

ViaPlate®

Products and Solutions

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ViaCon ViaPlate® is used mostly as buried flexible steel bridges & culverts, also called soil-steel structures. They are used for roads and railways infrastructure as well as for some industrial applications.

Typical applications include:

- Culverts
- Bridges
- Overpasses
- Underpasses
- Ecological crossings
- Conveyor belt protection
- Protection of utility pipes
- Relining of existing structures
- Tunnels
- Hangars
- Shelters

A few of the most commonly used applications listed above are presented at the end of this brochure, along with a description of the important aspects of buried flexible steel bridges & culverts technology.

1. Introduction

ViaCon ViaPlate consists of hot-dip galvanised corrugated steel plates, connected by hot-dip galvanised bolts and nuts. Depending on the categories of environment aggressiveness specified in the EN ISO 12944 (water, backfill and air), appropriate corrosion protection is designed, including a painting system, if necessary.

These structures have been successfully used in civil engineering for over 100 years. The first applications, such as construction, took place in North America, where the idea of using them in road and rail construction was born. Today, buried flexible steel bridges & culverts are widely used in construction around the world. Soil-steel interaction allows buried flexible steel structures to act in conjunction with the surrounding soil fill to support the loads. This technology is economical, easy and quick to build. The average installation time of a typical culvert or bridge is only a few days.

Buried flexible steel structures have been used in Europe since 1954.

2. Advantages

- Quick to design due to the standard drawings and a calculations database for typical applications
- Fast and easy installation with light equipment
- Assembly possible in temperatures below zero
- Assembly possible with no traffic interruptions
- Assembly possible with total or partial prefabrication of the structures
- Lightweight, the corrugated steel plates can be delivered efficiently and economically to distant locations
- Reduction in the total time and cost of construction
- Reduction in the environmental impact compared to other solutions



Approvals and Certificates:

- CE Certificate of Factory Production Control
- Environmental Product Declaration Type III
- ISO 9001:2015, - Quality Management System
- ISO 14001:2015 - Environmental Management System
- ISO 45001:2018 - Safety Management System
- BBA HAPAS 17/H270 of Corrugated Steel Culverts

3. Sustainability

Using lightweight corrugated steel structures instead of reinforced concrete structures for bridges & culverts, both energy consumption in manufacturing and installation and CO2 emissions can be reduced. The main advantage of corrugated steel structures over reinforced concrete structures is the lower mass of the material necessary to achieve similar capacity and function in the expected lifetime. The net recycling benefits, which acknowledge the value of steel scrap, enable corrugated steel structure solutions to reduce their environmental impacts significantly. A comparative life cycle analysis confirms that buried flexible bridges & culverts using corrugated steel structures reduce CO2 emissions by more than 50% versus the use of reinforced concrete.

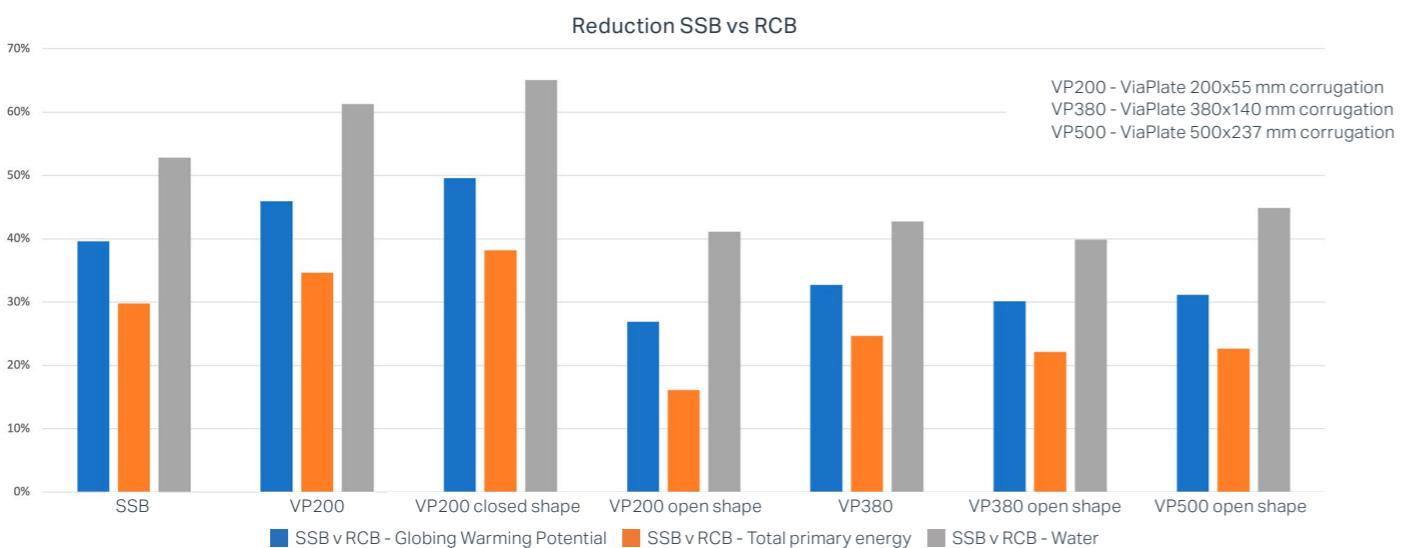


Fig. 2. LCA comparative analysis between soil-steel bridges (SSB) made with corrugated steel structure and reinforced concrete bridge (RCB)

