VIACON ACADEMY

WEBINAR SERIES - AUTUMN 2021

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Constructing connections.
Consciously.

ViaCon Group

The ViaCon Group is an international provider of state-of-the-art innovative engineering solutions to build:

- culverts,
- bridges,
- grade separations,
- wild and rural crossings,
- tunnels etc.,

in addition to GeoTechnical and StormWater Solutions, using our corrugated steel and plastic pipes, as well as corrugated steel structures.

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ViaCon's Geography

- ViaCon Member
- ViaCon Partner
- ViaCon Project

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ViaCon’s Solution Offerings

With more than 30 years of civil engineering experience, we provide specialized, world-class Bridges and Culverts solutions that are strong and durable, cost-efficient, and sustainable.

Our state-of-the-art Geotechnical

solutions and products help solve all issues in the field of geotechnical engineering. Our solutions range from soil reinforcement to landfills and much more.

With our outstanding technical and engineering prowess, ViaCon’s StormWater solutions and products are designed to meet the challenges of stormwater management, ranging from storing stormwater to infiltration and drainage, to treating polluted wastewater.

Applicable Industries

We focus on constructing diverse solutions that match the needs of our customers and contribute to meeting the challenges of our changing world.

ViaCon’s solutions are used by the following industries:

ROADS

RAILWAYS

FORESTRY

COASTAL AND WATERWAY ENGINEERING

MINING

AGRICULTURE

ENVIRONMENT

MILITARY

BUILDING AND INDUSTRIAL AREAS

AIRPORT

Webinar Agenda

1. **Introduction** – definitions, relining concept, possibilities and limitations
2. **Nordic market experiences** – product applications and assembly techniques
3. **German market experiences** – products diversification and assembly techniques
4. **Case presentation** – Largest rehabilitated bridge in Europe
5. **Q&A** Session
6. **Summary**

Rehabilitation and Relining

Piotr Tomala, Jouko Selkämaa, Christian Hammes

10th November 2021

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Introduction

At times, **liner plate** or **structural plate** sections are used to reline culverts. Such repairs can be used:

- to address spalling concrete culvert wall-sections; and
- to repair damaged coatings and wall-sections in stone, concrete, or metal pipe culverts.

The section of the culvert needs to be cleaned, repaired, and then coated or painted.

Suitable repairs can be made to restore the culvert to an acceptable level of structural adequacy and integrity. Once this has been accomplished, appropriate rehabilitation methods and procedures can be undertaken to improve the culvert's performance and extend its useful service life.

Introduction

Rehabilitation costs and the ***time*** associated with such repairs are often significantly less than what is required for total replacement of these structures.

Safety issues must be taken into consideration. Relining or rehabilitation is often a much safer undertaking for construction crews, as well as the travelling public.

Accessibility of roads, meaning keeping roads open, or at least partially open, is often more desirable and safer than costly and time-consuming detours and road closures.

When do bridges require repairs?

Bearing Capacity

- Rapid development of civilization
- Increase in the number of vehicles
- Development of design codes
- Service life (expired)
- Polluted air

Utility Issues

- Required widening of the roads - the need to build new lanes to increase traffic capacity
- Service life (expired)

How to repair culverts and/or bridges?

Basically, two techniques of rehabilitation of bridges can be used:

1. Total – Full demolition of existing bridge/culvert and building the new structure

2. Relining – lining the existing conduit with use of one of the ViaCon products.

   In this case, free space between the new and existing structure is grouted. It results in minimizing any deflections of the existing superstructure.

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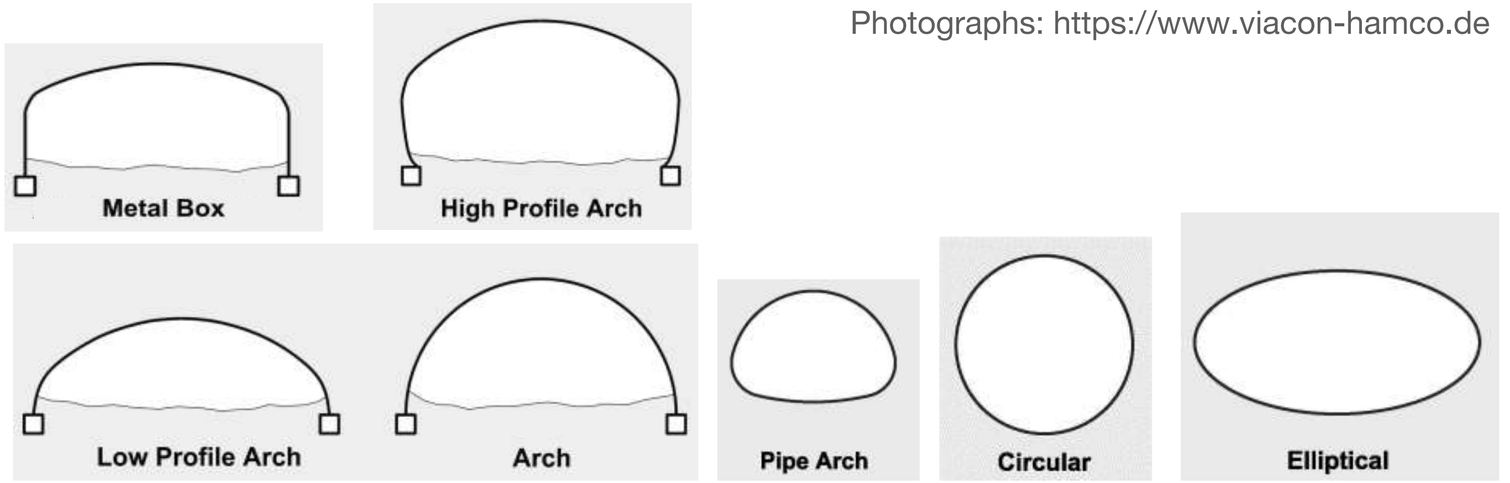
Definitions

- Rebuilding
- Rehabilitation
- Repair
- Restoration
- Reconstruction
- Replacement
- Modernization

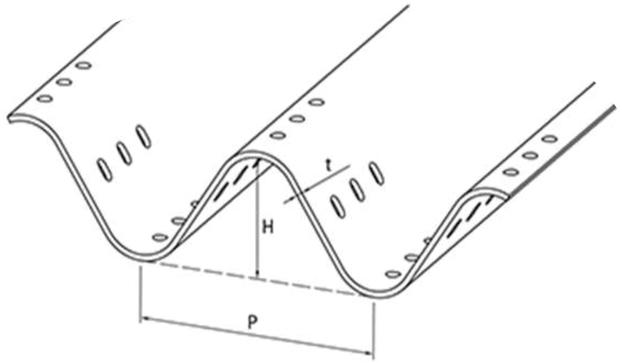
What does ViaCon do?

- Variety of Shapes & Sizes
- Wide range of spans (over 800 pcs cataloqued steel profiles + custom shapes on demand; over 110pcs of Reinforced concrete profiles)

Photographs: https://www.viacon-hamco.de



Corrugation



Diversification of the corrugation

HelCor
68x13
125x26 [mm]

Closed-shape profiles: Diameters up to 3.9 m

MultiPlate
200x55 [mm]

Open-shape profiles:
Spans up to 12 m

Closed-shape profiles: Spans up to 12 m

SuperCor
381x140 [mm]

Open-shape profiles:
Spans up to 25 m

Closed-shape profiles:
Spans up to 16 m

UltraCor
500x237 [mm]

Open-shape profiles:
Spans over 30 m

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Corrugation

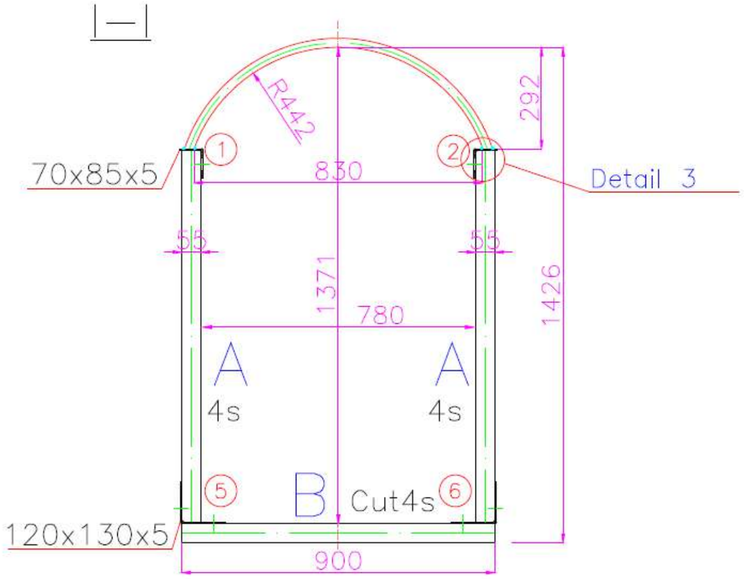
HelCor

68x13 and 125x26 [mm]

MultiPlate

200x55 [mm]

Diversification of the corrugation



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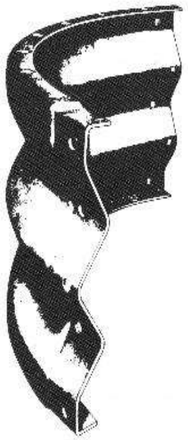
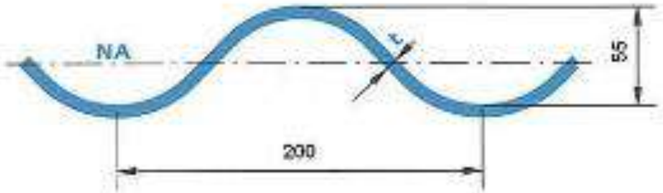
Corrugation



Diversification of the corrugation

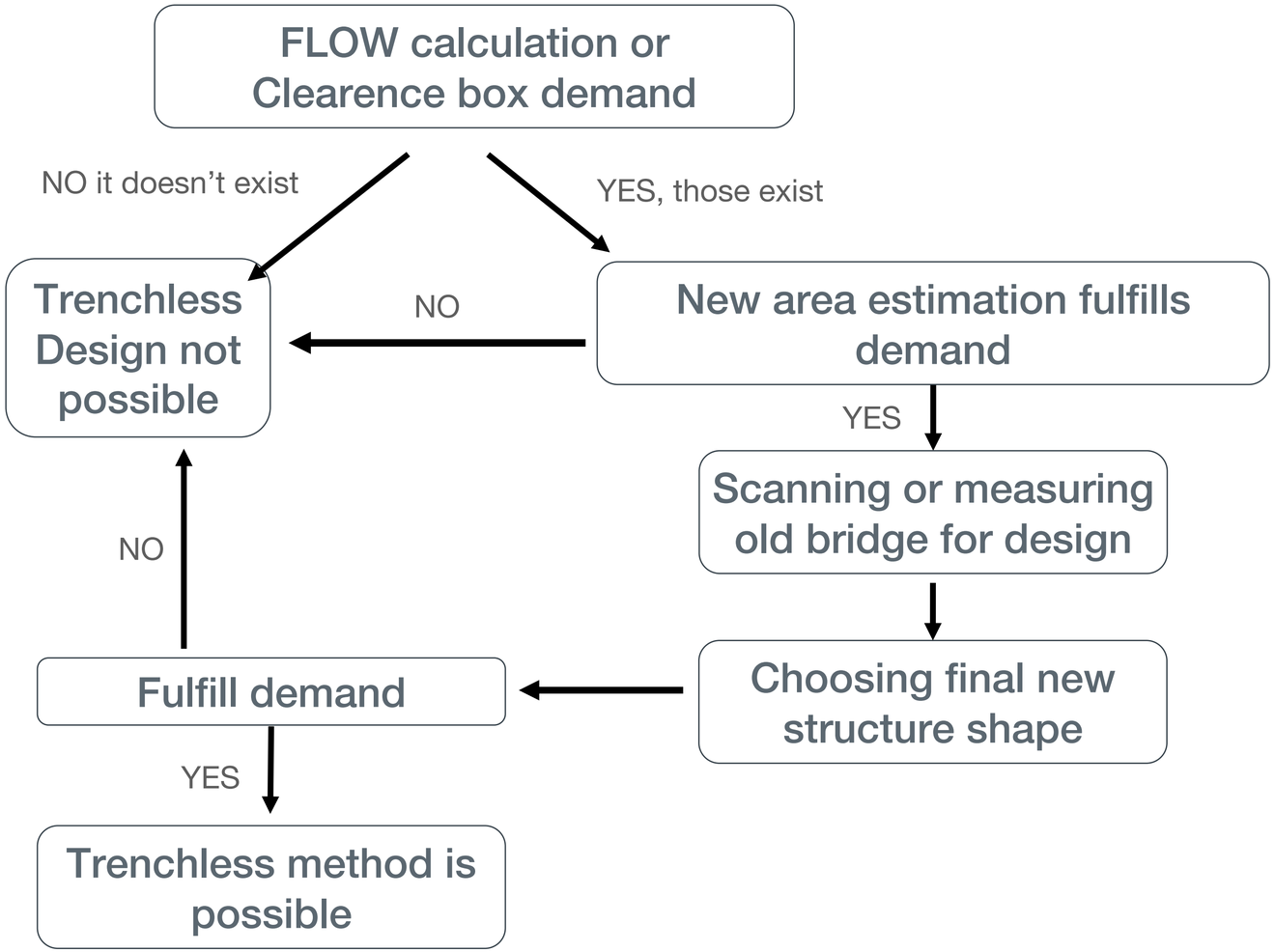
Hamco LP 2F (2Flange)



