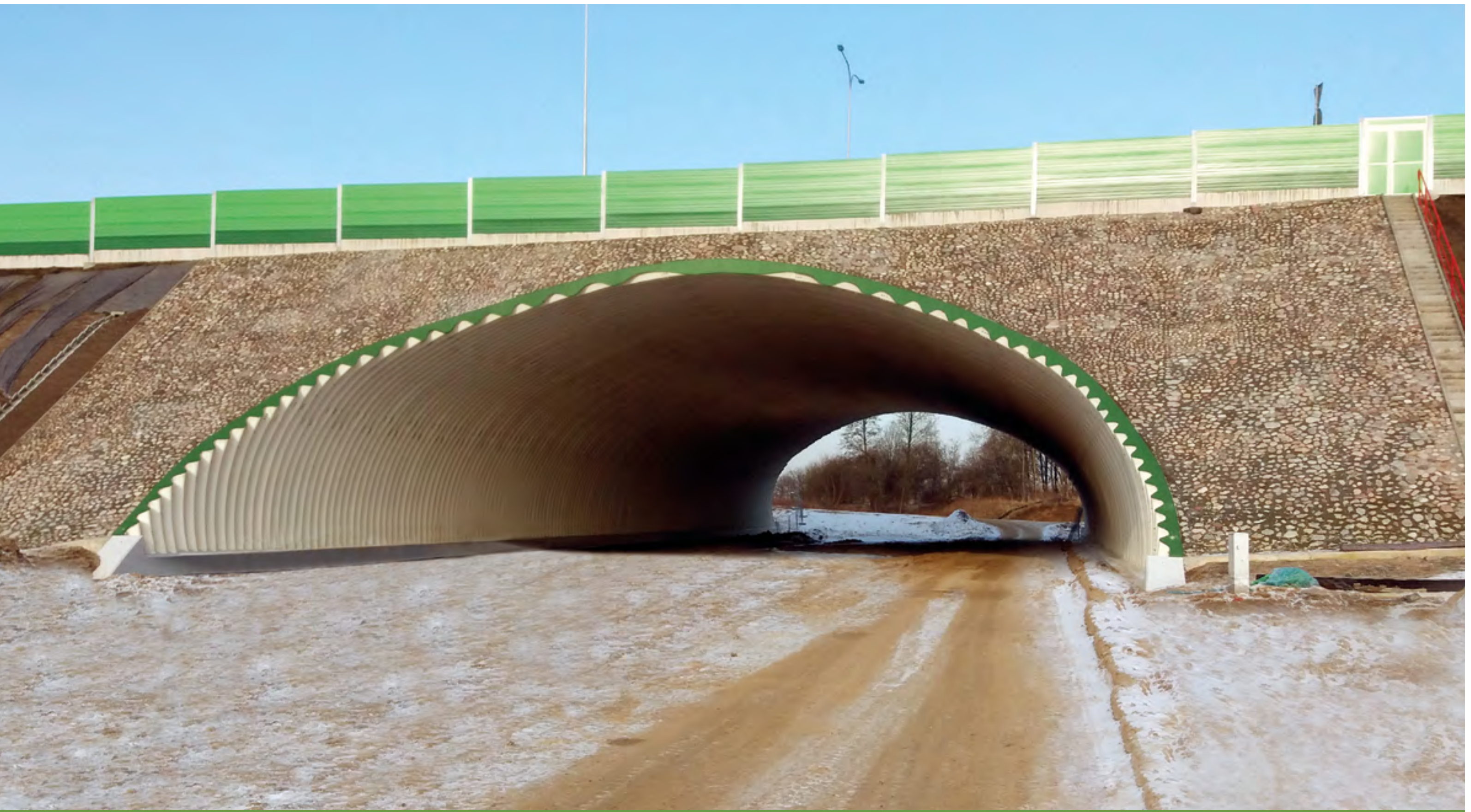
CORRUGATED STEEL STRUCTURES

UltraCor®

THE NEWEST GENERATION OF FLEXIBLE STRUCTURES

ViaCon



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

- bridges
- overpasses
- tunnels
- culverts
- underpasses
- pedestrian tunnels
- ecological crossings
- hangars
- shelters
- underground storages

Introduction

UltraCor® structures are the new generation of flexible structures made of galvanized corrugated steel plates. As the world's deepest corrugation profile, UltraCor® combines all the advantages of lightweight construction with previously unheard-of strength and durability to create the largest corrugated steel structures in the world today.