The following factors have influenced the buried flexible steel structure's durability:

- Category of environmental aggressiveness
- Abrasion
- Selection of the appropriate corrosion protection method and its quality
- Frequency of maintenance and repair

4. Durability

Our customised corrosion protection design accounts for the longevity of buried flexible steel bridges & culverts solutions. From the urban landscape to sea water, it can be designed for all corrosivity classes.

While the level of corrosion protection suitable for different environments varies based on the environmental conditions in which the structure will be built, when properly applied and maintained ViaPlate ensures a long service life of 100-120 years.

Procedure to verify the durability of corrugated steel structure:

- Define the function of the structure
- Define the required durability/design life of the structure
- Define the aggressiveness of the environment (water, backfill, air)
- Specify the plate thickness based on bearing capacity calculations
- Specify the corrosion protection layers (added thickness as sacrificial steel, thickness of zinc coating, and paint coating if necessary)
- Define annual loss of the protection layers in the upper and lower part of a structure
- Calculate the structure durability by considering the corrosion progress over the service lifetime
- Compare calculated live time with the required live time

Several algorithms show how to calculate the durability of corrugated steel structures.

In most of the methods, a synergy effect is assumed. It means that the durability of the combined layers system (zinc + paint = duplex system) is higher than the sum of the durability of the separate protection layers and can be calculated as:

$$SD = \alpha (SC + SZ)$$

where:

- SD – total durability of the protection layer
- SC – durability of zinc coat
- SZ – durability of the paint coat
- α – synergy factor (from 1.5 to 2.0)

Characteristics	Requirements acc. TS_EN ISO 461	
	Minimal local zinc coating thickness [μm]	Minimal average zinc coating thickness [μm]
Steel plate: >6 mm	70	85
>3 mm to \leq 6 mm	55	70
\geq 1,5 mm to \leq 3mm	45	55
Bolts, nuts, anchor bolts	40	50



To prevent discoloration from UV radiation, polyurethane paint should be applied as a top layer to the surface exposed to direct sunlight, where we care about aesthetic appearance and uniform colour.

ViaCon is a producer of three different type of corrugated steel structures:

- ViaPlate with corrugation 200x55 mm, up to 12m span
- ViaPlate with corrugation 381x140 mm, up to 25m span
- ViaPlate with 500x237 mm corrugation, over 30m span

5. Production

The flexible steel structures production process involves the mechanical shaping of flat steel plates into curved corrugated plates, including hole punching and edge cutting. Such prepared plates are later hot-dip galvanised.

The finished corrugated plates can also be optionally painted if additional corrosion protection is needed.

All of the manufacturing takes place in a quality-controlled factory process.

The steel used for production conforms to EN 10025 and EN 10149.

Detailed information about each product's parameters can be found in the respective ViaCon Technical Data Sheets.

The ViaCon technical document called "Catalog of Production Standard Solutions and Details" shows the manufacturing details of all of the aforementioned elements and can be presented on demand.

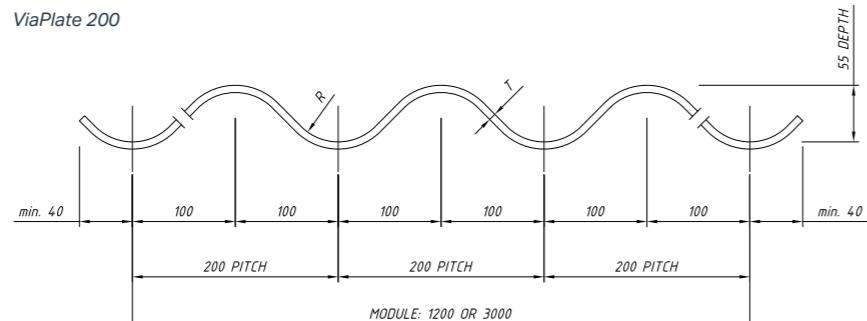
6. Shape of the Cross-section

The mechanical shaping of flat steel plates into curved corrugated plates provide the possibility for creating several different cross-section profiles, such as: circular, horizontal ellipse, vertical ellipse, pipe-arch, regular arch, low arch and high arch. Details of each profile type are presented in the attachment to Technical Data Sheet.

