

Fortezza da Basso • FLORENCE (Italy)

30th September • 2nd October 2019

Recent developments of GRP solutions in the booming transportation market

Laurent Hesters<sup>1</sup> and Marc Sadok <sup>2</sup>

- <sup>1</sup> Head of Application Engineering, Amiblu France
- <sup>2</sup> Sales Manager France, Tempe, Amiblu France



#### TRANSPORT SECTOR

Recent significant development of GRP open cut and particularly trenchless pipe solutions has been notified in one of the world's largest industries, the transportation market:

- Roads to motorways,
- Airports,
- High speed and freight railways,
- Urban tramways,
- Multimodal platforms

Massive investments for new and existing infrastructures are made all over the world ensuring efficient, long lasting and environmentally friendly transport systems









Among the significant advantages of trenchless GRP solutions, we can mention:

- Tailor made solution (Pipe profile shape, Jacking Pipe Thickness),
- GRP Mechanical features and Design in line with severe service conditions,
- Installation simplicity (Bell and spigot coupling system, reduced weight...)
- Long life expectancy (long term strength, corrosion and abrasion resistance)















#### **GRP SOLUTION – CASE STUDY**

GRP Solution and associated method will be studied based on two examples :

- JACKING PIPE PROJECT, "TAC CHATENAY MALABRY" TRAMWAY (FRANCE),
- REHABILITATION OF NON-CIRCULAR CORRUGATED METAL CULVERTS UNDER A9/A61 HIGHWAY (FRANCE)



### **GRP SOLUTION – JACKING PIPE PROJECT, "TAC CHATENAY MALABRY" – TRAMWAY (France)**

### **Project Presentation**

- Part of a larger project of the future T10 tramway implying urban reconfiguration work and update of the water network, especially in the sections located under the future tramway,
- The need to minimize the construction impact in a very dense urban area, the depth of work located on average at 12 m underground, the geotechnical parameters and the presence of numerous existing adjacent water networks imposed the choice of micro tunneling,
- Initially planed with two drives of about 500 meters in DN 2000
- Project includes connections to the existing network, as well as the installation of a dozen of lateral access to facilitate operations and maintenance of the collector.



### **GRP SOLUTION – JACKING PIPE PROJECT, "TAC CHATENAY MALABRY" – TRAMWAY (France)**

### **Project Presentation**

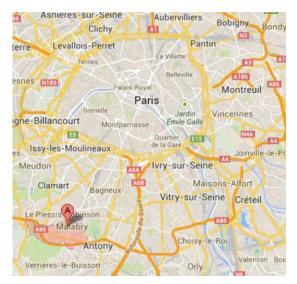




Figure 1 - Vue aérienne du site - source ARTELIA

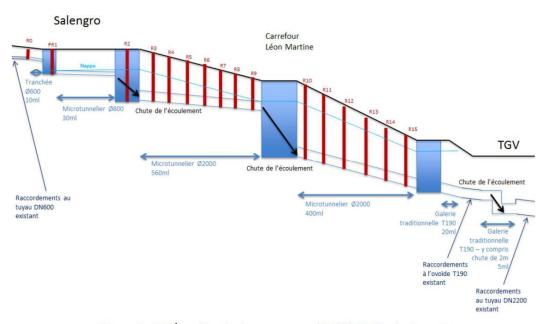


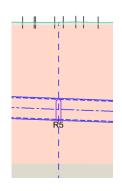
Figure 2 - Schéma de principe -source - ARTELIA Etude de projet



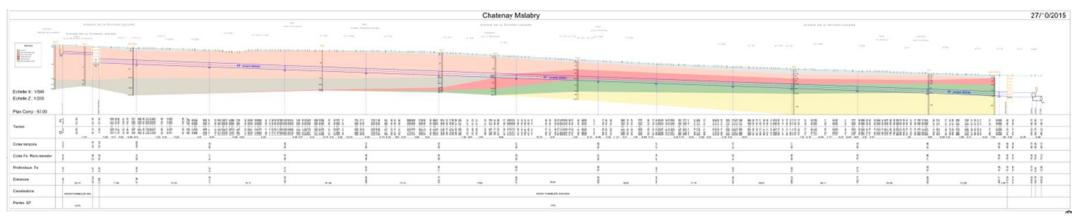
### **GRP SOLUTION – JACKING PIPE PROJECT, "TAC CHATENAY MALABRY" – TRAMWAY (France)**

## **Project Presentation / New Records**

The contractor formulated an interesting alternative by proposing a single drive, with only one starting
pit and one receiving pit, reducing the impact of the construction site, its duration and the associated
costs.