UltraCor® structures are designed for all road and railway live load classes as well as under the load of special vehicles.

Approvals and Certificates:

- CE Certificate according to norm EN 1090-1.

Corrugation:

The UltraCor® corrugation profile is 500 x 237 mm.

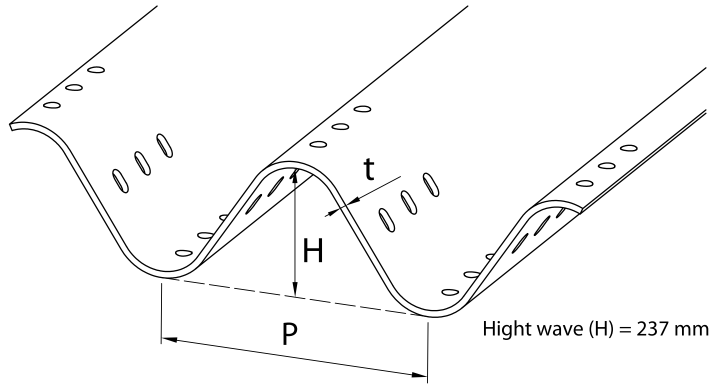


Fig. 1. Wave profile of UC plate

UltraCor® structures have many advantages over traditional bridge solutions:

- larger structure end area
- larger bearing of the structure
- higher range of cover depth
- lower costs of transportation
- reduction in total time and cost of building a bridge
- fast and easy assembly

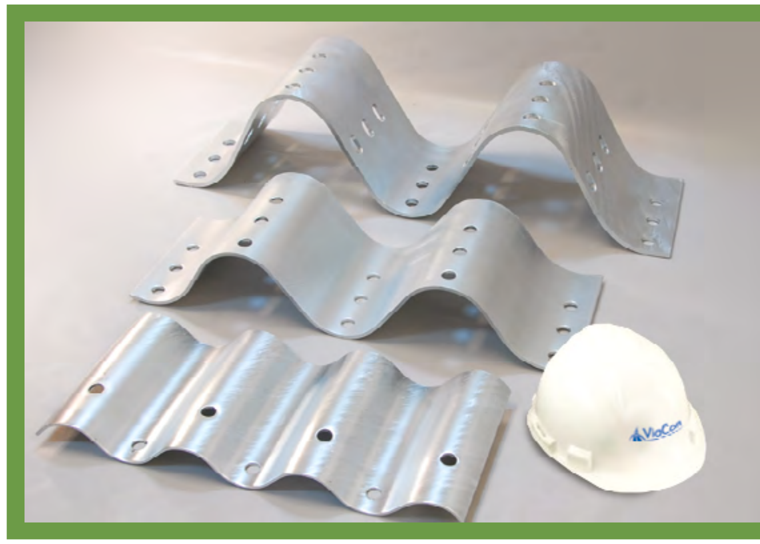
Product features:

- the highest structural strength among the buried flexible steel structure in the world
- large range of shapes and sizes
- easy and short installation time
- **spans of 30 m and greater**

UltraCor®

SuperCor®

MultiPlate MP200



Fot. 1. Wave height comparison in the structures

Production

The UltraCor® process involves the mechanical shaping of flat steel plates into corrugated curved plates which are later hot-dip galvanized.
The finished corrugated plates can also be epoxy painted on request.
All of the manufacturing is completed in a quality controlled factory process. Steel used for production of UltraCor® conforms to EN 10149-2 or EN 10025-2, Steel grade S355MC, S420MC and S500MC.*

