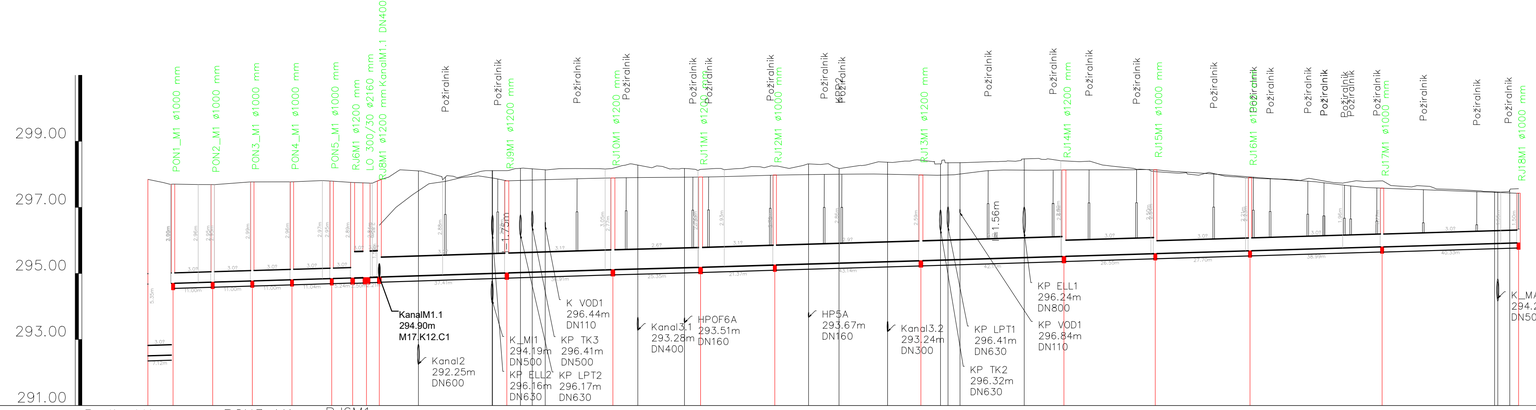
OBJEKT	Ureditev gospodarske javne infrastrukture na območju - I FAZA Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

VRSTA DOKUMENTACIJE	PZI
VRSTA PRIKAZA	TEHNIČNI PRIKAZ
VSEBINA RISBE	VZDOLŽNI PROFIL KANALA 4
DATUM	avgust 2025

ŠT. PROJEKTA:	9013_1F
ŠT. NAČRTA:	9013_1F/2_2
MERILO:	1:1000/100
ŠT. RISBE:	G.3.7

© 2025 x:\projekti\9013_9013_ipd_pcl_5_pzi_f112_2_nacrt kanalizacija\grafika\9013_pcl_vzd_pzi_fk_mk.dwg

0.18m²



NAZIV	Preliv_M1	PON1_M1	PON2_M1	PON3_M1	PON4_M1	PON5_M1	RJ6M1	RJ8M1	LO 300/30	RJ9M1	RJ10M1	RJ11M1	RJ12M1	RJ13M1	RJ14M1	RJ15M1	RJ16M1	RJ17M1	RJ18M1
STACIONAŽA	0.00	7.62	19.62	31.62	43.62	55.66	62.00	66.18	70.07	108.68	140.80	167.35	189.82	234.06	277.37	305.02	333.71	373.71	415.03
KOTA TERENA	297.85	297.70	297.69	297.77	297.77	297.79	297.75	297.74	297.82	298.11	298.18	298.15	298.25	298.43	298.41	298.08	297.89	297.80	297.57
KOTA IZTOKA, VTOKA	292.5	294.70	294.74	294.78	294.81	294.85	294.87	294.88	294.88	295.02	295.12	295.19	295.26	295.39	295.52	295.60	295.69	295.81	295.93
GLOBINA IZKOPA	3.33	3.16	3.11	3.15	3.12	3.10	3.04	3.05	3.02	3.26	3.23	3.12	3.15	3.20	3.05	2.64	2.36	2.15	1.80
NAKLON		3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.2	3.1	2.6	3.1	2.9	3.0	3.0	3.0	3.0	
DOLŽINA		7.62	12.00	12.00	12.00	12.04	6.34	4.18	3.89	38.61	32.11	26.55	22.47	44.24	43.31	27.65	28.70	39.99	41.33
CEV, PROFIL/DOLŽINA	GRP PN1 SN10000 DN300 , L=8.07 m			GRP PN1 SN10000 DN800 , L=110.02 m						GRP PN1 SN10000 DN600 , L=207.30 m				GRP PN1 SN10000 DN500 , L=27.65 m		GRP PN1 SN10000 DN400 , L=110.02 m			
STACIONAŽA OBJEKTOV	0.00	7.62	19.62	31.62	43.62	55.66	62.00	66.18	70.07	81.91	104.34 108.68 116.37 120.30	140.80	148.35	162.47 167.35	189.82	200.04	209.26	223.97	234.06 240.00 244.22 245.90	265.34	277.37	305.02	333.71	373.71	408.76 412.37 415.03

VZDOLŽNI PROFIL KANAL M1

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA iC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