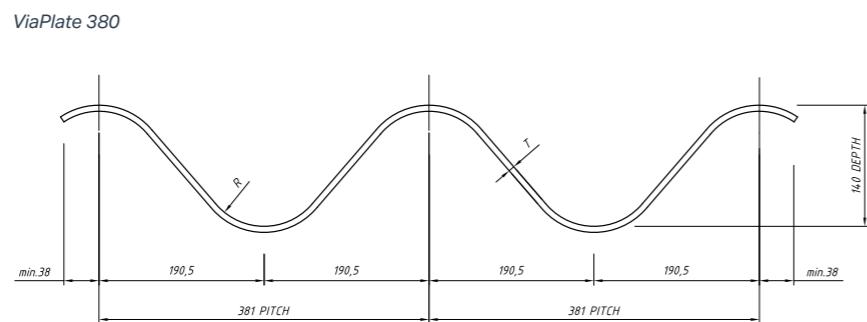
ViaCon can also provide, on demand, a DWG file with all cross-sections.

The cross-section can also be customised and designed individually to optimise for the specific need.

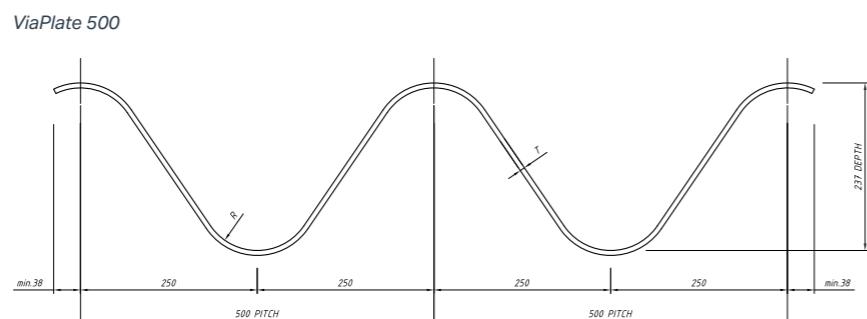
ViaPlate 200



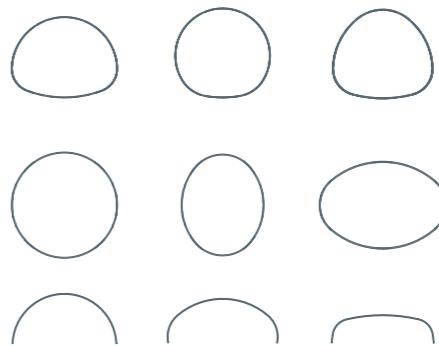
ViaPlate 380



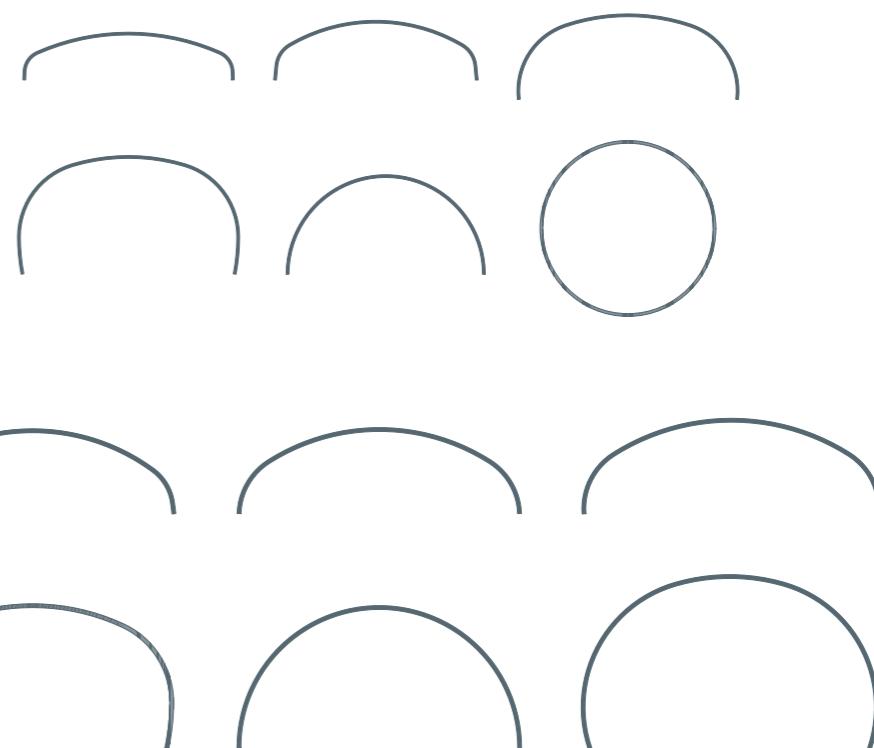
ViaPlate 500



ViaPlate 200 – Up to 12m span



ViaPlate 380 – Up to 25m span



ViaPlate 500 – Over 30m span



7. Bolts, Nuts, Anchor bolts

Corrugated steel plates are joined with M20, M22, and M24 bolts class 8.8. and 10.9.