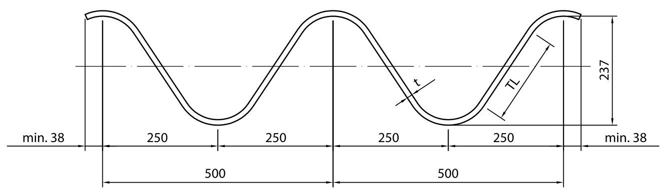


Fig. 2. Cross section of UltraCor® plate

Tab. 1. Section properties of UltraCor plate

UltraCor®					
Plate thickness	Yield stress	Area	Moment of inertia	Section modulus	Plastic section modulus
t [mm]	[MPa]	[mm²/mm]	[mm⁴/mm]	[mm³/mm]	[mm³/mm]
6,00	355 / 420 / 500	8,662	54 849	451,43	607,80
7,00	355 / 420 / 500	10,110	64 131	525,67	710,15
8,00	355 / 420 / 500	11,559	73 457	599,65	812,81
9,00	355 / 420 / 500	13,009	82 827	673,39	915,79
10,00	355 / 420 / 500	14,460	92 243	746,91	1019,09
11,00	355 / 420 / 500	15,913	101 706	820,21	1122,72
12,00	355 / 420 / 500	17,366	111 217	893,31	1226,68

* non-standard steel grade, used only for special design requirements

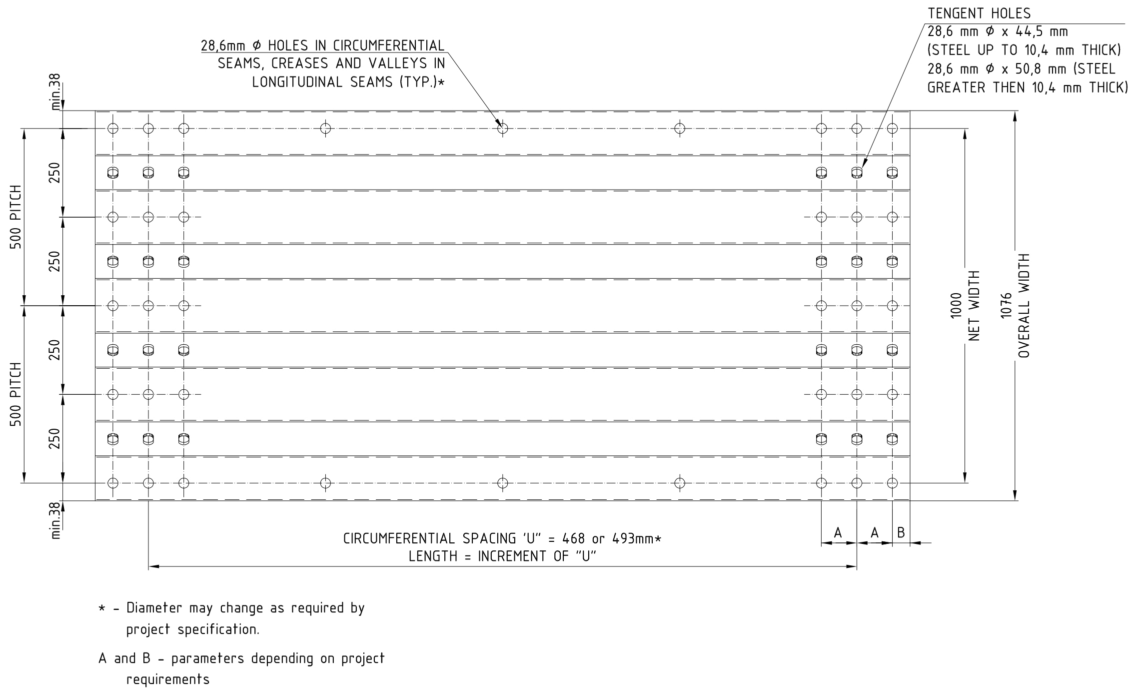


Fig. 3. Geometry of UltraCor plate.

Bolts, nuts, anchor bolts, base channels

Corrugated steel plates are joined by bolts M22 or M24 (class 10.9). The lengths of bolts are related to thickness of connected plates and type of connection (60, 80 mm).

Bolts and nuts are made of steel according to EN ISO898-1 and EN ISO 898-2.

Anchor bolts casted into concrete with a diameter of 22 mm and length of 225 mm or 430 mm are made of steel conforming to the requirements of EN 10025-2:2007.

Base channels have dimensions of 260 x 310 x 70 x 7 or 10 and conform to norm EN 10025-2.