Hamco 200 Flange

Design

Trenchless Feasibility Study



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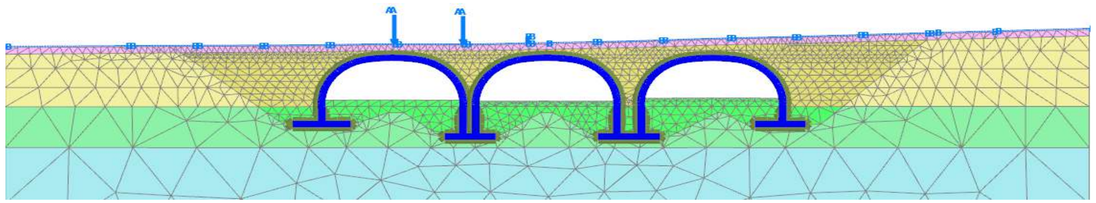
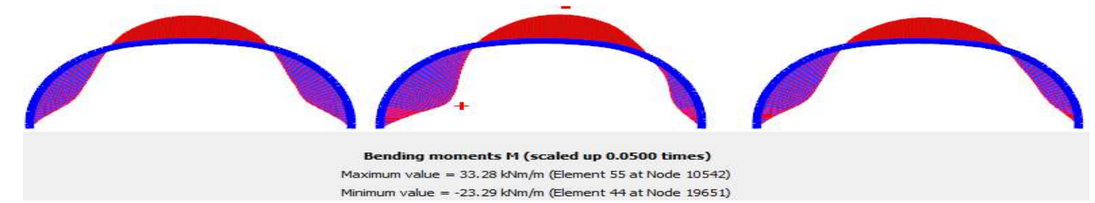
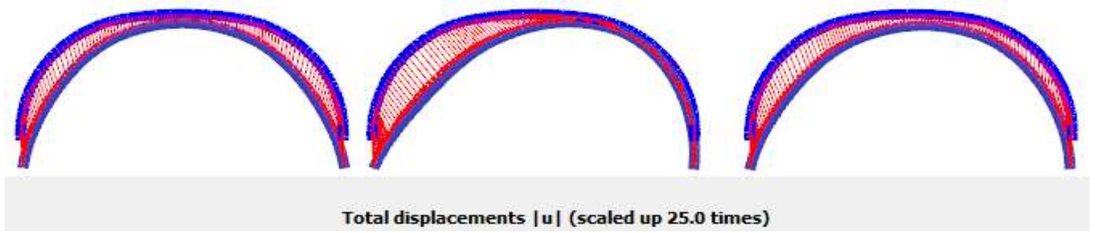
Design

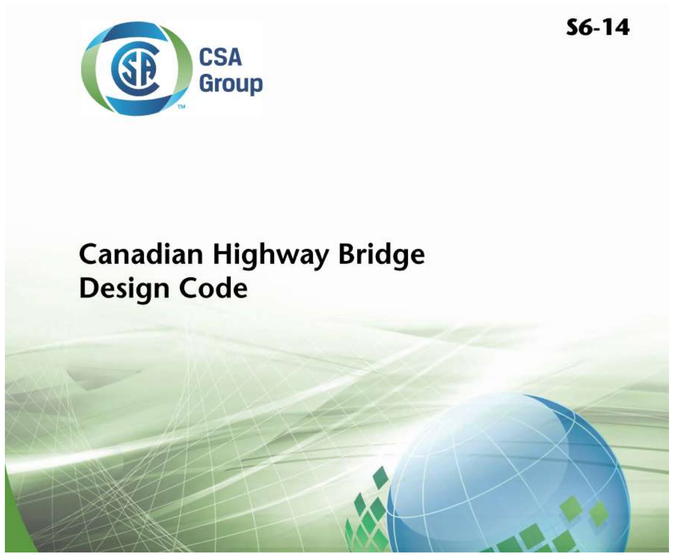
Assumptions

- Existing structure capacity = 0
- New structure takes all of the dead and live loads









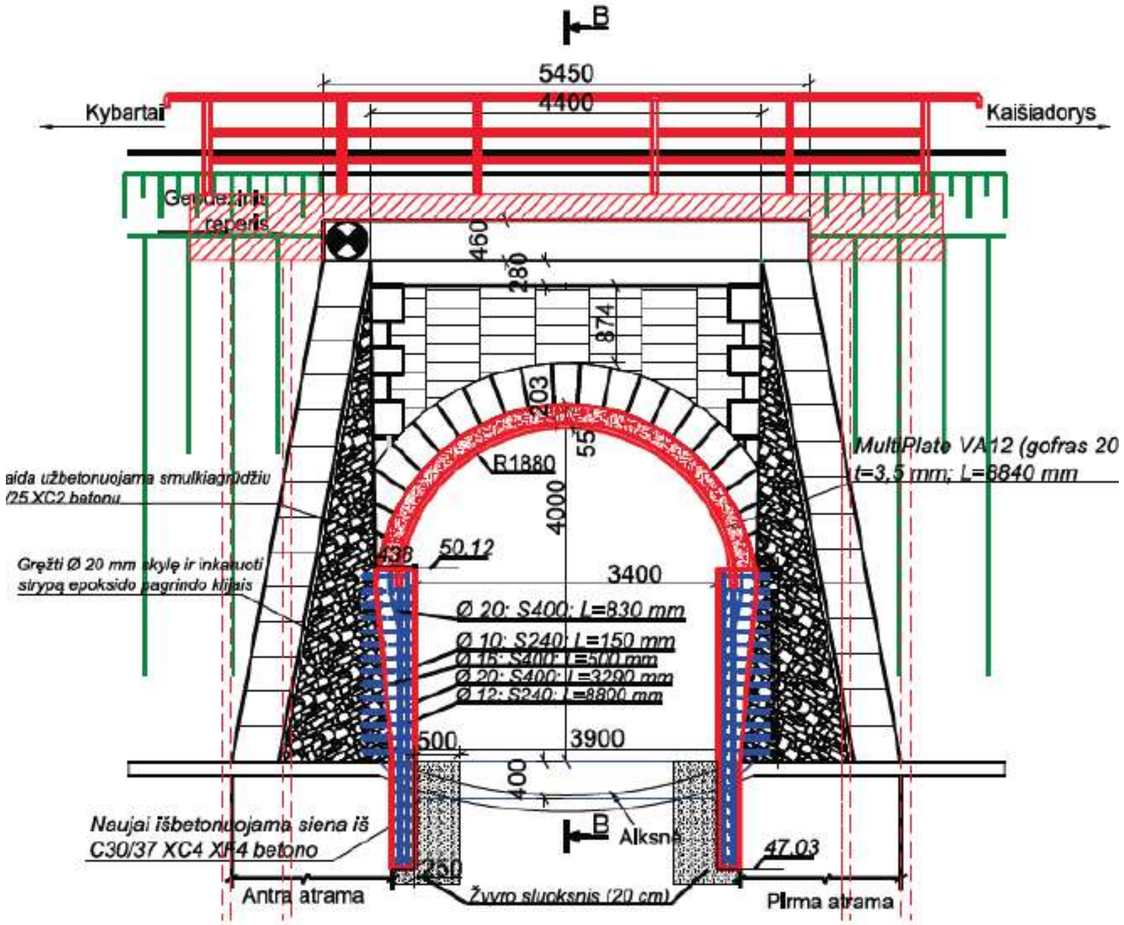
Relining

- Relining – instalation of a new shell to en existing structure to provide a facial or structural restoration

- Aging engineering structures experiencing cracking, spalling or corrosion may require a new Surface to prevent further detoriaration

- Detoriorated structures in danger of failing may require a full structural relining

Relining



Relining – The construction process

1. **Culvert relines involve a slip-lining process:**

   - Slide a pre-assembled or coupled pipe liner into the existing conduit
   - Utilize bracing or blocking to hold the structure into place
   - Pump the grout between new and existing structure. All the voids must be filled to perform as structural liner

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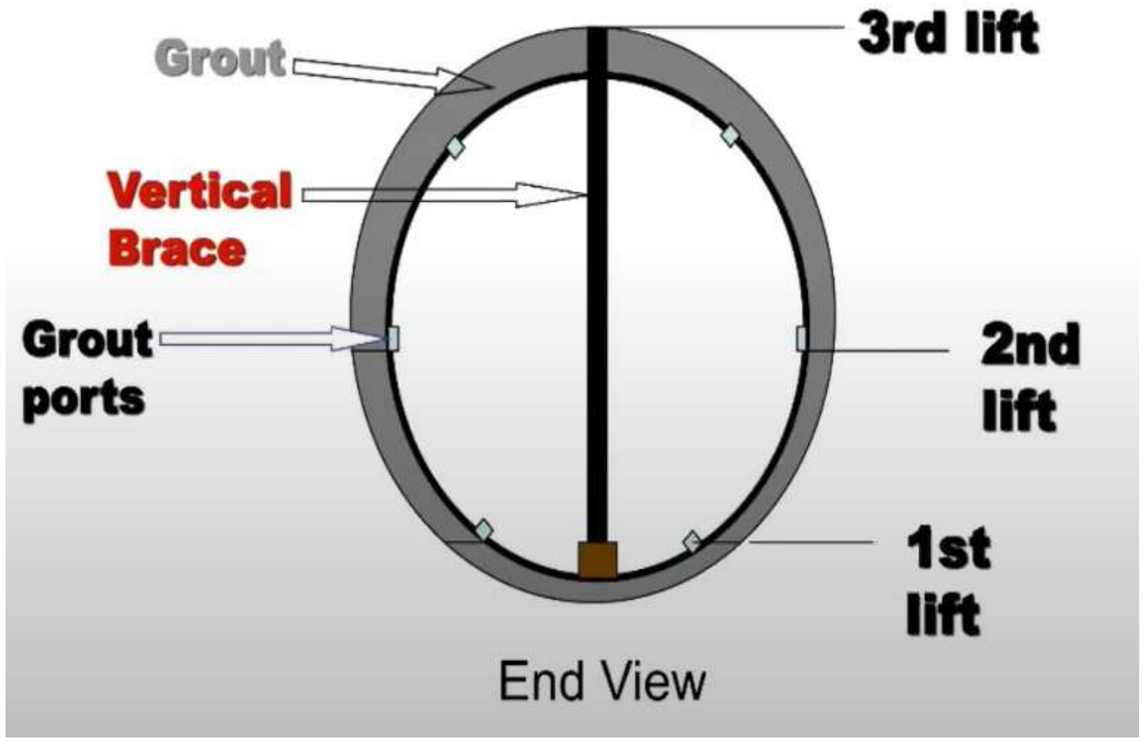

Source: Armtec

Relining – The construction process

2. Flanged liner plates – always assembled in place

Relining – grouting process

1. **Prevent pipe flotation**
   - Jacks should be extended through the top of grout ports
   - Staged grouting procedure
   - Set as specified
2. **Venting**
   - Vent pipes
   - Grout holes
   - Top cavity/vent pipes
3. **Grout lifts**
   - Allow 24 hours between
   - Height as specified

Source: Armtec

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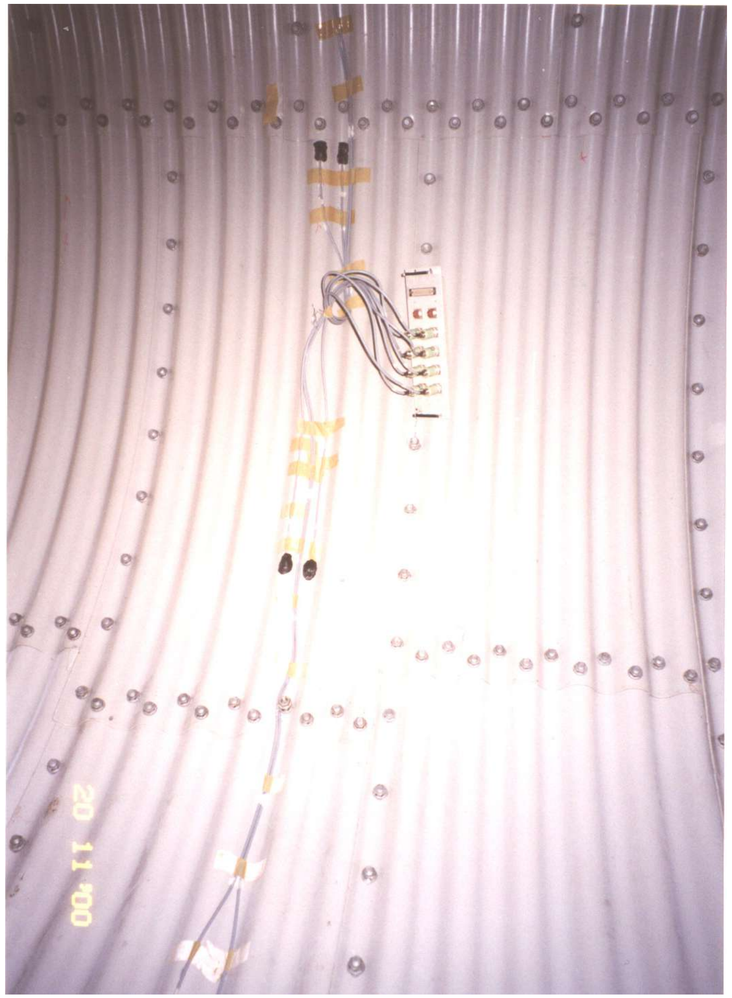
Source: Armtec

Is the solution really working?