The lengths of the bolts are related to the thickness of connected plates and the type of connection.

The bolts, anchor bolts, and associated nuts correspond to the requirements norm of EN ISO 898-1 and EN 20898-2. All of the ancillary items mentioned above are delivered to the job site together with corrugated plates as a complete set.



The design process of the flexible steel structures consists of the following steps:

- Design of the structure (steel thickness, steel grade, corrugation type, bolted connection configuration)
- Design of engineered backfilling
- Design of the foundations
- Design of inlet, outlet, and other associated fittings and elements
- Design of corrosion protection



8. Fittings

Buried flexible steel structures can be equipped with additional elements depending on its function of the structure, e.g.:

- Steel face of collar for beveled ends
- Lighting boxes
- Connectors for ventilation system
- Security or service chambers
- Skylights
- Connectors with utility pipes
- Shelves for animals
- Technical holes

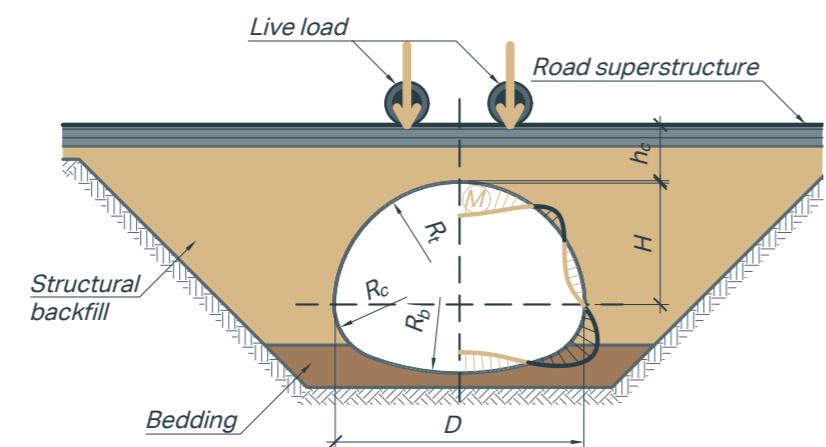
9. Design

The selection of corrugation and profile type, plate thickness, steel grade and the bolted connection option depends on cross-sectional size of the structure needed, subsoil bearing capacity and foundation type, depth of cover, and live load. ViaCon's technical experts are always ready to advise and assist you with optimal choice.

Buried flexible steel structures may be designed for all road and railway live load classes according to Eurocode EN 1991-2 or according to other national standards for corrugated steel structures worldwide.

The ViaCon technical document "Design Details Catalog" shows typical ready-made design details based on best practices, coming from more than 30 years of engineering experience. This catalog can be presented on demand.

The ViaCon company also provides design service on demand according to the internal "Corrugated Steel Structures Solution Policy", which is based on many years of experience in cooperation with designers and scientists in Europe and North America and guarantees safety and compliance with applicable norms.



10. Structural Analysis

The bearing capacity of buried flexible steel structures is designed with the use of one of the following design methods:

- Swedish Design Method, developed by Prof. Sundquist and Prof. Petterson
- German Design Method, developed by Prof. Kloppel and PhD Glock / Glock acc. to ZTV-ING 8.5
- Canadian Design Method, described in CHBDC - Canadian Highways Bridge Design Code
- AASHTO LRFD Bridge Design Specifications
- Finite element method (FEM) in complex cases
- Or other design methods as required for the region

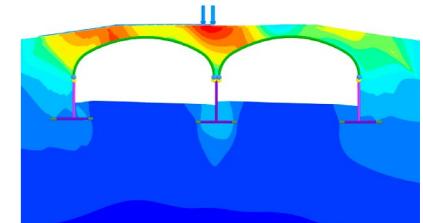


Fig. 2. Finite element method (FEM) model of twin structure

11. Cover Depth

Definition of the cover depth for road structures:

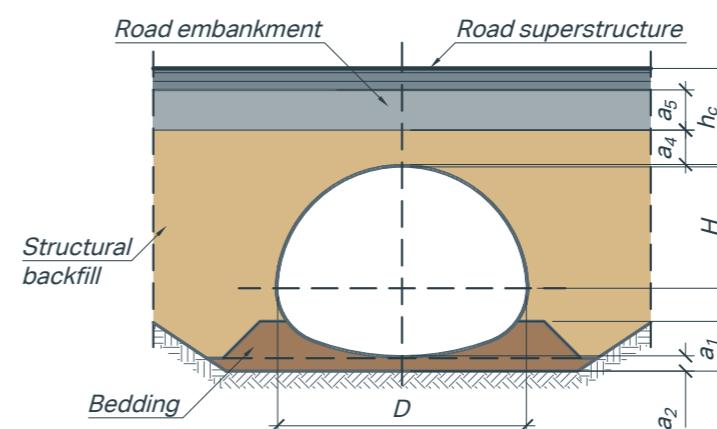
The vertical distance between the top of the steel structure main barrel and the top of the pavement, including the pavement layer.