All of the ancillary items mentioned above are delivered together with corrugated plates as a complete package for the structure.

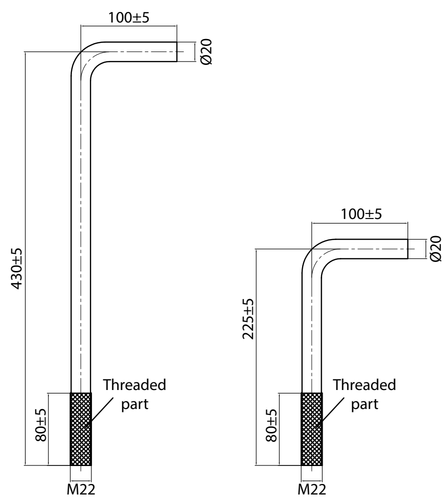


Fig. 4. Anchor bolts used to mount structure in foundation.

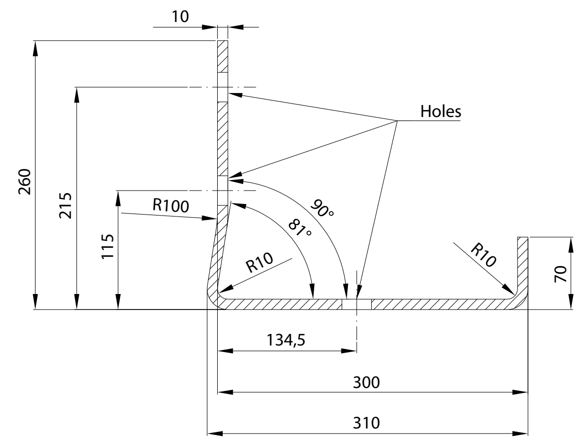


Fig. 5. Base channel used to connect structure to foundation.

Corrosion protection

Coatings applied by immersion including hot-dip galvanizing provide a durable method of corrosion protection to steel surfaces. The protection is particularly effective due to the lasting bond between the galvanizing coating and the steel surface, thereby providing extended service life. The zinc coating layer on UltraCor® structures are according to PN-EN ISO 1461 (table 2).

In order to extend the durability of UltraCor® structures, particularly in aggressive environments, additional corrosion protection can be provided by applying epoxy paint.

The protection of structures both by hot-dip galvanizing and epoxy paint creates the ViaCoat system conforming to PN-EN ISO 12944-5. Surfaces exposed to UV radiation are also coated with a polyurethane paint layer in order to prevent discoloration.

Tab. 2. Zinc layer

Characteristics	Requirements acc. PN-EN ISO 1461	
	Minimal local zinc coating thickness [µm]	Minimal average zinc coating thickness [µm]
Steel plate: >6 mm >3 mm and ≤ 6 mm	 70 55	 85 70
Bolts, nuts, anchor bolts	40	50
Base channel	70	85

