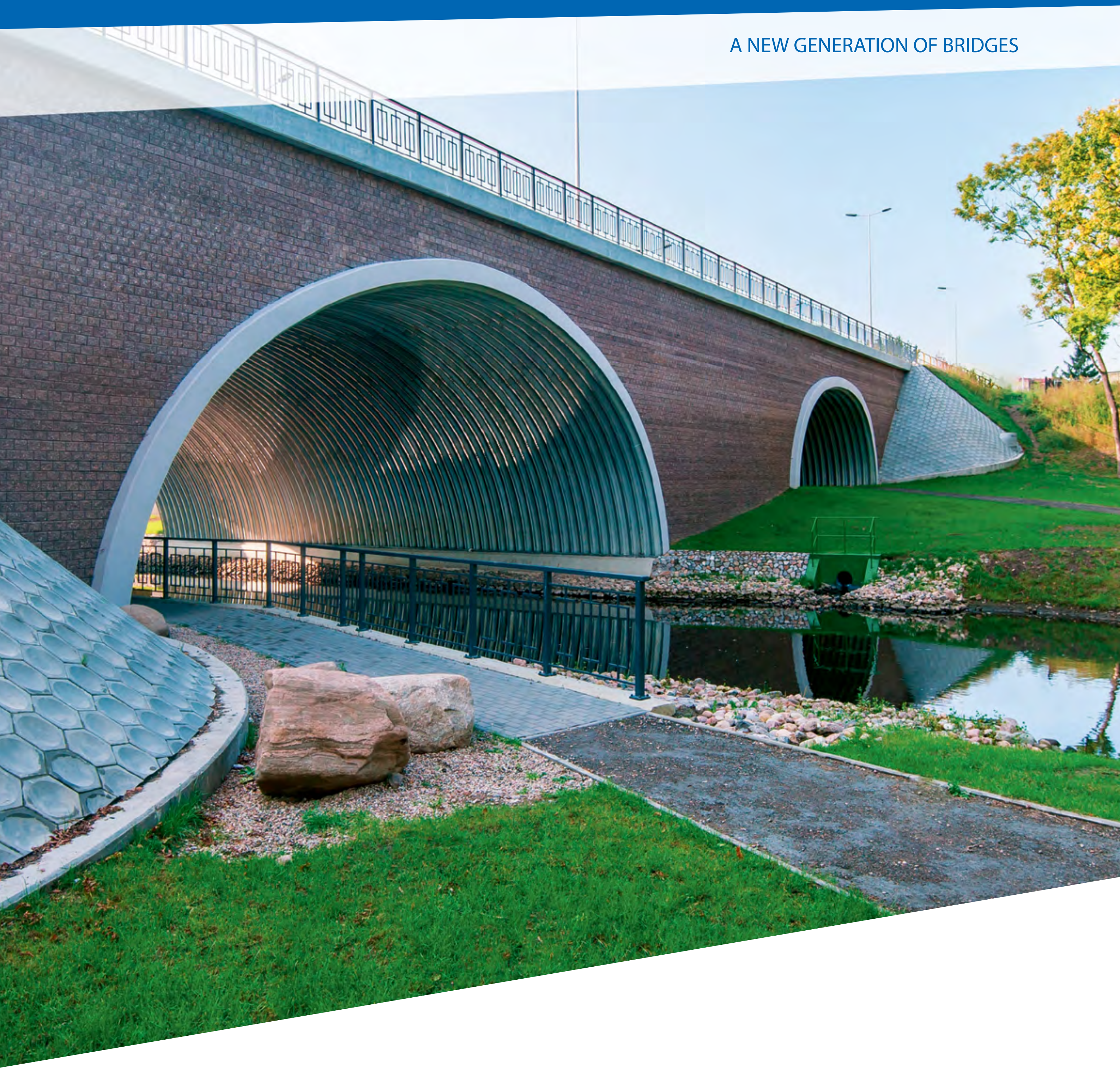
BURIED FLEXIBLE STEEL STRUCTURES

SuperCor

A NEW GENERATION OF BRIDGES



ViaCon

SuperCor® versatile structures are used for roads and railways and industrial applications as well as for reinforcement and reconstruction of existing structures such us:

- bridges
- overpasses
- tunnels
- culverts
- underpasses
- pedestrian tunnels
- ecological crossings, hangars
- shelters
- underground storages
- belt conveyor protection

Application

SuperCor® structures are the new generation of flexible structures made of galvanized corrugated steel plates of a very high stiffness.