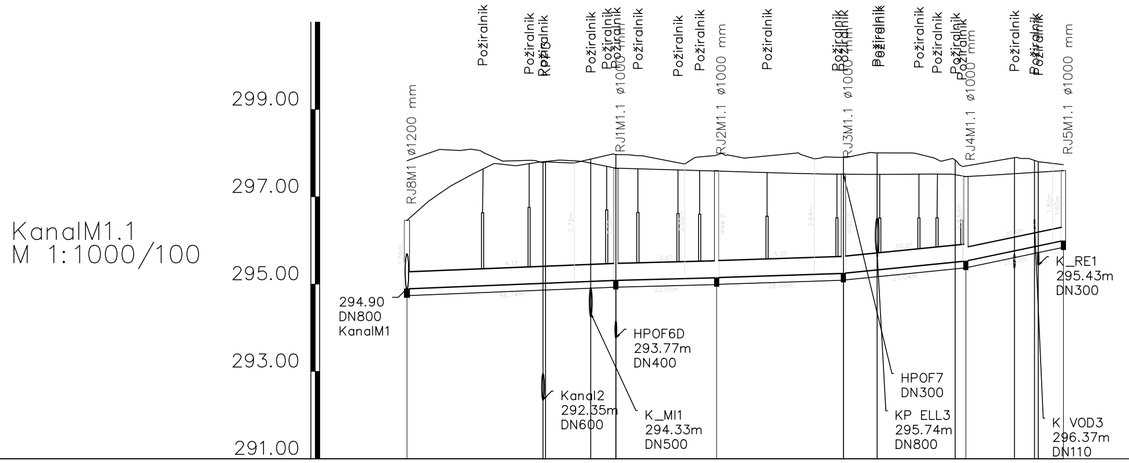
OBJEKT	Ureditev gospodarske javne infrastrukture na območju Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

VRSTA DOKUMENTACIJE	PZI
VRSTA PRIKAZA	TEHNIČNI PRIKAZ
VSEBINA RISBE	VZDOLŽNI PROFIL KANAL M1
DATUM	avgust 2025

ŠT. PROJEKTA:	9013 1F
ŠT. NAČRTA:	9013_1F/2_2
MERILO:	1:1000/100
ŠT. RISBE:	G.3.8

© 2025 x:\projekti\9013_9013_ipd_pcl_5_pzi_f112_2_nacrt kanalizacija\grafika\9013_pcl_vzd_pzi_fk_mk.dwg

0.23m²



NAZIV		RJ8M1 – KanalM1			RJ1M1.1		RJ2M1.1		RJ3M1.1		RJ4M1.1		RJ5M1.1	
STACIONAŽA	0.00				47.84		70.91		99.95		127.99		150.32	
KOTA TERENA	297.82				297.97		297.95		297.90		297.70		297.74	
KOTA IZTOKA, VTOKA	294.90				295.09	295.09	295.15	295.15	295.25	295.25	295.53		296.00	
GLOBINA IZKOPA	3.09				3.04		2.97	2.96	2.81	2.81	2.33	2.33	1.89	
NAKLON		4.1			2.6		3.3		10.0		20.9			
DOLŽINA		47.84			23.07		29.04		28.04		22.33			
CEV, PROFIL/DOLŽINA		GRP PN1 SN10000 DN400 , L=127.99 m							GRP PN1 SN10000 DN300 , L=22.33 m					
STACIONAŽA OBJEKTOV	0.00		~~31.13~~		42.09	47.84	70.91		99.95	107.65	125.54	127.99	139.10	~~144.68~~ 150.32

VZDOLŽNI PROFIL KANAL M1.1

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA IC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

OBJEKT	Ureditev gospodarske javne infrastrukture na območju Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

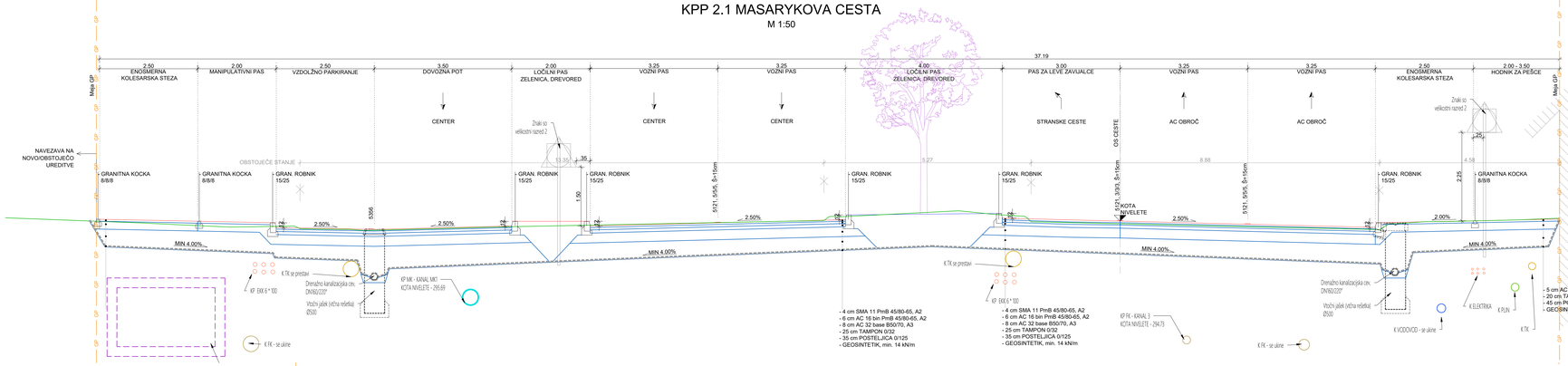
VRSTA DOKUMENTACIJE	PZI
VRSTA PRIKAZA	TEHNIČNI PRIKAZ
VSEBINA RISBE	VZDOLŽNI PROFIL KANAL M1.1
DATUM	avgust 2025

