Expert Report

№ 24G00232Rev2 /STMA **Date: 10-08-2024**

1 Basics

1.1 Site place : **CZ-Ostrava**

1.2 Building project: Renovation of an egg-shape profile with a glass-fibre reinforced CIPP, W:H = 1100:1850 mm; hostpipe condition II according to German worksheet DWA-A 143, part 2

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This report contains 10 pages.

The results of the tests are only for the named test pieces in this report.

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2 Content

3 Documents, standards

3.1 DWA-A 143-2, Sanierung von Entwässerungssystemen außerhalb von Gebäuden, Teil2: Statische Berechnung zur Sanierung von Abwasserleitungen und –kanälen mit Lining- und Montageverfahren, Entwurf November 2012

3.2 ATV-DVWK-M 127E, Part 2, Static Calculation for the Rehabilitation of Drains and Sewers Using Lining and Assembly Procedures, Supplement to Advisory Leaflet ATV-DVWK-A 127E, January 2000 – withdrawn 2015.

3.3 ATV-DVWK-A 127E, Static Calculation of Drains and Sewers - 3rd Edition, August 2000

3.4 Information, regarding input data; E-Mail by RelineEurope GmbH, 07-11-2024, groundwater level, hostpipe condition, material properties CIPP.

3.5 General type approval № Z-42.3-447, valid until 03-01-2026, DIBt, Berlin

4 Description and content of the job

Renovation of existing sewers in the city of Ostrava in the Czech Republic. Cross section of the hostpipe are egg-shape profiles with the measurements of host width:height W:H = 1100:1850 mm. Hostpipes are made of masonry (multi-layers) in the top and concrete in the bottom of the pipe. They are declared to be *state II* according to [3.1], where the hostpipe is broken (four longitudinal cracks) but the hostpipe-soil-system is stable.

In a short section of the pipe, there are concrete walls in the springlines and a flat concrete cover in the crown (see fig. 1.1 in the annex). This part of the cross section will be re-profiled with a suitable material before renovation.

4 Characteristic loads and operational conditions

Hostpipe condition for the profiles is declared as state II [3.1], in which CIPP must carry only external groundwater load. The value of the load (long-term) is:

$$h_{W,inv} = 3.00 \text{ m}$$

over invert of hostpipe (mWC).

Partial safety-factor for changeable loads is γ_F = 1.50 according to [3.1].

5 Materials (characteristic values)

The material properties of CIPP are published by the manufacturer “RelineEurope GmbH” in the DIBt-Approval [3.5] where all relevant test-results are collected.

CIPP (Alphaliner 1800H)

Material:	glass fibre reinforced CIPP
Short-term E-Modulus:	E_S= 21209 MPa
Long-term E-Modulus:	E_L= 16190 MPa
Short-term bending strength (tensile):	$\sigma_{fb,S}$ = 320.0 MPa
Long-term bending strength (tensile):	$\sigma_{fb,L}$ = 244.0 MPa
Short-term bending strength (compr.):	$\sigma_{c,S}$ = 320.0 MPa
Long-term bending strength (compr.):	$\sigma_{c,L}$ = 244.0 MPa
Specific gravity:	γ_L = 16.0 kN/m³
Poisson ratio:	μ = 0.16

Partial safety-factor for CIPP material is γ_M = 1.35 according to [3.1].

6 Surrounding soil

Because of hostpipe condition II, there are no requirements, regarding the soil structure around the existing pipe.

7 Static Calculations

Renovation of the egg-shape profiles shall be done by CIPP – thickness of t_L = 14.0 mm should be proofed in operational state. The declared host pipe conditions are state II [3.1], so that the lining will be verified just for groundwater loads.

The evidence will be done by finite element calculations (FEA); the software “SIMCENTER FEMAP” is used in version 2021.2, which works with the NX Nastran solver.

The finite element analysis is a numerical procedure, which is especially applied for examination of static problems. The advantage of this method is the possibility to calculate structures, which cannot be calculated in an analytical way. The real construction will be modelled geometrically. This geometry will now be subdivided in elements by a mesh tool. The elements carry the physical information, which are material properties (Young´s-modulus, Poisson-ratio...) and stiffness properties (cross section, moment of inertia...).

In this way, for example a straight line of 10 m length can be subdivided in 100 beam-elements with a length of 0.1 m. Because of different element-types (beam-, plate-, shell-, 3D-solid elements ...) different structures can be described. Nodes realize the connection between elements. For example, a beam-element has two nodes.

Now the numerical program automatically develops the system of equations:

$$F = K \cdot u$$

F: load
K: stiffness matrix (mechanical properties of the structure)
u: nodal deformations

With this system of equations, defined loads and material properties could calculate the resulting deformations, stresses, and internal forces numerically.