Design

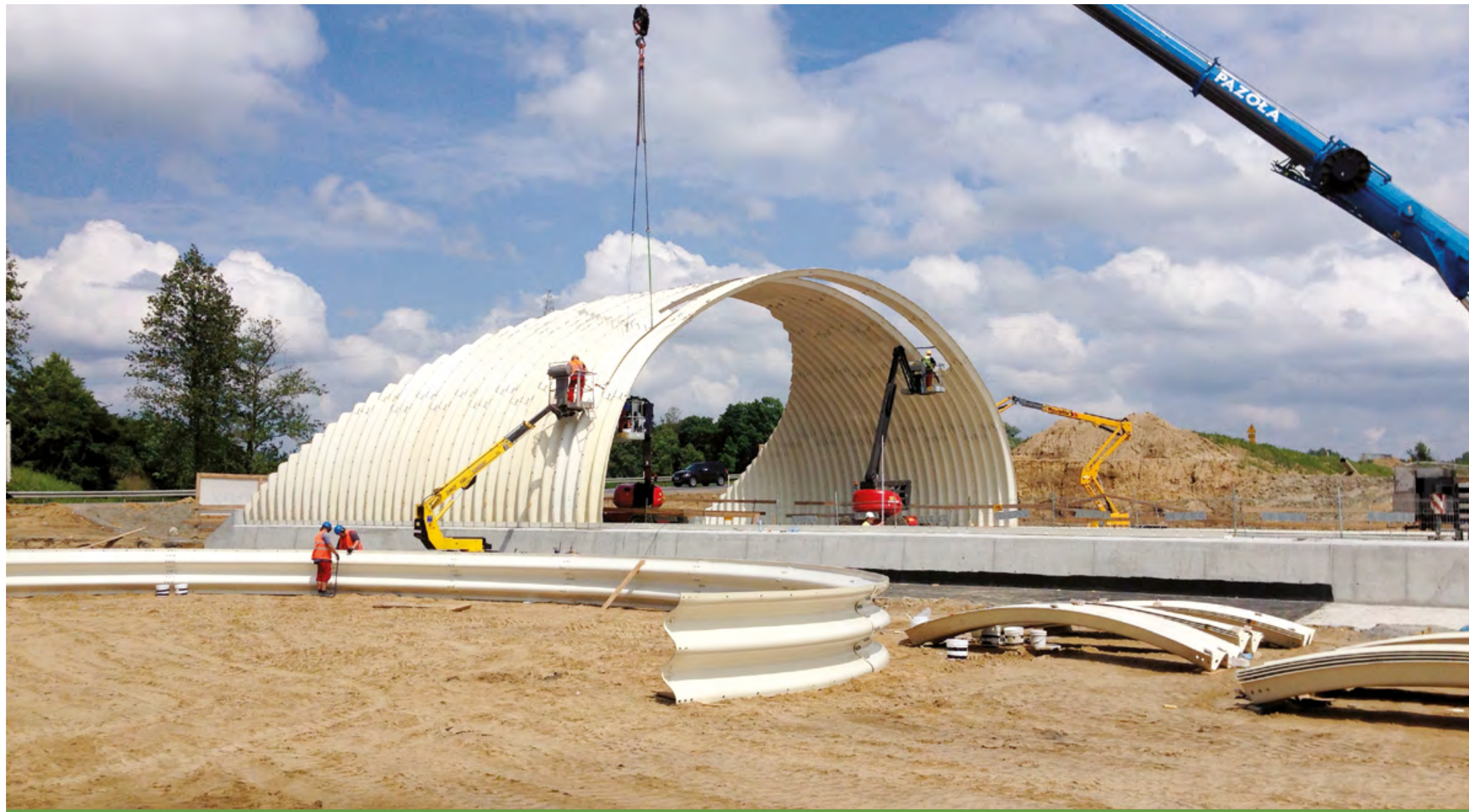
The design process of an UltraCor® structure constists of the following steps:

- design of the UltraCor® structure (including assembly)
- design of engineered backfilling procedure
- design of the foundations
- design of inlet, outlet and other associated fittings and elements

Structural analysis

UltraCor® are designed with use of one of the following methods:

- Swedish Design Method, developed by Prof. Sundquist and Prof. Petterson,
- CHBDC - Canadian Highways Bridge Design Code,
- AASHTO LRFD Bridge Design Specifications,
- finite element method (FEM) in complex cases.



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.

Tab. 3. Cover depth

Type of construction	Min cover depth
Arched construction – low profiled	H = 1/12 × B [m]

Definition of the cover depth for rail structures

Vertical distance between top of a steel structure main barrel and bottom of railway sleeper.
Lower cover depth is permissible when appropriate static calculations are conducted.
In cases where construction traffic is travelling over a structure, the cover depth must be checked by ViaCon's Technical Department.

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

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

Lover 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.

Geometry of a structure in longitudinal direction

The base length of UltraCor® structures should conform to the following formula:

$$L_d = 38 + n \times 1000 + 38 \text{ [mm]}$$

where n – number of full rings alongside length

Top length of a structure varies depending on each jobsites constraints (considering inlets and outlets).

