TUBOSIDER

ASSEMBLY MANUAL

LARGE SPAN LOAD BEARING STRUCTURES

VERSION 2023

Sede Legale:
S.S. 231 n. 8/A - 12066 Monticello d'Alba (CN) Italia
Tel. +39 0141 418411 - Fax +39 0141 211373
Stabilimento:
. Reg. S. Antonio, 71 - 12066 Monticello d'Alba (CN) Italia
Tel. +39 0173 64715 - Fax +39 0173 64184

PREMIO CIVILTÀ DEL LAVORO

Cod.Fisc. e P.IVA 03141780019
P.IVA Intracomunitaria IT 03141780019
Cap. Soc. Delib., Sott. e Versato € 10.000.000,00
Iscrizione Reg. Imprese Cuneo al n. di Cod. Fisc. 03141780019
Iscrizione R.E.A. della C.C.I.A.A. Cuneo al n. 218830
Tubosider S.p.A.
società soggetta alla direzione ed al coordinamento di Itinera S.p.a.

E-mail: info@tubosider.it
Web: www.tubosider.it

INTRODUCTION

The underground culverts in corrugated sheet, otherwise known as Corrugated Steel Culverts or Soil Steel Composite Bridges, are flexible metallic structures, consist of more corrugated metal plates, appropriately curved and joined together by means of bolted joints, available in various shapes such as circular, elliptical, lowered and arch.

The load-bearing function of the culverts is based on the exploitation soil-structure interaction that is established between the metal structural profile and the detected technical surrounding, which plays a fundamental role in ensuring the structural stability.

The underground culverts are comunamente employed in the civil engineering sector for road applications, hydraulic or railway, such as bridges, culverts crossing, vehicle or pedestrian underpasses, ducts.

The market for Soil Composite Steel Bridges grew rapidly, starting from the first applications of the ‘70s up to today's implementations they see the metal culvert in great light itself as a viable alternative to other more conventional types of construction of major engineering works such as bridges road, rail or concrete or structural steel concrete tunnels.

They are structures that provide great savings in terms of material, time and resources, thanks to the high resistance of the sheet, the reduced thickness used, the high level of prefabrication, the optimization of transportation time and implementation.

This structural methodology was implemented by Tubosider the late '70s.

The span currently covered by the types of standard ducts arrive to a maximum of 7 ÷ 8 m., up to reach 10 ÷ 12 m. of light in the case of culverts arch equipped with lateral thrust reinforced concrete beams.

1.0 WORKING PRINCIPLES

Culvert design is based on the ring compression theory.

Because of its elasticity, the metal structure interacts with the soil surrounding it.

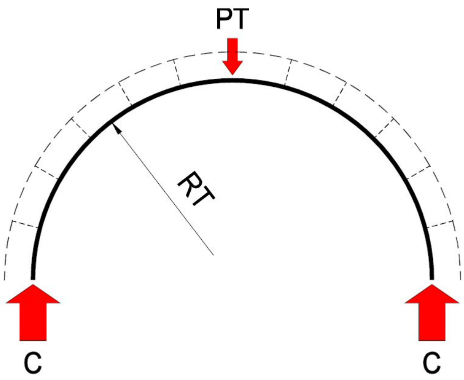
The loads transmitted by the soil are distributed evenly over the whole surface of the culvert.

The structure is therefore compressed and the stress induced, “**C**” (ring compression) is proportional to:

- the pressure exerted by the soil on the ring, “**PT**”;

- the crown curvature of the structure, “**RT**” (in a circular structure RT corresponds to half the diameter);

according to the formula: **C** = **PT · RT**



The theory assumes that the soil transfers the loads evenly to the metal structure and that this reacts in a uniform manner, without any points of discontinuity.

If the principle of the loads being correctly distributed over the ring is missing, i.e. if the structure does not work perfectly under compression, then a culvert would be considered unstable.

In practical terms, great importance is therefore given to:

- the formation of the technical block, i.e. the composition and degree of compaction selected and laid for the materials that make up the sub-base and the covering for the culvert: materials which must ensure that, in order for the culvert to hold, the pressure of the soil PT is in fact translated totally into radial pressure C;

- the sizing of the joints for the plates that make up the culvert, because they must be able to ensure the structure continuity.

A culvert’s culvert deformation under load, is not considered as a calculation criteria for determining the longitudinal section of the structure and therefore the thickness.

Experience has in fact shown that the presence of a technical block built to perfection is more than adequate to allow the culvert to bear working loads when the ring is compressed up to full resistance.

For a technical block built to perfection, deformations less than or equal to 2 % of the theoretical rise of the culvert are permitted.

Deformations greater than this can be attributed to defects in how the technical block has been made.

In any case the steel structure is able to behave flexibly also in the presence of deformations less than or equal to 3 % of the culvert rise.

2.0 MATERIAL CHARACTERISTICS

All the culverts are produced with materials of the following types:

2.1 Plates

According to standard EN 10025-2 April 2005, grade **S235JR** steel plates must have the following mechanical properties:

• ***tensile strength***		Rm	360 ÷ 510	N/mm^2
• ***yield strength***		ReH	235	N/mm^2
• ***resilience***	***Temperature***		20	°C
	Energy		27	J
• ***elongation percentage***	Th. > 1.0 ÷ ≤ 1.5 mm.	A	≥ 18	%
	Th. > 1.5 ÷ ≤ 2.0 mm.	A	≥ 19	%
	Th. > 2.0 ÷ ≤ 2.5 mm.	A	≥ 20	%
	Th. > 2.5 ÷ < 3.0 mm.	A	≥ 21	%
	Th. ≥ 3.0 ÷ ≤ 40.0 mm.	A	≥ 26	%

The thicknesses shown on the tables are the nominal ones and refer to raw material without galvanization coating.
Tolerance on thicknesses according to EN 10051 standards.
The weights too are the theoretical ones so they may vary according to the sane tolerances on the thicknesses.

According to standard EN 10149-2 May 1997, grade **S355MC** steel plates must have the following mechanical properties:

• ***tensile strength***		Rm	430 ÷ 550	N/mm^2
• ***yield strength***		ReH	355	N/mm^2
• ***resilience***	***Temperature***		20	°C
	Energy		40	J
• ***elongation percentage***	Th. < 3.0 mm.	A	≥ 19	%
	Th. ≥ 3.0 mm.	A	≥ 23	%

The thicknesses shown on the tables are the nominal ones and refer to raw material without galvanization coating.
Tolerance on thicknesses according to EN 10051 standards.
The weights too are the theoretical ones so they may vary according to the sane tolerances on the thicknesses.

2.2 Nuts and bolts

High resistance class 8.8 bolts are used, with the mechanical properties stated in standard EN ISO 898-1 (screws) and in standard EN ISO 898-2 (nuts).

Depending on the type of corrugation, the following types of bolts are used with the relative tightening torques [a]:

Type of corrugation	Bolt type	Tightening torques [a] Class 8.8	
		Min. [b] Nm.	**Max.** [c] Nm.
T70 **T100**	M12	45	90 [d]
T200	M20	220	439 [d]

a Tubosider SpA recommends to carry out the regular calibration of the tools (torque wrench, air impact wrench,etc..).

b The acceptability limit is anyway at the discretion of the Third Party Engineer.

c According NTC D.M. 17 January 2018 (NTC 2018) 4.2.8. Joints – Table 4.2…… Tightening torques for bolts 8.8, Factor K = 0.16.

d Higher values of the maximum tightening torque are admitted at the discretion of the Third Party Engineer provided that the tightening torque applied does not lead to breakage of the bolts and/or the deformation of the plates to be connected.

2.3 Surface protection

In order to protect against corrosion, a hot-dip galvanisation bath is prescribed for plates and nuts and bolts, with a quantity of zinc that varies according to the thickness of the plates and the type of nuts and bolts, complying with standard EN ISO 1461: 2009, and more specifically :

Plates

Steel thickness mm.	**Minimum local thickness of the coating** μm.	**Minimum average thickness of the coating** μm.
> 6.0	70	85
> 3.0 ÷ ≤ 6.0	55	70
≥ 1.5 ÷ ≤ 3.0	45	55
< 1.5	35	45

Nuts and bolts

Diameter mm.	**Minimum local thickness of the coating** μm.	**Minimum average thickness of the coating** μm.
> 6	40	50
≤ 6	20	25

or other current standards.

The protection is adequate for ensuring product durability under normal environment conditions.

Aggressive environmental conditions other than those identified above must be the subject of a special study, in order to decide the type of supplementary protection to be given (sacrificial thicknesses or epoxy treatments).

Environmental categories, risks of corrosion and corrosion levels

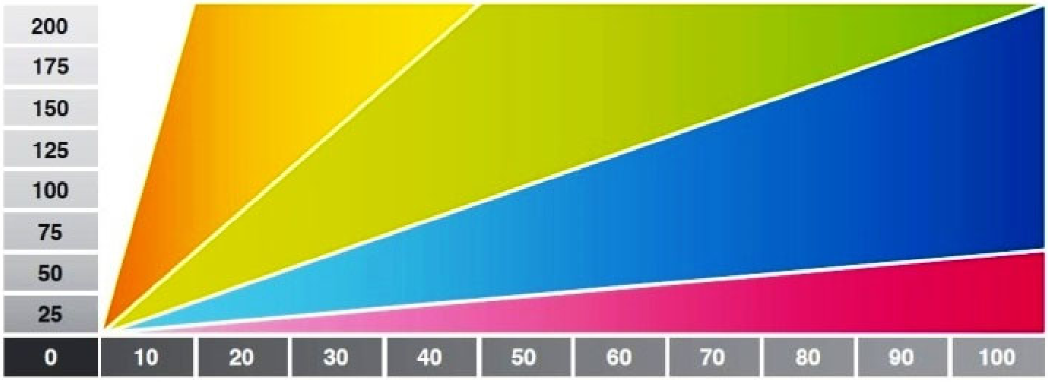
Code	Corrosion category	Risk of corrosion	Corrosion level average zinc thickness loss [e, f] µm/year
C1	Inside: dry	Very low	≤ 0.1
C2	Inside: occasional condensation Outside: rural environment	Low	From 0.1 to 0.7
C3	Inside: high humidity slight pollution Outside: urban or temperate coastal environment	Average	From 0.7 to 2
C4	Inside: swimming pools, chemical plants, etc. Outside: industrial environment or urban coastal	High	From 2 to 4
C5	Outside: industrial environment with high humidity or high coastal salinity	Very high	From 4 to 8
Lm2	Sea water in temperate regions	Very high	From 10 to 20 [g]

e The thickness loss values are identical to those in ISO 9223, except for the levels of 2 mm. (per year) or more, which have been rounded up to the nearest whole number.

f Changes in the air for the different environments through the years.
A substantial reduction in pollution, especially of sulphur dioxide, has taken place over the past 30 years world-wide.
This means that the current corrosion levels (the table is based on data for the period 1990 to 1995) for each environmental category are much lower that historical levels, even lower levels can be foreseen in the future if pollution continues to diminish.

g Sea water in temperate regions is less corrosive to zinc than tropical sea water, which is usually warmer.
This table can be used in marine environments in European temperate regions.
For tropical conditions the advice of a galvanising specialist should be sought.