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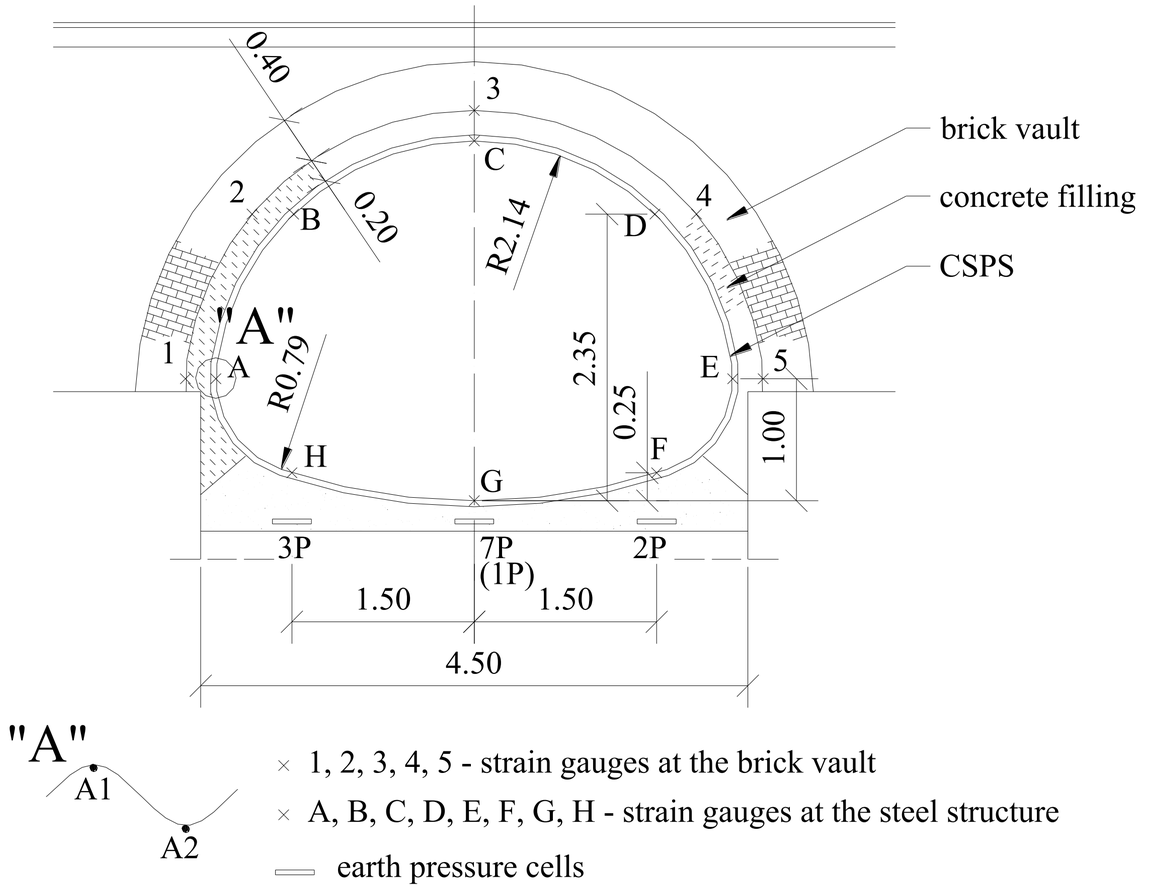
In-situ test

Murzynowo Leśne (Poland)

- The old brick vault was reinforced by a corrugated steel plate structure.
- Scope of the test was evaluation of the degree of interaction of CSPS with the brick culvert and evaluation of the reinforcement effect.
- For the veriffication of the test results the FEM was performed



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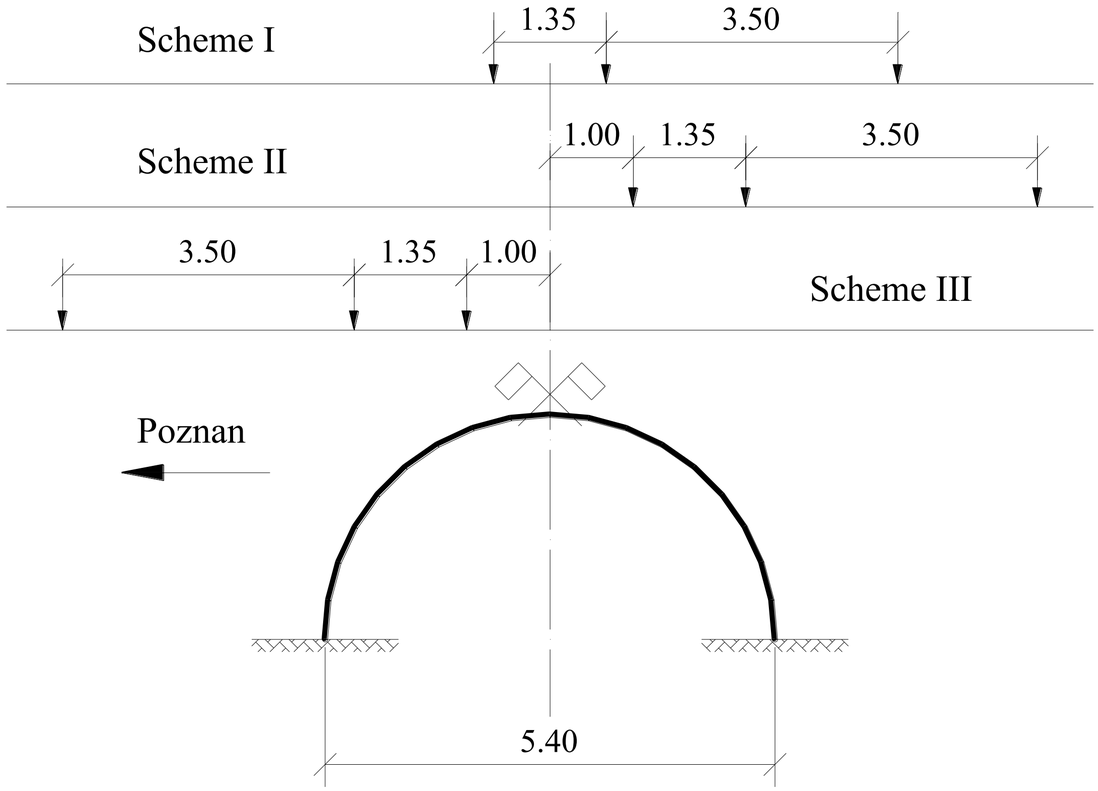

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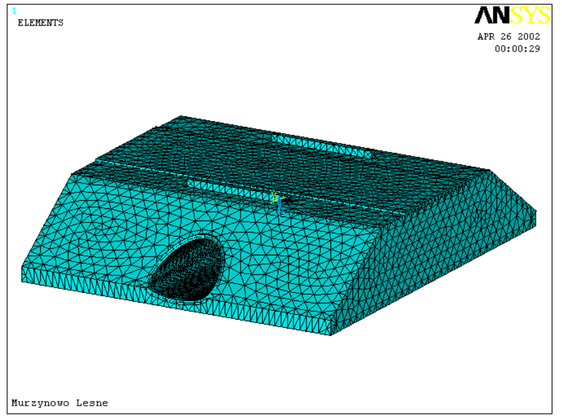

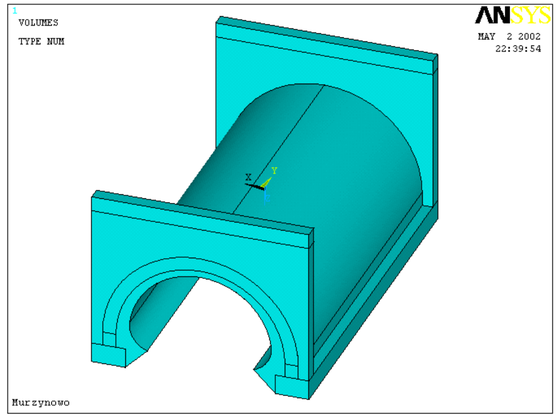

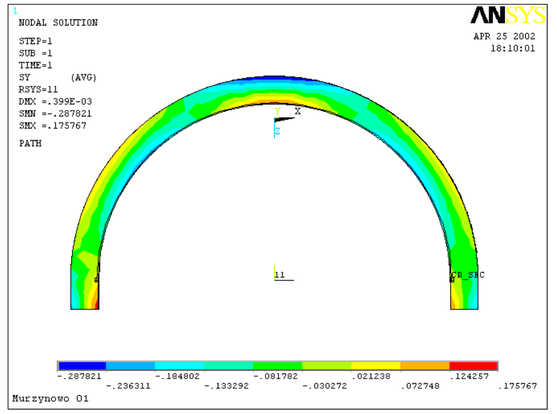

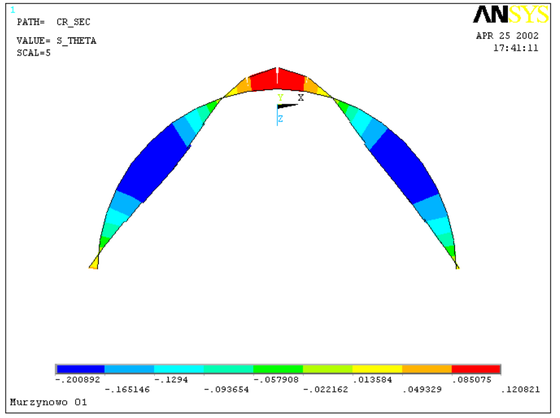

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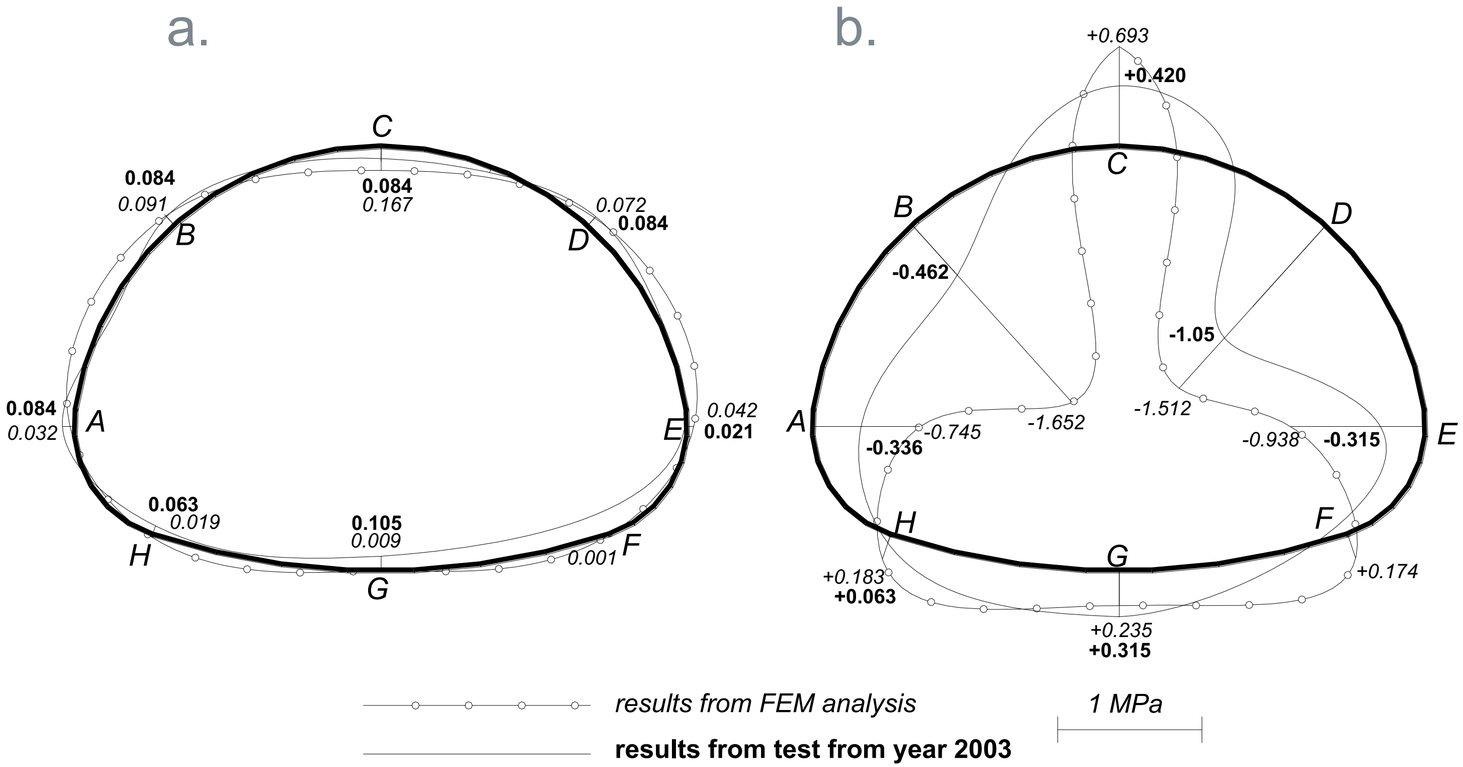