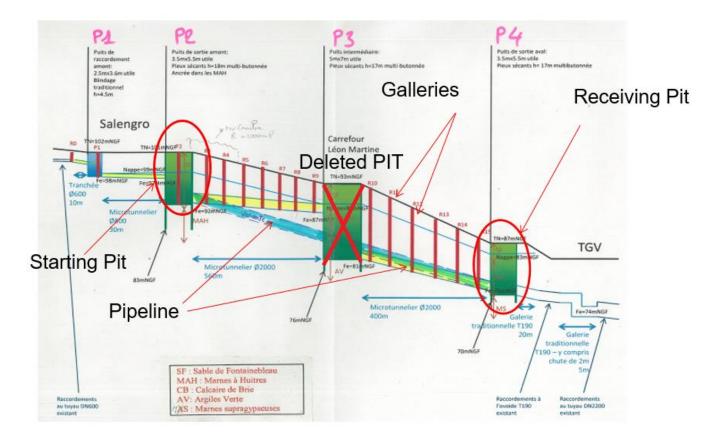
- French Record in length for a rectilinear jacking installation with GRP Jacking pipe DN 2160 mm : 928 m





## **GRP SOLUTION – JACKING PIPE PROJECT, "TAC CHATENAY MALABRY" – TRAMWAY (France)**

**Project Presentation / New Records** 





**GRP SOLUTION – JACKING PIPE PROJECT, "TAC CHATENAY MALABRY" – TRAMWAY (France)** 

**GRP Product : Hobas GRP Jacking Pipe** 

- GRP Jacking Pipes OD2160/ID2000 Unit Length 3m thickness 79mm
- Allowable jacking force 9020 KN (incl. 3,5 SF).
- High compression strength: 90 Mpa
- Weight 1134 kg/m
- Compatibility with AVN 1800 Herrenknecht







**GRP SOLUTION – JACKING PIPE PROJECT, "TAC CHATENAY MALABRY" – TRAMWAY (France)** 

**Product Standard** 

#### ISO 25780:2011

Plastics piping systems for pressure and non-pressure water supply, irrigation, drainage or sewerage -- Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin -- Pipes with flexible joints intended to be installed using jacking techniques

Product Standard Providing Admissible Jacking Force Design

150 25780:2011(6

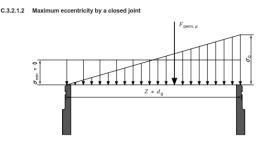
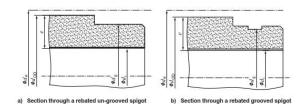
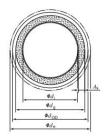


Figure C.4 — Closed joint — Maximum eccentricit

#### ISO 25780:2011(E)





c) Cross-section through spige



## **GRP SOLUTION – JACKING PIPE PROJECT, "TAC CHATENAY MALABRY" – TRAMWAY (France)**

#### The Drive

- Total length of the drive 928 m
- 7 intermediate jacking stations installed. Only 3 IJS were used
- Maximum Jacking Force reached during the drive: 6000 kN
- Usual working pushing force: 3000 kN



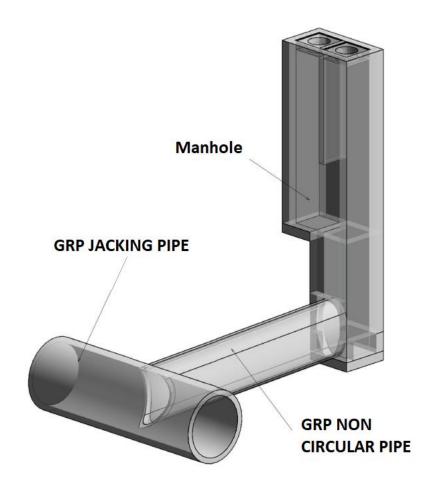




## **GRP SOLUTION – JACKING PIPE PROJECT, "TAC CHATENAY MALABRY" – TRAMWAY (France)**

### **Lateral Connections**

- 15 perpendicular 6-meter long galleries dug to create access to the network from the sidewalk
- Galleries were relined with non-circular (NC) ovoids made of GRP.
- A perfect continuity of the mechanical resistance and tightness between the collector and the galleries (4m of water table above the pipe crown)
- Ensuring the stability of the assembly in the very long term