Typical durability of zinc coating up to the first maintenance in different environmental situations



Coating thickness > **µm**

Durability up to the first maintenance > ***years***

Aggressive industrial environment from 4 to 8 > ***µm /years***

Moderate or marine industrial environment from 2 to 4 > ***µm /years***

Urban environment from 0,4 to 2 > ***µm /years***

Rural environment from 0,1 to 0,7 > ***µm /years***

2.4 Technical block

The static function of the culvert is guaranteed not only by the steel structure but also by the compacted soil around it that forms the technical block.

The correct sizing of the technical block and its perfect execution are illustrated in *Chapter 5.0*.

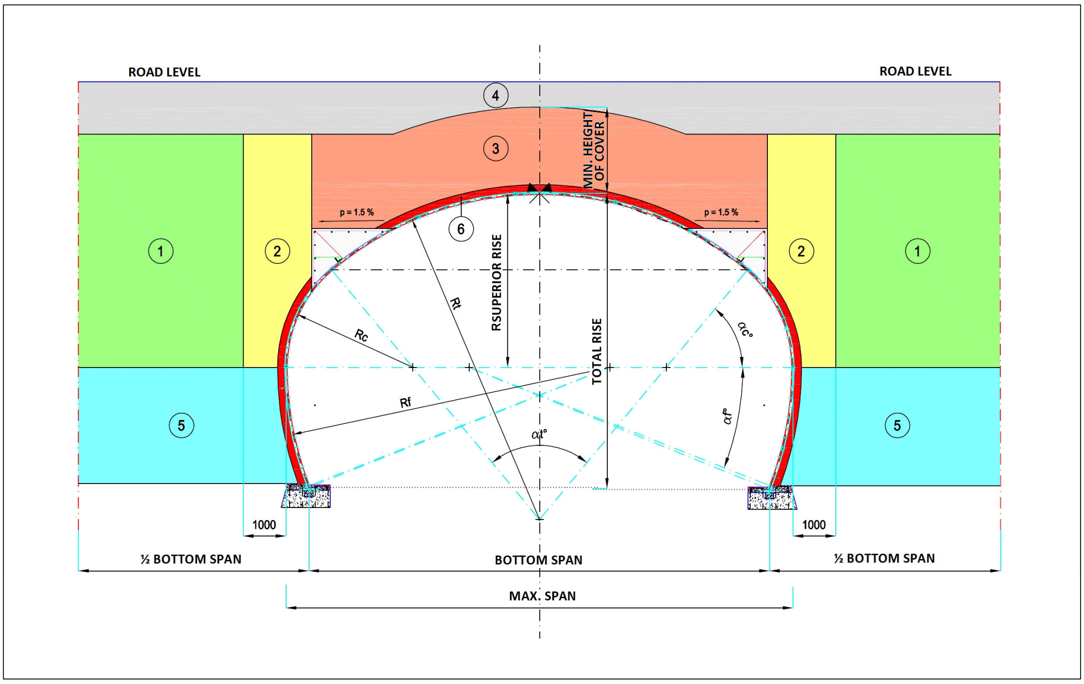
For a layer around the culvert of 20 cm., called layer "**ht**", the use of single size material with a max. diameter of 5 mm. is recommended.

The remaining part of the technical block will be made with backfill classified according to AASHTO M145-91 standards, i.e. according to CNR UNI 10006, of the group A1-A2-A3, free of any organic and non-organic impurities.

Soil classification according to AASHTO M145-91/CNR UNI 10006

General Classification	Granular Materials (35% or less passing 75µm) [No. 200]							Silt-Clay Materials (More than 35% passing 75µm) [No. 200]			
Group Classification	A-1		A-3*	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6
Sieve Analysis:											
Percent passing:											
2mm (No. 10)	50 max.	---	---	---	---		---	---	---	---	---
425µm (No. 40)	30 max.	50 max.	51 min.	---	---	---	---	---	---	---	---
75µm (No. 200)	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.
Characteristics of fraction passing No. 425µm (No. 40):											
Liquid Limit	---		---	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.
Plasticity Index	6 max.		N.P.	10 max.	10 max.	11 min.	11 min.	10 max.	10 max.	11 min.	11 min**
Usual Types of Significant Constituent Materials	Stone Fragments Gravel and Sand		Fine Sand	Silty or Clayey Gravel and Sand				Silty Soils		Clayey Soils	
General Rating as Subgrade	Excellent to Good							Fair to Poor			

*The placing of A-3 before A-2 is necessary in the "left to right elimination process" and does not indicate the superiority of A-3 over A-2.
**The plasticity index of A-7-5 is equal to or less than the liquid limit minus 30. The plasticity index of the A-7-6 subgroup is greater than the liquid limit minus 30.



For the final layer, before the road foundation, the use of a layer with a minimum height of 30 cm. is recommended, using materials from the group A1-A2-4-A2-5.

The size distribution of the technical block materials must satisfy the general requirements specified in standard EN 13242.

For durability, in order to prevent premature onset of steel corrosion and to ensure the perfomance stated in *chapter 2.3* the use of materials which offer electrical resistance of more than 8000 Ohm/cm and with a Ph close to the neutral value of 7 (values between 6 and 8) is recommended.

In addition, water leakage into the technical block of ground around the structure should be avoided, as in time this could affect the mechanical and material compaction properties.

With the choice of materials and adequate means for the construction of the road embankment and in accordance with the criteria and good engineering practice for its execution , compaction between 85 to 90 % Proctor, you can ensure to the technical block around the structure a module of elasticity “**Es**” at least equal to 60 MPa, satisfactory in terms of stability of the structure in most applications and verifiable at site by load tests with plate.

3.0 SITE PREPARATION AND ORGANISATION

The plates must be unloaded by mechanical means or by hand, throwing or pushing the plates off the delivery vehicle could deform the plates and edges could be bent, making assembly more difficult and therefore more expensive.

Transfer to the place of installation must be carried out carefully, making sure that the sheets are subjected to as little movement and dragging as possible, in order to prevent damage being caused to the zinc coating that protects the steel, or any additional protection.

A copy of this “ASSEMBLY MANUAL” is always enclosed with the supply.

3.1 Staff

Installation team must consist of a minimum of 4 to a maximum of 6 persons.

Several teams can work simultaneously on the same site.

3.2 Equipment

The minimum assembly equipment (although not always required) for each installation team, consists of:

- hammers;
- hooks;
- keys 22 (T70/T100 corrugation) and/or 32 (T200 corrugation);
- crowbars;
- scales;
- scaffolding;
- truck with crane;
- chains for lifting with shackles;
- current source;
- compressor;

- an electric or pneumatic Impact Gun (capable of achieving the required torque settings) should be used to assemble the seams.

To ensure the required torque settings for the bolts are achieved, a torque wrench “dynamometer” (with suitable capacity) can be used to confirm this.

3.3 Times of installation

The typical times for installation using a team of specialized technicians (4 people) with suitable equipment and with the materials available on site, will be approximately 4 ÷ 6 tons per day.

The installation times can vary from site to site depending on the preparation of the bed and also access for lifting equipment.

4.0 INSTALLING THE CULVERTS

4.1 Assembling the structure

Each supply consists of the material and the relative “ASSEMBLY DIAGRAM”.

The standard plates are identified by the type of corrugation and the number of intervals.

The type of corrugation (T200) is however always the same for each type of pipe.

The number of intervals on the contrary varies from plate to plate depending on the culvert size.

The term “**interval**” means the linear distance between two adjacent holes along the circumferential joint.

The above mentioned diagram clearly shows the progression of the plates, always referred to the top and bottom axis of the culvert, and to the number of intervals for each plate.

Where special processes are to be carried out on the culvert (cutting the bevelled ends, planimetric/altimetric curves, side joins, etc…) relevant detailed drawings are supplied with the structure.

In this case the individual shaped sheets will be marked so their exact position on the detailed drawing can be identified.

Assembly takes place by fitting a limited number of bolts to hold the plates together in the correct position

Only after a certain number of rings have been assembled should the rest of the bolts be fitted.

The bolts should be left loose to allow the plates to undergo those small movements that allow them to settle in correctly.

4.2 Tightening the bolts

Once the whole structure has been assembled, the bolts can then be tightened up to the requested torque level (See *chapter 2.2*).

This operation is very important and the bolts must be tight enough to make the structure an integral unit.

Pay special attention to the longitudinal joints which are the ones that bear the loads.

For culverts that can be inspected it is recommended that, once the technical block has been made, the tightness of the bolts be checked again and provision made, where necessary, to adjust the torques to the values prescribed.

4.3 Tolerances

The actual dimensions of the culverts, referred to the neutral axis, may differ from the theoretical ones within a tolerance of ± 2 %.