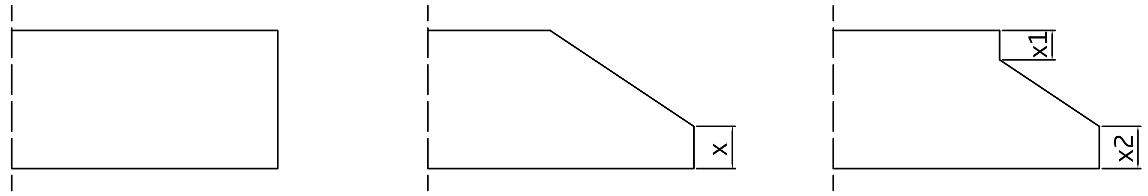


Fig. 6. End finishes of UltraCor®

Skew angels

Special consideration is required for skew angles smaller than 55 degrees. Concrete collars and/or reinforced soil can be applied to the inlet and outlet zones.

Please contact ViaCon's Technical Department for advice.

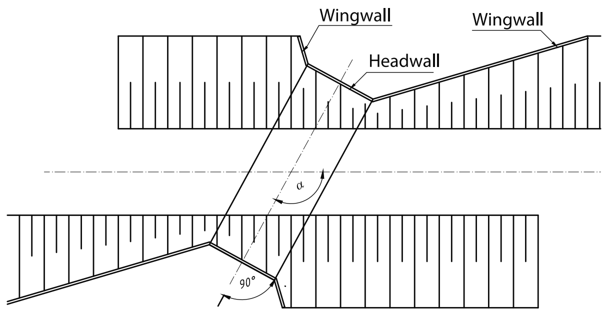


Fig. 7. Skewed structure

Multiple installation

For multiple structure installations, the smallest clear spacing between adjacent structures should be sufficient for the placement and compaction of soil. The minimum spacing requirement depends on the shape and size of structures.

All details are described in the Technical Data Sheet provided by ViaCon's Technical Department.

Foundation

Closed shaped UltraCor® structures (round, elliptical, pipe-arch) are placed on soil bedding as follows:

- minimum thickness of soil bedding should be 60 cm
- the top surface 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 the hauches
- top 25 cm layer of the bedding should be relatively loose material

UltraCor® structures with open shapes (arches, boxes) are placed on concrete footings.

Connection of the structure to the concrete footings is completed by using anchor bolts, taking the following into account:

- anchor bolts for concrete foundations are to be installed in the concrete footings prior to delivery of a UltraCor® structure
- anchor bolts should not stick out from the top of the footing more than 50 mm
- placing of anchor bolts should conform to the 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; the better the accuracy, the easier the assembly of the structure