3D finite element models are used to carry out the static calculations. For the investigation of groundwater loads, hostpipe is modelled with 8-noded solid-elements; CIPP will be discretized by 4-noded plate elements. Connections between liner and host are simulated by special contact elements. If tensile forces occur, misclosures result. The method requires a linear material behaviour – deadweight is represented by assigning the material-specific weighting to the corresponding elements. Groundwater load is applied by a height-dependent surface load, which is raised systematic over time up to the design-load.

For the evidence of deformation (“usability check”) partial safety factors will be set to a value of $\gamma_F = \gamma_M = 1.0$.

Because of the stability problem, a geometric nonlinear static calculation has been performed. In state II calculation, there will be used 10 load-steps up to γ_F-times load.

8 Results

8.1 W:H = 1100:1850 mm, t_L = 14.0 mm, $h_{W,inv}$ = 3.0 mWC

The maximum tensile stress in CIPP under action of γ_F-times working load (Fig. 2.3) results to

max. $\sigma_{T,d}$ = 57.92 MPa.

Therefore, the safety against tensile failure is

57.92 / 180.74 = 0.32 ≤ 1.0.

The maximum compressive stress in CIPP under action of γ_F-times working load (Fig. 2.4) results to

max. $\sigma_{C,d}$ = -67.05 MPa.

Therefore, the safety against compressive failure is

67.05 / 180.74 = 0.37 ≤ 1.0.

The maximum horizontal deformation under working load (Fig. 2.5) results to

$\delta_{h,el}$ = 8.78 mm + |-20.13 mm| = 28.91 mm.

Based on the average diameter of CIPP (d_m = 1475 mm), this corresponds to a relative change of

$\delta_{h,el}$ = 1.96 % ≤ rec. $\delta_{h,el}$ = 3.0 %.

Therefore, the allowable vertical elastic deformation is not achieved. This also applies to the entire total deformation; the permissible value of $\delta_{h,tot}$ = 10.0 % is not reached, too.

Figures 2.3 and 2.4 show that the strength of the material will not be reached under the γ_F-times working load.

Fig. 2.5 and 2.6 show furthermore, that there is no buckling under the γ_F-times working load. Therefore, the required safety against failure of stability is observed.

9 Summary

Under assumption of hostpipe condition II and the given geometry-, material- and load parameters, there a no doubts concerning stability. All necessary evidence of stresses, deformations (elastic & total) and buckling are observed.

Relevant thickness of CIPP has been calculated to **t_L = 14.0 mm**.

All thicknesses in this document are regarded in cured condition after installation of CIPP without any wear layers. We recommend, cutting out a test sample of each section to determine the short-term material properties in a suitable laboratory.

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Distribution list:	Report	Attachments
Magistrát města Ostravy	1 (PDF)	---
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10 Annex

Fig. 1.1: egg-shape profile W:H = 1100:1850 mm; straight section in front and normal section in the back

Figures to chapter 8.1

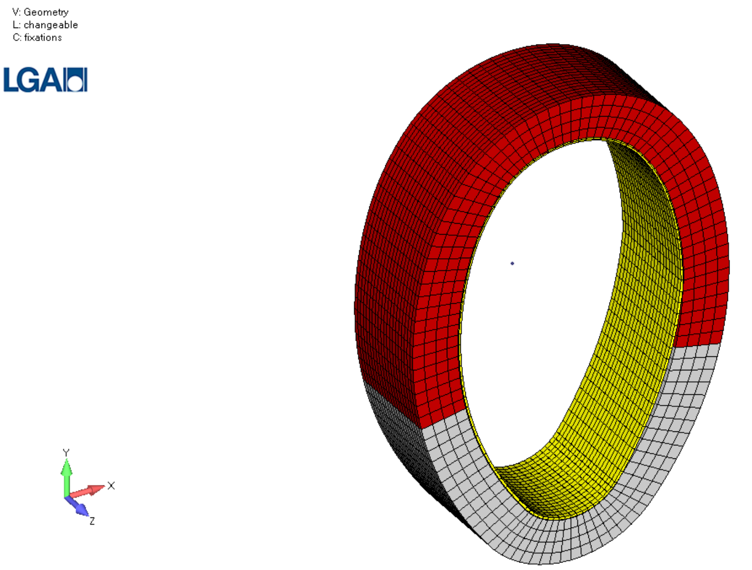

Fig. 2.1: discretized 3D-model W:H = 1100:1850 mm (normal & re-profiled section), ext. groundwater load