5.0 FORMING THE TECHNICAL BLOCK

The “**technical block**” is defined as the entire backfill that surrounds the culvert and which in fact contributes substantially to the static strength of the steel structure.

The technical block is made up of the bedding, the side embankments and the top covering.

The height “**H**” of the covering backfill, referred to the extrados of the culvert, is always specified and prescribed when establishing the dimensions of the structure, or indicated in the catalogue, for standard production culverts.

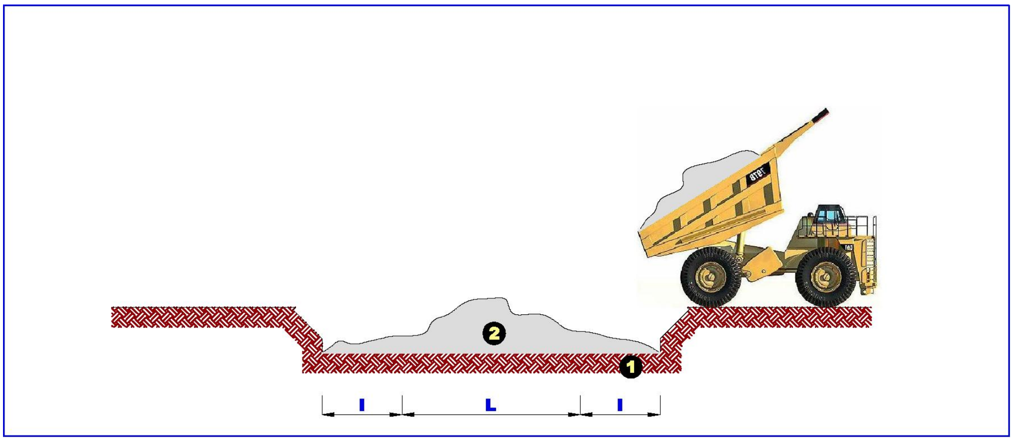
The technical block must be formed observing the height prescribed, according to the geometric and laying rules described below.

5.1 Preparing the surface on which the culvert will lie

5.1.1 Bedding

It is absolutely essential that the metal culvert be laid over an even, homogeneous, stable and resistant bed, avoiding rigid bottoms with undulations.

Under no circumstances should the structure be laid directly over a rocky bed or a concrete platform.



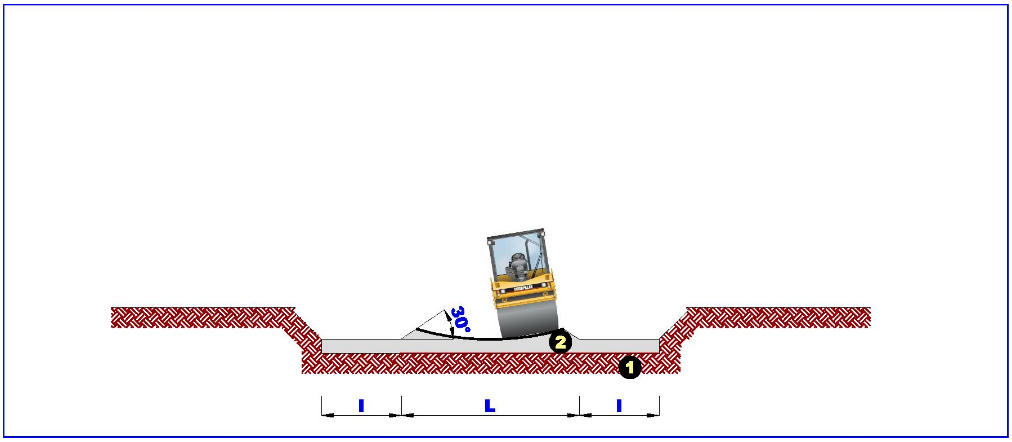
1 general main embankment (level to be determined depending on the capacity of the ground on site, client’s responsibility)
2 artificial foundation and bedding
l ≥ 1.50÷ 2.00 m. (3.00 ÷ 5.00 in case of structure having span ≤ 8.00 m)
L culvert span

The ground beneath the bedding must be able to guarantee enough support to prevent differentiated settling of the technical block in operation (as an indication, a load bearing capacity of at least 150 kPa is recommended).

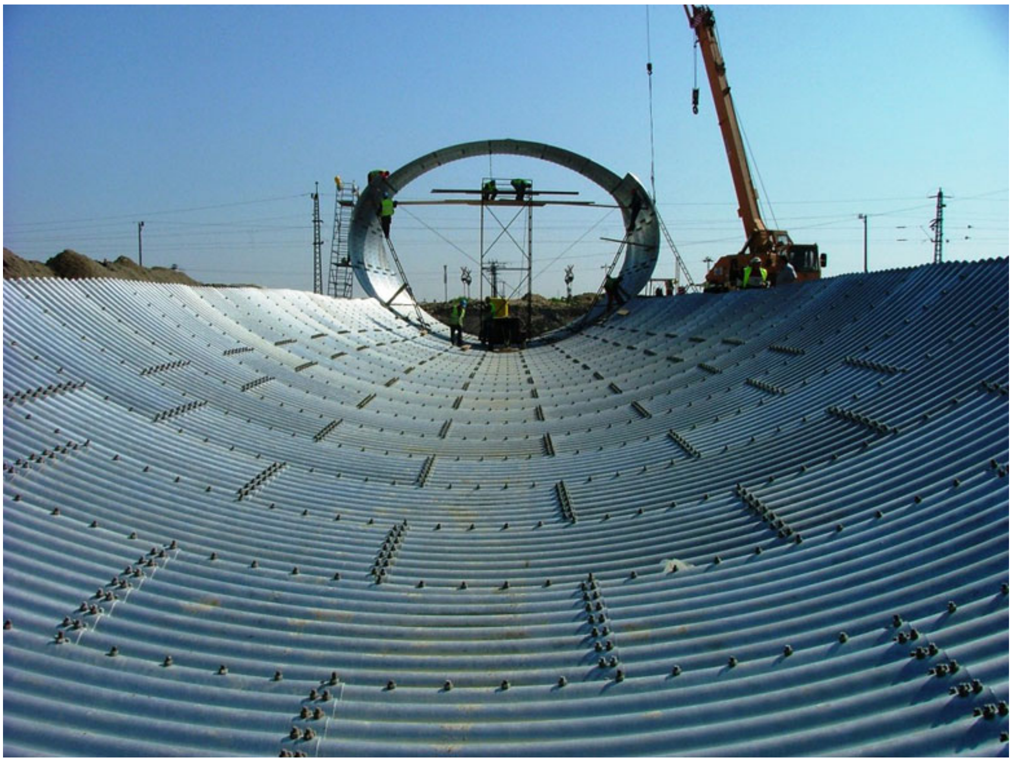
For ground with weak capacity it is best to create a bedding using a cushion of compacted granular material, of a width at least three times the culvert span, of suitable depth, to ensure that the pressures are evenly distributed over the ground beneath.

For rocky beds it is advisable to place a compacted granular material of 30 ÷ 40 cm. in depth between the structure and the base.

For the culvert bedding it is recommended that the bed be profiled according to the curvature of the base plates of the structure.



1 general main embankment (level to be determined depending on the capacity of the ground on site, client's responsability)
2 artificial foundation and bedding
l ≥ 1.50÷ 2.00 m. (3.00 ÷ 5.00 in case of structure having span ≤ 8.00 m)
L culvert span



This makes the subsequent burying phase easier, not having to fill in and compress the ground between the base of the structure and the bedding.

5.1.2 Presence of ground water

The presence of groundwater in the excavation areas is quite usual, especially when operating in specific geographical areas.

Through a preventive evaluation and an increased attention by preliminary ground design investigation, it is possible to prevent or partially solve the problems arising during the installation phase by defining the most adequate solution for drainage.

In presence of groundwater, in order to install the culverts, it is required to lower the ground water level below the excavation bottom.

In case of sandy or silty grounds, good results can be obtained by using a well system before the excavation; through this solution the excavation can be performed in conditions of dry ground.

In these cases, it is necessary to perform a preliminary study regarding the behavior over time of the water-bearing stratum, in order to perform the excavation when the stratum is less water bound, according to the theoretical information deriving from the previously mentioned ground investigation.

In case of coherent grounds (not sandy nor silty), if the water drainage cannot be performed by means of a well system, it is necessary to proceed first with the excavation, and only in a later phase by pumping.

The water must be pumped away gradually, in order to avoid the removal of solid fine-grained material from the ground.

In case of large excavations, it is suggested to use a double row of wells, each row being opposite to the other and placed along the excavation sides.

Sometimes it is possible to obtain the same effect by using only a single row from one side, but it is necessary to pump away the water more deeply in the ground.

Usually there are two rows for big culverts and just one row for small pipes.

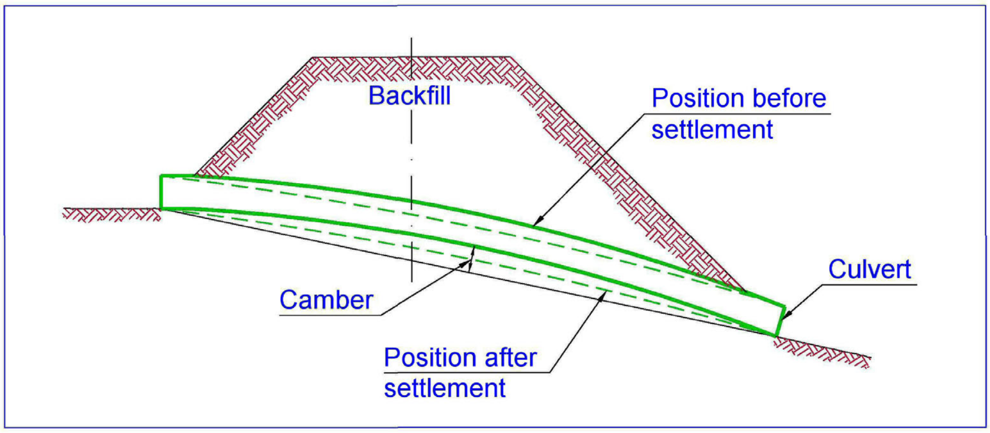
Those considerations are valid if the water bearing stratum is uniformly fed along the excavation section; if this is not the case, the water drainage solution must be studied case by case.