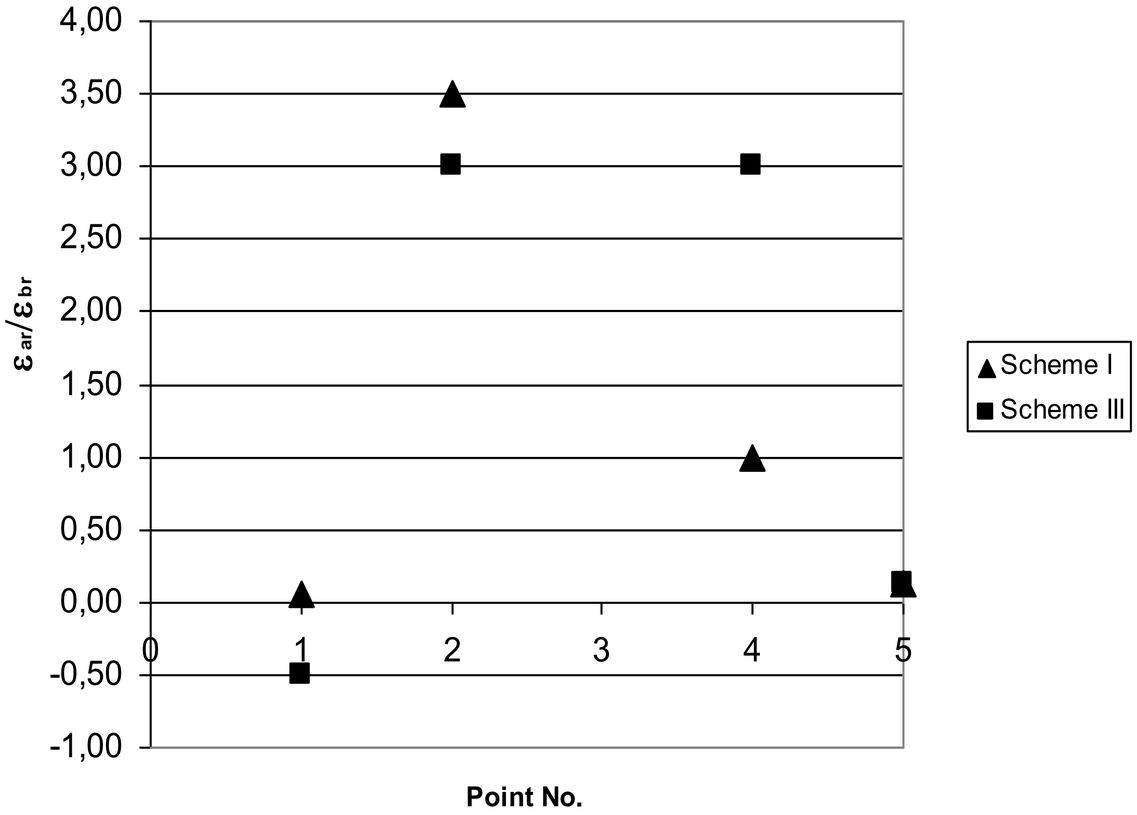
Distribution of stresses at the shell of CSPS obtained from FEM and from test from in 2003 for load scheme I [MPa]: a) bending stresses (bending stresses are situated on the side of tension fibers); b) hoop stresses (negative stresses indicate compression, positive stresses indicate tension)

In-situ test

Murzynowo Leśne (Poland)

Results

- Due to reinforcement of the brick bridge, the distribution of stresses in the brick vault under service load has changed
- It was observed that the smoothing of the stresses alongside the vault with significant reduction of the extreme stresses at the crown.



The relative change of the strains at the surface of the brick vault $\varepsilon_{ar}/\varepsilon_{br}$
(ε_{br} – strains before reinforcement, ε_{ar} – strains after reinforcement)

Rehabilitation and Relining

Piotr Tomala, Jouko Selkämaa, Christian Hammes

10th November 2021

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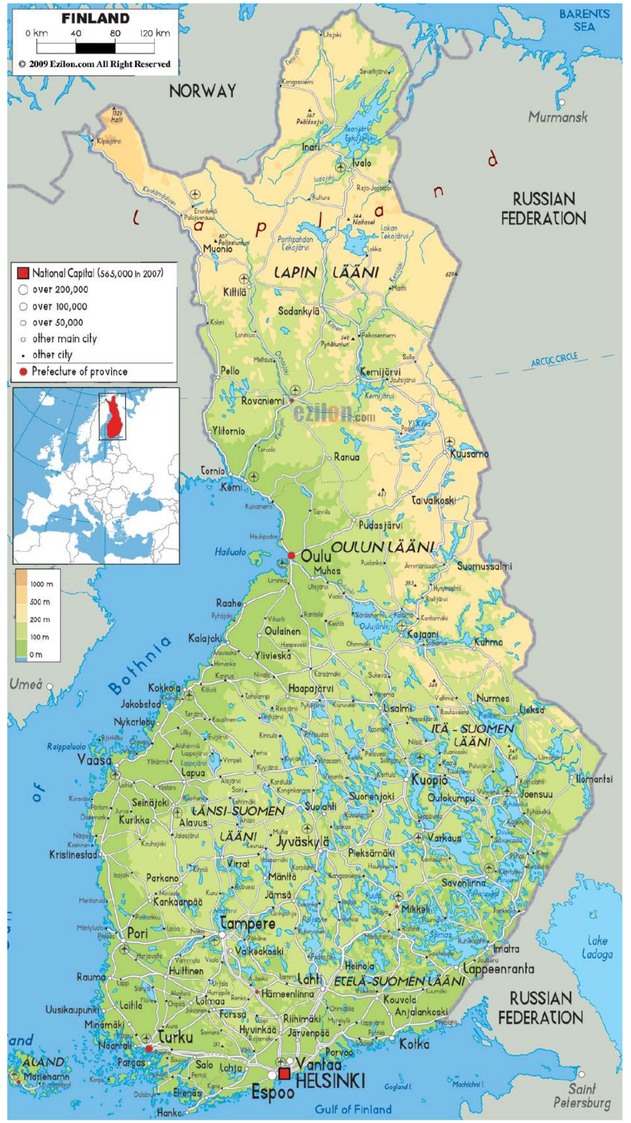
Culverts and Bridges in Finland

- Finland is a country of a thousand lakes.
- In Finland there are over 12500 pcs bridges with span < 10 m.
- Oldest Steel Pipe Bridges are from the 1950s.

- Average span of a pipe bridge in Finland is < 5 m
- Every year over 50 pipe bridges are renovated.

- The designed service life before 80s for bridges was 25-50 years with span < 10 m.
- After that, the designed service life was increased to 30-100 years



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Reasons of Repair in the Nordics

- In Nordic countries, the **cycle of temperature** and **humidity** affects concrete and steel a lot.
- The **salting** of the roads weakens both concrete and steel.
- Improving traffic areas with pedestrian walkways means also lengthening of constructions.
  Then the new part will be extended under the new pedestrian walkway.

.

Principles of Repair Systems in Finland

- In ***open-cut method***, the road or railway must be closed under renewing time.

  With Steel pipe bridges, span <5 m, it takes 1 - 3 days.

  Often this is impossible without bypass road

- . The ***trenchless method*** is to repair the old construction.

  Road or railway can be in use.

  It takes 2 – 5 days with span <5 m.

  Savings in bypass road cost is 30 000-150 000 €

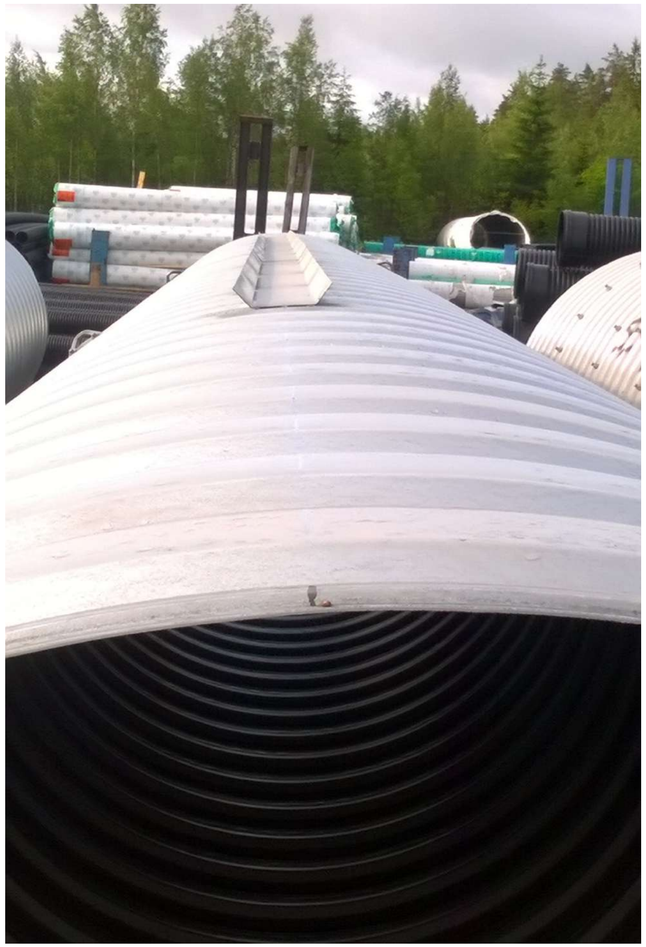
- I will focus on ***trenchless repair systems***, which can be delivered assembled.

Trenchless method
- Using whole pipe

- When the pipe is in totally bad condition.
- The whole pipe is pulled into the old.
- Ensure the sliding

- On old concrete constructions flat steel is not needed.

- On top of the pipe or arch there is a plate canal, where a concrete tube can push to the middle section of the construction.



Trenchless method
- Preventing uplift forces

- On both sides at 11 and 13 o´clock there is a steel L-beam, where the screw-beam can be wrenched to hit the roof of the old construction. These take the uplift forces.

Trenchless construction Procedure
- using whole pipe

Marking the job site

Making dams on the river to dry the pipe.

Cleaning the pipe

Pull the new pipe in

Seal the bevel area, so that the filling concrete doesn’t flow out

Cast the filling concrete to gap between old and new pipe

Open the dams after one day

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Trenchless method
- Calculations of whole pipe method

- **Calculations**

  Capacity calculation.

  Uplift force of concrete and strength of screw-beams.

  Possible dam effect of new construction

- The new pipe can be any profile (HelCor, Mp200 etc.)
- The life of the new pipe is according to national guidelines

Trenchless method
- Using bottom liner

- This method is widely used in Finland, because we have over 3500 Steel pipe bridges and oldest are from 50’s.