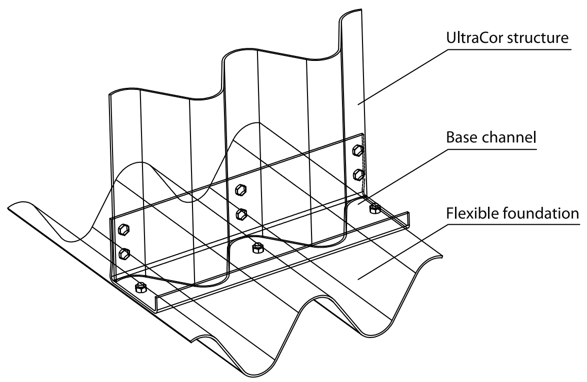


Fig. 8. Connection of UltraCor® structure with flexible footing

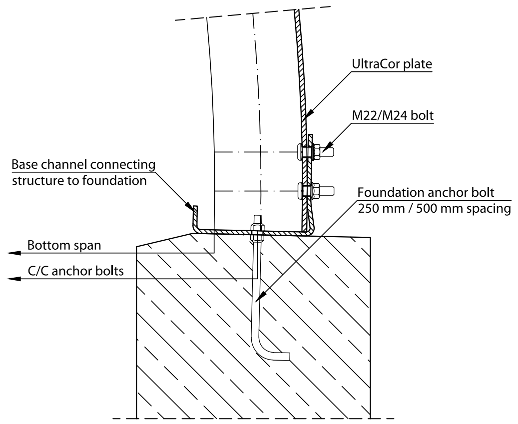


Fig. 9. Connection of UltraCor® structure with concrete footing

Bedding and backfill

- gravel, sand-gravel mix, well graded aggregates and crushed stone can be used as bedding and backfill material
- aggregate grain size depends on size of the corrugation profile; for 500x237 mm corrugations the max recommended aggregate particle size is 120 mm
- aggregate particle size should be 0-120 mm, uniformity coefficient Cu ≥ 4,0 , curvature coefficient 1 ≤ Cc ≤ 3 and permeability k10>6 m/24 hours
- the use of cohesive soil, organic soil and any frozen soils is not acceptable
- backfill material should be placed arround the structure in uncompacted layers maximum 30 cm thick and then compacted
- the backfill should be placed on both sides of the structure at the same time or alternating from one side of the structure to the other side. No more than one layer (30 cm) difference in elevation is permitted from one side to the other. Each layer must be compacted to the specified compaction index before adding the next layer
- backfill material adjacent to the structure should be compacted to minimum 95% of normal
  Proctor density and to 98% of normal
  Proctor density - in the remaining area unless otherwise noted

Deviation from these principles requires consultation with the ViaCon Technical Department.

Protection against water ingress

In order to protect structures against water infiltrating through the backfill protective measures may be applied. Typically a layer of 1.0 mm thick HDPE geomembrane enclosed by two layers of protective non-woven geotextile (nominally 500g/m2) may be placed over steel structures. For some overpasses this infiltration protection has been provided using two layers of bentonite mat (geosynthetic clay liner).

Exceptions to the above are possible after consultation with ViaCon's Technical Department. Placing the membrane directly on the structures is allowed provided that protection layers are applied.

Please use the ViaCon Catalogue of Production Standard Solutions and Details for more details.