ŠT. PROJEKTA:	9013 1F
ŠT. NAČRTA:	9013_1F/2_2
MERILO:	1:1000/100
ŠT. RISBE:	G.3.9

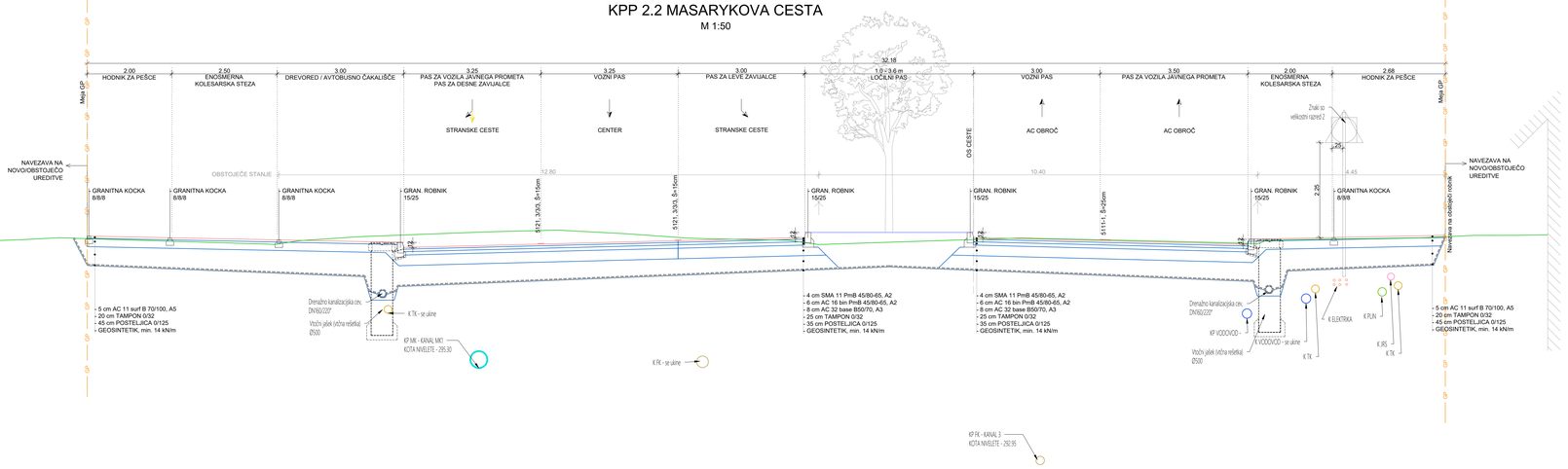
0.18m²

© 2025 x:\projekti\9013_9013_ipd_pcl_5_pzi_f1\2_2_nacrt kanalizacija\grafika\9013_pcl_vzd_pzi_fk_mk.dwg

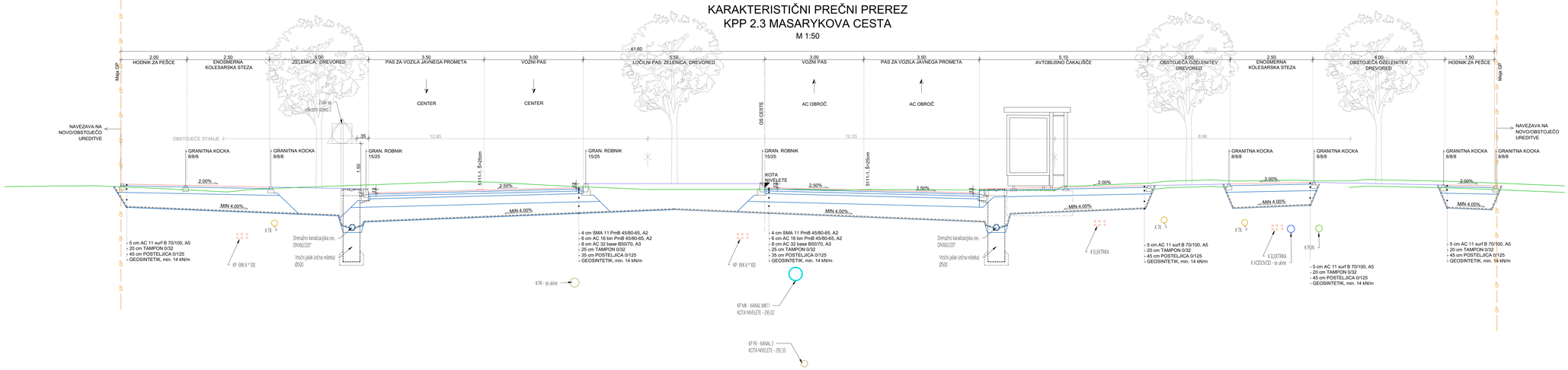
KARAKTERISTIČNI PREČNI PREREZ
KPP 2.1 MASARYKOVA CESTA
M 1:50



KARAKTERISTIČNI PREČNI PREREZ
KPP 2.2 MASARYKOVA CESTA
M 1:50



KARAKTERISTIČNI PREČNI PREREZ
KPP 2.3 MASARYKOVA CESTA
M 1:50



KARAKTERISTIČNI PREČNI PREREZ 1

PROJEKTANT / JV	LUZ, d.d. Verovškova ulica 64, 1001 Ljubljana Telefon +386(0)1 360 24 00 www.luz.si • info@luz.si
	ELEA iC d.o.o. Dunajska cesta 21, Ljubljana Telefon +386(0)1 474 10 00 www.elea.si • info@elea.si
OBJEKT	Ureditev gospodarske javne infrastrukture na območju - I FAZA Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

VRSTA DOKUMENTACIJE	PZI	ŠT. PROJEKTA:	9013_IF
VRSTA PRIKAZA	TEHNIČNI PRIKAZ	ŠT. NAČRTA	9013_IF/2_2
VSEBINA RISBE	KARAKTERISTIČNI PREČNI PREREZ	MERILO:	1:50
DATUM	avgust 2025	ŠT. RISBE:	G.4.1