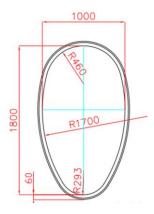


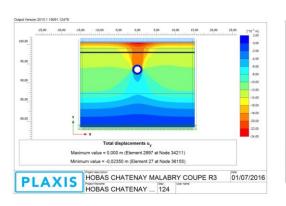
GRP SOLUTION – JACKING PIPE PROJECT, "TAC CHATENAY MALABRY" –

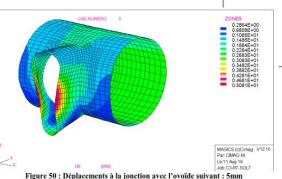
TRAMWAY (France)

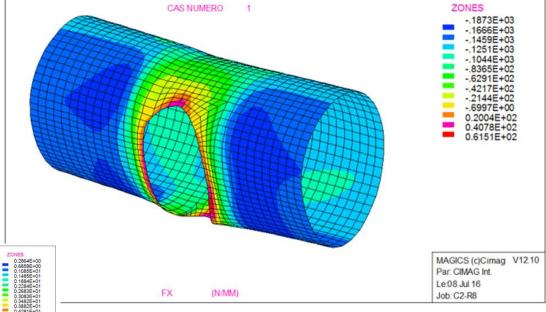
### **Design Method**

- 3D Soil/Structure Interaction Model
- TSAI WU Failure Criterion (Composite Material)





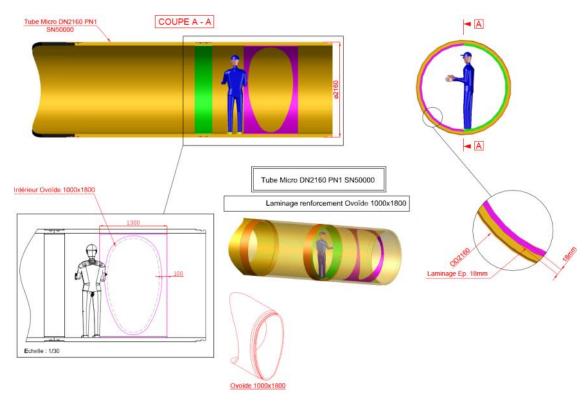






### **GRP SOLUTION – JACKING PIPE PROJECT, "TAC CHATENAY MALABRY" – TRAMWAY (France)**

## **Lateral Connections STEP N°1: Pipe Reinforcement**





© Copyright 2019 IATT. All rights reserved. Full or partial reproduction is prohibited.



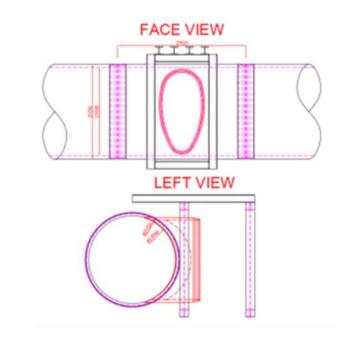
**GRP SOLUTION – JACKING PIPE PROJECT, "TAC CHATENAY MALABRY" – TRAMWAY (France)** 

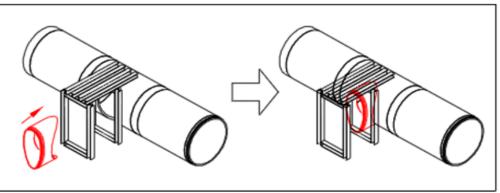
**Lateral Connections STEP N°2: Pipe Cutting and N.C. connection installation** 











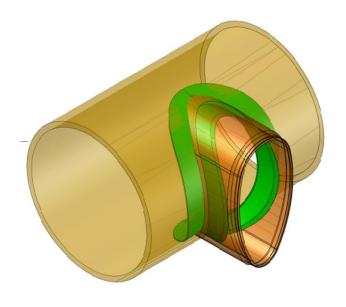


**GRP SOLUTION – JACKING PIPE PROJECT, "TAC CHATENAY MALABRY" – TRAMWAY (France)** 

Lateral Connections STEP N°3: To Laminate the "T" Connection

- Internal leak tight laminates reinforcement
- realized on site by Amiblu technical staff
- https://www.youtube.com/watch?v=6ZUxk7opcN4

