



POST-TENSIONING INSTITUTE  
*Stressing the Stronger Concrete Solution™*

## 2015 PTI CONVENTION

### Strengthening of Pont de l'Europe with PT Products

Dipl.-Ing. Werner Brand, Technical Director, DYWIDAG Systems International GmbH



*Local Presence – Global Competence*

# Content of Presentation



## Introduction

---



## Project Description

---



## Strengthening with Bars

---



## Strengthening with External Tendons

---



## Conclusion

---

# European Technical Approval acc. to CPD

- The Construction Product Directive **CPD 89/106/EEC** from 1988 was introduced to abolish market barriers in EU by harmonization of European standards and of European Technical Approvals (ETA) for not standardized construction products.
- CE-marking of construction products and also of PT-kits became the basis for their free movement within the European Community – European "passport" for products.
- CE-marking for PT-system kits required obtainment of
  - European Technical Approval (ETA)
  - EC Certificate of Conformity



# European Technical Assessment acc. to new CPR

- The Construction Product Regulation CPR (EU) No 305/2011 from March/April 2011 repeals the CPD from 1988. CPR is a stricter legislative act than CPD was. It aims for simplification and clarification of former Directive. CE-marking approval should become less slow and costly and should provide simplified processes for small enterprises.

came into effect on **1<sup>st</sup> of July 2013**

- European Technical Approvals became European Technical Assessments
- CE-marking is still the basis for free movement of products within EC but now is compulsory.



# European Technical Assessments for PT-systems

- ETAGs have been converted to EAD's – European Assessment Documents. Content are still testing provisions and provisions for attestation and evaluation of conformity.
- ETAss can be obtained at certified Technical Assessment Bodies (TAB – mostly former Approval Bodies).  
No change in testing and assessment  
No European consultation/circulation  
International organization of TABs
- Existing ETApp's are still effective for validity time and can be transferred into ETAss's
- EC Certificate of Conformity is basis for CE-marking and Declaration of Performance
- External surveillance system to be continued

The image displays two documents related to European Technical Assessments for PT-systems.

**Top Document: EOTA Guideline ETAG 013**  
 EOTA (European Organisation for Technical Approvals) logo and name in English, German, and French.  
 Title: GUIDELINE FOR EUROPEAN APPROVAL of POST-TENSIONING K PRESTRESSING OF STF (These are commonly called Post-Tensioning).  
 Edition: June 2002.  
 EOTA address: Kunstlaan 40 Avenue, B-1040 Brussels.

**Bottom Document: European technical approval ETA-13/0815**  
 Issued by: Österreichisches Institut für Bautechnik (OIB), Member of EOTA.  
 Title: European technical approval ETA-13/0815.  
 English translation, the original version is in German.  
 Trade name: DYWIDAG-Strand.  
 Holder of approval: DYWIDAG-Systeme International GmbH, Desrouchesstraße 68, 80716 München, Deutschland.  
 Licensee: Litzenpannenverf. Vorspannen von 1.  
 Bonded post-tensioning with 3 to 55 strands.  
 Validity: from 28.06.2013 to 27.09.2016.  
 Manufacturer: DYWIDAG-System, Max Planck-Ring 1, 40764 Langenfeld, Deutschland.  
 This European technical approval consists of 58 pages including 58 pages including.

**Right Document: EC Certificate of Conformity 0432-CPD-11 9241-21/1**  
 Issued by: MATERIALPRÜFUNGSAMT NORDRHEIN-WESTFALEN (MPA NRW).  
 Title: EC Certificate of Conformity 0432-CPD-11 9241-21/1.  
 In compliance with Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products (the Construction Products Directive or CPD), as later amended. It has been stated that the construction product.  
 Bonded post-tensioning kit for prestressing of structures with 3 to 55 strands.  
 placed on the market by: DYWIDAG-Systeme International GmbH, Desrouchesstraße 68, D-80798 München.  
 and produced in the factory: DYWIDAG-Systeme International GmbH, Max Planck-Ring 1, D-40764 Langenfeld.  
 It is submitted by the manufacturer to a factory production control and to the further testing of samples taken at the factory in accordance with a prescribed test plan and that the notified body No. 0432 – MPA NRW – has performed the initial type-testing for the relevant characteristics of the product, the initial inspection of the factory and of the factory production control and performs the continuous surveillance, assessment and approval of the factory production control and an audit testing of samples taken at the factory, on the market or at the construction site.  
 This certificate attests that all provisions concerning the attestation of conformity and the performances described in the ETA-13/0815 from 28.06.2013 were applied and that the product fulfils all the prescribed requirements.  
 This certificate was first issued on 30.06.2013 and remains valid as long as the conditions laid down in the harmonised technical specification in reference to the manufacturing conditions in the factory or the FPC itself are not modified significantly or latest on the expiry date of ETA-13/0815 on 27.09.2016.  
 Issued at: Dortmund, 30.06.2013.  
 Signature: Dipl.-Ing. G. Glöckner, Head of Certification Body.  
 The original of this document was issued in German language. In case of doubt only the German version is valid.  
 MPA NRW – Materialprüfungsamt Nordrhein-Westfalen – Telefon: +49 (0)211 4932-0 – Telefax: +49 (0)211 4932-49 – Internet: www.mpa-nrw.de