To take the loads, these structures use interaction with surrounding backfill soil. The load capacity of SuperCor® is far higher than traditional structures made of corrugated steel. SuperCor® structures are used for building engineering objects above and under roads and railways. Spans can reach 25 m.

Structures are simple and easy to assembly. Average assembly time takes a few days in assistance with small crew.

The beginning of SuperCor® use dates back to the middle of 80' in 20th century. Nowadays they have been used in many countries all over the world; in Poland ViaCon has been producing SuperCor® structures since 2008.

SuperCor® structures are designed for all road and railway live load classes according to Eurocode EN 1991-2:2003 or according to nationals standards.

Approvals and Certificates:

- SuperCor® has the CE Certificate of Factory Production Control No. 1023-CPD-0447 F according to PN-EN 1090-1:2012
- AT/2005-03-0879
- Technical opinion of the Central Mining Institute (GIG):

ITC

NOTIFIED BODY No. 1023
Institute for Testing and Certification, Inc., Zlín, Czech Republic

Certificate of Factory Production Control
No. 1023–CPD–0447 F/a

Steel structures and aluminium structures according to PN-EN 1090-1

ViaCon Sp. z o.o.
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CE

Typical sequence for construction of SuperCor® bridges:

- foundations
- delivery
- assembly
- backfilling
- finishing works

SuperCor® structures have many advantages over traditional bridge solutions:

- simple design due to fewer details, drawings and calculations database for standard application
- easy and fast assembly
- possibility to assemble in temperatures below zero
- possibility to assemble structures without stopping traffic
- possibility to assemble with partial or total prefabrication of structures
- due to lightweight, corrugated plates can be delivered easily and economically to remote locations
- reduction in total time and cost of building a bridge

The process of SuperCor® production consists of mechanical forming of steel flat plates to the shape of corrugated curved plates which are later hot-dip galvanized.
Producing of holes, cutting is done prior to galvanizing.

Corrugated plates can be epoxy painted on request. Whole process is located indoor. Steel used for production of SuperCor® conforms to PN-EN 10149-2 or PN-EN 10025-2, Steel grade S315MC. Yield stress for this steel is min. 315 MPa.

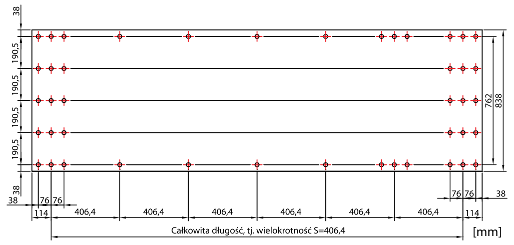

Fig. 1. Geometry of SuperCor® plate (total length, i.e. multiple S=406,4 mm)

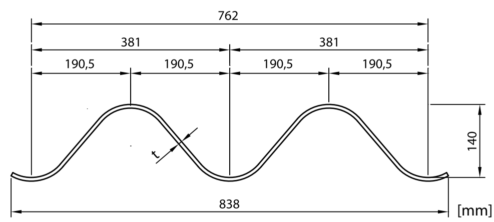

Fig. 2. Cross section of SuperCor® plate

Tab. 1. Geometrical parameters of SuperCor® plate.

Plate thickness [mm]	Area [mm²/mm]	Moment of interia [mm⁴/mm]	Section modulus [mm³/mm]
5,5	6,968	17 141,15	235,62
7,0	8,867	21 897,45	297,92

Other plate configurations are available upon request. Selection of plate thickness depends on structure shape, pan, depth of cover and live load. Before you specify any of SuperCor® structures, please take the opportunity to consult with ViaCon Technical Department for advice and assistance on your project.

Bolts, nuts, anchor bolts, base channels

Corrugated steel plates are joined by M20 bolts (class 8.8).

The lengths of bolts are related to thickness and number of connected plates.

There are two types of bolt heads: oval – shaped and cone – shaped at dimensions of 50 mm, 63 mm, 70 mm.

All joint elements mentioned above are delivered in marked boxes together with the structure.