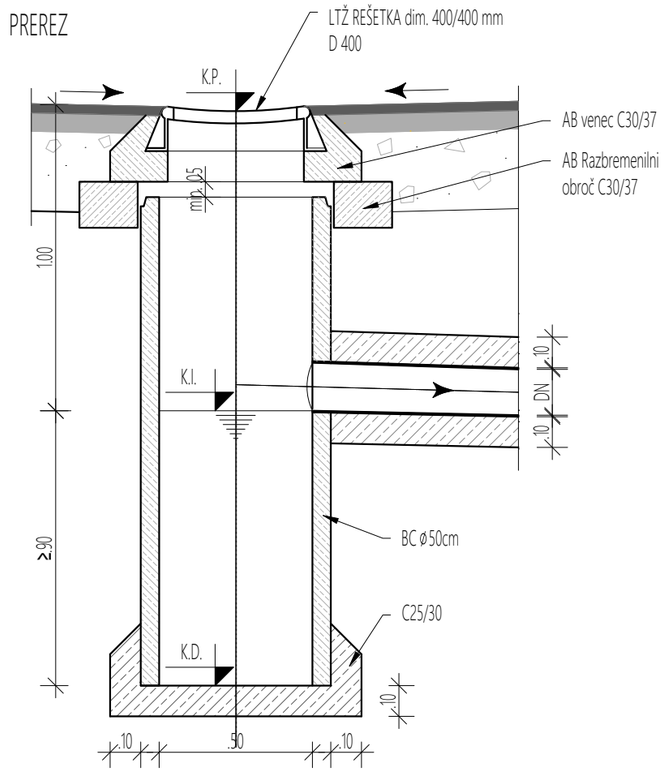
1.00m²

2025 x:\projekti\9013_ljc_pzi_fl\2_2_nacrt kanalizacija\grafika\9013_pzi_kpp_pzi_fk_mk.dwg

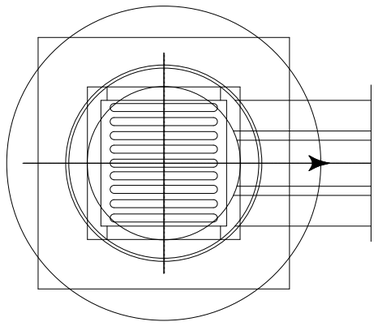
DETAJL CESTNEGA POŽIRALNIKA Z LTŽ REŠETKO

M 1:20

PREREZ



TLORIS



OPOMBA:
zasip v območju jaška do 0,50 m v plasteh deb. do 30 cm z drobljencem 0-32 mm, zbitost po Proctorju 97%

© 2025 x:\projekti\9013_9013_ipd_pcl_5_pzi_f1\2_2_nacrt kanalizacija\grafika\9013_pcl_det_pzi_fk_mk.dwg

0.12m²

DETAJL CESTNEGA POŽIRALNIKA Z LTŽ REŠETKO

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA IC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

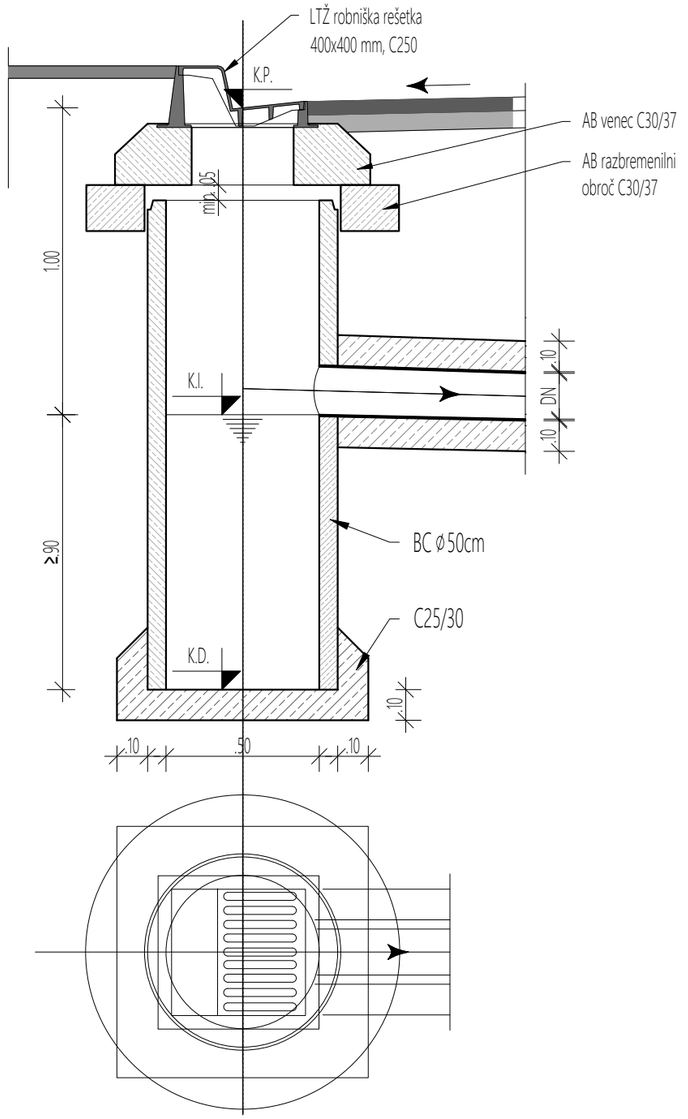
OBJEKT	Ureditev gospodarske javne infrastrukture na območju Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

VRSTA DOKUMENTACIJE	PZI	ŠT. PROJEKTA:	9013_1F
VRSTA PRIKAZA	TEHNIČNI PRIKAZ	ŠT. NAČRTA:	9013_1F/2_2
VSEBINA RISBE	DETAJL CESTNEGA POŽIRALNIKA Z LTŽ REŠETKO	MERILO:	1:20
DATUM	avgust 2025	ŠT. RISBE:	G.5.1

DETAJL CESTNEGA POŽIRALNIKA Z ROBNIŠKO REŠETKO

M 1:20

PREREZ



TLORIS

DETAJL CESTNEGA POŽIRALNIKA Z ROBNIŠKO REŠETKO

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA IC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

OBJEKT	Ureditev gospodarske javne infrastrukture na območju Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