# Content of Presentation



Introduction

---



**Project Description**

---



Strengthening with Bars

---



Strengthening with External Tendons

---

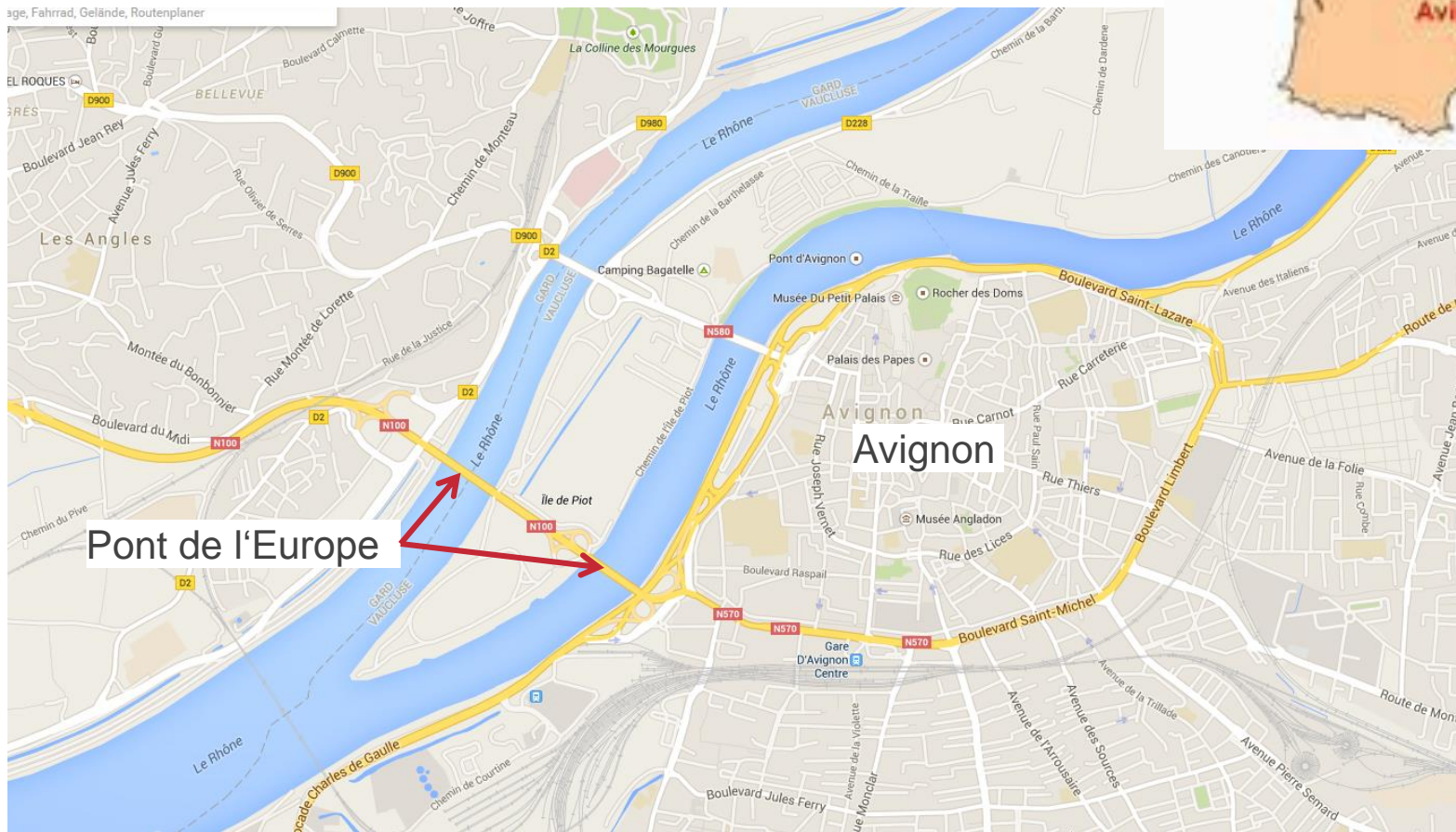


Conclusion

---



# Pont de l'Europe, Avignon, France



# Pont de l'Europe – Strengthening Project

2 identical bridges were built in line between 1973 and 1975 in Avignon, France over the Rhône River



The structural designers did not expect a higher traffic volume, currently up to 55.000 vehicles per day!



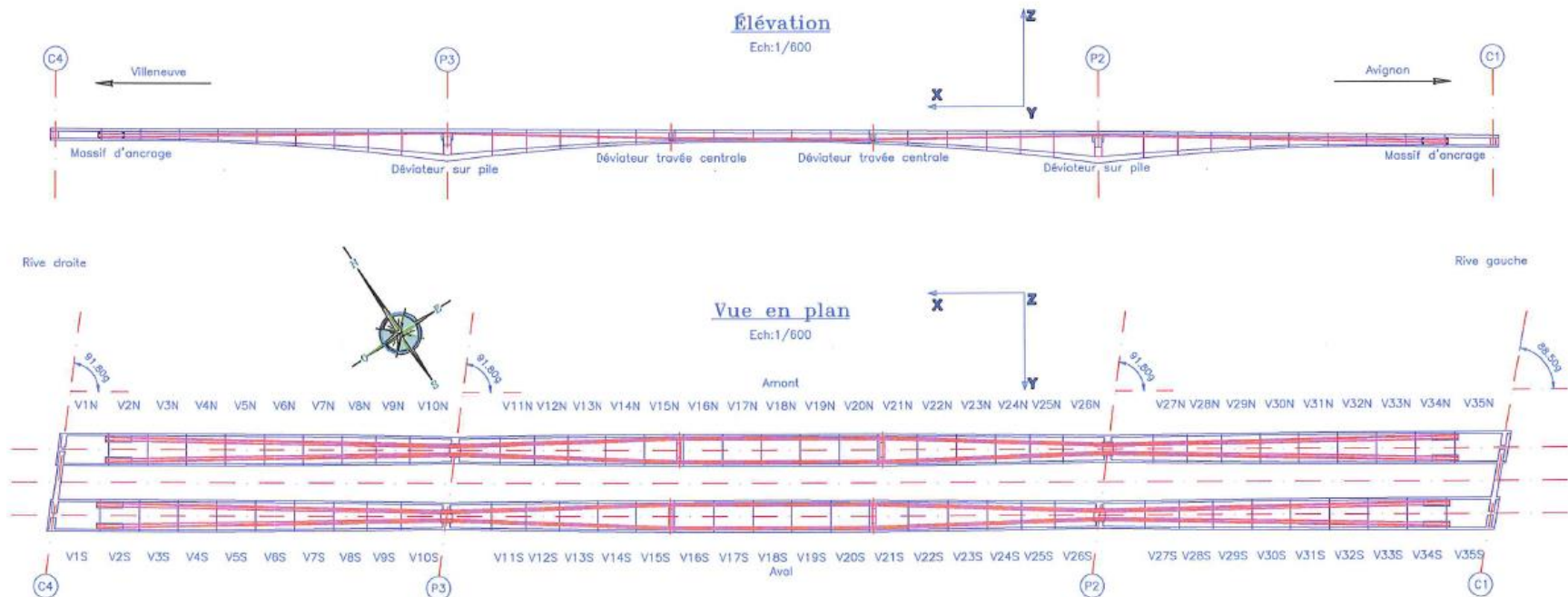
Related strengthening with external tendons was necessary!



# Pont de l'Europe – Strengthening Concept with PT Products

Bridge consists of a 3 span continuous box girder with variable height  
Cross section: 2 independent single box girders next to each other

- Increase shear capacity of box girder with bar tendons
- Strengthening with 6 external tendons in each box girder
- Connect new concrete anchor blocks for external tendons to existing concrete with bar tendons



# Content of Presentation



Introduction

---



Project Description

---



**Strengthening with Bars**

---



Strengthening with External Tendons

---



Conclusion

---

# ETA-05/0123 – Bar tendons

- Bonded bar tendons
  - Internal unbonded bar tendons
  - External bar tendons
- 
- Threadbar Type WR: Sizes 18 – 47 mm
  - Plain bar Type WS: Sizes 32 and 36 mm
- 
- Tensile strength 1050 N/mm<sup>2</sup>



Österreichisches Institut für Bautechnik  
Schenkenstrasse 4 | 1010 Vienna | Austria  
T +43 1 533 65 50 | F +43 1 533 64 23  
mail@oib.or.at | www.oib.or.at

**OiB**  
Member of EOTA

## European technical approval

**ETA-05/0123**

English translation, the original version is in German

Handelsbezeichnung

Trade name

**DYWIDAG – Stabspannverfahren**

*DYWIDAG – Post-tensioning bar tendon system*

Zulassungsinhaber

Holder of approval

**DYWIDAG-Systems International GmbH**

**Destouchesstraße 68  
80796 München  
Deutschland**

Zulassungsgegenstand und  
Verwendungszweck

Generic type and use of  
construction product

**Stabspannsystem für das Vorspannen von  
Tragwerken, intern mit und ohne Verbund sowie extern**

*Post-tensioning kit for prestressing of structures with bars,  
internal bonded and unbonded and external*