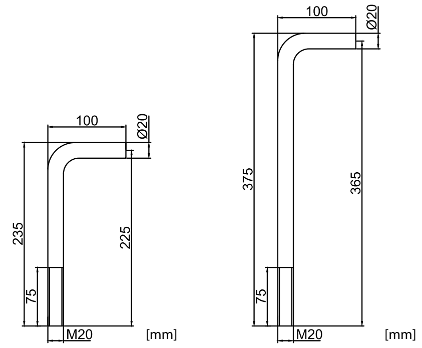

Fig. 3. Anchor bolts used to mount structure in foundation and anchor bolts for concrete collar

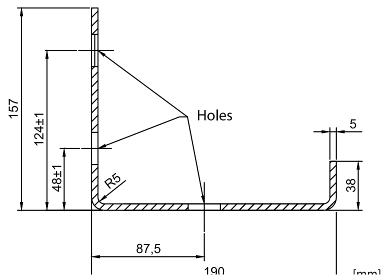

Fig. 4. Base channel used to connect structure to foundation

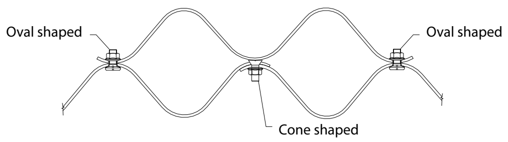

Fig. 5.Connection of ribs to main barrel plates

Corrosion protection

Hot–dip galvanizing is the most durable method of corrosion protection. In order to extend the durability of SuperCor® structures, especially in an aggressive environment, there is a possibility to apply an additional corrosion protection.

Corrosion protection of SuperCor® structures is made in a production plant and consists of:

- hot-dip galvanizing of steel plates and additional fitting elements
- epoxy painting of galvanized plates (if specified additionally)

SuperCor® structures are protected by hot-dip galvanizing as a standard, with zinc coating layer according to EN ISO 1461. Other thickness of zinc layer is possible on request. The protection of structures both by hot-dip galvanizing and paint creates ViaCoat system conformed to EN ISO 12944-5.
Paint coat thickness is controlled by EN ISO 2808. Minimum adhesion of the paint to the zinc base measured by pull - off method shouldn't be less than 4 MPa, and control test is conducted in acc. to the norm PN-EN ISO 4624.
In order to obtain right adhesion galvanized plates are sweep blasted prior to application of paint. In order to obtain the proper protection effect, paint coatings are applied in special conditions i.e. inside of closed halls with controlled temperature and humidity. Keeping a technological regime is crucial for successful performance of the protection system.

Tab. 2. Zinc layer

Characteristics	Requirements acc. to PN-EN ISO 1461	
	Minimal local zinc coating thickness [µm]	Minimal average zinc coating thickness [µm]
Steel plate: ≥6 mm ≥3 mm do <6 mm ≥1,5 mm do <3mm	70 55 45	85 70 55
Bolts, nuts, anchor bolts	40	50
Base channel	55	70

Design

Design process includes the following:

- design of SuperCor® structure (including assembly and backfilling procedure)
- design of engineered backfill
- design of foundation
- design of in and outlet fitting elements

Design algorithm

SuperCor® structures are designed for all road and railway live load classes according to Eurocode EN 1991-2 or according to nationals standards. They also meet requirement of AASHTO and CHBDC and other national standards or corrugated steel structures in the world.

Selection of structure cross section

In order to select a typical shape of a structure please use tables provided on CD. These tables include standard shapes. Other shapes are available on request.

A profile of a structure should fit to a clearance box. Allow for tolerances of structure dimensions. Acceptable tolerances are given on CD.

Cover depth

Definition of the cover depth for road structures
Vertical distance between top of a steel structure main barrel and top of the pavement including the pavement layer.

Definition of the cover depth for rail structures
Vertical distance between top of a steel structure main barrel and bottom of railway sleeper.

Tab. 3. Cover depth

Type of construction	Min. cover depth
Box structures	$0{,}45 \le H \le 1{,}5$ [m]
Other construction	$H = 0{,}1 \times B$ [m]

Minimum cover depth also depends on the thickness of the pavement layer (Gn) and should not be less than:

$$H = Gn + 0{,}15\ [m]$$

Lower cover depth is permissible when appropriate static calculations are conducted. Maximum depth of a cover is always designed individually. For high cover depth load reduction techniques are available.