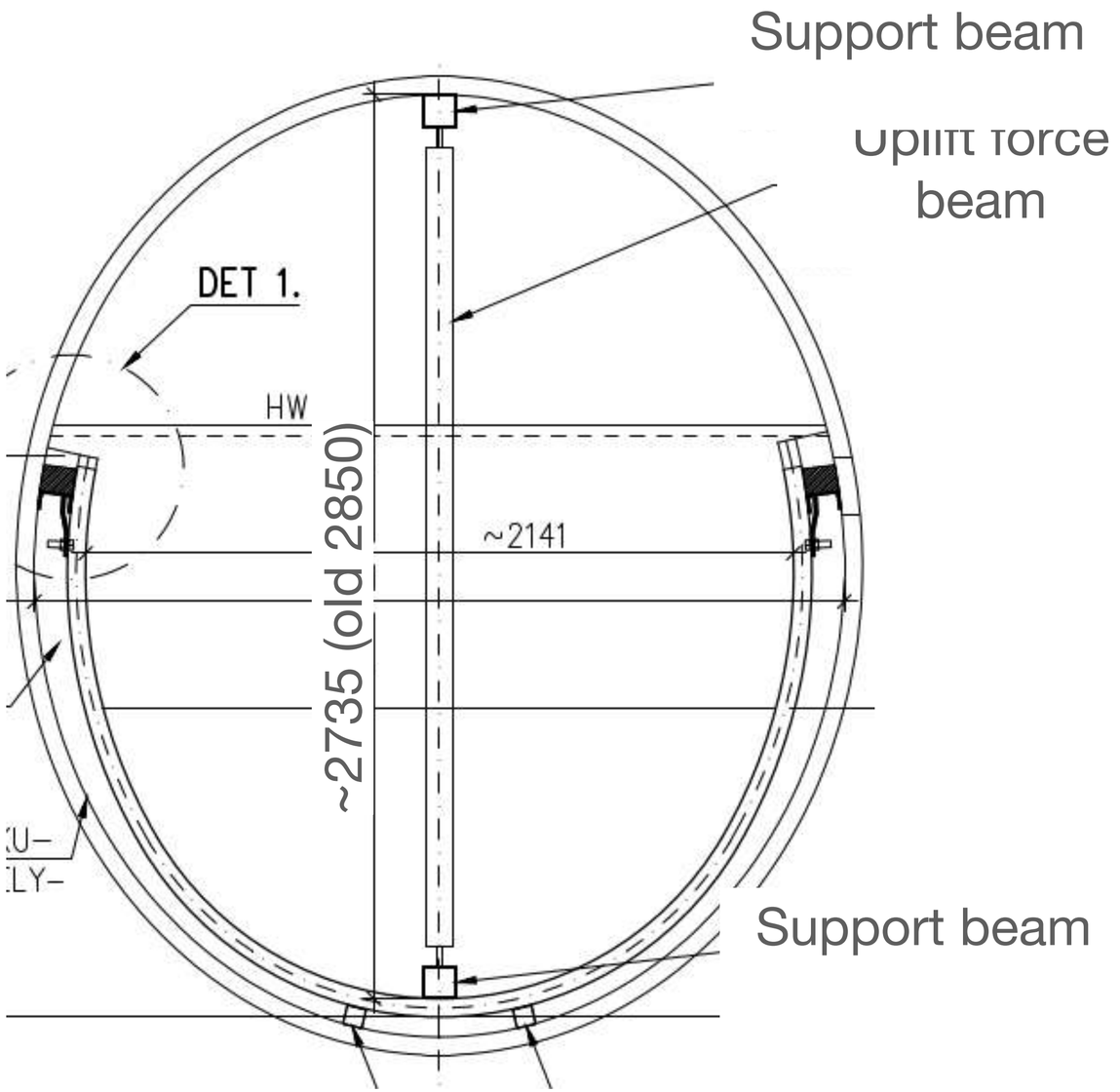
- When the old pipe is only partly bad condition.

Trenchless method
- Bottom liner demands

- This method needs usually special design of liner shape
- The cap between the old and new pipe have to be approx. 100 mm.
- The height of the new liner has to be estimated. The level is approx. 20 cm above worn area of bridge.

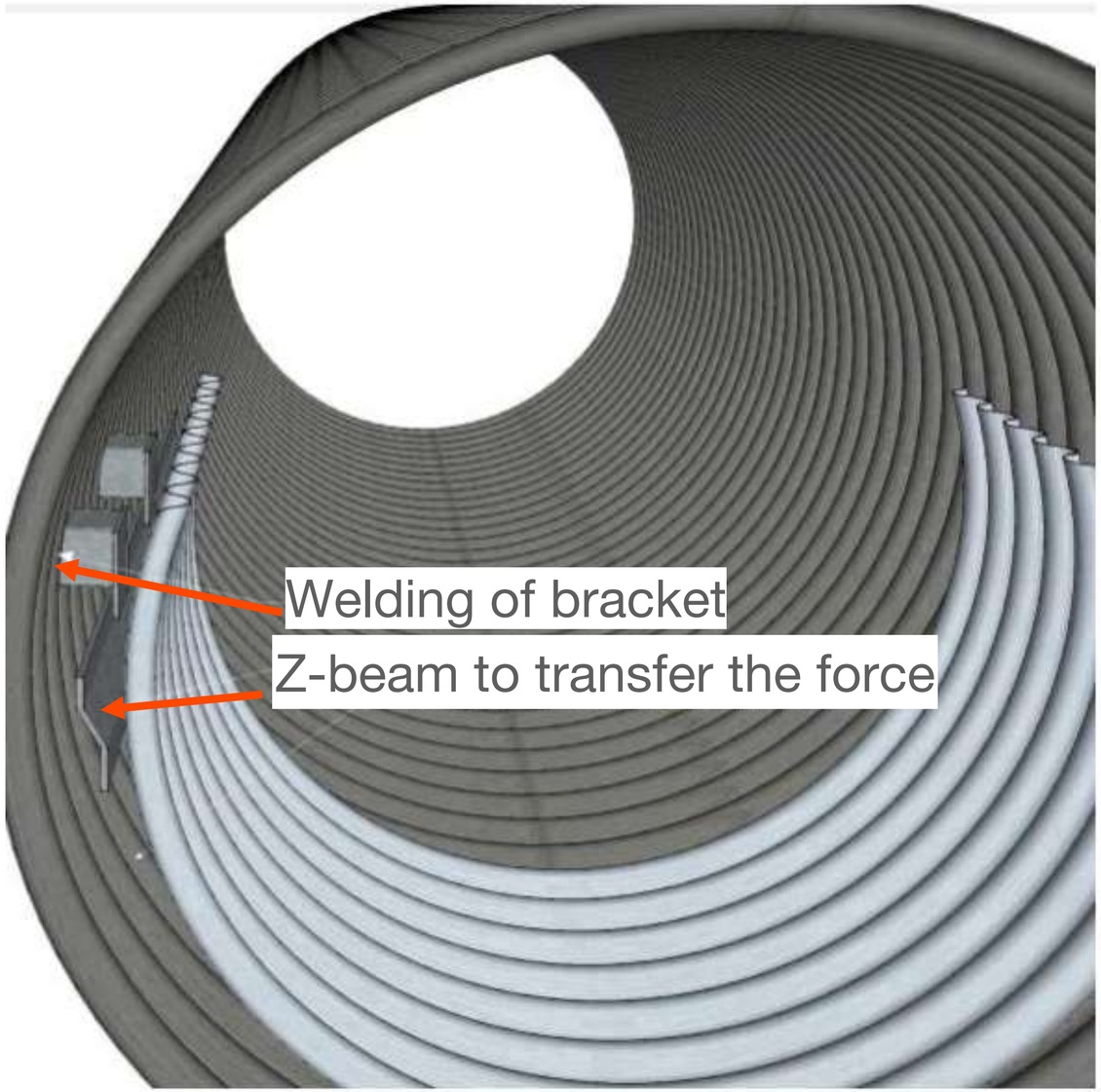
Trenchless method
- Bottom liner without forces

- If the repair is only lining, the new construction is just attached to the old one.
- The only force to be handled is the casting uplift force.
- Then the sides need only light beams to be welded to the old pipe wall and support wood beams are used from bottom to roof.



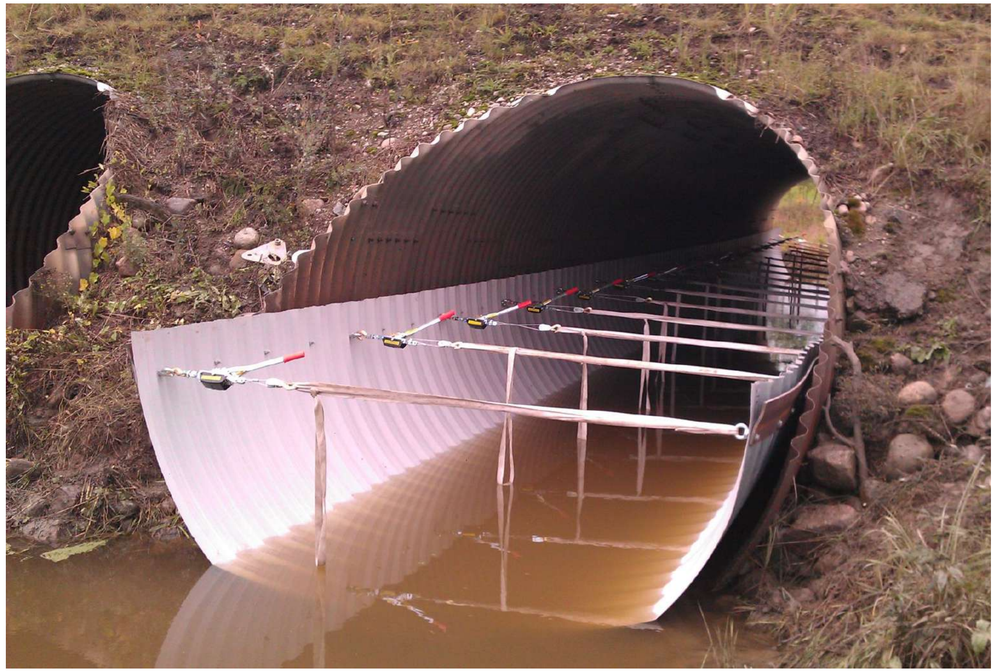
Trenchless method
- Bottom liner taking forces

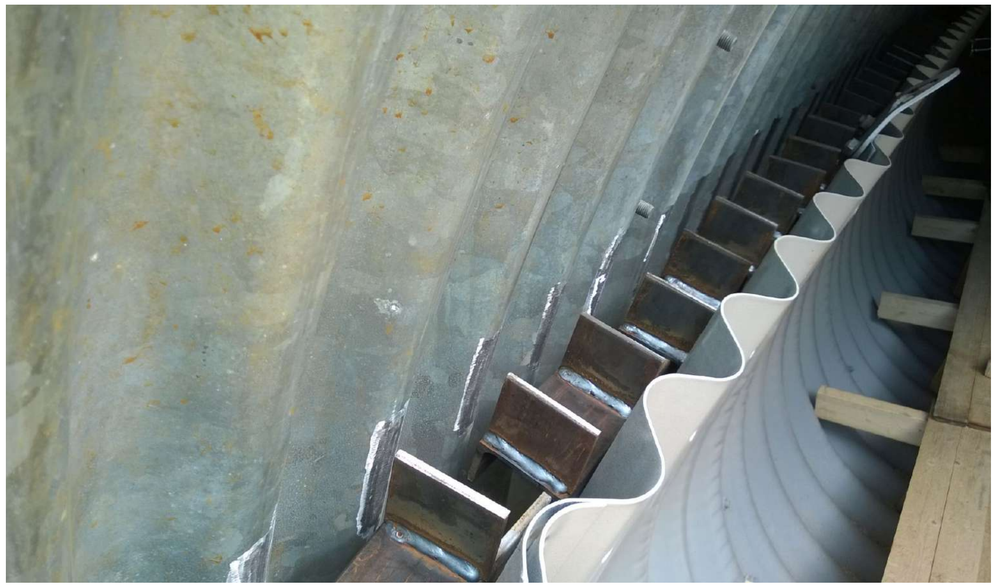
- When the new construction must take also forces from the old one, the construction needs strong side brackets.
- These brackets are welded to old pipe wall and attached to a z-beam, which is on the new bottom liner.
- The z-beam is easiest way to handle the different distances of brackets.