Geltungsdauer vom

Validity from

bis zum

to

**30.06.2013**

**29.06.2018**

Herstellwerk

Manufacturing plant

**DYWIDAG-Systems International GmbH**

**Max-Planck-Ring 1  
40764 Langenfeld  
Deutschland**

Diese Europäische technische  
Zulassung umfasst

*This European technical approval  
contains*

**77 Seiten einschließlich 39 Anhängen**

*77 Pages including 39 Annexes*

Diese Europäische technische  
Zulassung ersetzt

*This European technical approval  
replaces*

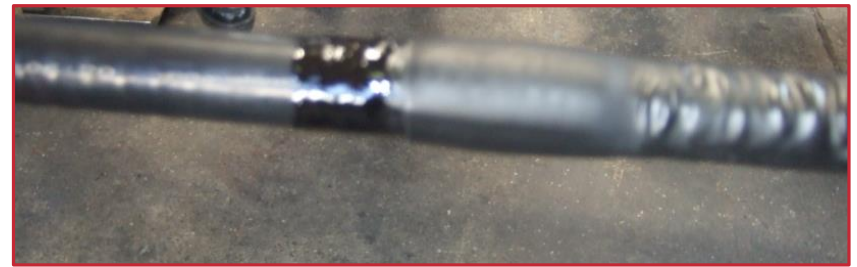
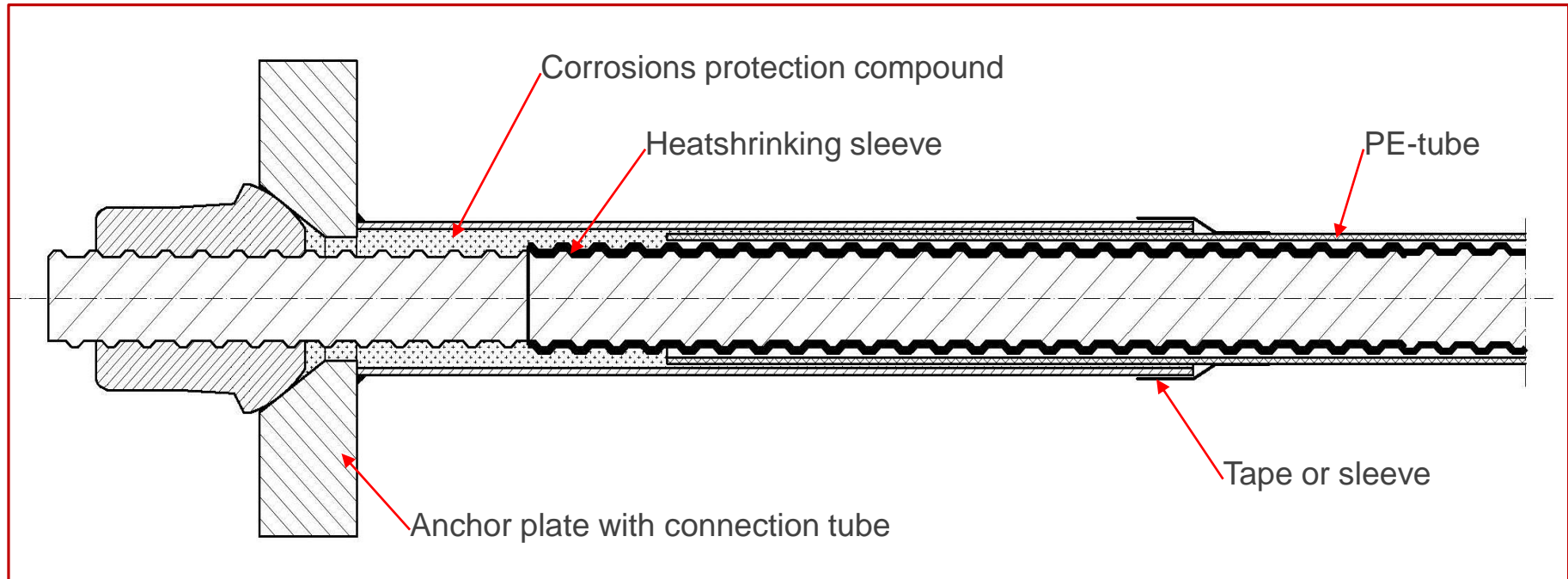
**ETA-05/0123 mit Geltungsdauer vom 14.11.2011 bis  
zum 18.09.2015**

*ETA-05/0123 with validity from 14.11.2011 to 18.09.2015*



European Organisation for Technical Approvals  
Europäische Organisation für Technische Zulassungen  
Organisation Européenne pour l'Agrément Technique

## Standard application for unbonded or external bar tendons: Corrosion protection with heatshrinking sleeve



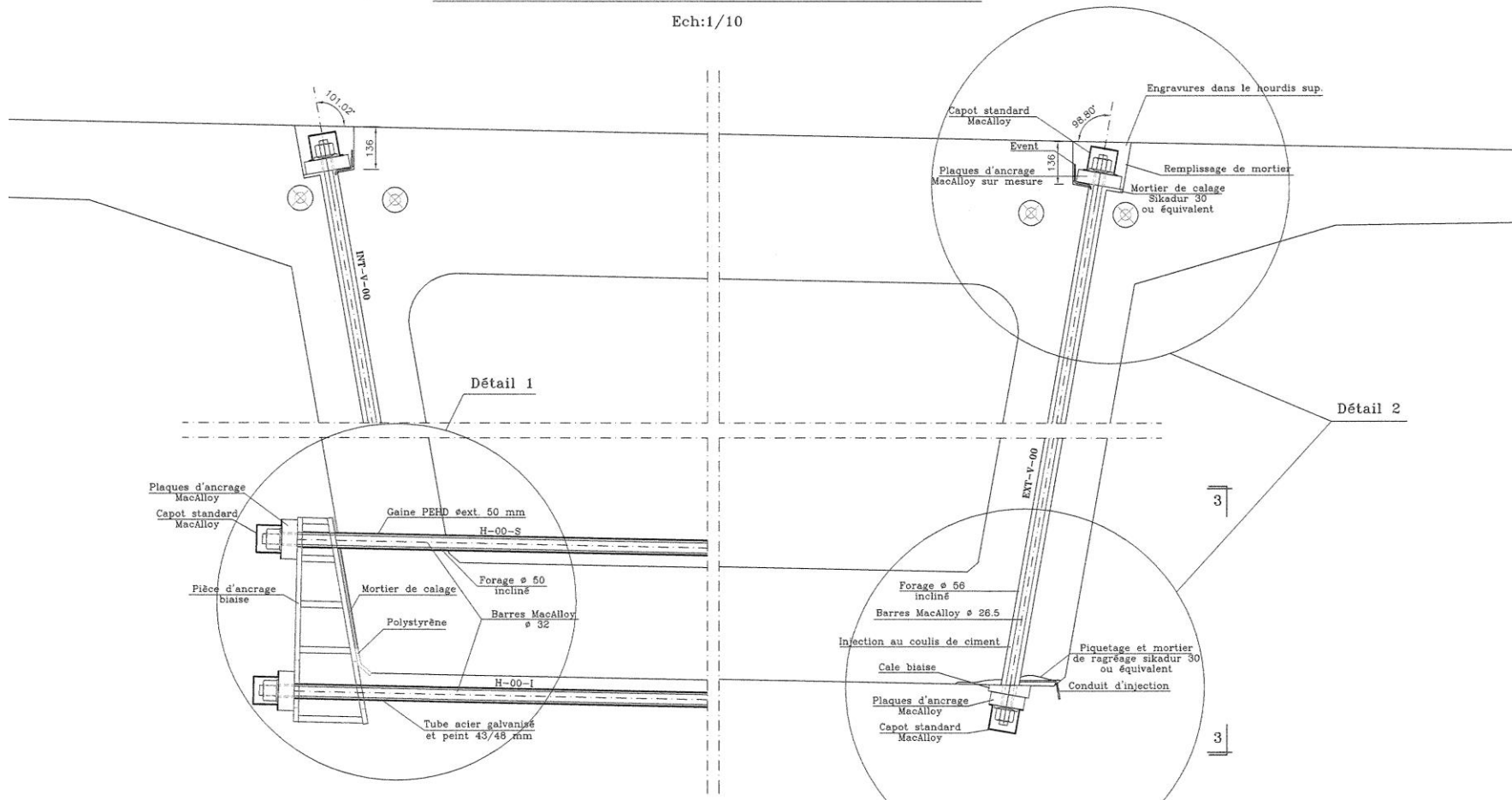


# Pont de l'Europe – Strengthening Project

## Shear strengthening with bar tendons

### Précontrainte transversale additionnelle

Ech:1/10



## Strengthening with transverse bar tendons WR 32



Transverse bar tendons in the inside of the box girder



Anchorage of the bar tendon at the outside of the box girder

## Strengthening with vertical bar tendons WR 26



Sealing cap on the driving surface



Sealing caps of the bar tendons on the bottom side of the box girders



# Strengthening of anchorage area for external tendons



Transverse and vertical bar tendons WR 36  
strengthen the anchorage area of the longitudinal  
external tendons





# Content of Presentation



Introduction

---



Project Description

---



Strengthening with Bars

---



**Strengthening with External Tendons**

---



Conclusion

---

# DYWIDAG External Tendons ETA 09/0068

- For up to 37 strands 0,62“, 1860 N/mm<sup>2</sup>
- For corrosion protection with grout or wax
- Restressable
- Exchangeable
- Encapsulated
- Working life 100 years

**Sétra**  
46, avenue Aristide Briand  
BP 100  
92 225 BAGNEUX CEDEX  
Tel: + 33 (0)1 46 11 31 31  
Fax: + 33 (0)1 46 11 31 69