Lateral Connections STEP N°4: Gallery/GRP pipe annular space Grouting







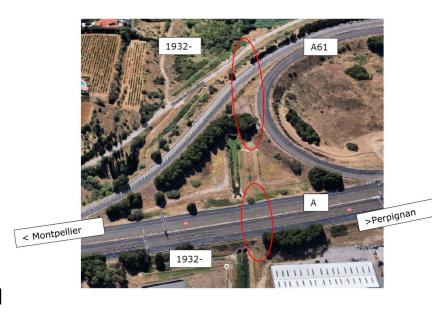
## GRP SOLUTION – REHABILITATION OF NON-CIRCULAR CORRUGATED METAL CULVERTS UNDER A9/A61 HIGHWAY (FRANCE)

**Project Presentation / Configuration** 

ARMCO / HAMCO Corrugated Metal Culverts arch profile 4040m x 2840 mm

Length: 2x65m + 2x130m

Pipe diagnostic underlines that the corrugated metal culvert is locally deformed and significantly corroded, so it is classified as STATE III according French Recommendation 3R2014. Worst culvert deformations reduced the cross section to  $w = 3,75m \times h = 2,58m$ 





## GRP SOLUTION – REHABILITATION OF NON-CIRCULAR CORRUGATED METAL CULVERTS UNDER A9/A61 HIGHWAY (FRANCE)

### **Project Presentation / Configuration**



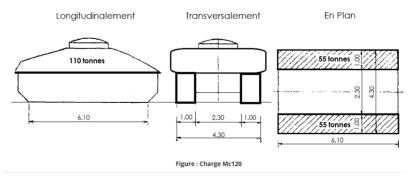


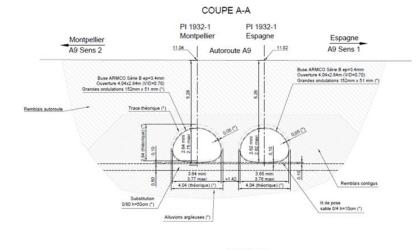


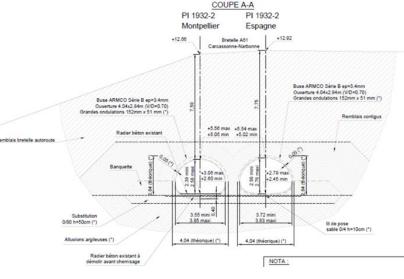
## GRP SOLUTION – REHABILITATION OF NON-CIRCULAR CORRUGATED METAL CULVERTS UNDER A9/A61 HIGHWAY (FRANCE)

### **Project Presentation / Loads**

- Cover depths: 5,2 m to 7,8 m
- worst traffic model for the highest and lowest cover depths: Military System Mc 120 (110 t) according to Fascicule N°61 (French National Document)
- Ground Water Hydrostatic Pressure: according 3R2014 Equal to the highest level reached by the water table, can not be lower than 0,5m above the lining top or 1,5m above the lining bottom (whatever is the greatest value).









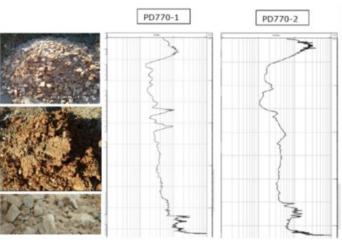
## GRP SOLUTION – REHABILITATION OF NON-CIRCULAR CORRUGATED METAL CULVERTS UNDER A9/A61 HIGHWAY (FRANCE)

### **Project Presentation / Geotechnical Context**

In situ geotechnical investigations were made to define different soil layers properties.to define the surrounding environment of the existing pipe (Nature, Specific weight, E-Modulus "Ménard pressuremeter test", Poisson's ratio, friction

angle, cohesion, water table levels...).







## GRP SOLUTION – REHABILITATION OF NON-CIRCULAR CORRUGATED METAL **CULVERTS UNDER A9/A61 HIGHWAY (FRANCE)**

#### **Product Standard**

#### ISO 16611:2017

Plastics piping systems for drainage and sewerage without pressure -- Noncircular pipes and joints made of glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resins (UP) -- Dimensions, requirements and tests

**Product Standard** 

#### ISO 16611:2017(E)

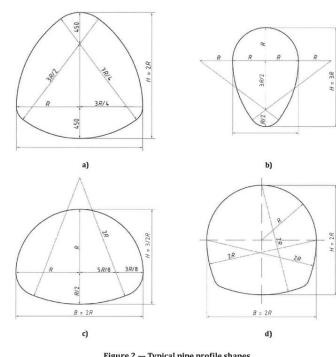


Figure 2 — Typical pipe profile shapes

## GRP SOLUTION – REHABILITATION OF NON-CIRCULAR CORRUGATED METAL CULVERTS UNDER A9/A61 HIGHWAY (FRANCE)

**Product : Amiblu GRP Non Circular Pipe Profile** 

Non-Circular GRP Profiles is then geometrically designed and model according its mechanical Properties described in the Standard ISO 16611 "Plastics piping systems for drainage and sewerage without pressure -- Non-circular pipes and joints made of glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resins (UP) -- Dimensions, requirements and tests".