In case if construction (technological) traffic is assumed over the structure the cover depth must be agreed with Technical Department of ViaCon company.

Geometry of a structure in longitudinal direction

Bottom length of SuperCor® structures should conform to the following formula:

$$L_d = 38 + n \times 762 + 38\ [\mathrm{mm}]$$

where n – number of full rings alongside length

Ends of SuperCor® structures can be vertical or beveled to match the embankment slope (Fig. 6). For beveled ends minimum X-step is 0,16 m. For structures curved in plane use bends to align to designed curvature.

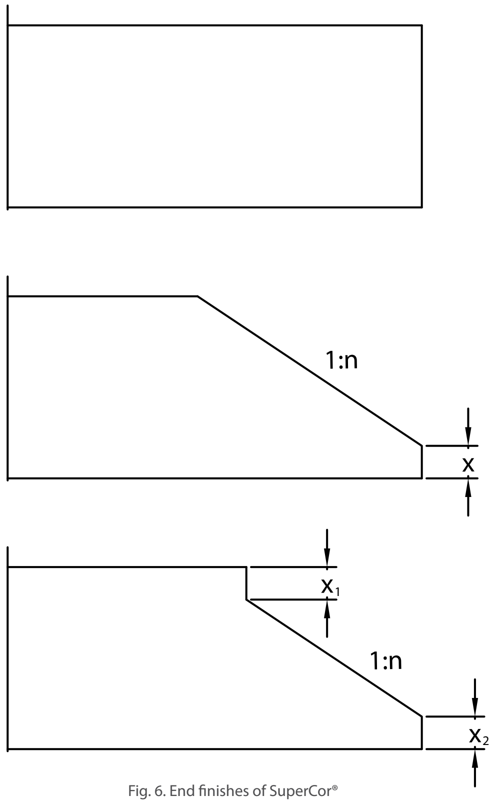

Fig. 6. End finishes of SuperCor®

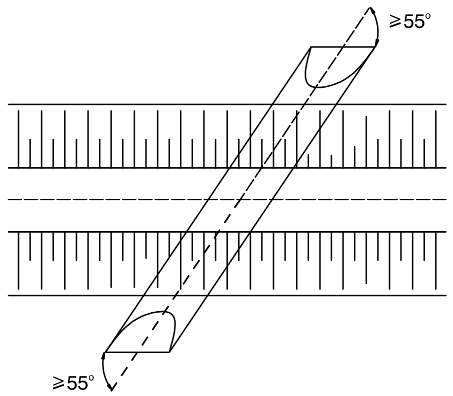

Fig. 7. Skewed structure

Skew angles

Minimum permissible angle for skewed ends is 55°. Concrete collars are used for large skews.
Steel meshes attached to SuperCor® structure can be also used for skewed areas.
Please contact Technical Department for advice.

Reinforcing ribs

Reinforcing ribs should be used when flexural capacity of the section is exceeded. Ribs can be used for all shapes of structures.

Reinforcing ribs:
in cross section (Fig. 8)

- in haunch and crown
- on whole perimeter

longitudinal section (Fig. 9)

- continuous –placed on the whole top length of the structure
- spaced at intervals of 762 mm, 1143 mm or 1524 mm

In order to get a bigger capacity, space between main barrel and reinforcing ribs can be filled with concrete (EC ribs).

The use of EC ribs can be necessary for large span structures. C25/30 concrete is used as filling acc. to EN 206-1:2000. Thanks to such solution used for arch structures, bigger cross sectional area is achieved, which leads to decrease of compression stresses in steel wall.

For boxes, higher flexural capacity is reached by connecting ribs to the main barrel.