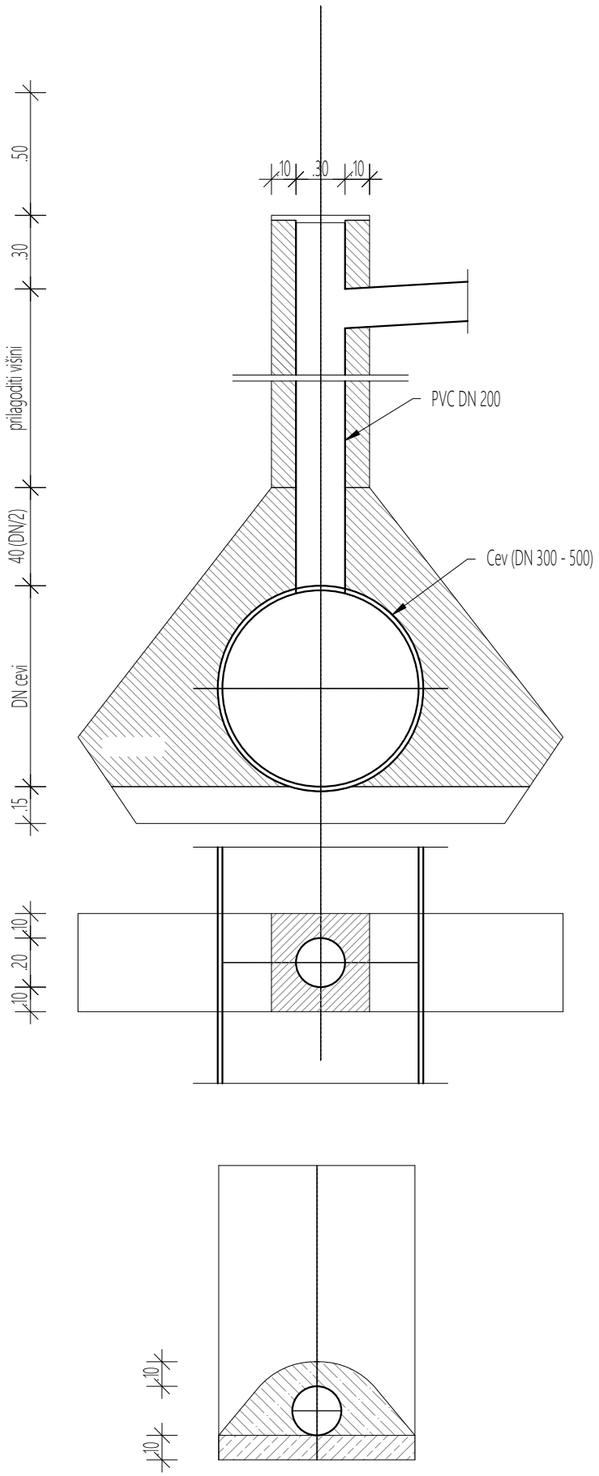
VRSTA DOKUMENTACIJE	PZI	ŠT. PROJEKTA:	9013_1F
VRSTA PRIKAZA	TEHNIČNI PRIKAZ	ŠT. NAČRTA:	9013_1F/2_2
VSEBINA RISBE	DETAJL CESTNEGA POŽIRALNIKA Z ROBNIŠKO REŠETKO	MERILO:	1:20
DATUM	avgust 2025	ŠT. RISBE:	G.5.2

© 2025 x:\projekti\9013_9013_ipd_pcl_5_pzi_f1\2_2_nacrt kanalizacija\grafika\9013_pcl_det_pzi_fk_mk.dwg

0.12m²

VPAD IZ CESTNEGA POŽIRALNIKA IN HIŠNEGA PRIKLJUČKA

M 1:25



DETAJL VPADA CESTNEGA POŽIRALNIKA

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA IC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

OBJEKT	Ureditev gospodarske javne infrastrukture na območju Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

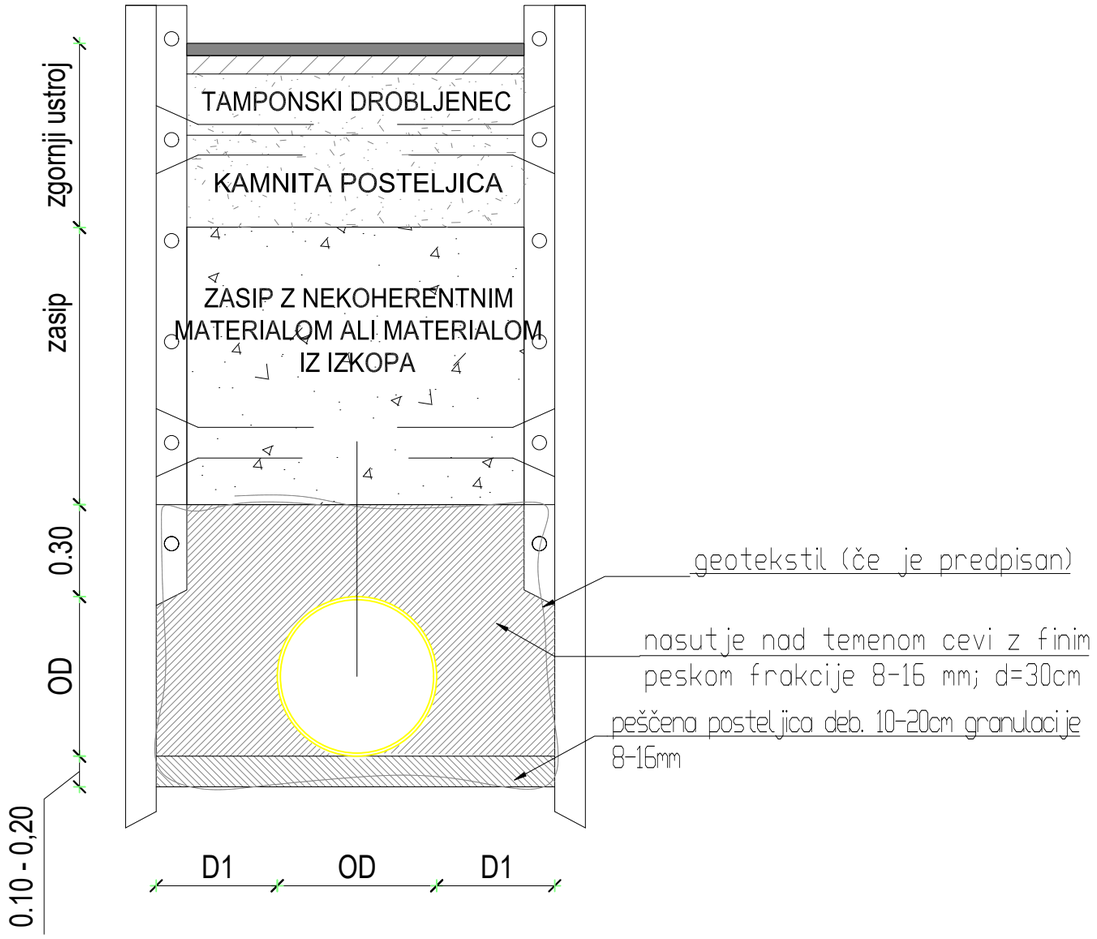
VRSTA DOKUMENTACIJE	PZI	ŠT. PROJEKTA:	9013_1F
VRSTA PRIKAZA	TEHNIČNI PRIKAZ	ŠT. NAČRTA:	9013_1F/2_2
VSEBINA RISBE	DETAJL VPADA CESTNEGA POŽIRALNIKA	MERILO:	1:25
DATUM	avgust 2025	ŠT. RISBE:	G.5.3