Definition of the cover depth for rail structures:

The vertical distance between the top of the steel structure barrel and the bottom of the railway sleeper.

The minimum and maximum depth of cover is designed individually for each structure, including cases where construction traffic is assumed over a structure before the final stage. Several reduction techniques of the dead load are available in cases with high cover. ViaCon's technical experts can help to design the optimal cover depth.



12. Geometry of Structure in Longitudinal Direction

Each type of corrugated steel structure can be designed and produced as an arch or even "snake shape" in-plane. Multiple linear increments are used to align to the designed curvature for curved structures in-plane. It is also possible to design and produce structures adjusted to variable slope inclinations or to connect two different cross-sections. Geometrical modelling of the structure along its length is subject to certain technological limitations that should be always agreed with a ViaCon technical expert or ViaCon designer.

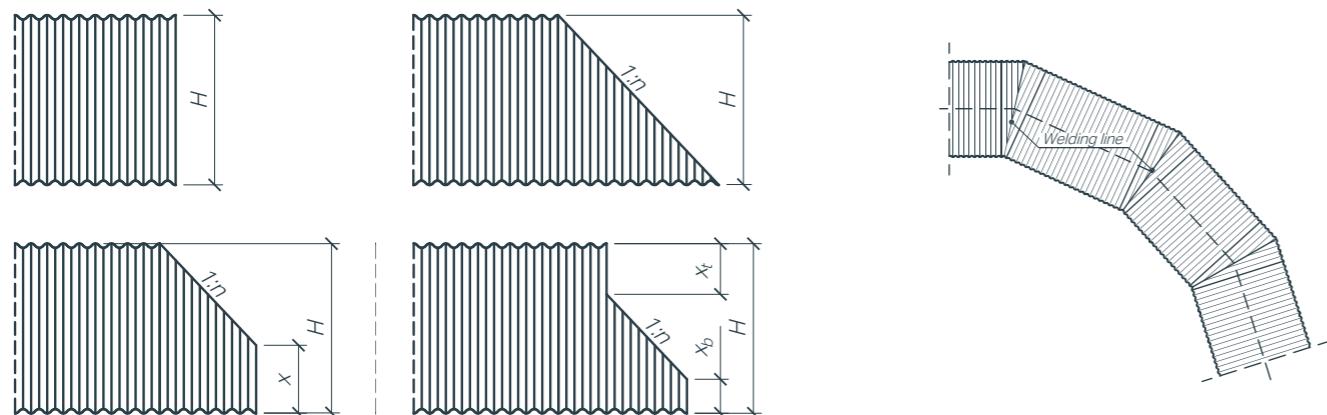


Fig. 5. End finishes in longitudinal section

Fig. 6. Curvature of the structure in plane view (top view).

13. Inlet and Outlet Shape and Reinforcement

The ends of corrugated steel structures can be squared or beveled to match the embankment slope. The angle between road/rail axis and bridge/culvert axis could be different than 90 degrees.

When designing the inlet and outlet, the majority of the applications don't need any special treatment; however, consideration should be given to the need for reinforcement to prevent deformation, especially with an acute angle. Various techniques are used to reinforce steel structures' inlet and outlet ends. The need for reinforcement should be always decided by an experienced designer, and it should be precisely described in the design specification.



concrete collar – squared end.



concrete headwall – beveled end.



steel collar face

The most popular method to reinforce inlet and outlet ends is concrete collar.

For squared ends, reinforced concrete headwalls continuously surrounding the structure's opening can be used. As an alternative solution, MSE (Mechanically Stabilized Earth) walls may be applied using concrete blocks, panels, or gabions. Both solutions should be done with a concrete collar around the steel shell.

For beveled ends, the stiffening collar's geometry is based on lines smoothly curved in the three-dimensional space. This makes the construction of formworks complex and time-consuming.

To simplify the process of casting the concrete collars, ViaCon can produce and deliver a "steel collar face" that acts as a stay-in-place form, fitted to their smooth geometry. Ordering the structure with such elements makes casting the concrete collar easier and accelerates the construction process.

The "steel collar face" could be used also as finish ends without the concrete collar. The slope around steel structure ends may be finished with grass, block-paving, gabions, reinforced earth, or other end treatments.

Special consideration is required for skewed angles. If smaller than 60 degrees, concrete collars and/or reinforced soil can be applied to the inlet and outlet zones to avoid skew deformation. Such reinforcement depends on many structure parameters and should be designed individually for a particular project.