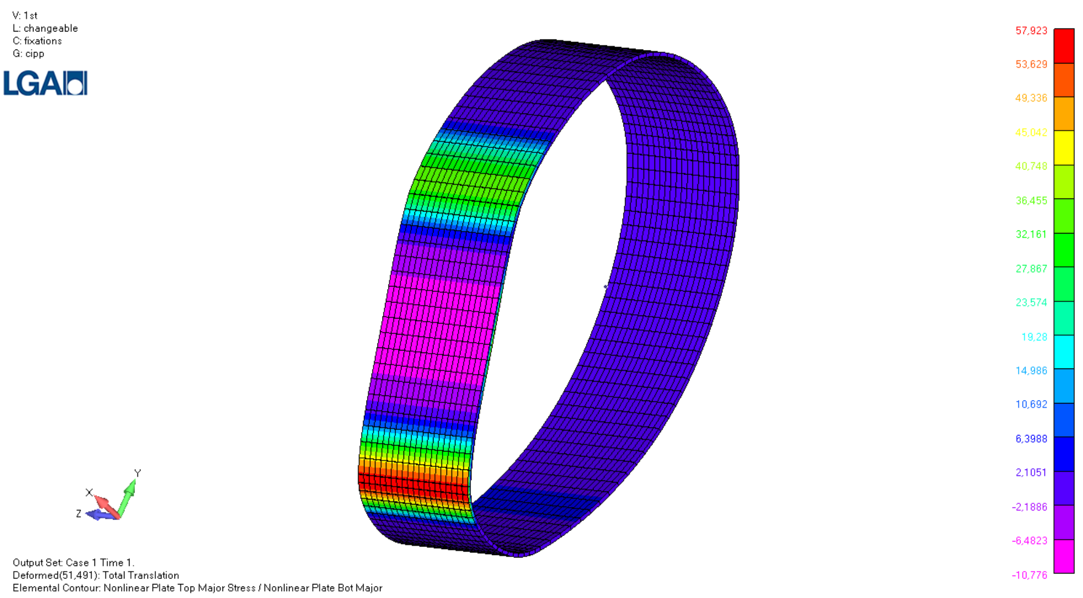

Fig. 2.2: 1st principal Stress [MPa] under condition of γ_F-times load

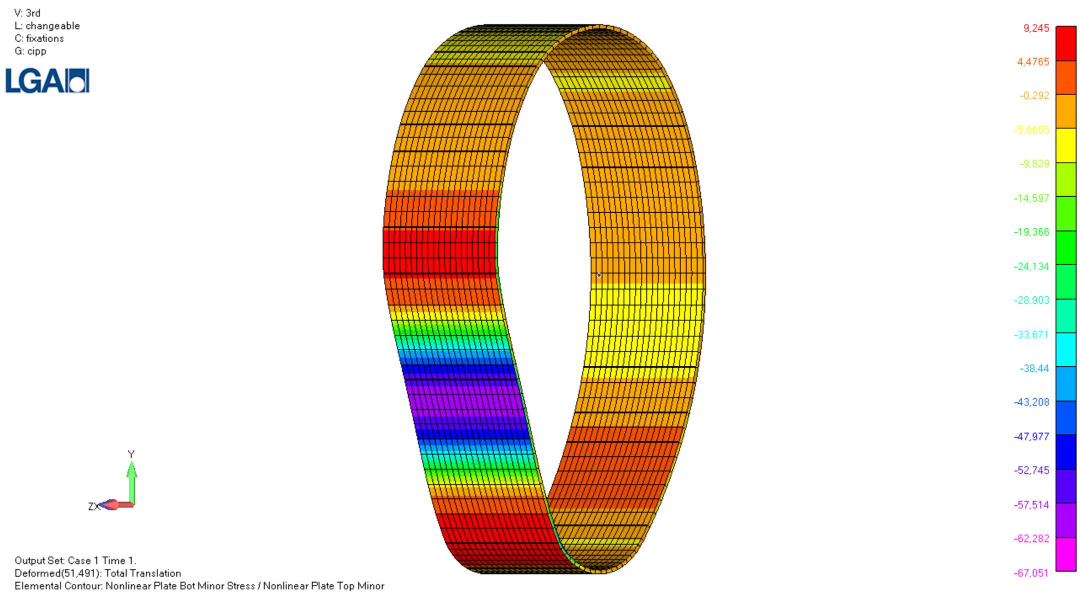

Fig. 2.3: 3rd principal Stress [MPa] under condition of γ_F-times load