© 2025 x:\projekti\9013_9013_ipd_pcl_5_pzi_f1\2_2_nacrt kanalizacija\grafika\9013_pcl_det_pzi_fk_mk.dwg

0.12m²

DETAJL POLAGANJA KANALIZACIJSKIH CEVI V VERTIKALNEM IZKOPU

M 1:25



DETAJL POLAGANJA KANALIZACIJSKE CEVI

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA IC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

OBJEKT	Ureditev gospodarske javne infrastrukture na območju Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

VRSTA DOKUMENTACIJE	PZI
VRSTA PRIKAZA	TEHNIČNI PRIKAZ
VSEBINA RISBE	DETAJL POLAGANJA KANALIZACIJSKE CEVI
DATUM	avgust 2025

ŠT. PROJEKTA:	9013_1F
ŠT. NAČRTA:	9013_1F/2_2
MERILO:	1:25
ŠT. RISBE:	G.5.5

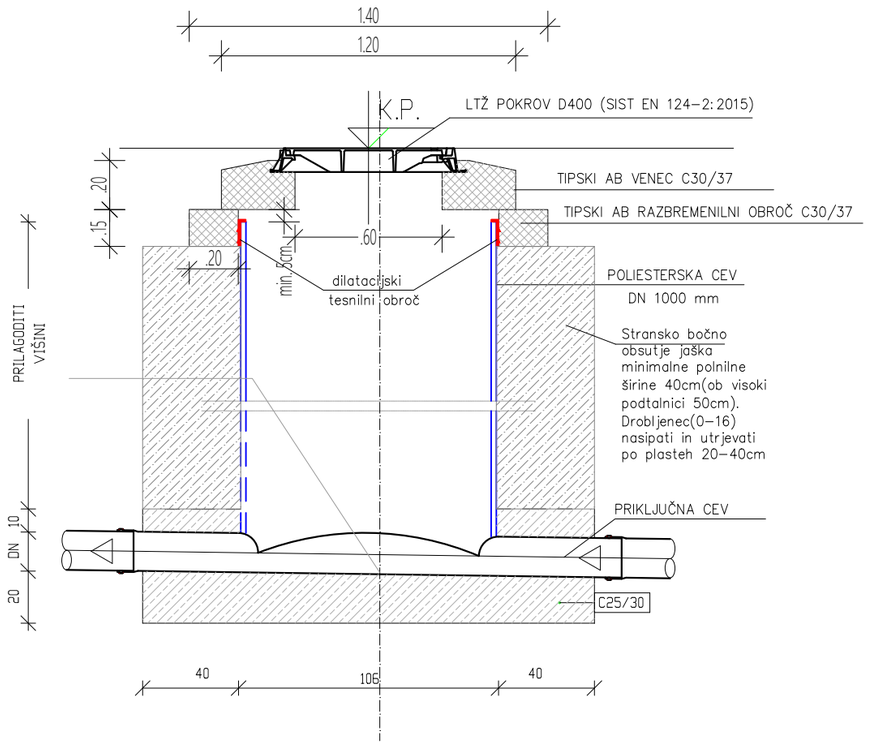
© 2025 x:\projekti\9013_9013_ipd_pcl_5_pzi_f1\2_2_nacrt kanalizacija\grafika\9013_pcl_det_pzi_fk_mk.dwg

0.12m²

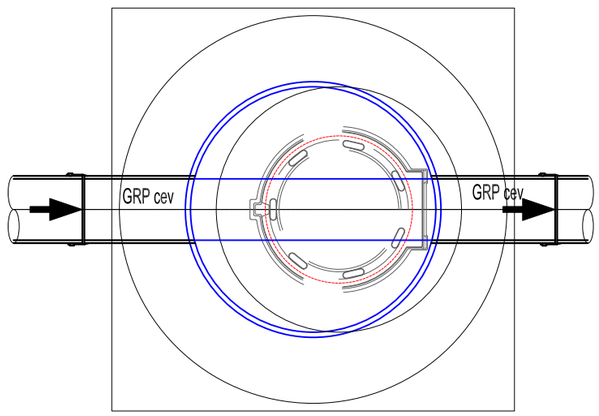
POLIESTRSKI REVIZIJSKI JAŠEK DN 1000 mm

M 1:25

PREREZ



TLORIS



OPOMBA:

v notranjih prostorih objekta se vgradi protismradne pokrove, dim. 600x600 mm, EN 124, A15

v povoznih površinah se vgradi LTŽ pokrove, premera 600 mm, z zaklepom in protihrupnim vložkom, EN 124, D400

DETAJL REVIZIJSKEGA JAŠKA

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA IC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

OBJEKT	Ureditev gospodarske javne infrastrukture na območju Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