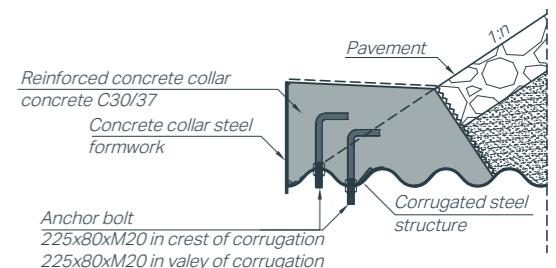
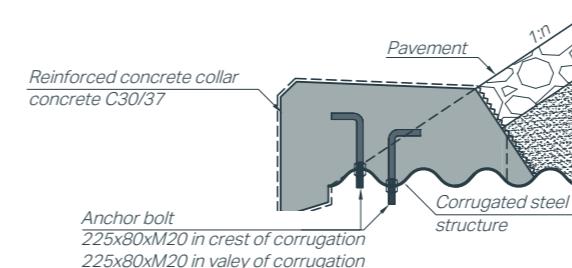
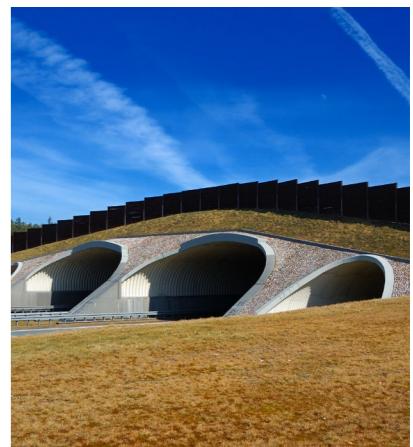


Fig. 7. Example of a concrete collar

14. Multiple Installation

A bridge or culvert can be designed as multiple structures next to each other. In such situations the minimum spacing between adjacent structures should be sufficient for the compaction of backfill. Distance depends on the dimensioning method used.

When the recommended distance cannot be achieved, the space between structures should be filled with C12/15 concrete or cement-stabilised soil to the level where the distance between structures is not less than 10% of the structure span. Don't hesitate to get in touch with a ViaCon expert for advice.



15. Foundation

Existing ground conditions have to have sufficient bearing capacity or should be reinforced.

Open-shape structures are typically placed on concrete foundations.

The connection between foundation and steel structures is presented in figure 8.

There is an option to place corrugated steel structures on flexible steel footings. Such an option requires a unique foundation design technique and can be chosen in a situation with high load-bearing capacity parameters of the subsoil. Such a foundation needs a dedicated design method.

ViaCon designers offer foundation design services.

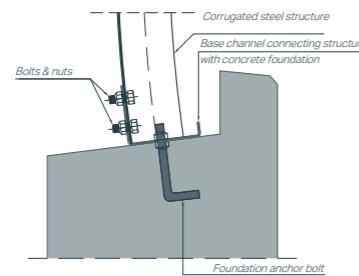
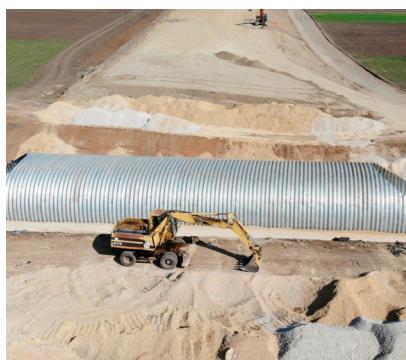


Fig. 8. Connection of the steel structure with concrete foundations



Closed-shape structures (circular, elliptical, pipe-arch) are placed on prepared soil bedding as follows:

- minimum thickness of compacted soil bedding should be 30 cm and depends on the span
- the top surface portion of the bedding should be shaped to fit the radius of bottom plates of a structure
- particular attention should be exercised in compacting soil under the haunches
- top 5 - 15 cm of the bedding (depends on the corrugation) should be relatively loose material so that the corrugation of plates could immerse in the soil.



16. Bedding and Backfill

The following materials are recommended for bedding and backfilling: gravel, sand-gravel mix, well-graded aggregates, and crushed stone. Aggregate grain size for backfill depends on the size of the corrugation profile:

- for 200x55 mm corrugations, the max recommended aggregate particle size is max.45 mm
- for 380x140 mm corrugations, the max recommended aggregate particle size is max. 61 mm
- for 500x237 mm corrugations, the maximum recommended aggregate particle size is max. 61 mm

The following backfill parameters are recommended:

- $\Phi \geq 33^\circ$
- $18,5 \leq y_d \leq 21,0 \text{ kN/m}^3$
- compactibility: recommended $C_u \geq 4; C_c > 1$
- permeability coefficient 8m/24 hours
- cohesive soil, organic soil, and frozen soil are not acceptable.

The backfill material should be placed around the structure in uncompacted layers, not more than 30 cm thick and then compacted. It 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 to keep close to the same elevation on both sides of the structure at all times. No more than one layer (30 cm) difference in elevation is permitted from one side to the other. Before adding the next layer, each layer must be compacted to the specified compaction index.

The backfill material adjacent (up to 20 cm) to the structure should be compacted to minimum of 95% of standard Proctor density and 98% of standard Proctor density in the remaining area. The range of the backfill should always be specified by the designer.