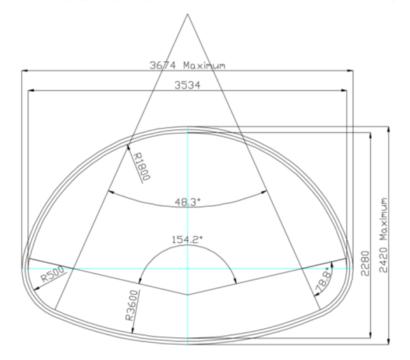
Arch Shape Pipe Profile: 3534mm x 2280mm – Thickness: 40mm



#### Non-circular, glass fiber reinforced plastics profiles (NC Line)

Value	Unit	Standard	Material Property (Mechanical properties refer to structural laminate without liner)	No
~9500	MPa	ISO 178	Short-term bending modulus	1
6000	MPa	ISO 10468	Long-term bending modulus	2
200	MPa	ISO 178	Short-term bending strength	3
80	MPa		Long-term bending strength	4
0.8	%	ISO 10952	Long-term bending strain (strain corrosion)	6
18	MPa	ISO 8513	Short-term longitudinal tensile strength	7
	N/mm	ISO 8513	Longitudinal tensile force (unit tensile strength)	8
~90	MPa	ISO 8521	Short-term hoop tensile strength	9
0.3	mm	CEN/TR 157299)	Abrasion test	10

#### Non-circular GRP profiles (NC Line)





## GRP SOLUTION – REHABILITATION OF NON-CIRCULAR CORRUGATED METAL CULVERTS UNDER A9/A61 HIGHWAY (FRANCE)

#### **New Method**

« Nouvelles Recommandations pour le Dimensionnement de la Réhabilitation par Chemisage et Tubage des Réseau d'Assainissement », ASTEE 2014

**Product Standard** 

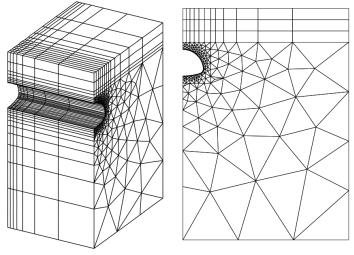


Figure 33. Exemple d'un maillage 3D (modélisation des charges de trafic) et 2D (modélisation des actions permanentes)

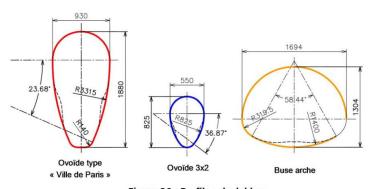


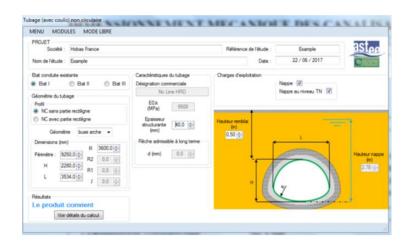
Figure 26: Profils calculables

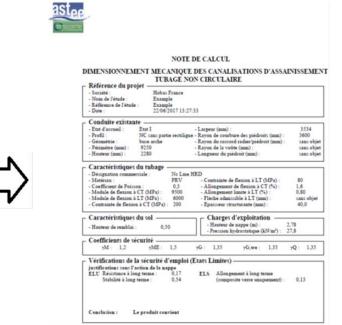


## GRP SOLUTION – REHABILITATION OF NON-CIRCULAR CORRUGATED METAL CULVERTS UNDER A9/A61 HIGHWAY (FRANCE)

### **Design Method**

Finite Element calculation has been then realized according to the French Recommendations 3R2014.