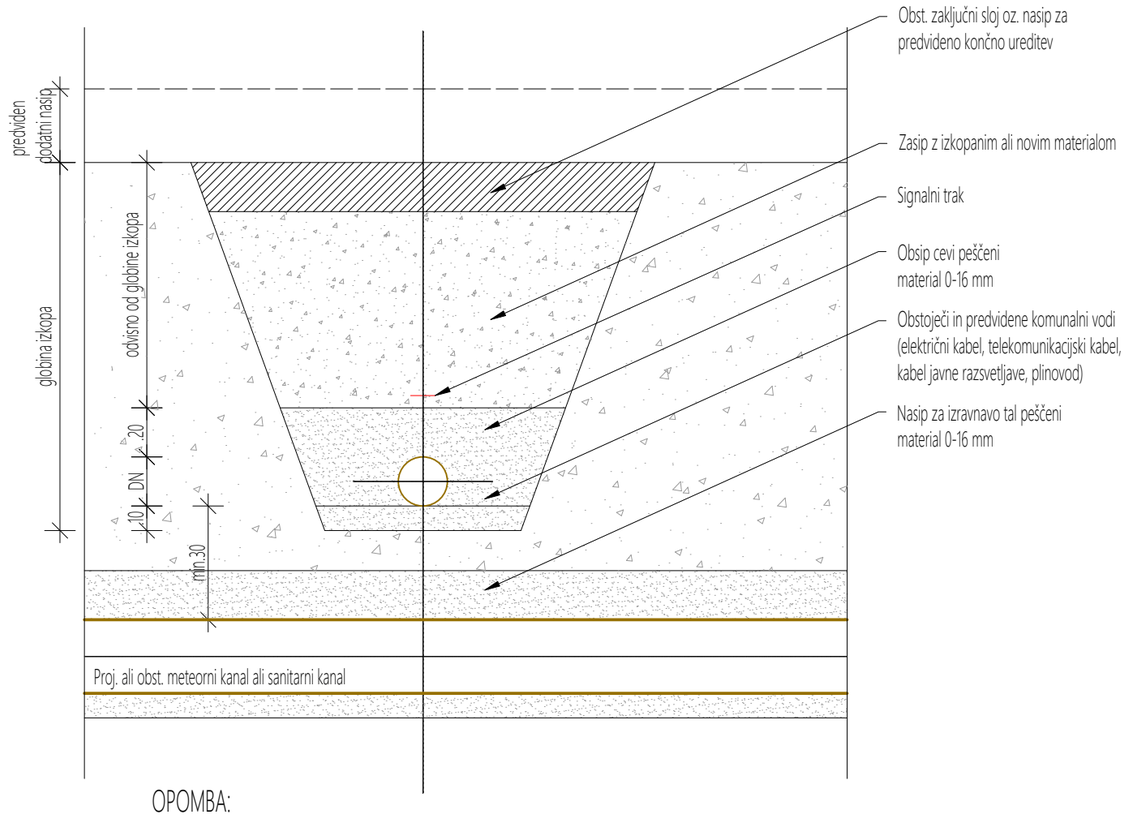
VRSTA DOKUMENTACIJE	PZI	ŠT. PROJEKTA:	9013_1F
VRSTA PRIKAZA	TEHNIČNI PRIKAZ	ŠT. NAČRTA:	9013_1F/2_2
VSEBINA RISBE	DETAJL REVIZIJSKEGA JAŠKA	MERILO:	1:25
DATUM	avgust 2025	ŠT. RISBE:	G.5.4

© 2025 x:\projekti\9013_9013_ipd_pcl_5_pzi_f1\2_2_nacrt kanalizacija\grafika\9013_pcl_det_pzi_fk_mk.dwg

0.12m²

DETAJL PREČKANJA KOMUNALNIH VODOV NAD PROJEKTIRANIM KANALOM

M 1:25



OPOMBA:

Minimalni dopustni vertikalni razmik med komunalnima vodoma znaša 30 cm. V primeru manjšega razmika se je potrebno pred vgradnjo posvetovati z upravljavci komunalnih vodov.

DETAJL PREČKANJA KOMUNALNIH VODOV

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA IC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

OBJEKT	Ureditev gospodarske javne infrastrukture na območju Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

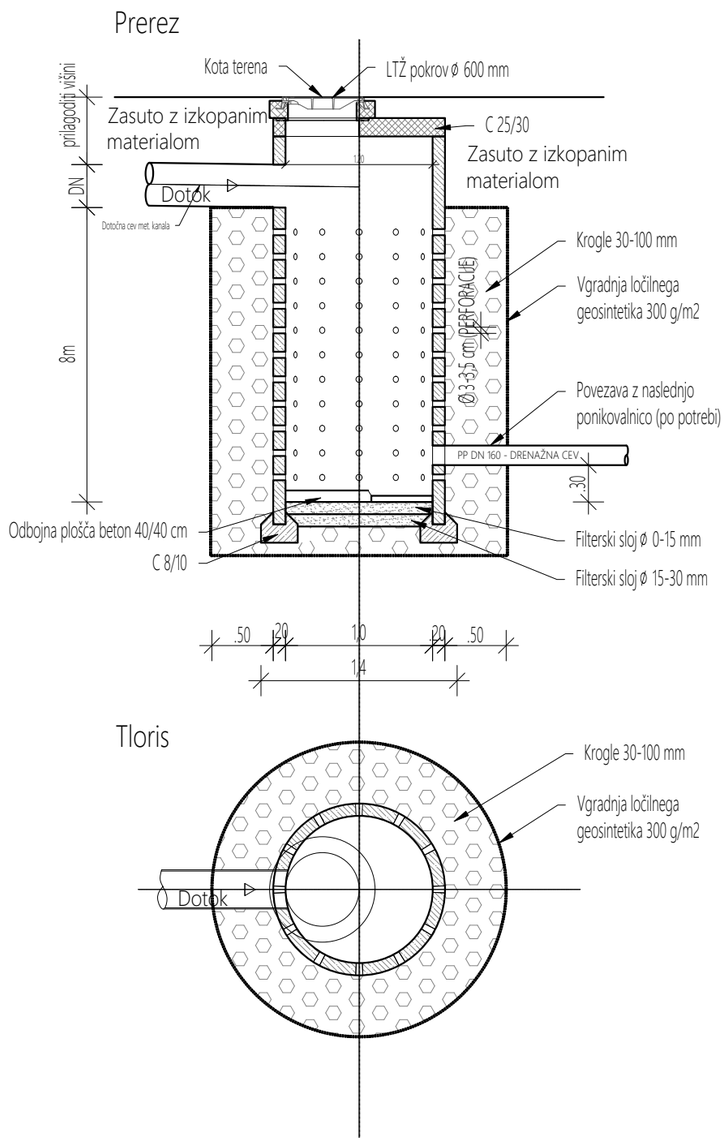
VRSTA DOKUMENTACIJE	PZI	ŠT. PROJEKTA:	9013_1F
VRSTA PRIKAZA	TEHNIČNI PRIKAZ	ŠT. NAČRTA:	9013_1F/2_2
VSEBINA RISBE	DETAJL PREČKANJA KOMUNALNIH VODOV	MERILO:	1:25
DATUM	avgust 2025	ŠT. RISBE:	G.5.6