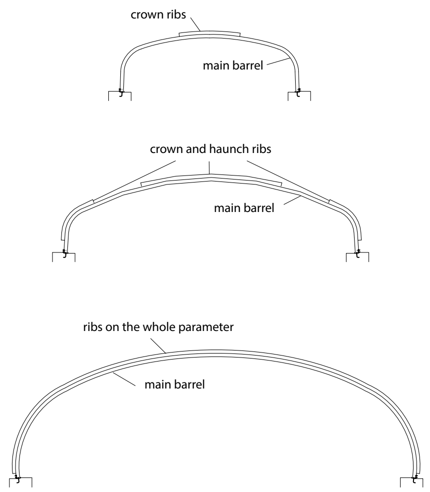

Fig. 8. Placement of the ribs in cross section of the structure

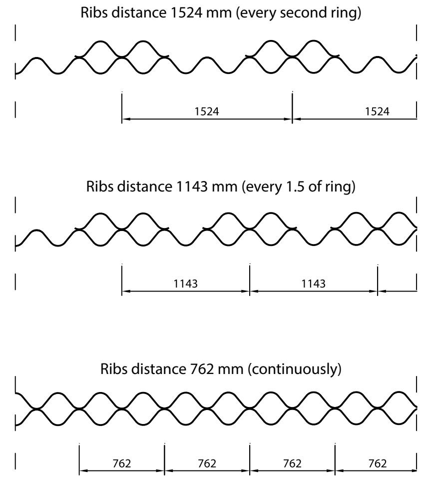

Fig. 9. Placement of the ribs in longitudinal direction of the structure

Multiple installation

For multiple structure installations, the smallest clear spacing between adjacent structures should be sufficient for the placement and compaction of soil (page 44 Fig. 7).

The minimum spacing requirement depends upon the shape and size of structures.

When the required distance cannot be achieved, space between structures should be filled with C10/15 concrete or cement stabilized soil to the level where the distance between structures is not less than 10% of structure span. Please contact Technical Department of our company for advice.

Foundation

SuperCor® structures with closed shapes (round, elliptical, pipe-arch) are placed on soil bedding as follows:

- thickness of soil bedding – minimum 60 cm
- top portion of the bedding should be shaped to fit to the bottom plates of a structure
- particular care should be exercised in compacting soil under haunches
- upper 15 cm layer of the bedding should be relatively loose material so that the corrugation can seat in it

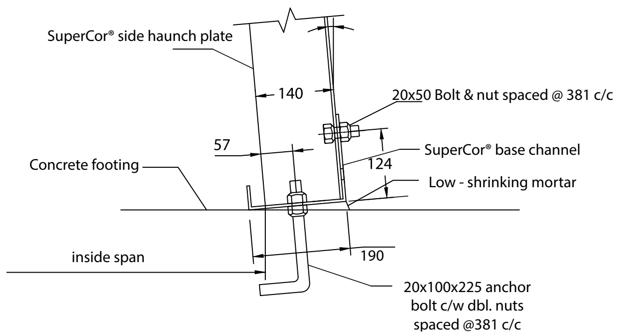

Fig. 10. Connection of SuperCor® structure with concrete footing

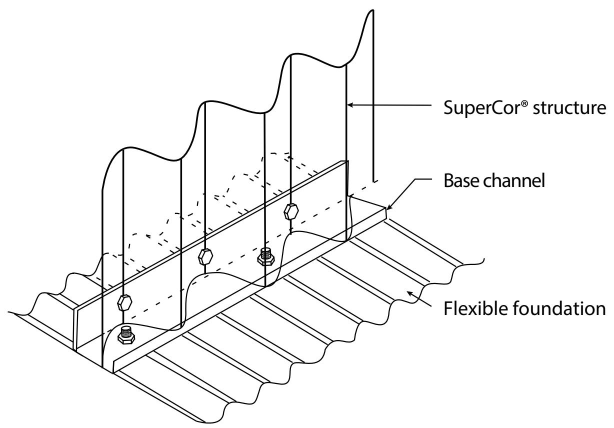

Fig. 11. Connection of SuperCor® structure with steel footer pads of a full steel invert

SuperCor® structures with open shapes (arches, boxes) are placed on concrete footings, steel footer pads or a full steel invert.
Connection of the structure to the concrete footings is realized by the means of anchor bolts, taking the following into account:

- anchor bolts for concrete foundations to be installed in concrete footings prior to delivery of a SuperCor® structure
- anchor bolts should not stick out from the top of the footing more than 40 mm
- placing of anchor bolts should conform to assembly drawing; the allowable tolerance is ±3 mm in longitudinal direction and ±2 mm in the transverse direction
- to minimize a risk of mistake, the location of each anchor should always be measured from the starting point (first anchor)
- parallel placement of anchor bolts on each footing and perpendicular placement of each pair of anchor bolts for individual rings are of great importance; better accuracy, easier assembly of the structure