As a standard, **TUBOSIDER** requires the absence of water in the foundation ground, both of water flowing upstream (by diversion) and of groundwater; the ground load bearing capacity must be no less than 0.5 kg./cm^2.

A thorough geological analysis is required for full consideration when designing a structure in the above conditions.

5.1.3 Settlement below the backfill load

When faced with large backfills it is a good rule to raise the centre “camber” of the artificial foundation.



One practical method is that of keeping the half upstream of the structure at a lesser angle than the downhill half, but being careful not to raise the centre too much to prevent puddles forming at the entry.

The value of the camber to be given to the central part of the structure, compared to the straight condition is between 0.5 ÷ 1.0 % of the length of the culvert.

This procedure will guarantee the culvert, once it has settled, a constant slope therefore preventing any pools of water from forming inside it.

5.1.4 Foundations of arch sections

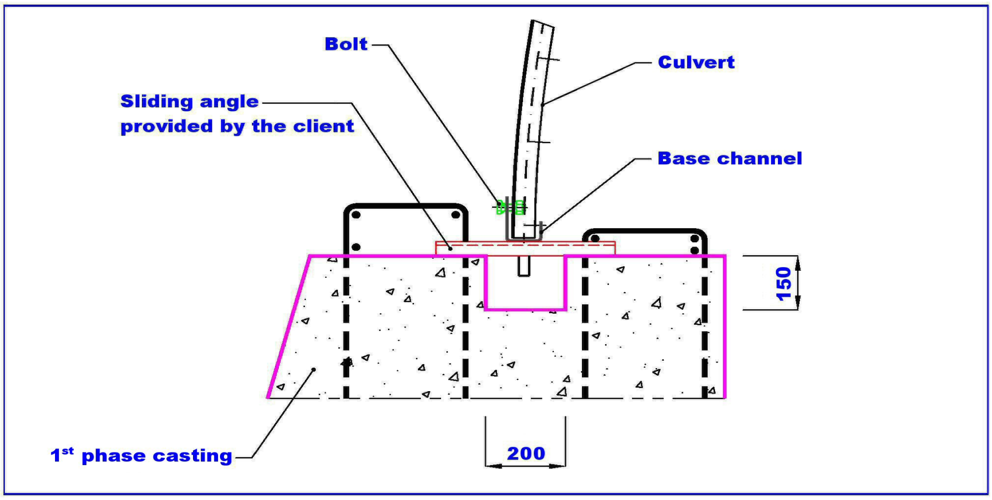
The reinforced concrete foundations of the steel culvert base channels must be dimensioned by the customer according to the horizontal (Rh) and vertical (Rv) loads indicated by the design calculation.

Reinforcement should be improved adherence type B450C, while the concrete shall have a minimum resistance Rck minimo di classe C25/30.

Depending on the capacity of the ground on site, the foundations in reinforced concrete can be formed of a single bed of reinforced concrete, or continuous beams in reinforced concrete.

In both cases, as for all rigid foundations, it will be necessary to prevent differential failures along the axis of the metal structure great enough to cause additional stress to the metal structure above.

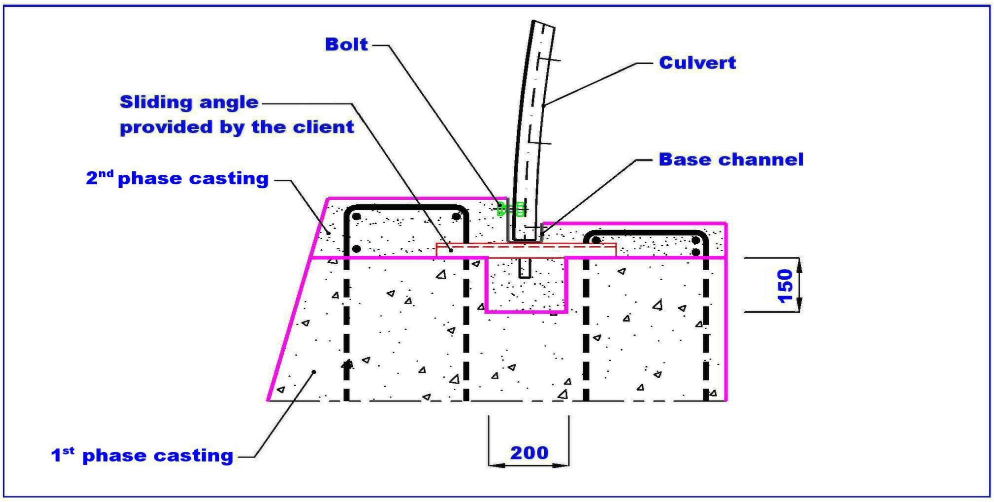
The plates that form the feet of the arch will be equipped with base channels; as the structure assembly progresses these channels will be placed against the 1st phase casting by means of angle sections or other suitable supports, to be supplied by the client.



During the construction phase, it may be necessary to temporarily secure the base channels to the steel reinforcements either by spot welding or using steel tie wires to prevent them from sliding.

As the assembly progresses distances, measurements and diagonals will be checked to keep the channels perfectly parallel and coplanar with the rings of the structure which are at right angles to the channel line observing the measurements and indications given in the drawing that will be supplied by **TUBOSIDER**.

Once the arch has been assembled a final check will be made and if this gives positive results the arch can then be cemented to the base channel by carrying out the 2nd phase casting.



The arch can be buried once this casting has set.

5.2 Side compaction and covering

The specifications of backfilling materials to be used for the technical cover of the large span culverts are the same as the ones used for the other TUBOSIDER structures.

Special care should be taken over this operation, as the resistance of the culvert depends on the lateral support of the compacted ground around it.

The material is initially laid in contact with the soil where it must be strongly compacted and wetted at frequent intervals (when the filling material is suitable), to enable it to penetrate:

- under the natural existing foundation in case of arch structures;

In general, for all other type of culvert, the load bearing capacity of the ground where the side bank is should not be less than 150 kPa (1.5 kg/cm^2).

The compaction material must be laid and compacted in horizontal layers of a max. thickness of 20 ÷ 30 cm. (**hc**).

The layers must progress symmetrically, from one side of the culvert to the other, so that the burial level is always the same.

It is recommended that each layer is well compacted in order to guarantee the characteristics of the backfill mentioned in the following table.

The side backfill will be carried out up to the height of the r.c. thrust beam setting.
After thrust beams casting ripening the side backfill will be completed beyond thrust beams height.

Heavy vehicles shall be used with caution during compaction phase near the steel cuvert, as not to damage the culvert itself.

Construction machinery should not be allowed to travel over the pipe until the structure is covered by an embankment thickness at least sufficient to distribute the loads caused by this equipment to avoid stresses higher than the ones foreseen by the design note.

Furthermore it can sometimes be difficult to carefully monitor the backfill layer compaction and also to exactly know at which distance from the structure the compaction machinery shall operate once the culvert is covered even by one layer only.

Some useful check methods are :

- make horizontal marks with chalk to highlight next layer height on culvert side;
- while the backfill increases in level (horizontal line), some markers shall be positioned to outline the traffic area for heavy plant;
- no operations during darkness shall take place; graduated markers shall be positioned on the high part of the structure.

The minimum backfill height “**hi**”, allowing site vehicles to circulate is always specified by the manufacturer or specified in the catalogue for standard production culverts.

The technical backfill compacted around the structure is normally made of the same material used for the road embankment and will be extended at culvert top level for a width equal to the pipe span in both sides; the total width at culvert top level will be therefore three times the span of the culvert.

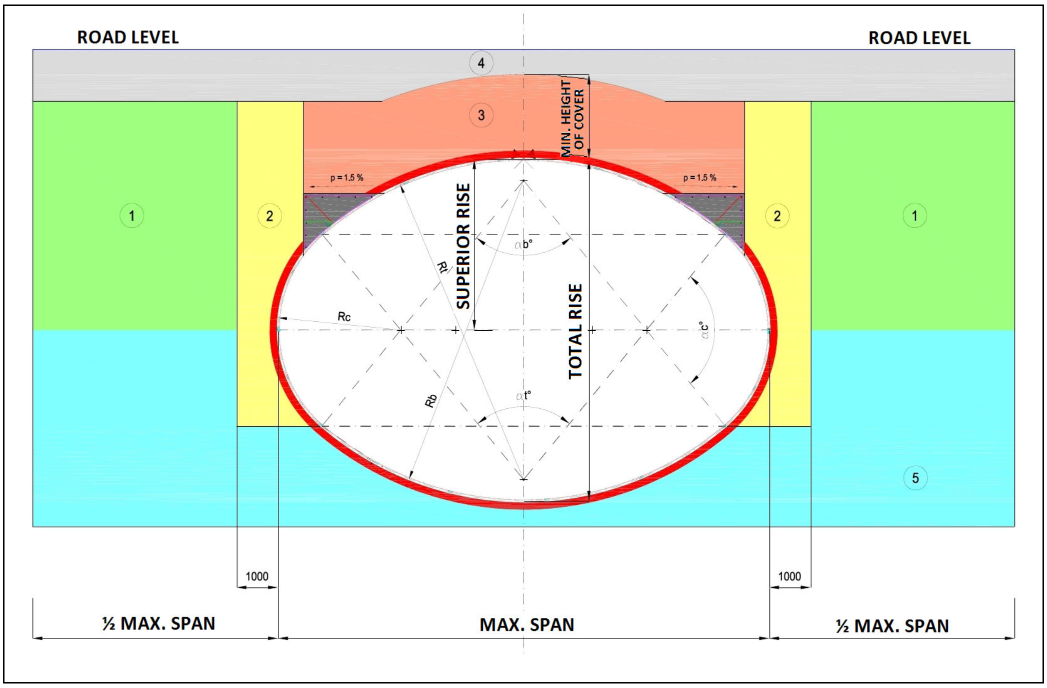
In case of multiple installations in parallel lines the technical block must have side banks of a width of at least 1.50 ÷ 2.00 m. (**lt**) (3.00 ÷ 5.00 m.), for structures with spans ≥ 8.00 m.) and in any case banks width will be sufficient to permit compaction machinery transit.