**Agrément Technique Européen**  
(version originale en français)

**ETA-09/0068**

**European Technical Approval**  
(original version in French language)

**ETA-09/0068**

Nom Commercial:  
*Trade name:*

Procédé de précontrainte extérieure DYWIDAG  
*DYWIDAG External Strand Post-Tensioning System*

Détenteur de l'ATE:  
*ETA Holder:*

DYWIDAG-Systems International GmbH  
Dywidagstrasse 1  
85609 Aschheim  
DEUTSCHLAND

Type générique et utilisation  
prévue du produit de  
construction:  
*Generic type and use  
of construction product:*

Procédé de précontrainte par post-tension DYWIDAG avec câble  
extérieur de 3 à 37 torons (140 et 150 mm<sup>2</sup>)  
*DYWIDAG External Strand Post-Tensioning System for 3 to 37 Strands  
(140 and 150 mm<sup>2</sup>)*

Validité: *from*  
*to*

03/03/2009  
03/03/2014

Producteur du Procédé:  
*Manufacturing plant:*

DYWIDAG-Systems International GmbH  
Dywidagstrasse 1  
85609 Aschheim  
DEUTSCHLAND

Le présent ATE contient:  
*This ETA contains:*

45 pages incluant 25 pages d'annexes (dessins)  
*45 pages including 25 pages of annexes (drawings)*

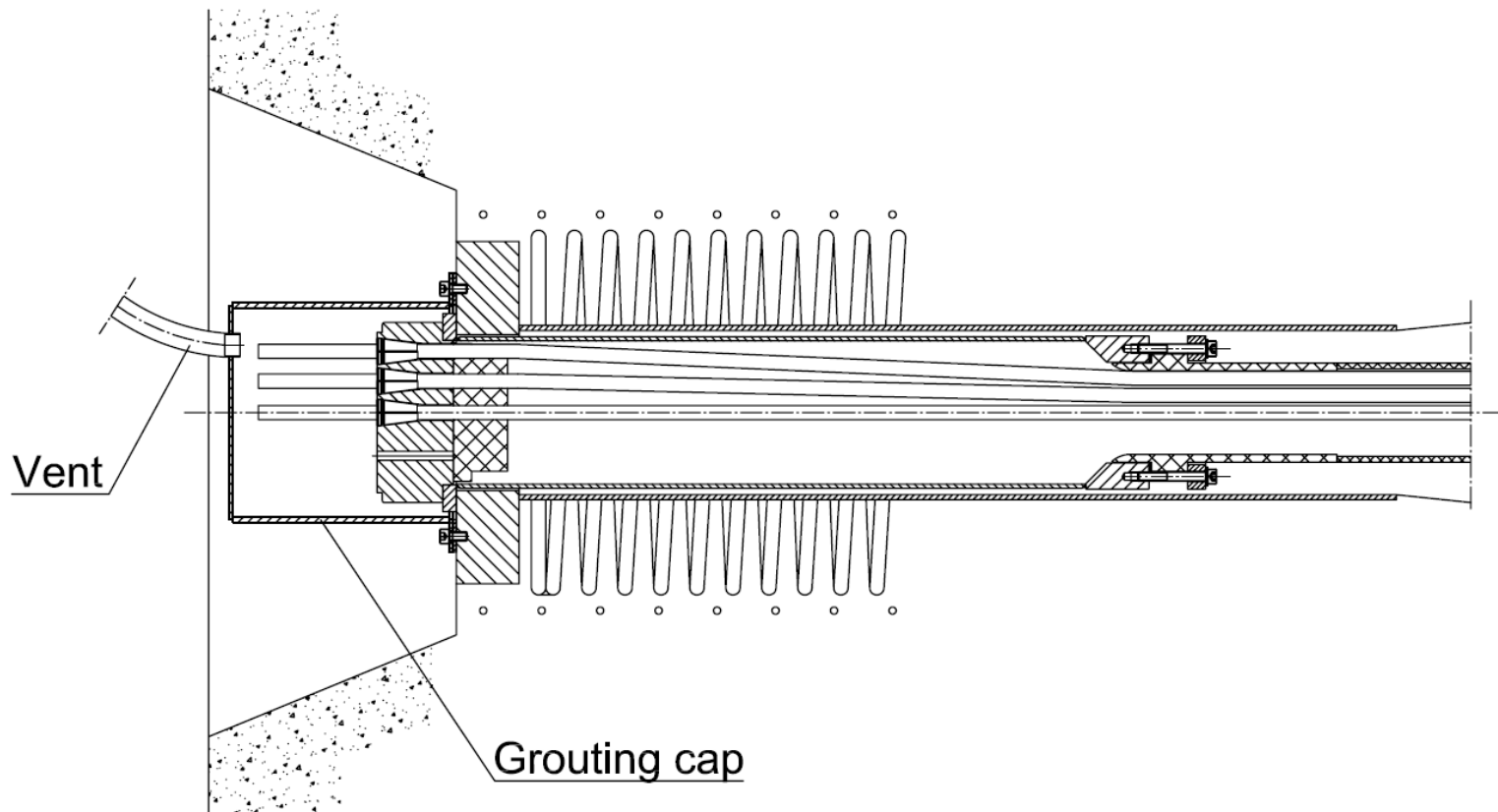


Organisation pour l'Agrément Technique Européen  
European Organisation for Technical Approvals

# Pont de l'Europe – Strengthening Project

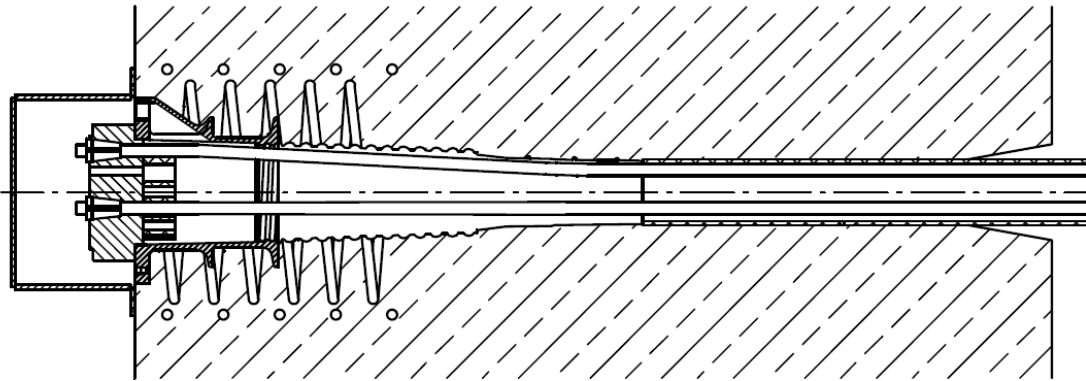
Anchorage of the tendons according to ETA-09/0068

## Stressing anchorage



# External Strand Tendon for hot wax injection – MA anchorage

## DYWIDAG external tendons according to ETA-13/0979



Service d'études sur les transports, les routes et leurs aménagements  
110 rue de Paris  
77171 Sourdun

Tel : + 33 (0)1 60 52 31 31  
Fax : + 33 (0)1 60 52 31 69



**Sétra**  
Service d'études  
sur les transports,  
les routes et leurs  
aménagements

MEMBRE DE L'EOTA

MEMBER OF EOTA

**European Technical Approval ETA-13/0979**  
(English language translation, the original version is in French language)

Nom commercial : Trade name :	Procédé de précontrainte extérieur DYWIDAG DYWIDAG External and Internal unbonded Strand Post-Tensioning System
Détenteur de l'ATE : Holder of approval :	DYWIDAG-Systems International GmbH Destouchesstrasse 68 80796 München DEUTSCHLAND
Type générique et utilisation prévue du produit de construction :	Procédé de précontrainte par post-tension DYWIDAG avec câble extérieur et intérieur non adhérent de 3 à 37 torons (140 et 150 m <sup>2</sup> ).
Generic type and use of construction product :	DYWIDAG External and Internal unbonded Strand Post-Tensioning System for 3 to 37 Strands (140 and 150 m <sup>2</sup> ).
Valid from: to:	27.06.2013 27.06.2018
Producteur du procédé : Kit manufacturer :	DYWIDAG-Systems International GmbH Max-Planck-Ring 1 40764 Langenfeld DEUTSCHLAND
Le présent agrément technique européen contient :	50 pages comprenant 27 pages de dessins faisant partie intégrante du document.
This European Technical Approval contains :	50 pages including 27 pages of drawings which form an integral part of the document.