Trenchless construction procedure - using bottom liner

- Marking the job site
- Making dams to river to dry the pipe.
- Cleaning the old construction
- Pull the new liner in
- Build the walking area (if needed)
- Adjust the gap between walls (gap 100mm)
- Weld the brackets





Trenchless method
- using bottom liner

Put the vertical support beams

Seal the bevel area, so that the filling concrete doesn’t flow out

Cast the filling concrete to gap between old and new pipe

Open the dams after one day

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Trenchless method
- Bottom liner Calculations

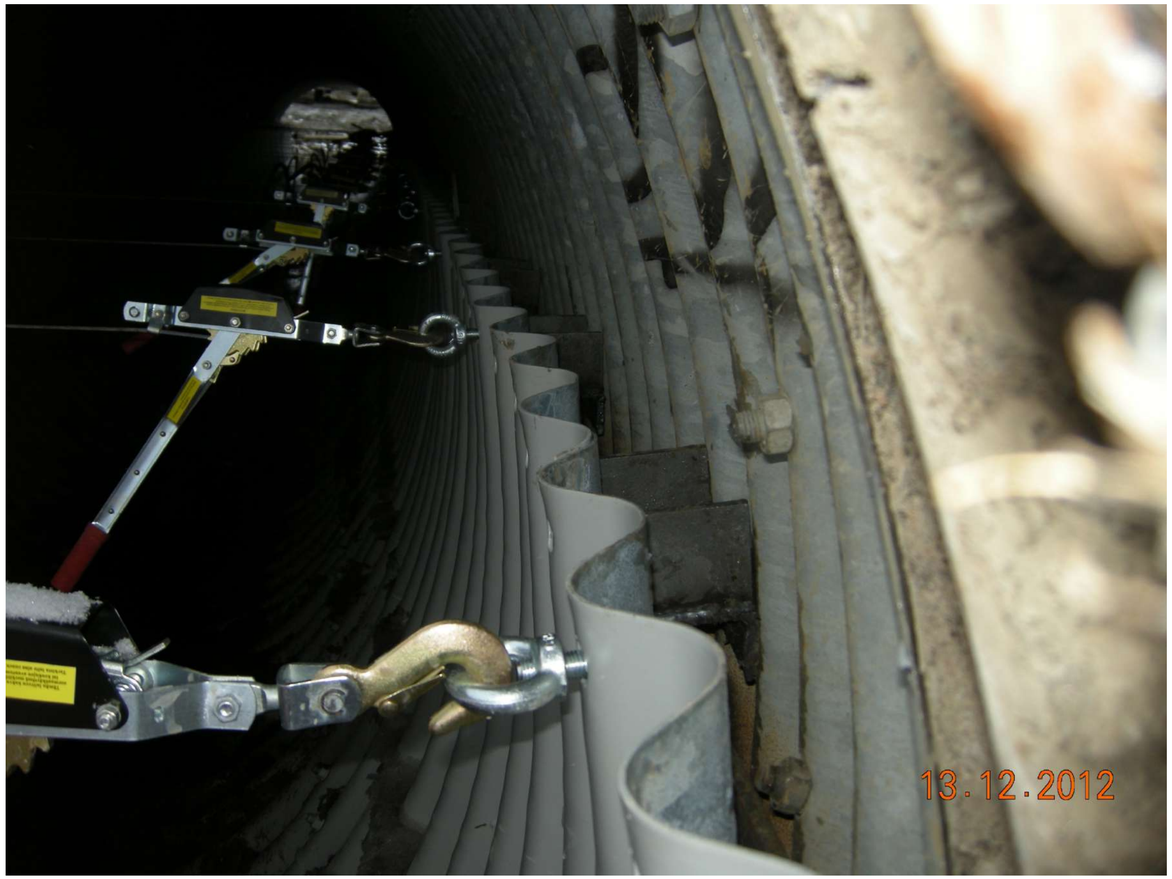
- **Calculations**

  Capacity calculation of the old pipe and new liner.

  Capacity calculation of the brackets.

  Possible dam effect of the new construction.

- The new liner can be any profile (HelCor, Mp200 etc.)
- The life of new liner is according to national guidelines



Trenchless methods increase estimated service life

In Finland these methods has saved costs and durability of old bridges . These methods are suitable for every country.

Rehabilitation and Relining

Piotr Tomala, Jouko Selkämaa, Christian Hammes

10th November 2021

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Road and rail network in Germany

Road network

230.000 km
highways, federal roads, state roads and country roads

413.000 km
municipal roads

=> 643.000 km in total

Rail network

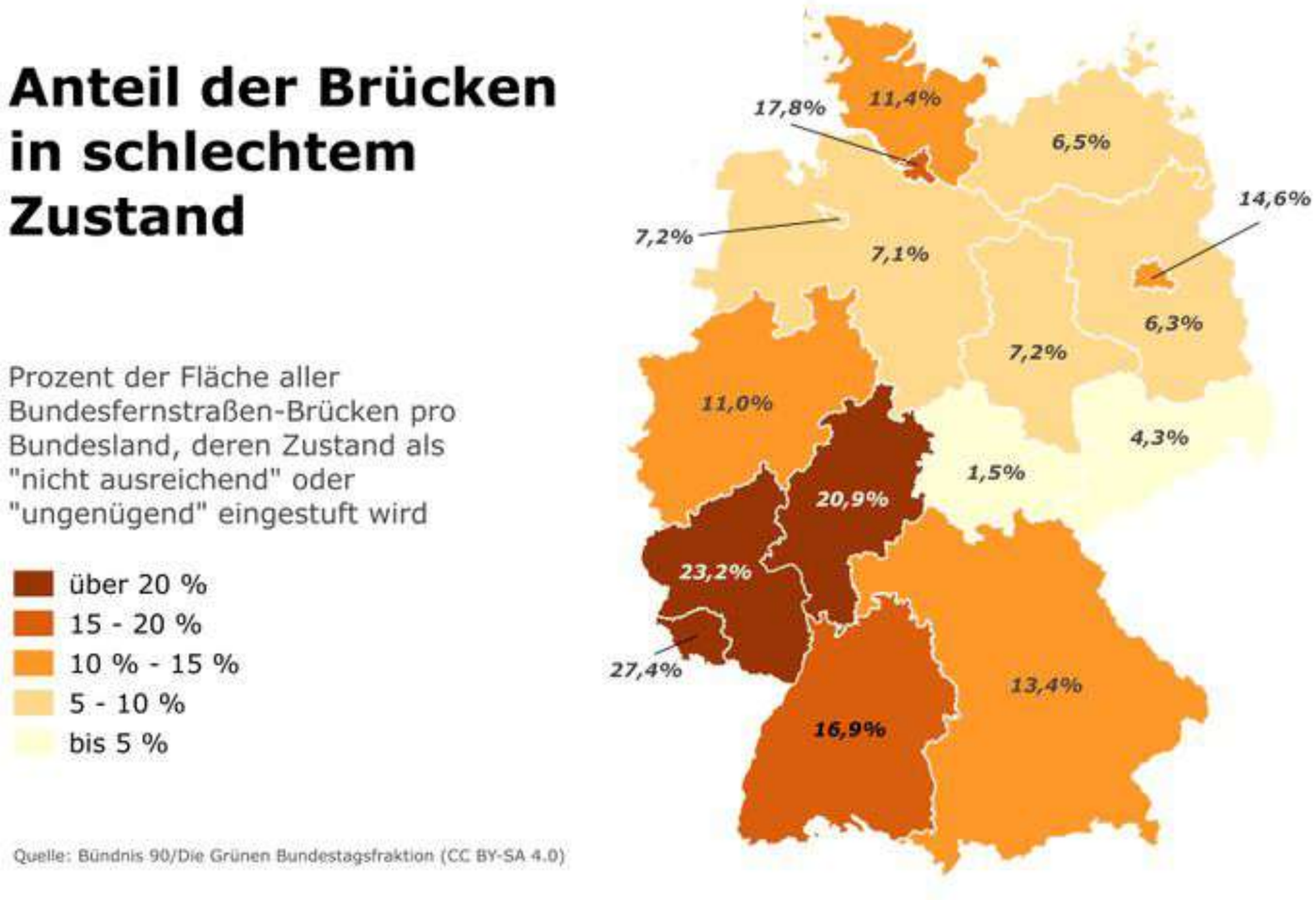
38.400 km in total

of which 33.400 km are operated by Deutsche Bahn

Source of pictures: lahistoriaconmapas.com

Highway area and main railway lines only: 65.000 bridge buildings

Road and rail network in Germany



Proportion of bridges in poor condition

Percentage of the areas of all highways and federal bridges per federal state whose condition is insufficient.

Different rehabilitation methods

REHABILITATION METHODS

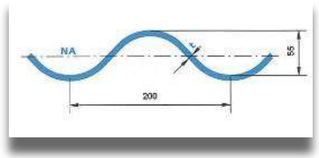
Rehabilitation method #1
Pulling ring by ring / structure

applicable for all kinds of corrugated steel products
HelCor, MultiPlate, SuperCor, UltraCor

Rehabilitation method #2
From inside of existing building

Hamco LP-2F®

Hamco MP200flange®



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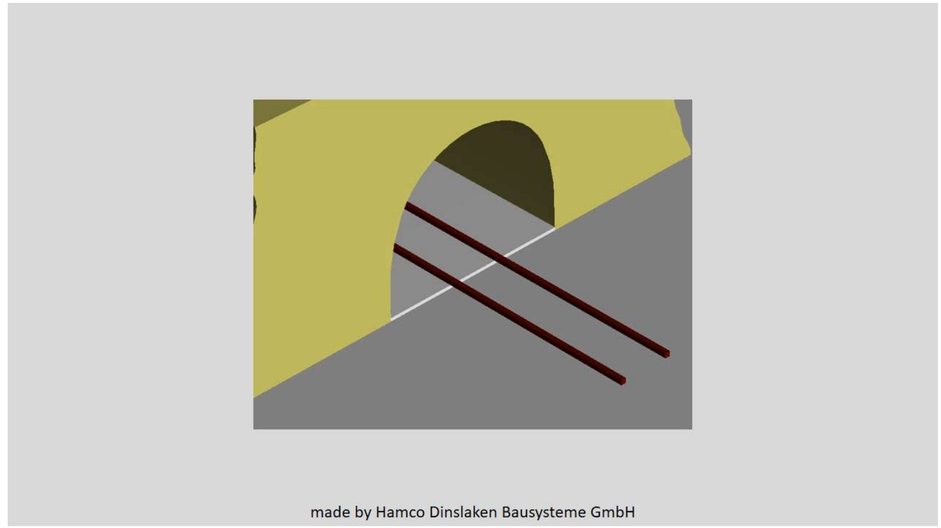
Rehabilitation method #1
– ring-by-ring / structure pulling

- Inside the existing building a **cleanliness layer (closed CSP profiles)** or **concrete strip foundation (open CSP profiles)** are required
- **Working space** in front of the existing building is needed for pre-assembling of the new cross-section
- Parallel placed **rails** (mostly wooden bars) fixed on the **cleanliness layer** or on-site made **concrete strip foundations** which reach up to the working space
- **Pulling-in** of the pre-assembled cross-section into the existing building
- The **remaining space between old and new cross-section** is filled in stages with a concrete suspension



made by Hamco Dinslaken Bausysteme GmbH

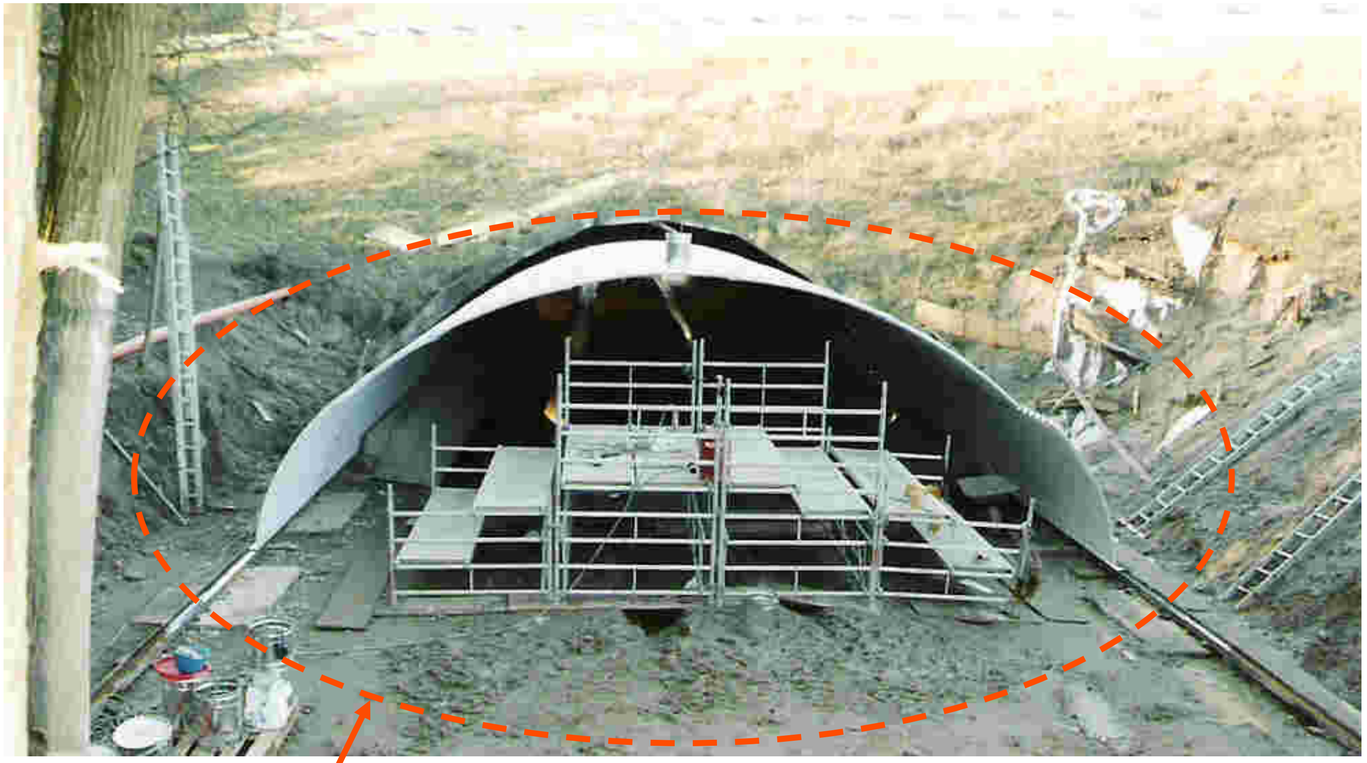
Rehabilitation method #1 – *example 1*

Project task

- **rehabilitation of an old polygon concrete bridge under a highway**
- **efficient water-bypassing inside the existing tunnel => using a circular profile**
- **due to the large dimensions of the new structure the pulling-in process had to be ensured at all times**