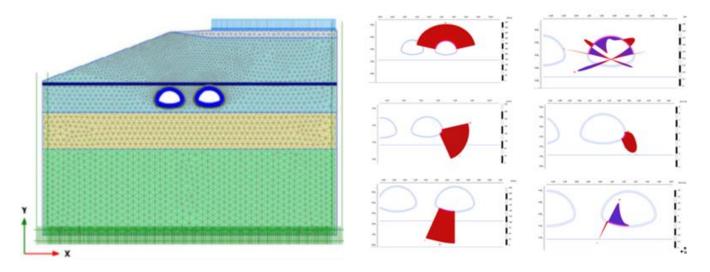




## GRP SOLUTION – REHABILITATION OF NON-CIRCULAR CORRUGATED METAL CULVERTS UNDER A9/A61 HIGHWAY (FRANCE)

### **Design Method**

Finite Element calculation has been then realized according to the French Recommendations 3R2014.



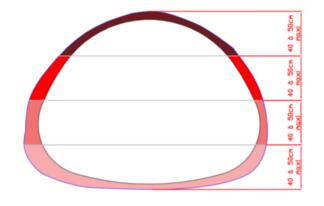


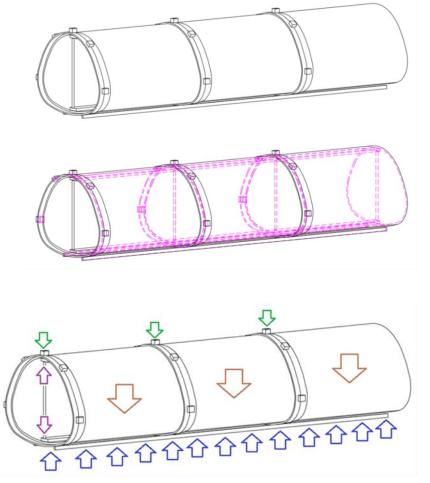
## GRP SOLUTION – REHABILITATION OF NON-CIRCULAR CORRUGATED METAL CULVERTS UNDER A9/A61 HIGHWAY (FRANCE)

#### **Installation Recommendations**

Installation. Avoid GRP panel significant deformation due to buoyancy resulting force during grout injection (liquid grout)



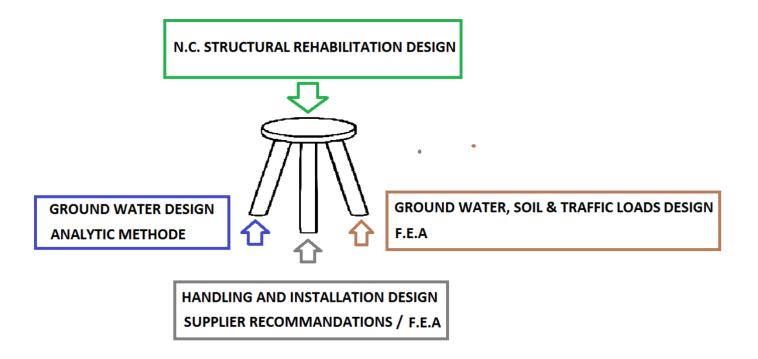






GRP SOLUTION – REHABILITATION OF NON-CIRCULAR CORRUGATED METAL CULVERTS UNDER A9/A61 HIGHWAY (FRANCE)

GRP thickness definition is based on short term installation and long term design





## GRP SOLUTION – REHABILITATION OF NON-CIRCULAR CORRUGATED METAL CULVERTS UNDER A9/A61 HIGHWAY (FRANCE)

#### Installation









## GRP SOLUTION – REHABILITATION OF NON-CIRCULAR CORRUGATED METAL CULVERTS UNDER A9/A61 HIGHWAY (FRANCE)

### **Operation Complete**









## GRP SOLUTION – REHABILITATION OF NON-CIRCULAR CORRUGATED METAL CULVERTS UNDER A9/A61 HIGHWAY (FRANCE)

### **Operation Complete**





© Copyright 2019 IATT. All rights reserved. Full or partial reproduction is prohibited.



#### **CONCLUSION**

Digging up and/or replacing old underground pipeline systems is often an expensive choice, with aggravating conditions in urban areas (i.e. disruptions to traffic and to the landscape). Trenchless methods usually provide a more cost and time effective solution.

Glass fiber reinforced plastics is particularly suitable for to suit trenchless technology and provides a long-lasting high corrosion resistant pipeline solution.

## Finally,

- The recent Standards associated to N.C. GRP pipe (ISO 16611 2017) and to GRP Jacking pipe (ISO 25780 2011)
- The recent published national methods for trenchless GRP design as the French 3R2014 recommendations (ASTEE 2014)
- and the increasing use of Finite Element Modeling

enables to provide optimized tailor-made GRP solution in the context of the present booming transportation market.