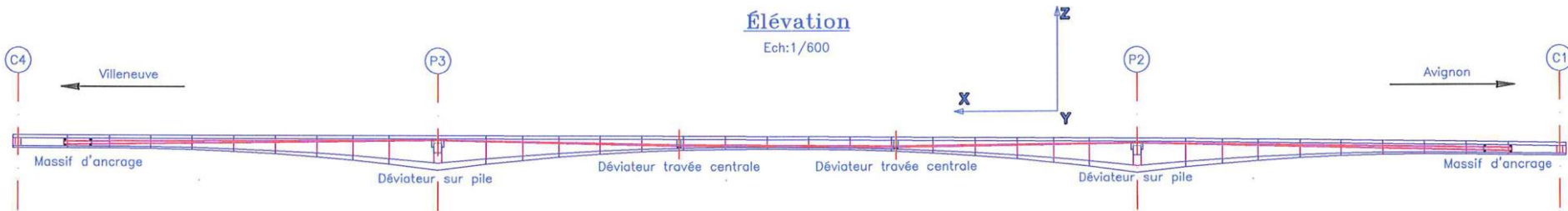


Organisation pour l'Agrément Technique Européen  
European Organisation for Technical Approvals

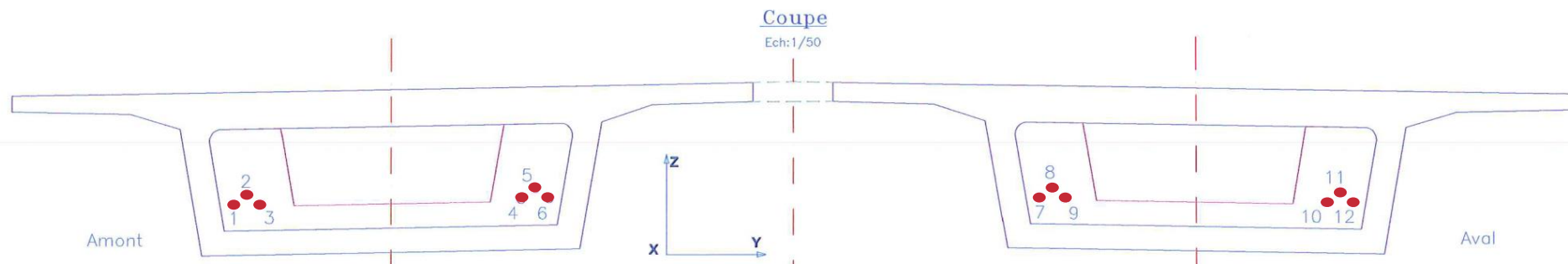


# Pont de l'Europe – Strengthening Project

## Profile of the external tendons

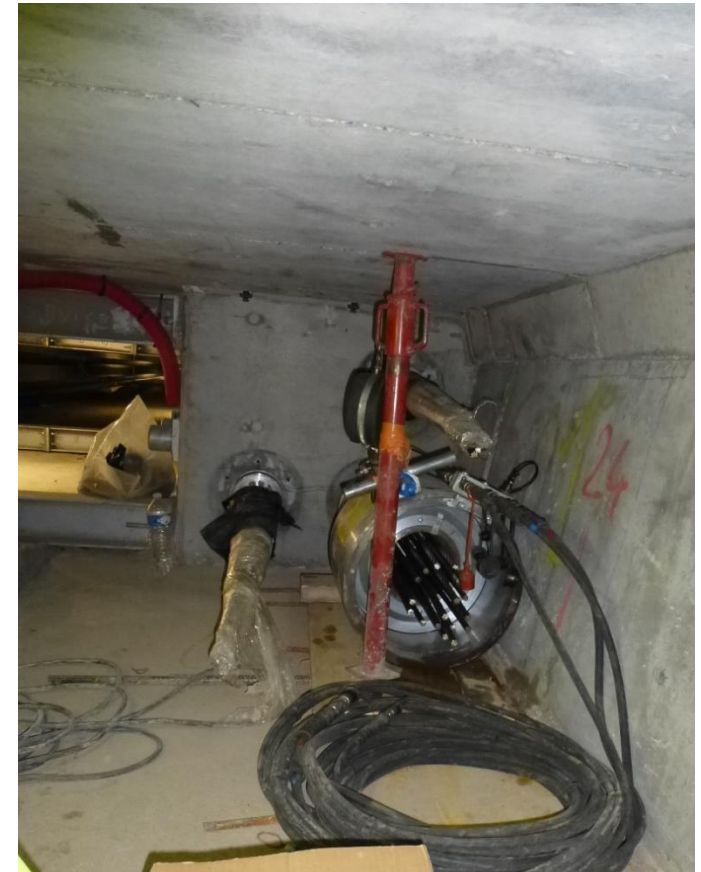


- Six tendons with a length of 209 m were placed in each of the two box girders
- Every tendon consists of 19 bare 7-wire strands 0,62" with ultimate strength of 1.860 N/mm<sup>2</sup>



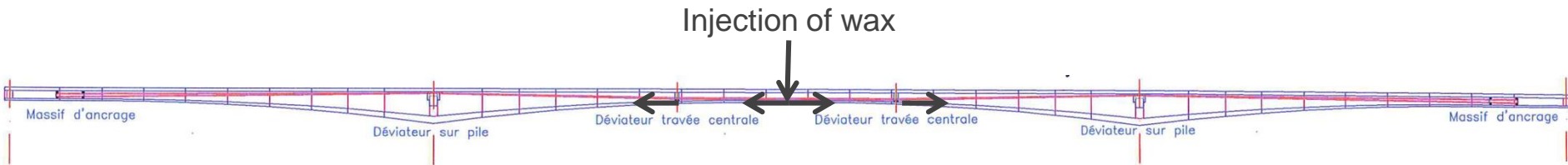
# Strengthening with external tendons

Stressing of the external tendons with HOZ 5400



# Wax filling of the external strand tendons

Hot wax was injected into the tendon PE ducts from the low point of the tendons which is the middle of the 2<sup>nd</sup> span. The wax is flowing in both directions until the ducts are completely filled.



1<sup>st</sup> injection point

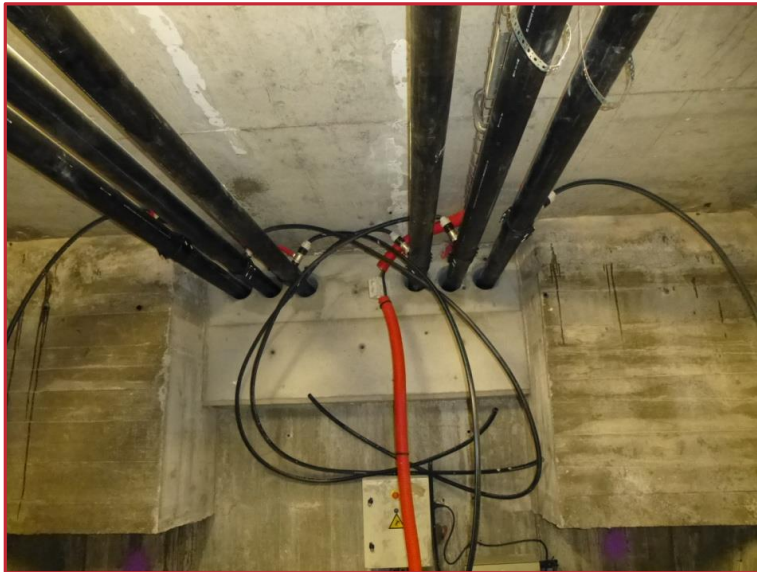
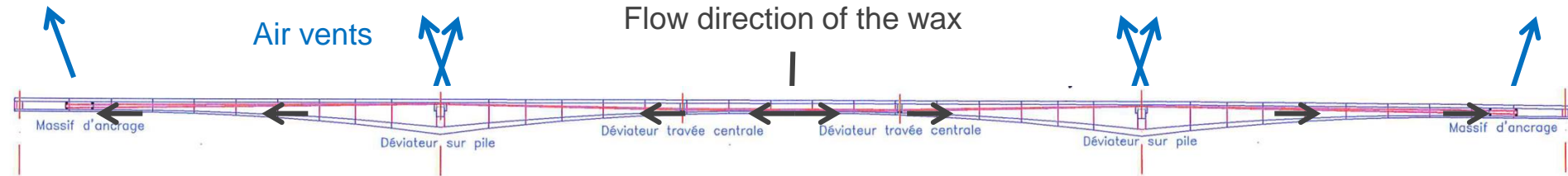