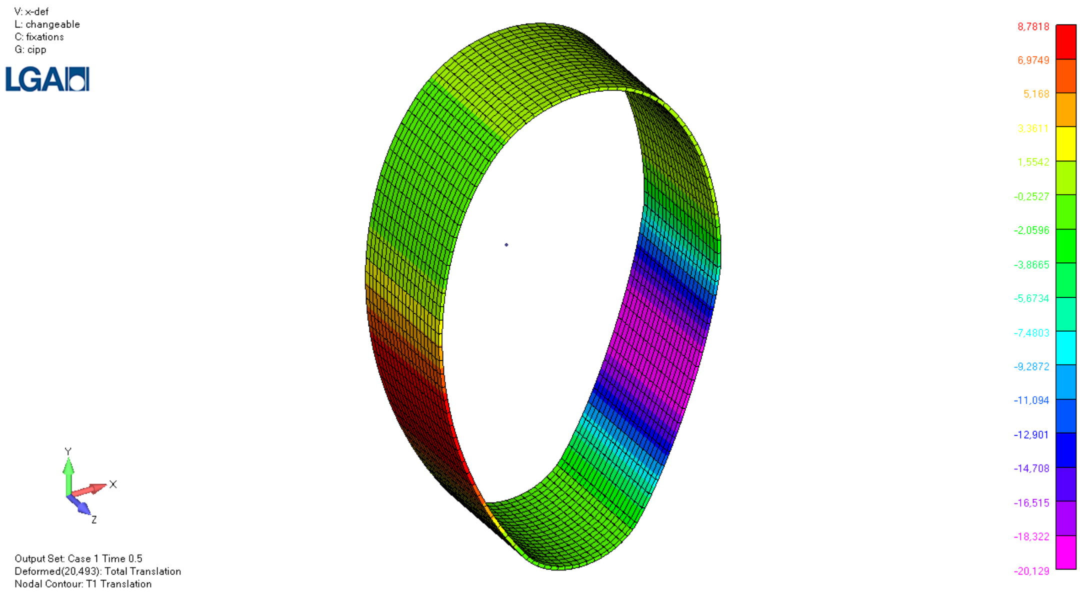

Fig. 2.4: horizontal deformation (springlines) [mm] under condition of service load

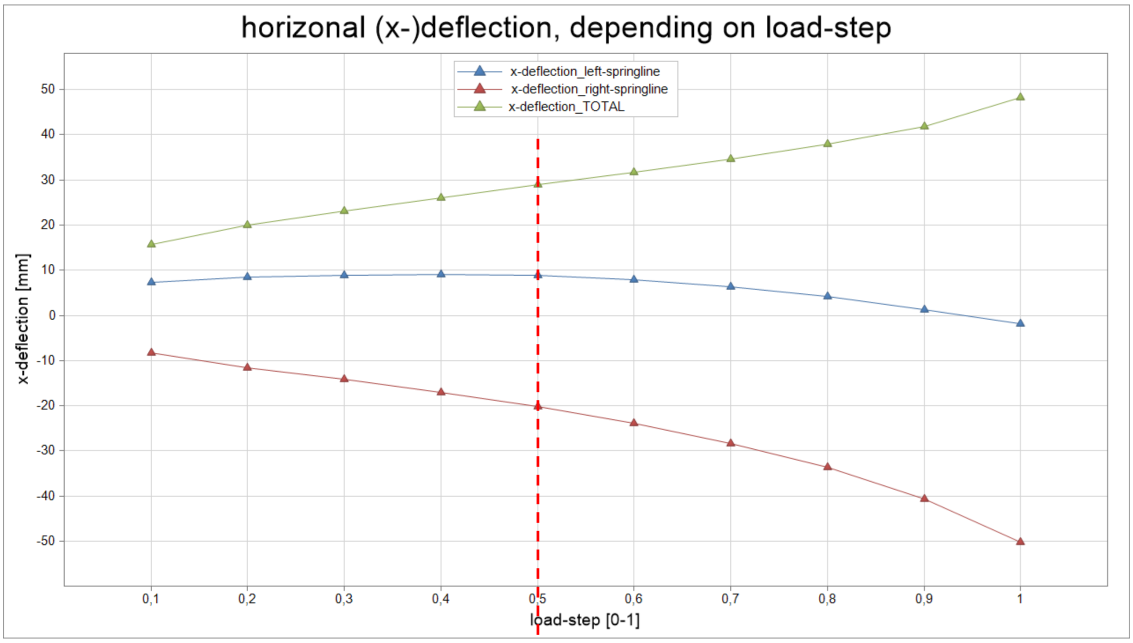

Fig. 2.5: horizontal deformation (springlines) [mm] depending on load step (step 1 ≙ γ_F-times load)