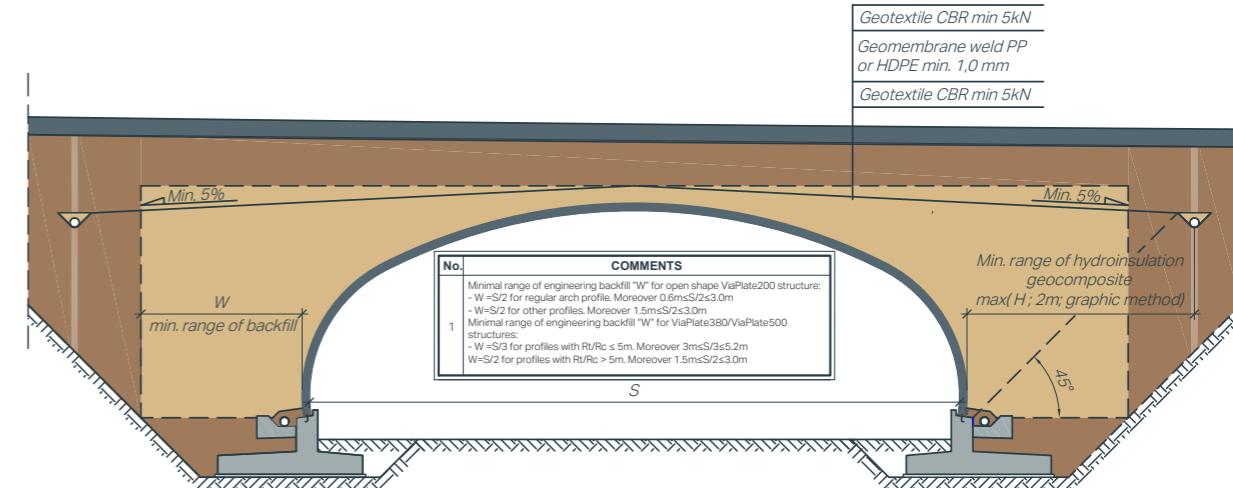


Fig. 11. Scheme of protection against water infiltration "umbrella".

17. Protection against water infiltration

Protective measures may be applied to protect structures against water infiltration through the backfill. A recommended solution is the so-called protective "umbrella" with 1.0 mm thick HDPE geomembrane, enclosed by two layers of protective non-woven geotextile over the steel structures. Such protection could also be achieved by use of a bentonite mat layer (geosynthetic clay liner) above the structure.

If tightness of the structure is required, a recommended solution is an EPDM membrane placed directly on the structure (or even around the structure with a closed shape).

In addition, a sealing system with sealant on plates overlaps and bolted connectors with plastic caps can also be used. The design of protection against water infiltration may take into account one of the above techniques or their combination.

Comments Fig. 11.

Minimal range of engineering backfill "W" for open shape ViaPlate 200 structure:

- $W = S/2$ for regular arch profile. Moreover $0.6m \leq S \leq 3.0m$
- $W=S/2$ for other profiles. Moreover $1.5m \leq S \leq 3.0m$

Minimal range of engineering backfill "W" for ViaPlate 380/ViaPlate 500 structures:

- $W = S/3$ for profiles with $R_t/R_c \leq 5m$. Moreover $3m \leq S \leq 5.2m$
- $W=S/2$ for profiles with $R_t/R_c > 5m$. Moreover $1.5m \leq S \leq 3.0m$



18. Delivery

The corrugated steel structures are delivered to the site, including the following:

- the plates are shipped nested in bundles. Each bundle includes plates of the same length and radius
- the plates are colour-coded for easy identification, corresponding to the accompanying assembly drawing
- the cut plates (inlet and outlet of the structure for beveled ends) are numbered and delivered in one separate package
- the base channels for footing connection (these items could be delivered earlier on demand – whenever the foundation is prepared)
- the bolts, nuts, anchor bolts and assembly tools (crowbar, bolts feeder, gripper, punch) are delivered in one separate package. In the same package an envelope with a laminated assembly drawing and instructions for assembly & backfill is provided
- extra cans of paint are also provided to repair any damages that may happen during unloading and assembly



Unloading can be undertaken with a crane or an excavator and with straps. It is the contractor's responsibility to ensure that the unloading equipment has a suitable capacity to unload the materials safely. Small amounts of damage that may have occurred during transport and unloading may be repaired on the construction site after assembly. A repair paint kit is always delivered with each structure.

ViaCon standard procedures are defined in "Storage, Packing and Loading Instructions for ViaPlate" and can be provided on demand.