Material for bedding and backfill

- gravel, sand -gravel mix, all-in aggregates and crushed stone can be used as bedding and backfill material
- aggregate grain size depends on size of corrugation profile and for 380 x 141 mm corrugation should have 0-120 mm grain size in the direct vicinity of the structures
- the use of cohesive soil, organic soil and soils included permafrost is not acceptable
- backfill material around the structure should be placed in layers of 30 cm thick and then compacted symmetrically on both sides of the structure
- un-uniformity coefficient Cu ≥ 4
- curvature coefficient 1 ≤ Cc ≤ 3
- permeability k10 > 6 m/day
- backfill material should be compacted to minimum 0,98 of Standard Proctor Density, but 0,95 of Standard Proctor Density in the adjacent to the structure is acceptable

Deviation from these principles requires consultation with the Technical Department of our company.

Rainwater protection of the structure

In order to protect the corrugated steel structure against rainwater which might penetrates embankment we recommend to use three layers “umbrella” (500 g/m2 nonwoven + 1 mm geomembrane + 500 g/m2 nonwoven), 10-15 m above the structure, which will efficiently cut-off water penetration.

Geomembrane provides water isolation and nonwoven above and under geomembrane protects this geomembrane against damages during backfilling and compaction process. Placing the membranes directly on the structures is allowed with provisions for protection layers applied.

In order to dewater structures, we recommend to use drainage pipes in both ends, parallel to the axis of the structure. Detailed information is on CD.

End treatment (inlet/outlet)

End treatment depends on the way the ends of structure are cut.

For beveled ends, slopes can be finished by paving with stones blocks, etc.

For bevel ends with gabion mattresses, waterproof solutions must be applied.

As an alternative to concrete headwalls MSE like ViaWall or ViaBlock® system (look at page No 93) or gabions can be applied.

Concrete collar

Concrete collar is used:

- in order to stiffen inlet and outlet of SuperCor® structure with beveled ends
- as finishing element used as support of end treatment

Concrete collar is applied mostly in following cases:

- structures with skew angles to the road axis , when skew angle on outlet and inlet is ≤ 65° and span is > 3,5m
- structures exceed 6,0 m span
- large skews

In other cases concrete collar can be used as support for slope pavement.