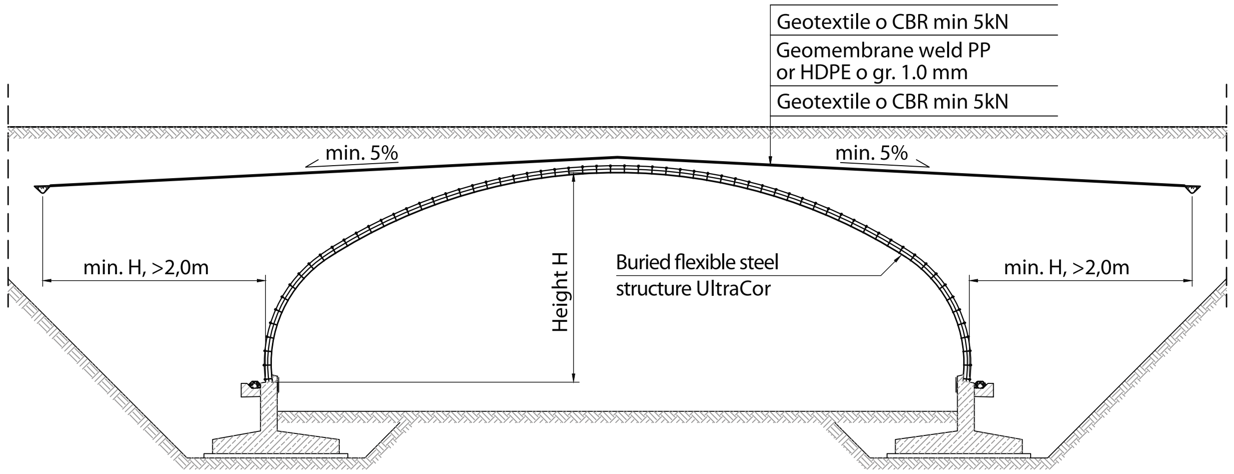


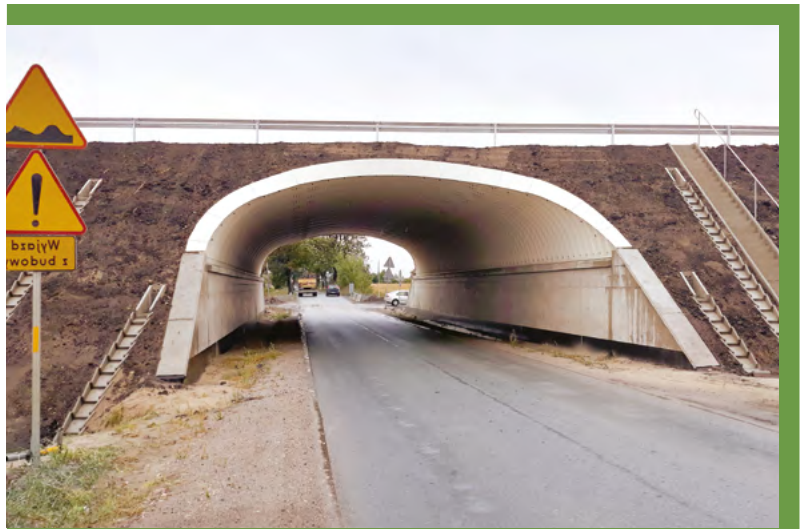
Fig 10. Scheme of rainwater protection

End treatment (inlet/outlet)

Slopes may be finished by paving with locally available stones, blocks, etc. If gabion mattresses are used, additional waterproofing should be considered. Please contact ViaCon's Technical Department for advice.

For vertically cut structures, as an alternative to reinforced concrete headwalls, MSE (reinforced soil) walls may be applied using either concrete blocks, panels or gabions.

If required, the ground around the UltraCor® construction can easily be reinforced during the backfilling process with geosynthetics.



Concrete collar

Concrete collars are used:

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

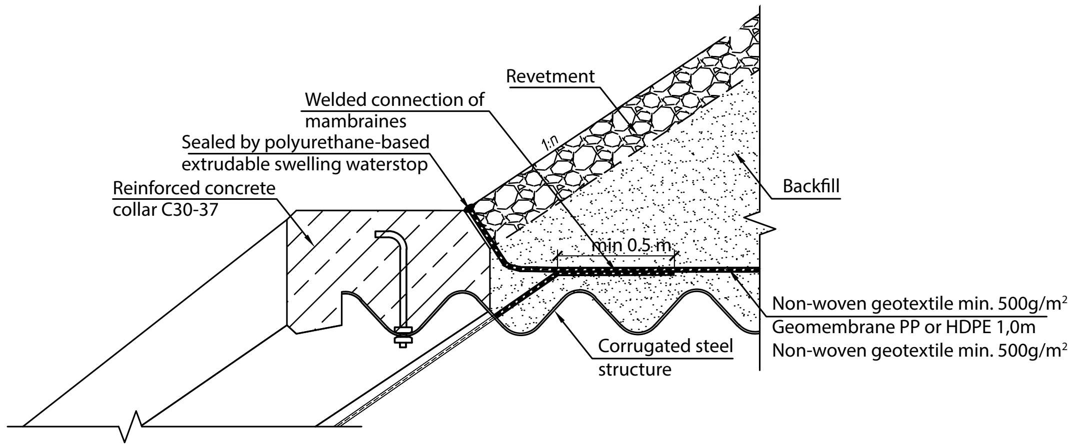


Fig 11. Detail of concrete collar with drip

Fittings

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

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

Tolerances

When the UltraCor® is assembled, it is recommended to take measurements of the shape of the structure.

Permissible tolerances of the structure dimensions are:

- for box structure
  - +2% of the span
  - +2%/-4% of the height
- for other shapes
  - +2% of the span
  - ±2% of the height

Deformation of the cross section after backfill should be within a tolerance of 2% of the span measured after assembly.

Technical advantages of the UltraCor® construction compared to SuperCor® structure

High covers

- For the simmilar span dimension and the same plate thickness, the UltraCor is able to carry higher covers.

Shallow covers, large live loads

- Depending on the structure shape **it is not always necessary to use** reinforcing ribs

Shallow covers

- Due to the high bending stiffness the UltraCor corrugation is preferred to be used for the Box shapes

Large Spans **and closed shapes**

- Due to high structural capacity UltraCor is more efficient then SuperCor especially for large spans.

INNOVATIVE INFRASTRUCTURE

MultiPlate MP200

SuperCor®

UltraCor®

HelCor®

HelCor PA®

PECOR OPTIMA®

PECOR QUATTRO

ViaWaterTank

Geogrids

Woven and nonwoven geotextiles

Gabions

HelCor® wells

Temporary and permanent
Acrow bridges

ViaBlock®

ViaWall A®

ViaWall B®

CON/SPAN

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Edition 10/2019