Horizontal fixation of the external tendons every 20 m

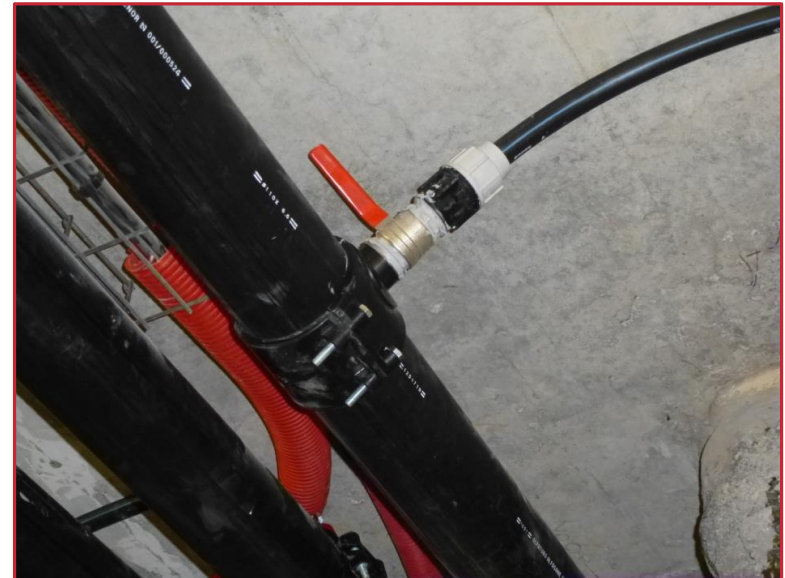


# Wax filling of the external strand tendons

Air in the tendon ducts can escape through air vents. Air vents are installed at both sides of high points and at both anchorages.



High point



Venting point



## Testing before wax filling

The air tightness test was carried out to find leakages.

Over the whole length the tendons were tested with air:

- Pressure of 5 bar over 5 minutes
- At the end of cap a pressure gauge was installed



Pressure gauge for  
air tightness control

## Preparation of masking in range of deviation and anchorages



- 1<sup>st</sup> layer: plastic foil
- 2<sup>nd</sup> layer: textile foil

The adjacently surfaces around the injection point had to be protected with water



## Preparation of masking in range of anchorages



Around the flange of caps a silicon sealing has to be used (resistance against high temperature)



# Preparation of masking in range of deviation

Connection for injection  
1<sup>st</sup> connection after the injection truck  
(to be cooled with water during injection)



Deviation area





# Injection truck and diesel power generator



## Truck with hot wax and the injection truck

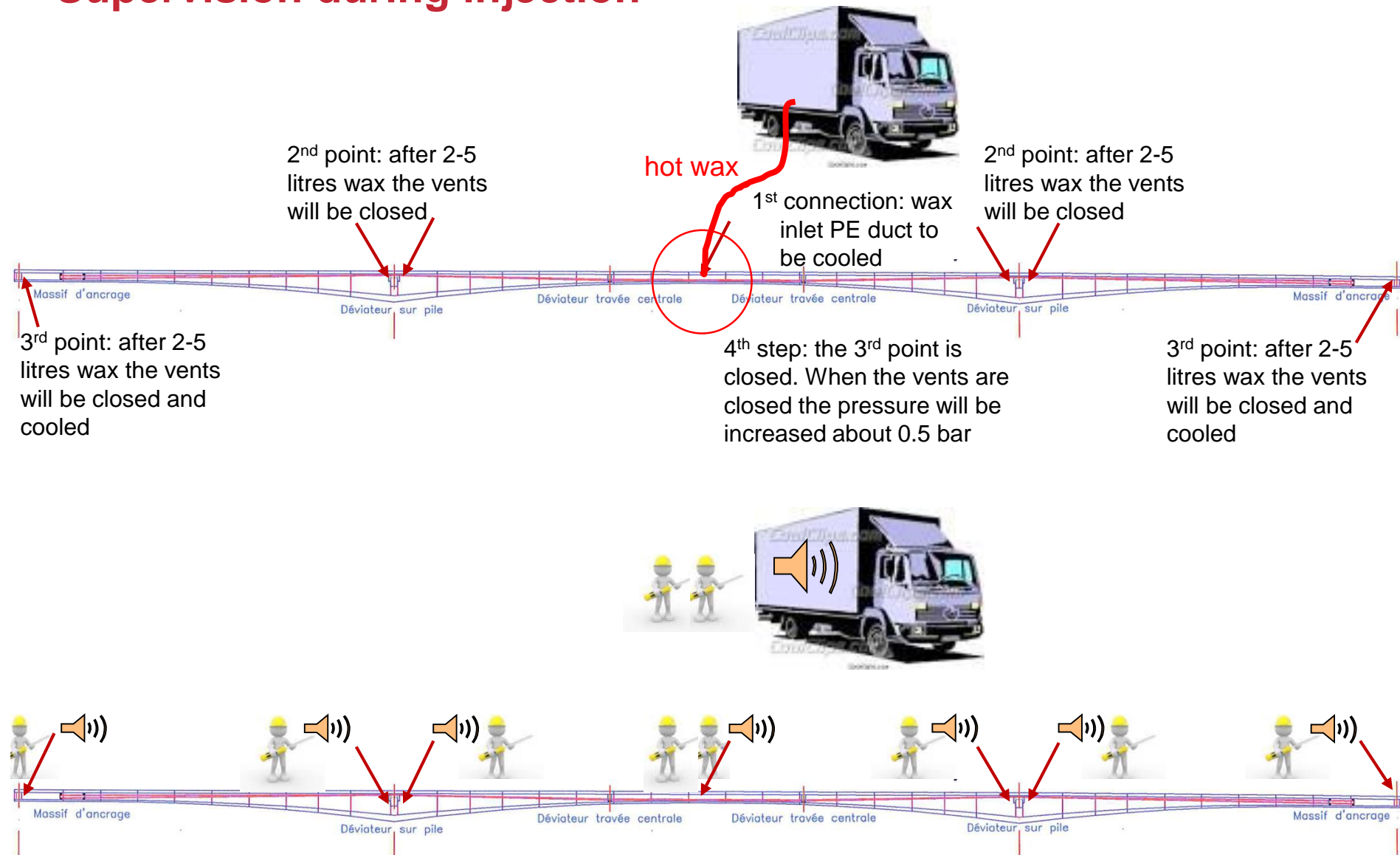


Temperature of hot wax 105 °C

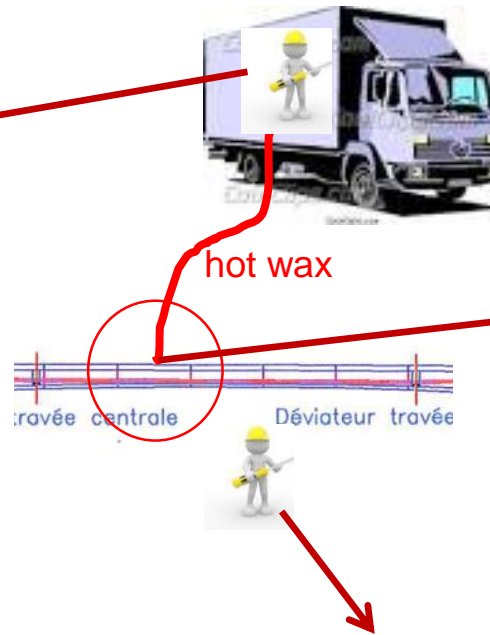
Injection equipment inside the injection truck