Project name	Rehabilitation of concrete bridge under the highway BAB 19
Product	Hamco MP200®
Cross-section	circular arch
Span / Rise	9,29 m / 2,99 m
Length	68,00 m
Plate thickness	7,00 mm
Total weight	70 tons
Assembly period	3 weeks

Rehabilitation method #1 *– example 1*



working space for pre-assembly

dimensioning of new structure as close as much to the existing cross-section

=> optimization of cross-section loss

Rehabilitation method #1 *– example 1*

Rehabilitation method #1 – *example 2*

Project task

- **rehabilitation and lengthening of an old railway vault bridge**
- **lengthening was required for having a double-railway line afterwards**

Client	Deutsche Bahn AG
Project name	Rehabilitation railway bridge ‚Sendelbach‘
Product	Hamco MP200®
Cross-section	circular arch
Span / Rise	8,50 m / 4,21 m
Length	21,45 m
Plate thickness	7,00 mm
Total weight	21 tons
Assembly period	1 week

Rehabilitation method #1 *– example 2*

Rehabilitation method #1 – *example 2*

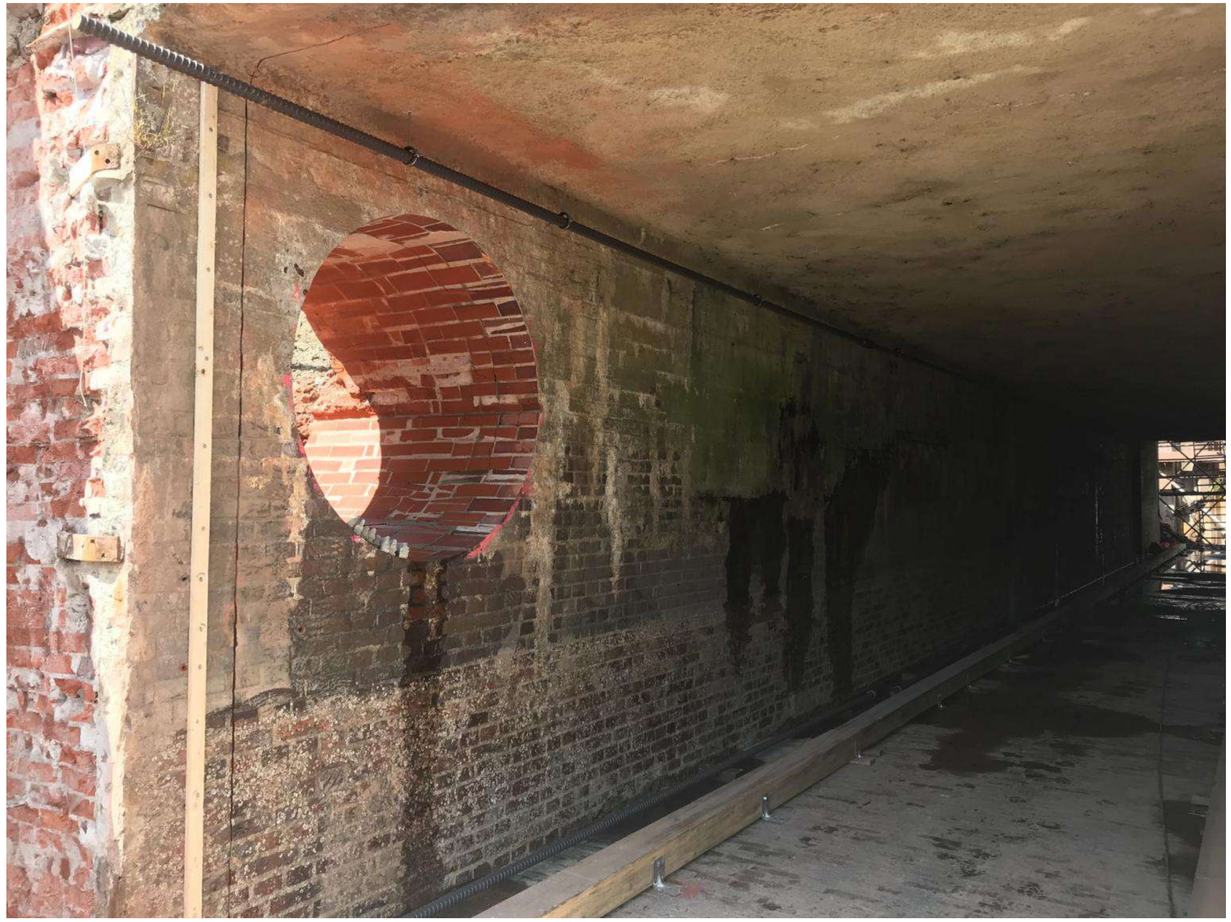
traditional earth backfilling of the structure parts outside of the existing bridge

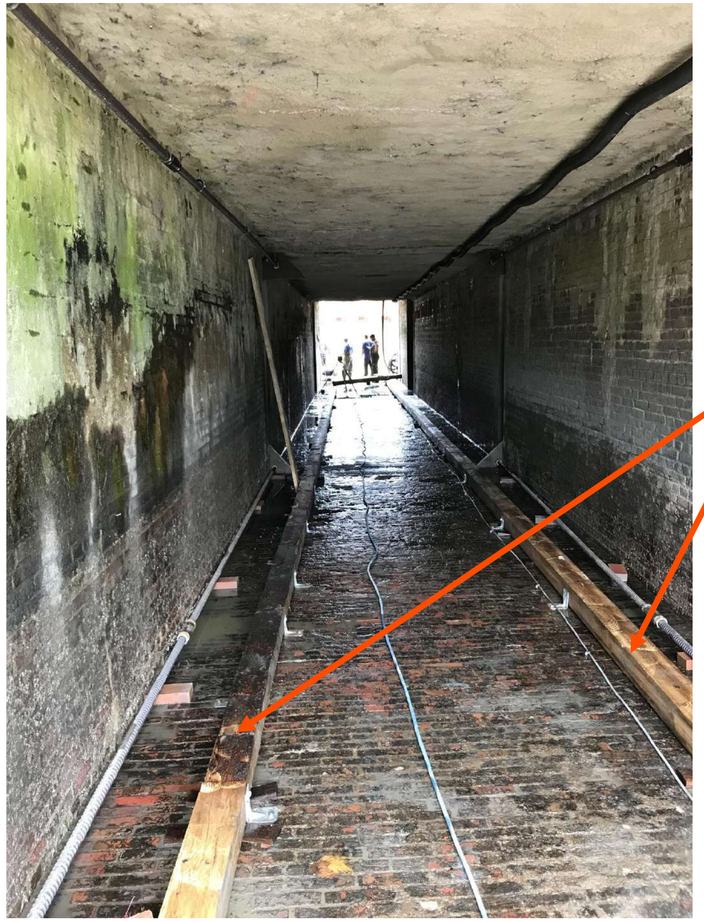
=> earth body serves as barrier for the injection procedure of the remaining space between old and new cross-section

Rehabilitation method #1 – *example 3*

Project task

- **rehabilitation of a 100-years-old water-bearing twin-tunnel**





installed wooden rails

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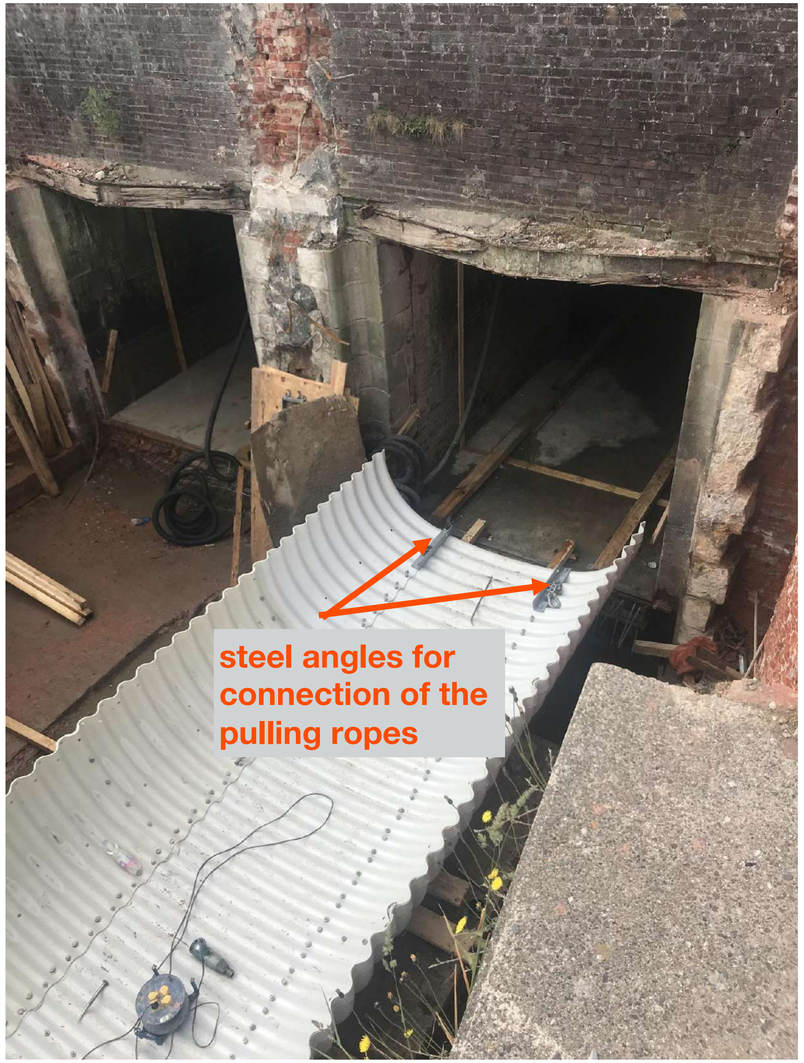
Rehabilitation method #1 – *example 3*



Rehabilitation method #1 – *example 3*

Rehabilitation method #2
– CSP installed from inside

- the **small-format corrugated steel elements** are brought into the bridge
- structure **assembled at the inside place** corresponding to the profile cross-section
- the **remaining space between old and new cross-section** is filled in stages with a concrete suspension

Rehabilitation method #2 – *example 1*

Project task

- **rehabilitation of a water-bearing structure under a highly-frequented traffic hub**
- **pulling-in method was not possible caused by the difficult accessibility as well as the huge length incl. several direction changes**

=> choice of a corrugated steel product that made the assembly from inside possible

Picture Source: googlemaps.de

Client	StBA Passau
Project name	Rehabilitation of culvert; national road 12
Product	Hamco LP-2F®
Cross-section	circular
Diameter	4,06 m
Length	141,50 m
Plate thickness	6,00 mm
Total weight	123 tons
Assembly period	6 weeks (two shifts)

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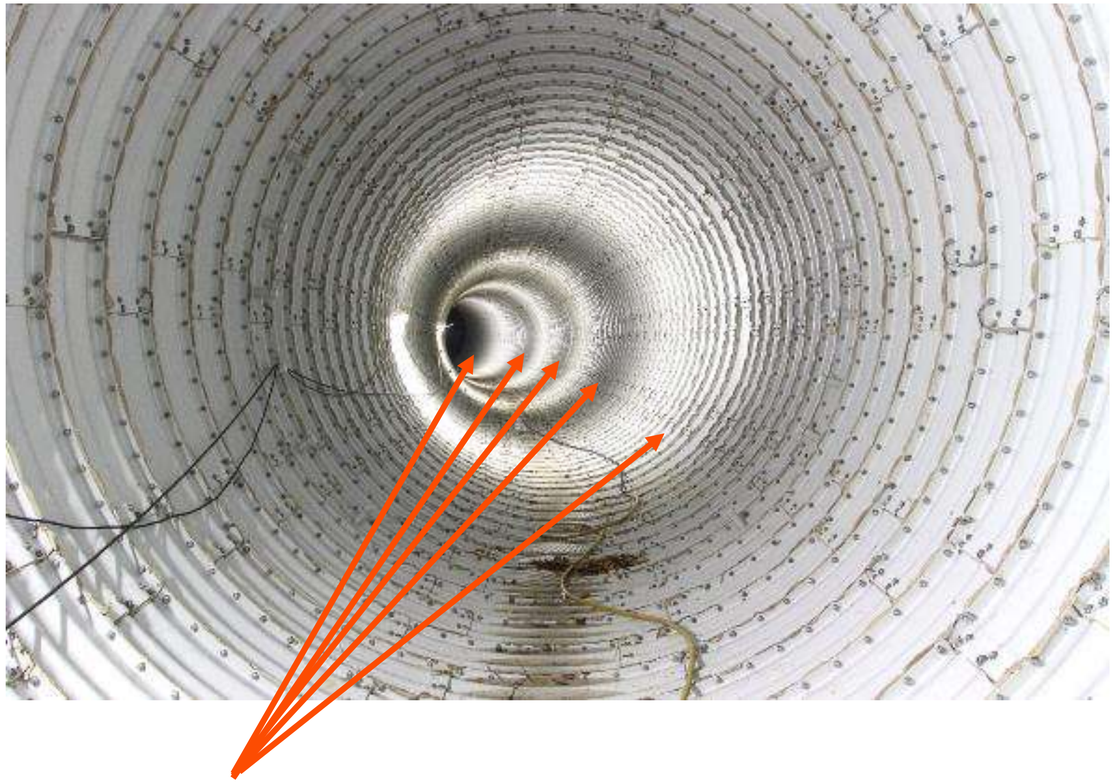
Rehabilitation method #2

Rehabilitation method #2 – CSP installed from inside



Injection methods

earth body serves as barrier for the injection procedure of the remaining space between old and new cross-section

injection from inside by means of inside openings positioned in circumferential direction and regular distances in longitudinal direction

at the ends of the structure: closing of the gap between old and new cross-section with wood, bricks, etc.