19. Assembly

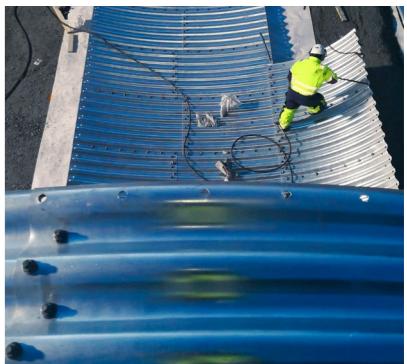
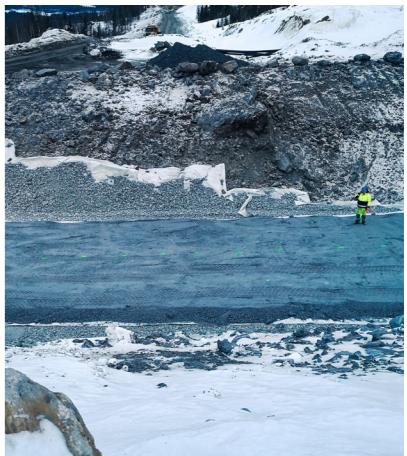
Assembly of corrugated steel structures is quick and easy. It is essential to study carefully the assembly drawings and instructions before installation. "The Assembly & Backfilling Instruction," together with the assembly drawing, provides information about the position of each plate in the structure and describes the assembly procedures.

For a closed-shape profile structure placed on a soil foundation, the assembly process starts following the bedding preparation.

For an open-shaped profile placed on a concrete foundation, the assembly process starts following the completion of the concrete foundation (with a channel in the top surface). The detail of the connection between the concrete foundation and corrugated steel structure will always be provided as a design detail.

When tightening the bolts during assembly, allow for some slack on the bolt connections. This allows for future adjustment of plates before full torque is applied on completion of assembly.

All details related to the installation (assembly and backfilling) process, like assembly tools, rules on bolt torque, assembly crew and time needed, deformation, and shape control, are presented in a separate document named "The Assembly & Backfilling Instruction," which is delivered together with material and could also be provided on request.



A. Water bridges & Culverts

When shaping a culvert or a bridge on a watercourse, we must have a water flow analysis and select such cross-sectional areas so that water can flow freely. ViaCon designers are ready to support in such water flow analysis, taking into account the friction of water on the corrugated sheet.

If the water velocity is significant and there is a high risk of abrasion, closed sections should be avoided and a steel arch solution based on reinforced concrete foundations should be used. The bottom of the river can be reinforced with stones or concrete slabs. The steel arch up to the height of "designed high water level" can be additionally protected with anti-corrosion paint layers, if water aggressiveness is expected.



B. Grade Separations

In the case of shaping the bridge as a two-level crossing, structures made of corrugated steel plates in the shape of an arch with low height are most often chosen.

The optimal geometry of the cross-section and the selection of the ViaCon product are determined by the size of the clearance box needed to exceed, as well as the terrain and the height of the embankment, which will allow for the minimum backfill above the steel structure.



C. Ecological Crossings

Soil-steel structures are a great choice as ecological crossings for small and large animals living in the wild. For many reasons, building passages for animals is necessary. One is to avoid collisions between vehicles and animals, which unfortunately often end tragically. The second important reason is the preservation of biodiversity.

In the case of small animals, these are usually underpasses, where the size of cross-section should be adequate to accommodate the type of animals that we expect should use this underpass. Such a passage must be sufficiently insulated for animals to use it, seeing the outlet on the other side. And in the case of large animals, overpass geometry should be created with a minimum width of 50m as passageway between anti-glare screens. The inclination of the entrance and exit slope of such a passage is also important. If the inclination allows animals to see the other side of the passage, they are more likely to use it.

For the proper shaping of ecological crossings, there are several handbooks, which are the result of multidisciplinary work between engineers and experts on the behaviour and migration of wild animals. ViaCon experts are familiar with these guides and will be happy to give advice on how to correctly design useful crossings.



D. Conveyor Belt Protection

Soil-steel structures are often used as conveyor tunnels under stockpile in aggregate mining. In such solutions, a special opening in the top part of the structure is designed and produced, usually reinforced by hardox steel. In such a tunnel, a floor made of steel trusses is also made, on which a conveyor belt is placed and a service technician can move around. A conveyor tunnel is usually connected to the so-called escape tunnel, which can also be made of corrugated steel structures. ViaCon has extensive experience with such applications all over Europe.



E. Relining

Corrugated steel structures are also commonly used to repair old culverts and bridges by inserting a steel structure inside an existing structure. This method is termed "relining". The space between the old structure and a new corrugated steel structure is filled with concrete of class minimum C16/20. This relining method allows the strengthening and rebuilding of old structures without traffic interruptions and eliminates the need to remove/demolish the old structure. This may have the added benefit of retaining the character and aesthetics of the old structure. Also, when the aesthetics of the old bridge are questionable, relining can give it a completely new look with great architectural value.





VIACON

**Constructing connections.
Consciously.**

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ViaCon is a leader in infrastructure construction solutions. Built on strong Nordic roots, ViaCon embodies a practical, human perspective that brings together technology and verifiable sustainability. The long-term view defines our vision, and by driving smart, future-friendly construction solutions for bridges and culverts, geotechnical and stormwater solutions, we will continue to shape and lead our industry.

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