# Supervision during injection



# Supervision during injection



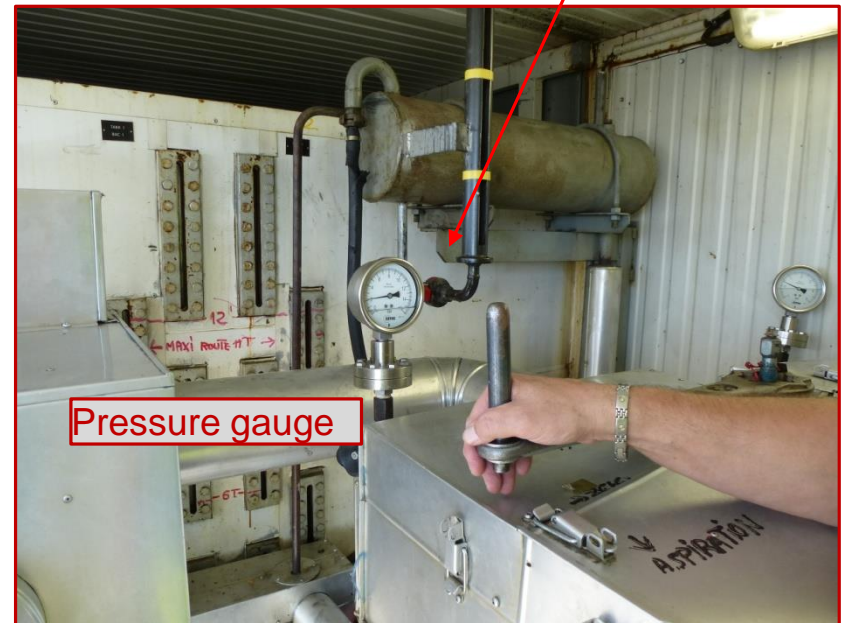
The injection volume of each tendon is calculated before and known to the staff.

In case of drop pressure, the injection failed and the tendon has to be controlled.

# Injection truck with equipment



Counter for wax litre



Pressure gauge

- Truck with 25000 liters tank
- Injection truck: tank with 2 x 10000 liters
- Pumps are working in both directions



# Supervision of injection of the unbonded tendons

<p>Service d'études sur les transports, les routes et leurs aménagements 46 avenue Aristide Briand BP 100 92 225 BAGNEUX CEDEX Tel : + 33 (0)1 46 11 31 31 Fax : + 33 (0)1 46 11 31 69</p>		<p>Authorised and notified according to Article 10 of the Council Directive of 21 December 1988 on the approximation of laws, regulations and administrative provisions of Member States relating to construction products (89/106/EEC)</p>		<p><b>Sétra</b> Service d'études sur les transports, les routes et leurs aménagements</p>	
<p>MEMBRE DE L'EOTA MEMBER OF EOTA</p>					
<p><b>Agrément Technique Européen No. ETA-10/0209</b> (version originale en français)</p>					
<p><b>Nom commercial</b> Trade name <b>Détenteur de l'ATE</b> Holder of approval</p>		<p>CIRINJECT®-CP CIVETEA BP 107- Route de Boran 60460 PRECY SUR OISE France</p>			
<p><b>Type générique et utilisation prévue du produit de construction</b> Generic type and use of construction product</p>		<p>Mélange d'huiles, de cire et d'additifs spécifiques pour la protection anti-corrosion des armatures de précontrainte</p>			
<p><b>Valid from:</b> to:</p>		<p>10 06 2010 10 06 2015</p>			
<p><b>Producteur du procédé</b> Kit manufacturer</p>		<p>AIGLON SAS BP 107- Route de Boran 60460 PRECY SUR OISE France</p>			
<p><b>Le présent agrément technique européen contient</b> This European Technical Approval contains</p>		<p>10 pages incluant 0 annexe 10 pages including 0 annexe</p>			
<p><b>EOTA</b> Organisation pour l'Agrément Technique Européen European Organisation for Technical Approvals</p>					

ETA-10/0209  
Used material, wax CIRINJECT®-CP

<p><b>EIFFAGE TP</b> DIVISION PRECONTRAINTES</p>		<p>PROTECTION DEFINITIVE DES ARMATURES DE PRECONTRAINTES EXTERIEURE A LA CIRE PETROLIERE</p>		<p>Page 3 sur 5</p>	
<p><b>CHANTIER : PONT DE L'EUROPE A AVIGNON</b></p>					
<ul style="list-style-type: none"> <li>Fermeture de la vanne d'injection</li> <li>Passage au câble suivant</li> <li>L'unité mobile d'injection est déplacée suivant le programme d'injection</li> </ul>					
<p><b>6 / PROGRAMME D'INJECTION</b></p>					
<p>Le programme d'injection est le suivant : BAV Amont câbles 1-2-3-4-5-6 ; BAV Aval câbles 7-8-9-10-11-12 ; BVI Amont câbles 1-2-3-4-5-6 ; BVI Aval câbles 7-8-9-10-11-12. <u>Nota :</u> l'injection des caissons Aval sera réalisée sans déplacer la centrale d'injection (alors positionnée sur le caisson Amont), en passant le flexible d'injection à travers les carottages diamètre 100mm préalablement réalisés dans les âmes.</p> <p>Pour chaque câble, le point d'injection se situe au milieu du câble (collier d'injection renforcé 1,5") ; les purges se font aux point hauts (avant et après les déviateurs sur pile) ainsi qu'au niveau des capots (collier de purge 1"). La température minimale d'injection est de <b>90°C</b> et la température maximale est de <b>110°C</b>.</p> <p><u>Volume théorique de cire par câble :</u> Longueur tendue d'un câble : 209m Longueur d'un capot : 1m Volume de cire purgée à chaque capot : 5 litres Volume de cire purgée à chaque point haut : 2,5 litres</p> $V = (209 + 2 \times 1) \text{ m} \times 4,5 \text{ L/m} + 2 \times 5 \text{ L} + 4 \times 2,5 \text{ L} = 969,50 \text{ L}$ <p>Le volume théorique de cire à injecter pour chaque câble est donc d'environ <b>970 litres</b>. Avec un débit moyen de 250L/min à la centrale, il faut environ <b>4 minutes</b> pour injecter un câble.</p>					
<p><b>7 / CONTROLE APRES INJECTION – FINITIONS</b></p>					
<ul style="list-style-type: none"> <li>Après 24h, la présence de cire est vérifiée sur l'ensemble des points hauts des câbles</li> <li>Les événements sont démontés et remplacés par des bouchons plastiques</li> <li>Nettoyage et rempli</li> </ul> <p><u>Nota :</u> afin de s'assurer du bon remplissage d'une gaine, il est procédé de la façon suivante :</p> <ul style="list-style-type: none"> <li>Vérification que le volume injecté correspond au volume théorique</li> <li>Vérification que la purge est effectuée à tous les événements</li> <li>La gaine est « sonnée » sur sa surface extérieure et sur toute sa longueur à l'aide d'un petit marteau afin de confirmer l'absence de vide à l'intérieur.</li> </ul>					

Quality plan for the project  
Pont de l'Europe a Avignon



# Supervision of injection of the unbonded tendons

**EIFAGE TP**  
DIVISION PRECONTRAINTE

Fiche contrôle n°: 0  
PR FC-BU-CIR Date: 06/06/2004

### CONTRÔLE DES INJECTIONS

Mise en œuvre selon procédure PE 05 et selon fiche produit correspondante

ENTREPRISE: **EIFAGE TP** PROCÉDE D'YNNADAG  
CHANTIER: **PONT de l'Europe** DATE: **2/10/2003**  
OUVRAGE: **RAV. AUGE ALBERT**