The side walls of the trench must be judged both suitable for offering enough counter force to the force transmitted by the metal structure to the technical backfill surrounding it, and being suitable for compaction of the backfill itself.

If it is not, the walls must be reclaimed by excavating any material thought to be unsuitable and replacing it with material that conforms to the specifications of technical bock.

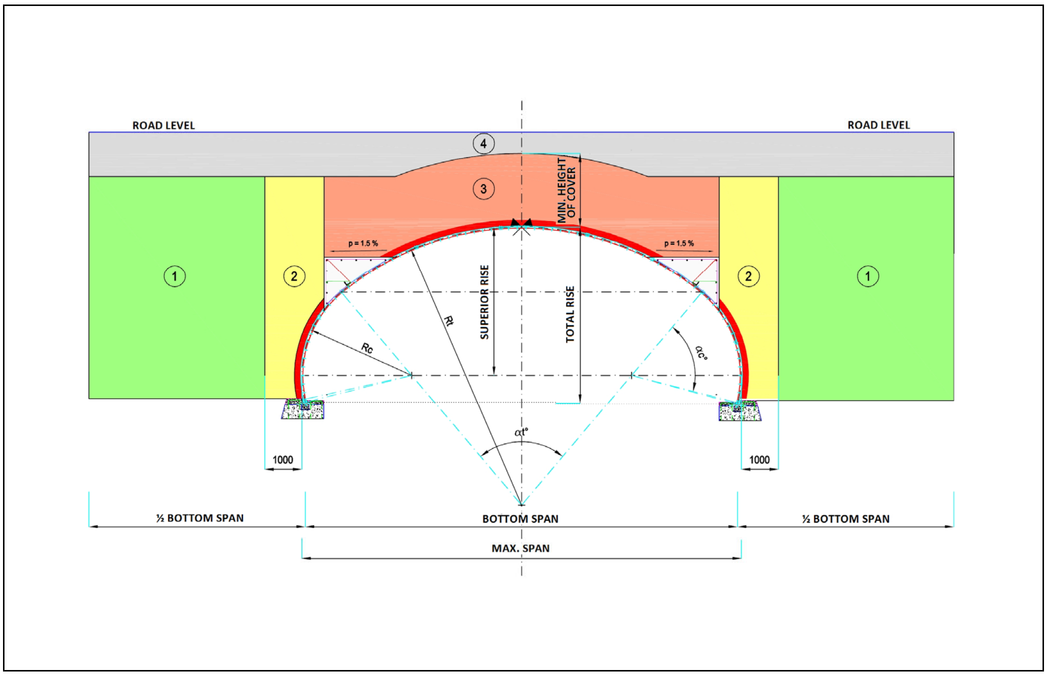
Each layer shall be compacted at the following density (test method T-99) :

Item	Type and dimensions of compaction vehicles	Standard Density Proctor
1	Dynapac/ingersol – Rand or Sheeps-Foot Static Type: Vibrating Compaction Rollers	90 %
2	Bomag 90 or similar machineries for compaction	90 %
3	Manually operated machine type Bomag 35 or similar one with mass ≤ 500 kg.	85 %
4	Sheeps-Foot Static Type – Tractor type Drawn or similar one recognized with mass ≤ 9000 kg.	90 %
5	Dynapac/ingersol – Rand or Sheeps-Foot Static Type: Vibrating Compaction Rollers	85 %
6	“**Ht**” single-size material with a max. diameter of 5 mm. for a layer around the culvert of 20 cm., compacted with manual vibrating	

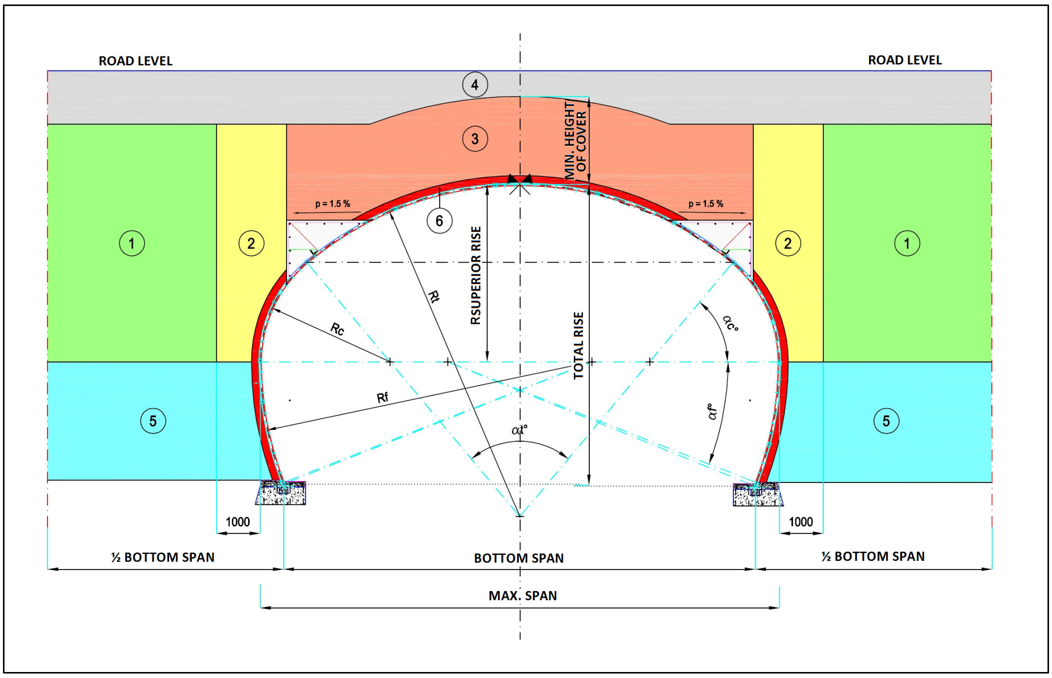


Structure backfill design – Horizontal Elliptical Section (HPE)

No compaction machineries or methods generating horizontal and vertical pressures on the ground causing excessive twisting or damages to the steel structure shall be used.



Structure backfill design – Raised Arch Section (LPA)



Structure backfill design – Raised Arch Section (HPA)

5.3 Special Applications

5.3.1 Protecting the ends

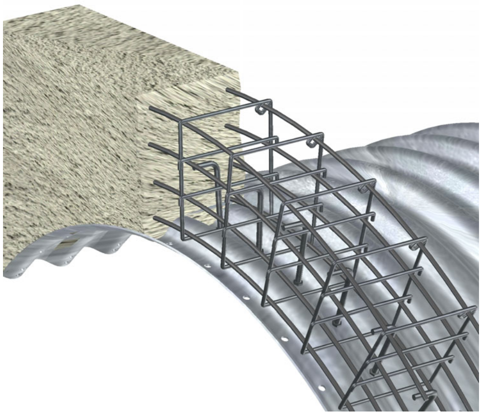
The ends of culverts installed under backfill with a longitudinal axis at right angles or at an angle in relation to that of the roadway, can be cut according to the slope of the embankment of the backfill itself in order to follow the shape of the road.

At these ends, because of the cut the complete culvert ring end is missing and consequently so this affects the design to rimg compression theory.

Therefore to prevent the deformation of these ends, the free length of cut of the structure must be kept within acceptable limits, taking into account the skew angle between the longitudinal axis of the culvert and the axis of the roadway (measured counter clockwise) between: 70° ≤ skew ≤ 110° .

These ends need structures subject to special studies, such as collar beams in reinforced concrete anchored to the metal structure by means of anchor bolts.

The purpose of the collar beam in reinforced concrete is to prevent the cut metal parts at the end of the pipe from flexing towards the inside of the structure, due to the thrust of the soil that makes up the backfill at the ends of the structure.

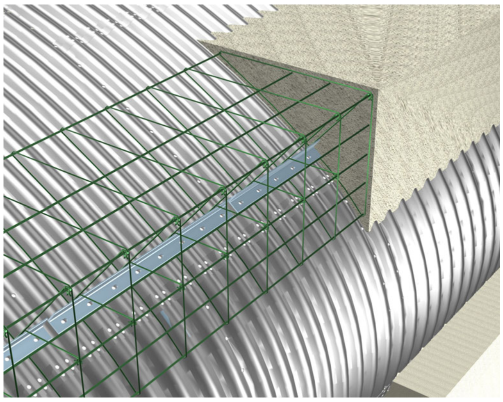


If the culverts are used for hydraulic applications, the ends of the structures must be protected by head-walls in reinforced concrete and draft mats for the entry and exit of water from the pipes, in order to prevent the compacted backfill surrounding the culvert from being washed out.

The curving radius of the top plates of this type of culvert is generally bigger than the one of an arch or multi-radii culvert having the same span.