© 2025 x:\projekti\9013_9013_ipd_pcl_5_pzi_f1\2_2_nacrt kanalizacija\grafika\9013_pcl_det_pzi_fk_mk.dwg

0.12m²

PONIKOVALNICA, DN 1000mm

M 1:50



DETAJL PONIKOVALNICE

PROJEKTANT / JV

LUZ, d.d.
Verovškova ulica 64, 1001 Ljubljana
Telefon +386(0)1 360 24 00
www.luz.si • info@luz.si

ELEA IC d.o.o.
Dunajska cesta 21, Ljubljana
Telefon +386(0)1 474 10 00
www.elea.si • info@elea.si

OBJEKT	Ureditev gospodarske javne infrastrukture na območju Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

VRSTA DOKUMENTACIJE	PZI	ŠT. PROJEKTA:	9013 1F
VRSTA PRIKAZA	TEHNIČNI PRIKAZ	ŠT. NAČRTA:	9013_1F/2_2
VSEBINA RISBE	DETAJL PONIKOVALNICE	MERILO:	1:50
DATUM	avgust 2025	ŠT. RISBE:	G.5.7

© 2025 x:\projekti\9013_9013_ipd_pcl_5_pzi_f1\2_2_nacrt kanalizacija\grafika\9013_pcl_det_pzi_fk_mk.dwg

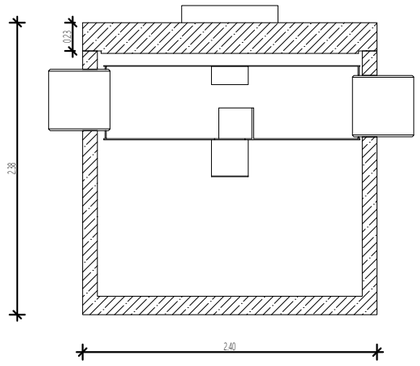
0.12m²

KOALESCENČNI LOVILEC OLJA

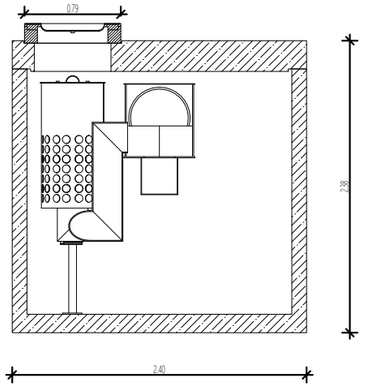
M 1:25

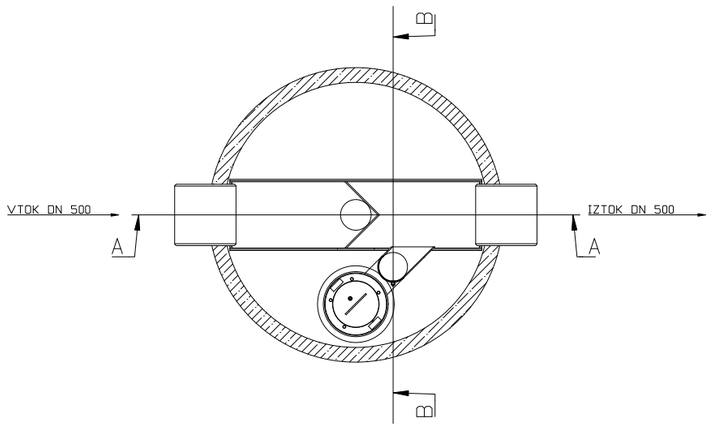
PREREZ

A – A



B – B





DETAJL LOVILCA OLJ 300/30

PROJEKTANT / JV	LUZ, d.d. Verovškova ulica 64, 1001 Ljubljana Telefon +386(0)1 360 24 00 www.luz.si • info@luz.si
	ELEA IC d.o.o. Dunajska cesta 21, Ljubljana Telefon +386(0)1 474 10 00 www.elea.si • info@elea.si
OBJEKT	Ureditev gospodarske javne infrastrukture na območju Potniškega centra Ljubljana
INVESTITOR	Mestna občina Ljubljana Mestni trg 1 1000 Ljubljana
VODJA PROJEKTA	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
POOBLAŠČENI INŽENIR	Uroš Maršič, univ. dipl. inž. grad. IZS št.: G-3272
SODELAVCI	Marko Fatur, univ.dipl.inž.grad. - Odgovorni nosilec naloge Polona Repnik, univ.dipl.inž.vod. in kom.inž

VRSTA DOKUMENTACIJE	PZI	ŠT. PROJEKTA:	9013 1F
VRSTA PRIKAZA	TEHNIČNI PRIKAZ	ŠT. NAČRTA:	9013_1F/2_2
VSEBINA RISBE	DETAJL LOVILCA OLJ 300/30	MERILO:	1:25
DATUM	avgust 2025	ŠT. RISBE:	G.5.8

0.12m²

© 2025 x:\projekti\9013_9013_ipd_pcl_5_pzi_f112_2_nacrt kanalizacija\grafika\9013_pcl_det_pzi_fk_mk.dwg