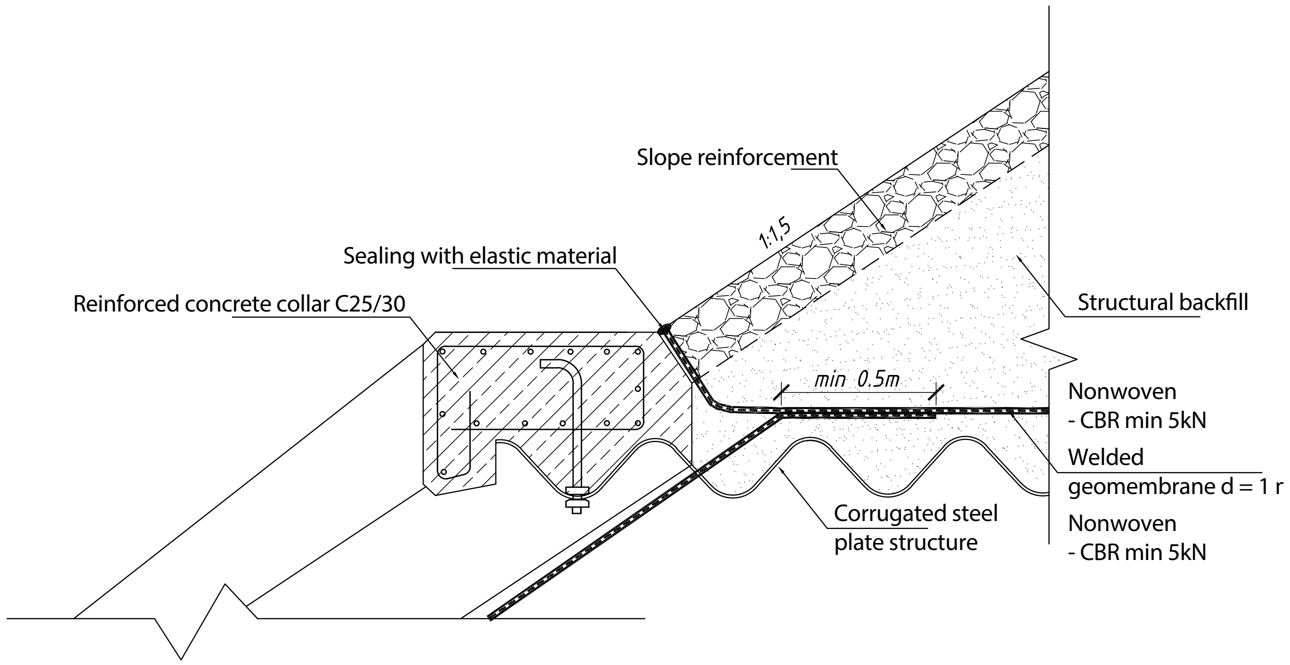

Fig. 12. Example of a concrete collar on inlet and outlet of the structure

Durability

Hot-dip galvanization is a basic corrosion protection of SuperCor® structures. Durability of SuperCor® structures can extend over 100 years.

SuperCor® structures are hot-dip galvanized according to EN ISO 1461.

If necessary, SuperCor® structures can be protected with an extra layer of zinc or additional corrosion protection by paint called ViaCoat. These solutions are applied for aggressive environments.

In most cases the extent of corrosion protection by epoxy coating is as follows:

- inside and/or outside on the whole area of a structure
- at inlet and outlet of the structure (1,5 m inside the structure)
- inside up to 0,5 m above mean water level
- as a combination of above mentioned

Most common thickness of paint layer is 200 µm, however other thicknesses are possible

Following factors have an influence on structure's durability:

- aggressiveness of an environment
- application of structure
- draining solutions
- abrasion
- installation damages
- corrosion protection
- plate thickness
- quality and frequency of maintenance of the structures in service

Procedure of calculating durability of SuperCor® structures:

- define the function of a structure
- define the required durability (lifetime) of a structure
- define the aggressiveness of the environment (water, backfill, air)
- select the type of a structure
- specify the plate thickness based on static calculations (acc. to Sundquist-Petterson method)
- specify the corrosion protection (thickness of zinc coating, paint coating, extent of painting, painting procedure)
- define annual loss of the protection layers in upper and lower part of a structure
- calculate the structure durability by considering corrosion progress over service lifetime
- compare calculated durability with the required
- adjust the corrosion solution and if required repeat the calculations

In cases, when the durability of SuperCor® structure is not enough, it is recommended to:

- change corrosion protection (thickness of zinc layer, paint coat)
- increase the plate thickness
- adjust the shape of a structure and section stiffness to allow for more
- corrosion reserve

Durability of the ViaCoat system is higher than sum of durability of the protection layers and can be calculated as:

$$S_D = \alpha\,(S_C + S_Z)$$

where:

- SD – total durability of the protection layer [years]
- SC – durability of zinc coat [years]
- SZ – durability of the epoxy coat [years]
- α – synergy factor (from 1,5 to 2,5) for 200 µm thick paint layer α = 1,5; for 400 µm thick paint layer α = 1,75

During the transportation and installation, the coating layers may be damaged. The repair of such damage is done at site after structure is assembled.

Relining

SuperCor® structures are also commonly used to repair old bridges where there are no possibilities to build a new one. This method is called relining.

Corrugated steel structure is placed inside the existing structure (bridge / culvert / underpass) and space between an old bridge / culvert and new structural plate is filled with concrete C16/20. This method allows to strengthen the structures without any traffic stops and eliminates the necessity to tear down the old structure.

The control of pouring concrete between existing structure and new steel structure should be done by revision holes. During pouring concrete it is necessary to control deformations of SuperCor®. They shouldn't exceed maximum allowed in section "Tolerances" located on CD.

In a case where so called "open" shapes will be used for relining there is a need to make concrete footings which could be connected to existing one. Existing footings can be used also but it will require separate analysis or expertise.

Researches made in the years 2000-2007 confirmed increasing of capacity of relined structures.

Fittings

SuperCor® structures can be equipped with additional elements depending on function of the structure e.g.:

- lighting boxes
- ventilation
- niche
- shelves for animals
- technical holes
- skylight
- connector pipes
- others

INNOVATIVE INFRASTRUCTURE ViaCon Sp. z o.o.

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PECOR OPTIMA

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HelCor wells

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Acrow bridges

ViaWall A

ViaWall B

ViaBlock

CON/SPAN

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