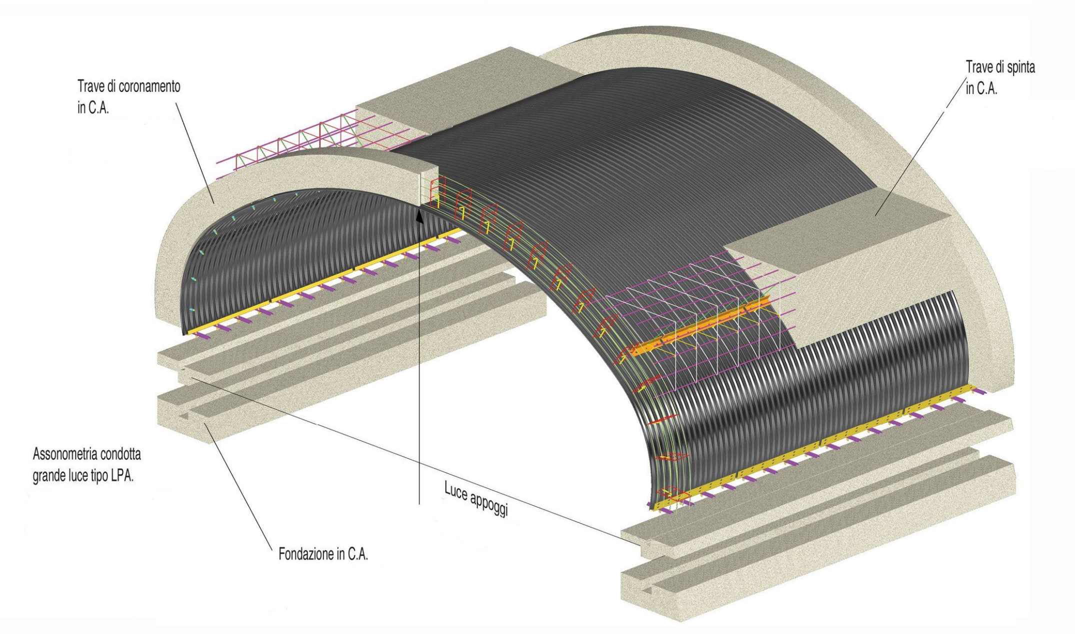
This peculiarity combined with the fact that these metal structures are mainly used for large spans makes sure that their top is particularly suitable to the concentrated loads that can be applied during the carrying out and the compaction of the high part of the side embankments.

For this reason and in order to allow the suitable and essential compaction in the side backfills, the triangular section r.c. thrust beams shall be made.

A crown beam shall be carried out by the cuts forming the planymetric curves for curves junction.

A connecting closing steel plate shall also be foreseen for concrete containment.
The reinforcing bars of the r.c. thrust beams shall be extended to the r.c. crown beams (steel structure ends), and to the r.c. crown beam (cut junction of planimetric curves).



The reinforcing bars of the a.m. r.c. crown beams shall be extended to the foundation casting of the structure.

The reinforcements and the sizes of thrust beams and concrete collars that will be indicated in TUBOSIDER final drawings are the minimum necessary ones in order to make a correct installation of the steel structure.

Reinforcement should be improved adherence type B450C, while the concrete shall have a minimum resistance Rck minimo di classe C25/30.

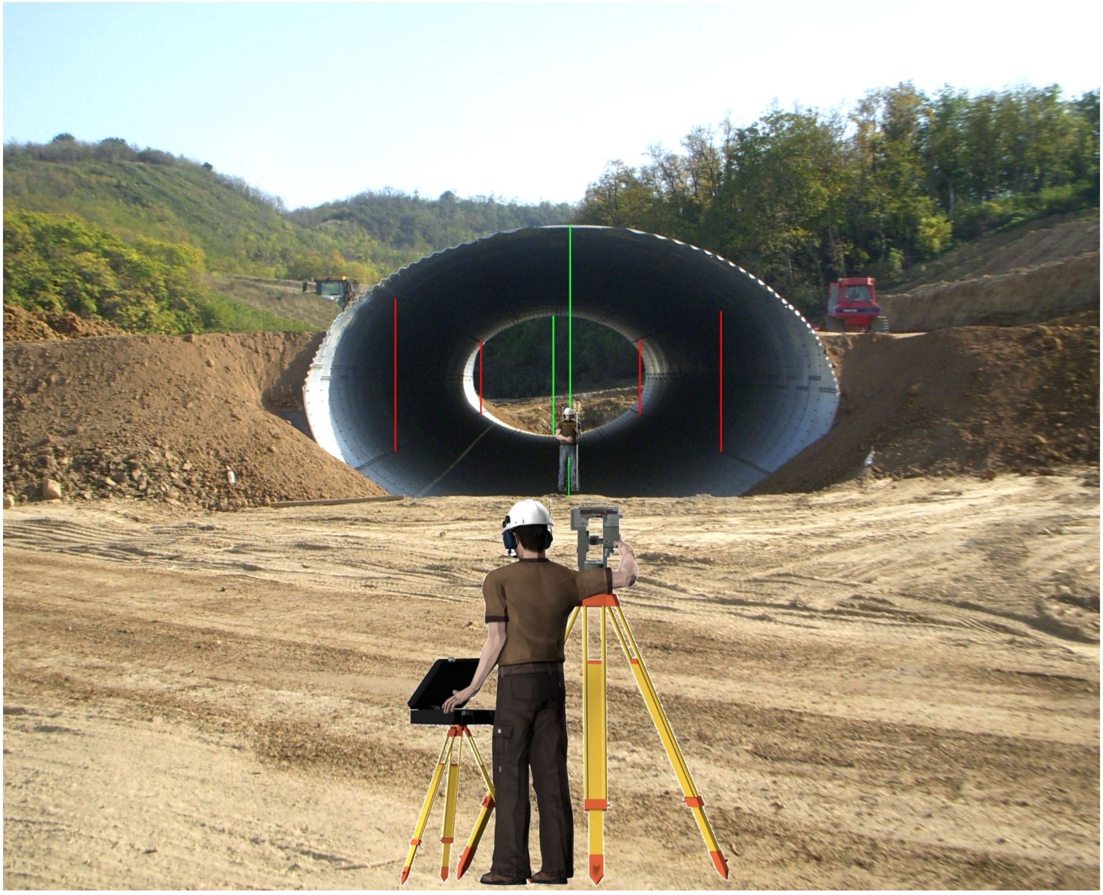
6.0 CHEKCS

6.1 Dimensions of culverts

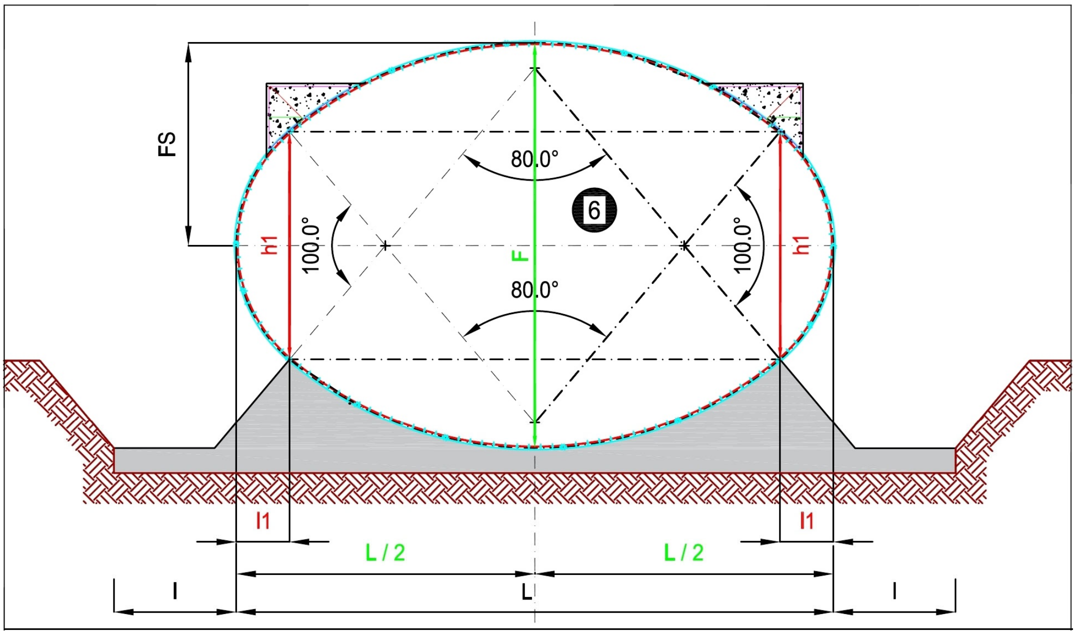
While placing and compacting the backfill, the dimensions of the structure must be checked in order to prevent excessive deformation.

This check can be carried out through a system of measurements taken during the backfilling phase, to identify horizontally and vertically at various points of the structure the dimensional variations compared to the theoretical measurements of the pipe and those found once assembly is complete (i.e. before commencing backfilling).

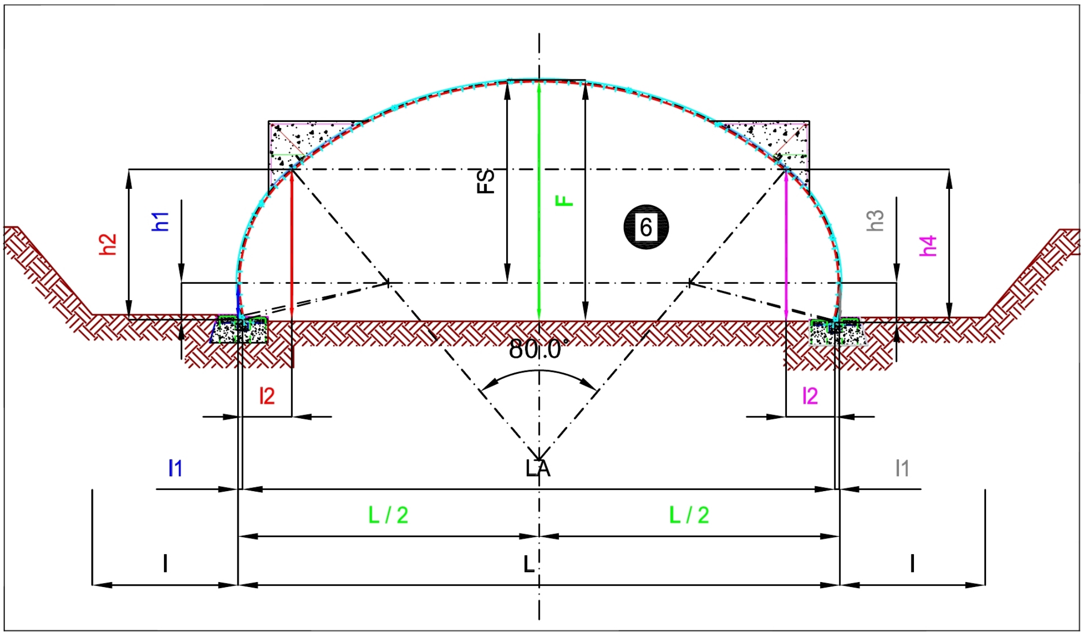
Normally plumb lines are dropped inside the arch at various key points of the structure, which with constant monitoring during the burial phase allow the side shifts (right-left) of the structure axis and the vertical drops and rises in the crown of the structure to be evaluated, at the same time permitting adjustments to the compaction to correct these deformations.