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Rehabilitation of bridges
- with the help of corrugated steel products

Due to the steadily growing infrastructures, the rehabilitation experiences of bridges with corrugated steel products presented here will surely gain increasing attention in Europe.

Rehabilitation and Relining

Piotr Tomala, Jouko Selkämaa, Christian Hammes

10th November 2021

VIACON

Constructing connections.
Consciously.

The Zgłowiączka River Case

THE PROBLEMS:

- Bad condition of the exisitng bridge and grade separation
- Obsolete parameters, not meeting new design requirements (technical load and safety)

THE CHALLENGE:

- Widening of the road
- Maintain continues traffic as the road runs through the city

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The Zgłowiączka River Case

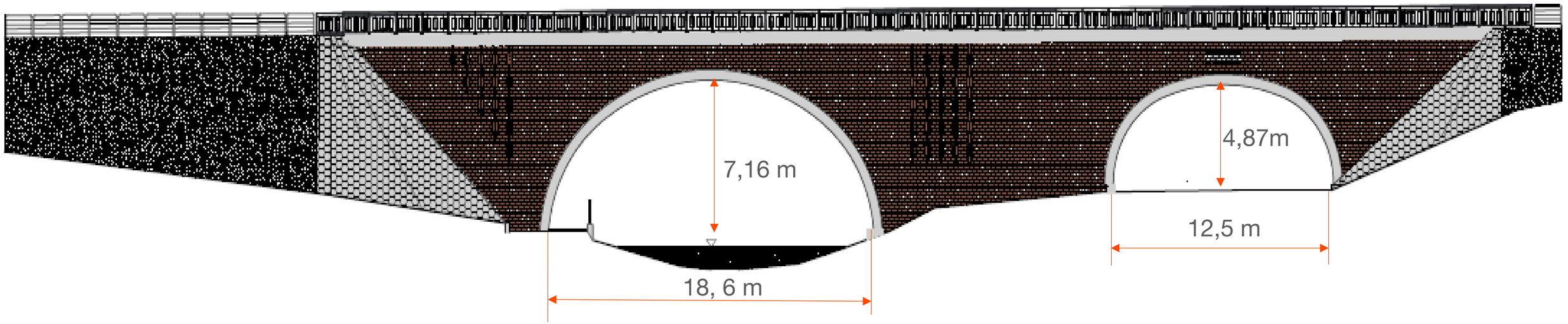
Bridge (built in 1927)

Grade separation (built in 1955)

Load class A (4x200kN) of the old Polish standard

The Zgłowiączka River Case

Eastern Side view



Corrosion protection:

- Galvanization Acc. to EN:1461
- Additional bitumous rich paint form the soil side

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The Zgłowiączka River Case

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The Zgłowiączka River Case

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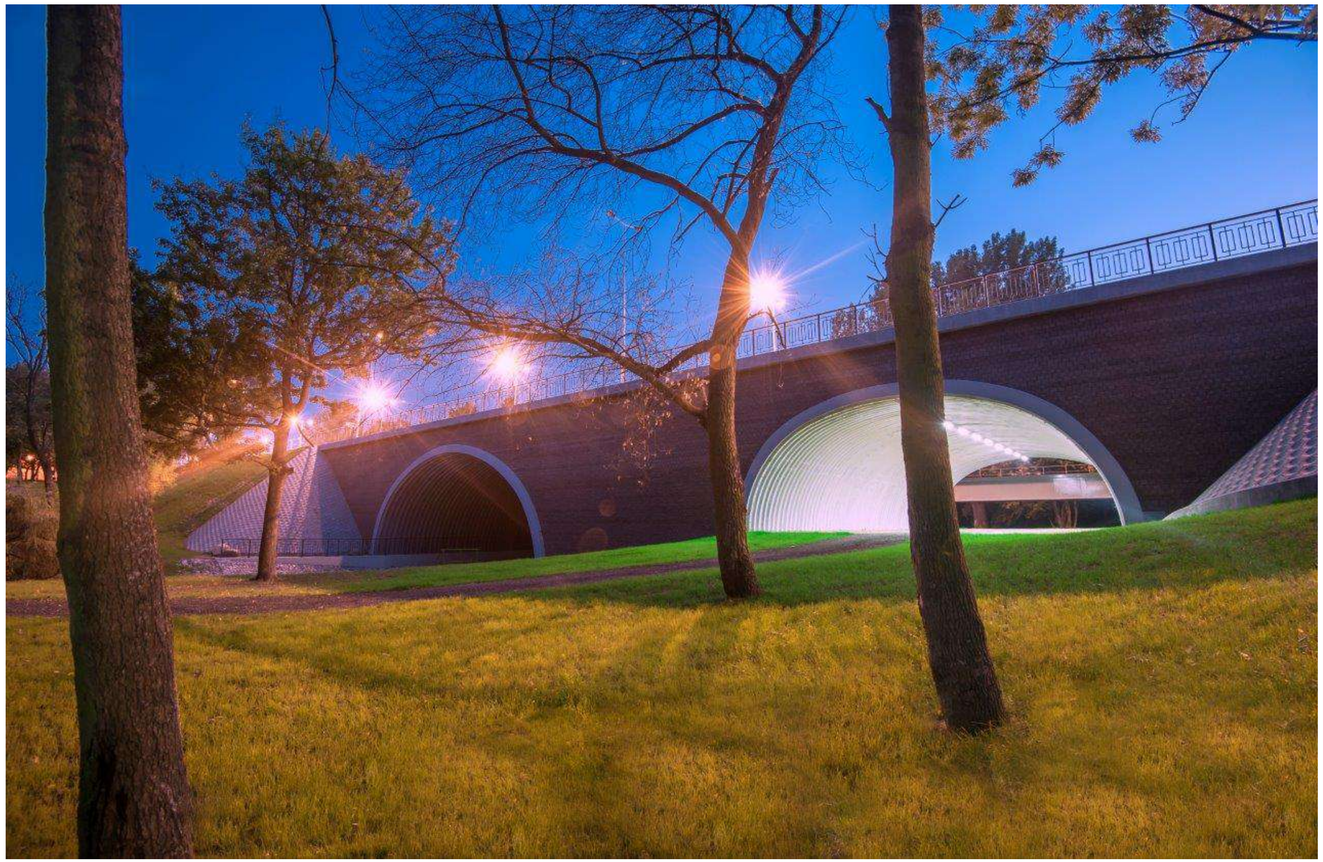
The Zgłowiączka River Case

Assembly of both structures lasted 5 weeks.
The assembly started on July 8th 2013, and was finished on August 14th 2013.
This was accomplished by a crew of 5 people.

SUMMARY

- Relining as a solution for deteriorated existing structures
- Rapid, and cost-effective solution
- ViaCon products provide flexibility in shaping suitable cross-section
- Wide range of spans for Bridges & Culverts
- Simple design process
- Geometrically complex structures
- **ViaCon support**



Questions and Answers

Piotr Tomala, Jouko Selkämaa,
Christian Hammes

10th November 2021

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Constructing connections.
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Q&A

- **Question 1: What is the estimated cost comparison between the relining method and building a new bridge?**
- It is hard to precisely say because costs are always country related. In the different countries there are different costs of materials and labor costs as well, but for rough estimation we can assume that for trenchless rehabilitation methods can cost between 10 and 50% of the open cut rebuilding process. Except the construction works It includes also organization the temporary bypass and the social costs which are limited or even eliminated for the trenchless construction method.
- **Question 2: What is the minimum distance required between the old structure and the new corrugated steel shell in this relining method? Does this distance have to be the same all around the arc?**
- In order to optimize the cross-section loss the main task is to dimension the new cross section as close as possible to the existing cross-section. The new cross-section refers to the most narrow area of the old cross-section resulting from the scan mentioned in the presentation part of Piotr Tomala. Generally, the minimum distance is between 7cm and 10cm. Except the bottom relining presented by Jouko Selkämaa is 10cm caused by the dimension of the job-site welded brackets.
- **Question 3: Does the corrugated steel structure still work as a flexible structure in the case of a reconstruction, using the relining method?**
- After filling the gap between old and new construction, the bridge acts as very strong composite bridge, which have very good embankment support. But it is not concrete bridge, because the filling material has no strength demand, because it’s main reason is to stream well to all parts. In Finland we use Swedish Design method and here we use very high E-modulus values, 2 times higher.
- **Question 4: What is the average lifetime of a culvert in Nordic countries until the bottom liner method could be necessary to be done?**
- In Finland we have National guidelines to exam old bridges. There are certain damage levels according inspectors decide should bridge repair. The inspection process is very simple. If the spike goes through any point, then the Steel Composite Bridge must repair, not before. This has come as normal procedure for old bridges.

Q&A

- **Question 5: Could the corrugated steel structure be used to repair tunnel, drilled in the rock, by using the relining method? Is it possible to ensure water-tightness and fire-protection of the structure in such an application?**
- Of course, it can be successfully used to repair tunnels and can be also use for the construction of new tunnels. We have some experience in that area of application, which is similar to NATM New Austrian Tunneling Method.
- For the water tightness we are using our 2 flange product where all the plate connections are sealed with commonly available permanently elastic material. It ensures the watertightness for the surface water, not for the water under the pressure.
- When talking about fire protection, we also have the solution. There ware some tests done to prove fire-resistant materials with soil-steel structures applications. Here I can turn you to the Promat Company. We have also some experience with such fire-resistant application. In the Town of Karpacz in Poland there is a ca 100m long tunnel covered from the inside with such of shotcrete with vermiculite particles. Such solution fulfill the fire-resistant requirements for this application.
- **Question 6: The grout needed for filling the void between the old and the new structure should be a special mortar / concrete with special characteristics, or can be used pumpable concrete?e applied to steel structure before putting it inside of old structure and filling with grout?**
- The filling material needs to be viscous enough to ensure that every gap of the remaining space between old and new structure is filled. In Germany, the use of a concrete suspension (high viscosity) offers very good results. This material is widely used for such rehabilitation projects. Generally, the used material will be injected (pumped) through existing inside positioned openings of the new structure or from outside at one of the end of the structure through openings integrated in the closed area (cement, bricks, wood, etc.) between the old and new structure.

The choice of the concrete material has to be discussed with the material supplier corresponding to the project.

Q&A

- **Question 7: Should geotextile be applied to steel structure before putting it inside of old structure and filling with grout?**
- There is no need to apply any of geosynthetic material. To protect the bottom of the liner we are using some rail-like or roll equipment. We are always taking care to do not destroy the corrosion protection layers. To do this we recommend to use the Teflon or PEHD strips or using custom design rolls.
- **Question 8: With regards to relining the invert only using structural plate in Finland, a slide was shown with water in the existing pipe as the new liner was pulled through. Was the pipe drained afterwards prior to grouting?**
- There can be water in pipe when pulling liner in. You dry the pipe before starting grouting. There can be few centimeter water on bottom, the cast concrete will replace it, this is shown in many cases.
- **Question 9: What kind of material is used between plate flanges?**
- Independent of the used corrugated steel product, every overlapping area in circumferential and longitudinal direction is provided with a flexible and durable strip preventing the flow of the filling material into the inside of the new structure.
- **Last Question: Is there a practice to inject from the road surface down, not from the relining construction?**
- Yes, that method has also used, when the road is very narrow. Then you can use tubes on bevel area. Normally this is not what we want, because the whole meaning with trenchless methods is not to disturb the traffic.

THANK YOU

AND SEE YOU AGAIN, SOON.