Alternatively, you can use topographic measurement tools with qualified personnel.

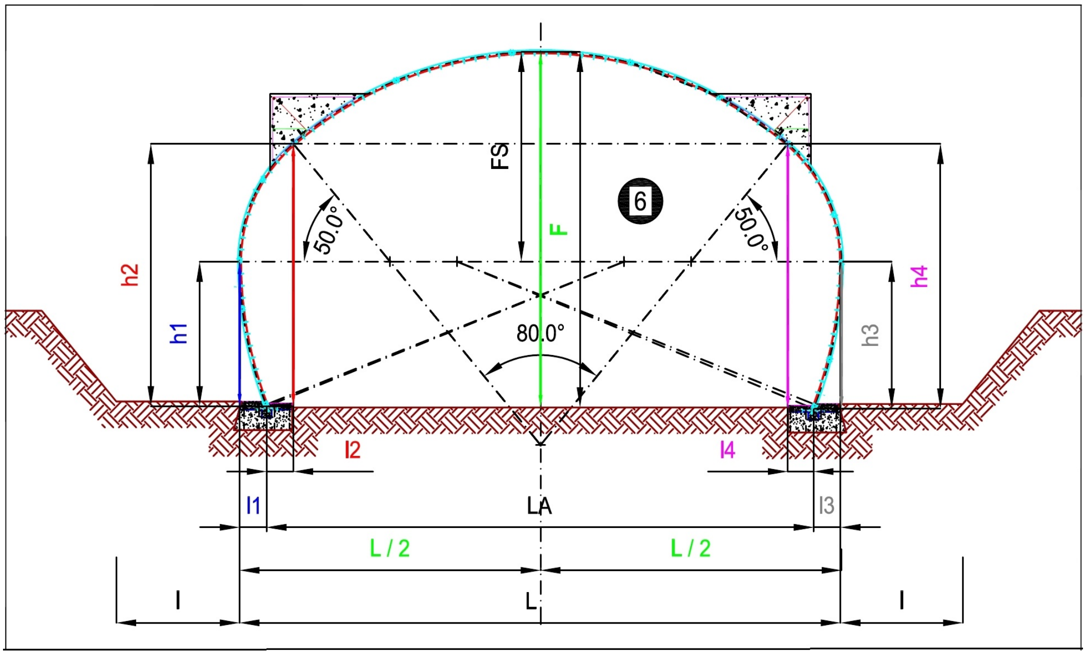


6 plumb lines positioning
l 1.50 ÷ 2.00 m. Min. (3.00 ÷ 5.00 m. in case of structures with span ≥ 8.00 m.)
L culvert span – horizontal size
L/2 culvert half span – horizontal size
F culvert total rise – vertical size
FS culvert upper rise – vertical size
h1 vertical size
l1 horizontal size



6 plumb lines positioning
l 1.50 ÷ 2.00 m. min. (3.00 ÷ 5.00 m. in case of structures with span ≥ 8.00 m)
L culvert max. span – horizontal size

L/2	culvert half span – horizontal size
LA	culvert span at the base – horizontal size
F	culvert total rise – vertical size
FS	culvert upper rise – vertical size
h1/h2/h3/h4	vertical size
l1/l2	horizontal size



6	plumb lines positioning
l	1.50 ÷ 2.00 m. min. (3.00 ÷ 5.00 m. in case of structures with span ≥ 8.00 m)
L	culvert max. span – horizontal size
L/2	culvert half span – horizontal size
LA	culvert span at the base – horizontal size
F	culvert total rise – vertical size
FS	culvert upper rise – vertical size
h1/h2/h3/h4	vertical size
l1/l2	horizontal size

Checking the dimensions, to be carried out by the Director of Works, should prevent that during the backfilling phase the culvert becomes so deformed as to change the shape of the structure from its theoretical one with the tendency of the structure walls to lose their original curving radius.

In particular it is necessary to prevent the formation of cusps towards the interior of the structure, that is, rotations of the plates at the joints providing bolted to re-tighten, where necessary, the bolts of joint that may be subject to loosening during burial.

With reference to the backfilling diagrams for the structure and compaction of the technical block, we emphaisize once again that, in laying and compacting layers of soil, deformations of the metal structure could take place limited to below 2 % of the theoretical rise of the culvert.

Greater deformations can be attributed purely to incorrect formation of the technical block.

The steel structure is in any case able to flexibly withstand deformations below 3 % of the true rise of the culvert.

For the express purpose of preventing any technical problems or even exceeding the prescribed deformation limits, the dimensions of the culvert must be measured when forming the technical block (before, during and after), in order to monitor the behaviour of the structure.

6.2 Compaction and load bearing capacity of the technical block

Checking the quality and perfomance of the technical block must be carried out by means of laboratory tests on the materials used to create it and, on site, on each individual finished layer, once laid and compacted.

A check must be made that the backfill material size distribution conforms to what is prescribed in the chapter of technical block, taking samples of material to be subjected to laboratory tests aimed at identifying geometric, mechanical and chemical properties.

The Proctor compaction test, modified according to AASHTO, on the materials that form the technical block must be verified in the laboratory according to EN 13286-2 and then confirmed on site, with samples taken of each layer, using suitable equipment for measuring the density on site (for example: calibrated sand method).

It must be ascertained that the density on site reaches at least 85 ÷ 90 % (according to previous instructions) of the maximum found in the laboratory.

The load bearing capacity of the soil must also be measured for each individual layer of soil by means of a load test on a circular plate aimed at verifying the modulus of elasticity of the soil, the pressures and yield.

Depending on the length of the culvert and of the number of layers, a relative number of samples and tests must be carried out.

A minimum number of tests for each layer of soil laid should in any case be carried out.

Documentation regarding the tests carried out and the succession of works phases (photographic documentation) must be kept and made available in the event of any structural malfunctions in order to identify better the possible causes and solutions.

6.3 Deformation under load

The vertical drop of a culvert is an important parameter to take into account when determining the camber to be applied in the mid point, or when there is the need to limit deformation of the structure or to prevent a vertical drop in the surface soil.

It is a good rule to take the vertical deformation of the structure as being equal to the vertical drop of the ground.

The vertical drops of the soil, under a given load, can only be determined by a knowledge of the tension – deformation ratio of the soil itself.

It is therefore essential to know the modulus of elasticity of the soil in relation to the compaction to be carried out during installation, the loads and the consequent pressures caused by the height of the backfill.

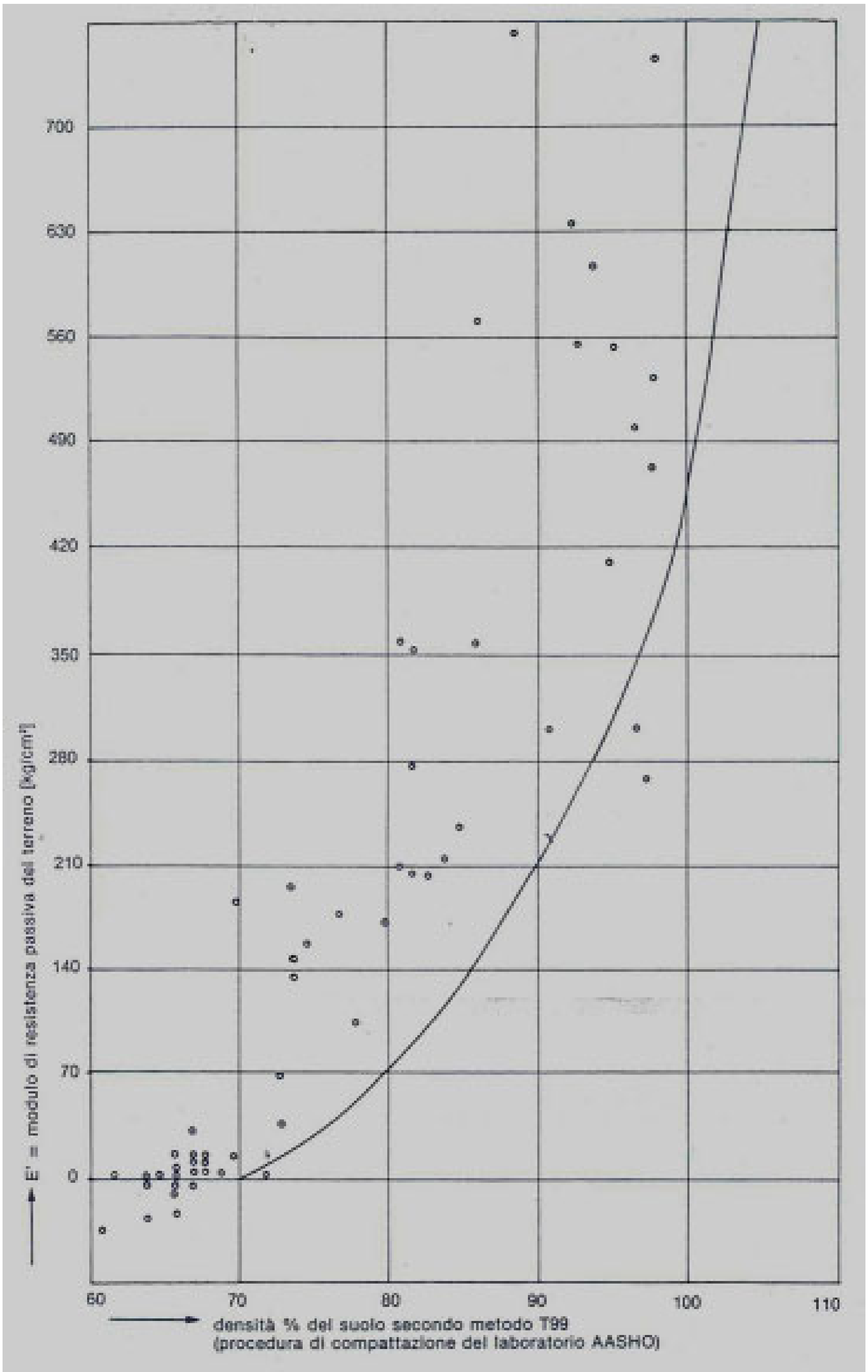
The maximum culvert deformation according to the Spangler-Jowa formula is calculated as follows:

$$\eta = Fd \cdot Fk \quad \frac{W \cdot r^3}{(E \cdot I) + 0.061 \cdot (E' \cdot r^3)}$$

where:

- η culvert deformation
- **Fd** 1.25 soil creep coefficient
- **Fk** 0.1 installation angle constant
- **r** radius or ½ span of the culvert
- **W** 2r (PS+PD) K vertical load per longitudinal centimetre of culvert
- **PS** static load (kg./cm^2)
- **PD** dynamic load (kg./cm^2)
- **I** moment of inertia of the corrugation (cm^4/cm.)
- **E** 2039400 modulus of elasticity of the steel (kg./cm^2)
- **E’** compressibility modulus of the soil (taken from the graph that follows)

For installations of significant importance it is better to take the value of **E’** depending on the results of the laboratory tests on the soil samples actually used to obtain the Standard Proctor compaction required.


700
630
560
490
420
350
280
210
140
70
0
E' = modulo di resistenza passiva del terreno [kg/cm²]
60
70
80
90
100
110
densità % del suolo secondo metodo T99
(procedura di compattazione del laboratorio AASHO)

7.0 RESPONSIBILITY

The sizing of the metal structures in corrugated steel is carried out following the project characteristics indicated by the client.

The calculations used follow the Construction Science criteria with special reference to calculation theories developed on these structures, and in accordance with the applicable laws.

The height "**H**" of the covering backfill, referred to the top of culvert, is always specified by **TUBOSIDER**:

- in the catalogue for standard production culverts;
- in special technical documentation enclosed with the sales contract for culverts not in the catalogue.

The following fall outside the responsibility of **TUBOSIDER**, and are the client's responsibility:

- an evaluation of the load bearing capacity of the soil on which the structure will be laid;
- the choice of materials that make up the technical block, and their placing;
- execution of the burial phases, and the relative compaction of the technical backfill;
- observation of the directions given in this manual.

The presence of a **TUBOSIDER** representative on site in no way absolves the client from the above stated responsibilities.

8.0 CERTIFICATE OF CONFORMITY OF THE FACTORY PRODUCTION CONTROL

IGQ

ISTITUTO ITALIANO DI GARANZIA DELLA QUALITÀ

Certificate of conformity of the factory production control

1608 CPR P126

In compliance with Regulation 305/2011/EU of the European Parliament and of the Council of 9 March 2011 (the Construction Products Regulation or CPR), this certificate applies to the constructions product:

Steel structural components
Steel corrugated plates for load bearing structures

whose characteristics are detailed in the attached annex,

produced by or for

Tubosider Spa

Corso Torino, 236 14100 Asti - IT

and produced in the manufacturing plant(s)

CBS Monticello d'Alba CN - IT

This certificate attests that all provisions concerning the assessment and verification of performance described in Annex ZA of the standard

EN 1090-1:2009+A1:2011

under system 2+ are applied and that

the factory production control fulfils all the prescribed requirements set out above.

This certificate was first issued on **20/12/2012** and will remain valid as long as the test method and/or factory production control requirements included in the harmonized standard, used to assess the performance of the declared characteristics, do not change, and the product, and the manufacturing conditions in the plant are not modified significantly.

Current issue: **25/06/2018**

The Director
Ing. Dario Agalbato

Sede IGQ - 20126 Milano - Viale Sarca, 223 - Tel. 02 6610 1348 - Fax 02 6610 8409 - info@igq.it - www.igq.it

9.0 APPENDIX TO CERTIFICATE 1608 CPR P126

IGQ

ISTITUTO ITALIANO DI GARANZIA DELLA QUALITÀ

APPENDIX TO CERTIFICATE **1608 CPR P126**

Design[1)] and manufacture of multiplate corrugated steel for load bearing structures according to EN 1090-1

Product name	Standard	Class of steel	Class of execution	Sizes	Delivery condition
Steel corrugated plates	EN 1090-2	EN 10025-2: S235JR EN 10149: up to S355 MC	EXC2	T70 - T100 -T150 - T200	Hot dipped galvanizing in accordance to EN ISO 1461
Bolts and threaded bars in accordance to Tubosider Spa drawing	Screw EN ISO 898-1 Nut EN ISO 898-2	Class of resistance 8.8		From M12 to M20	

Note 1): The applicability of the design shall be checked in compliance with the technical rules of each EU Member State.

first issue: **20/12/2012**
current issue: **25/06/2018**

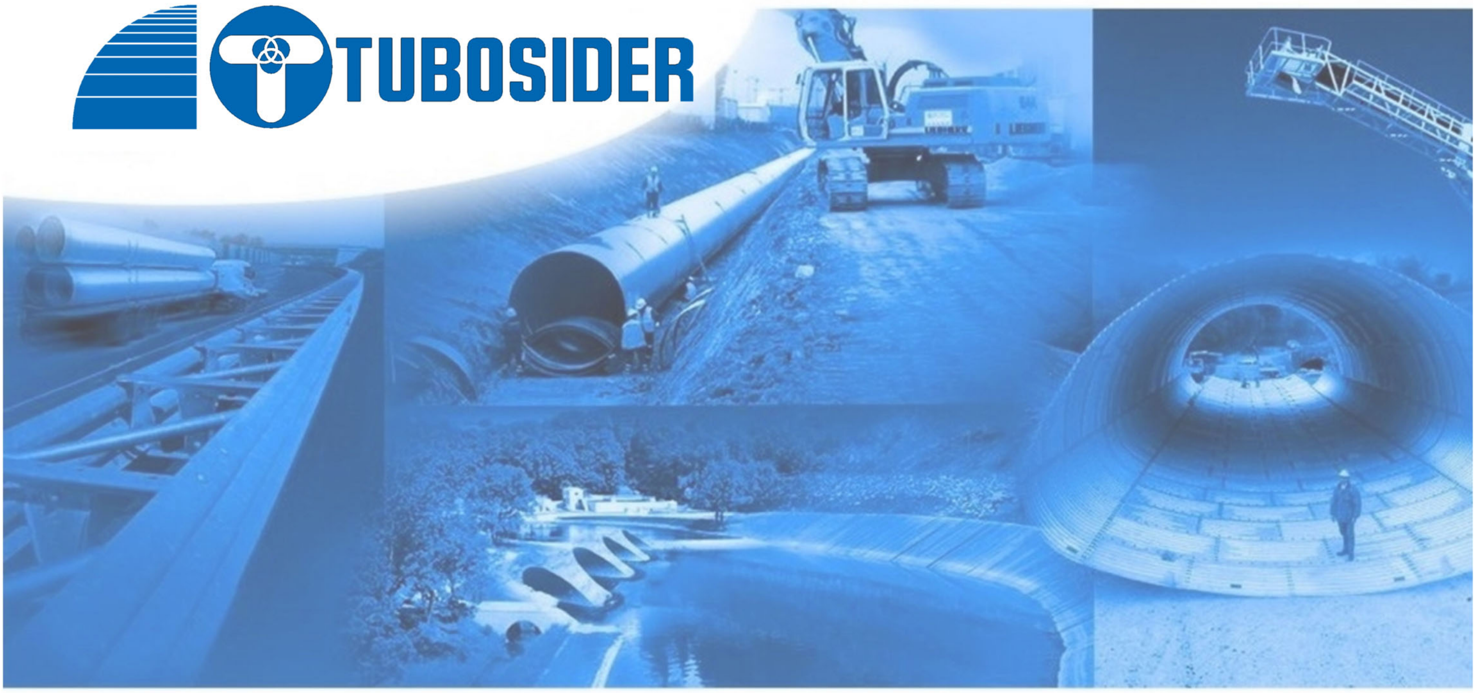
Il Direttore
ing. Dario Agalbato

Dario Agalbato

Sede IGQ - 20126 Milano - Viale Sarca, 223 - Tel. 02 6610 1348 - Fax 02 6610 8409 - info@igq.it - www.igq.it

10.0 NOTE

TUBOSIDER



"As the product is subject to continuous improvements, it is recommended that the user, before ordering, verifies with the Technical Department if the information contained in this document is updated".

Sede Legale:
S.S. 231 n. 8/A - 12066 Monticello d'Alba (CN) Italia
Tel. +39 0141 418411 - Fax +39 0141 211373

Stabilimento:
. Reg. S. Antonio, 71 - 12066 Monticello d'Alba (CN) Italia
Tel. +39 0173 64715 - Fax +39 0173 64184

PREMIO CIVILTÀ DEL LAVORO

Cod.Fisc. e P.IVA 03141780019
P.IVA Intracomunitaria IT 03141780019
Cap. Soc. Delib., Sott. e Versato € 10.000.000,00
Iscrizione Reg. Imprese Cuneo al n. di Cod. Fisc. 03141780019
Iscrizione R.E.A. della C.C.I.A.A. Cuneo al n. 218830
Tubosider S.p.A.
società soggetta alla direzione ed al coordinamento di Itinera S.p.a.

E-mail: info@tubosider.it
Web: www.tubosider.it