CIRE PETROLIERE  
Fournisseur: **CIVETEM**  
Provenance: **POCCY 818 DISP (80)**  
N° de lot: **13 340 408**

TYPE DE MATERIEL		TEMPERATURES	
Désignation: <b>Cable de béton</b>		Extérieure: <b>15.5 °C</b>	
N° matériel: <b>7</b>		Ciré: <b>103 °C</b>	

SUIVI DE L'INJECTION				CONTRÔLE		OBSERVATIONS
CABLE N°	RELEVÉ	VOLUME CIRÉ		Ciré aux points pointés		
	DÉBUT	FIN	THÉORIQUE	REEL	OUI	NON
1	08h58	09h04	920	1203		
2	08h58	09h11	920	1155		
3	09h23	09h29	920	1144		
4	09h21	09h27	920	1145		
5	09h24	09h35	920	1148		
6	09h40	09h44	920	1152		
7						
8	12h03	12h08	920	1166		
9	12h10		920			

Observations:

DATE: **02/10/2003** VISA CMP: VISA CONTRÔLE EXTERNE (eventuel):

Inspection sheet



After injection – control with thermal camera  
(this application was for this jobsite only)

# Content of Presentation



Introduction

---



Project Description

---



Strengthening with Bars

---



Strengthening with External Tendons

---



**Conclusion**

---

# Conclusion

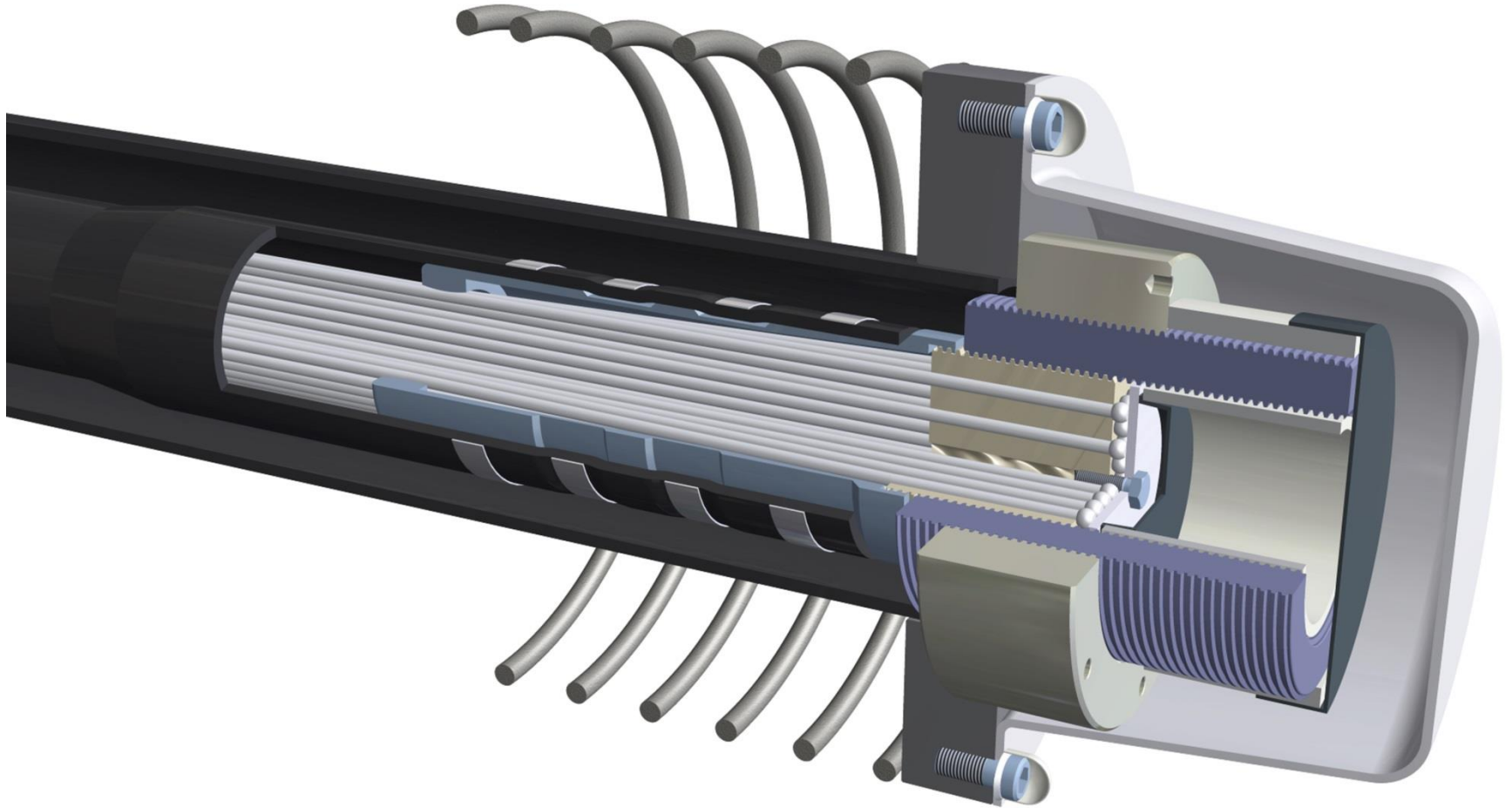
- PT bar systems and external tendons can be used efficiently for strengthening of bridges
- Wax filling of external tendons on site requires special know how and equipment
- Cement grouting of external tendons is still used in most countries
- New trends in Asia - especially Japan: external tendons with epoxy coated strands without outer duct
- Standard solution in Germany: prefabricated external tendons with parallel wires and wax filling

## Japan: External Tendon with ECS without outer pipe

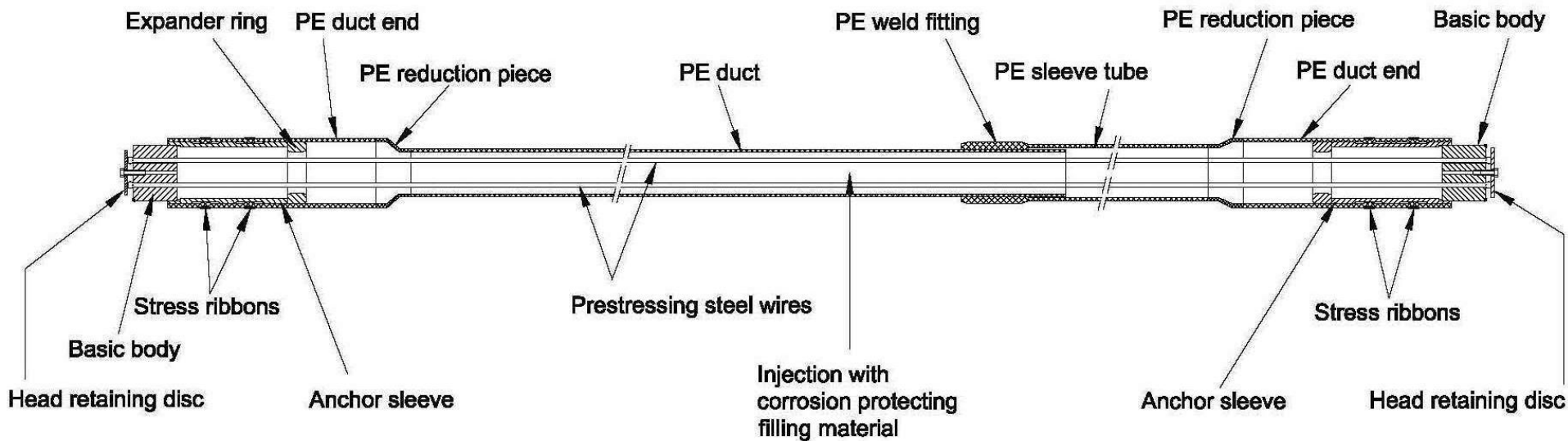




## Prefabricated External Tendon Type WIRE-Ex



# Prefabricated WIRE Ex Tendon



- Completely closed system filled with hot wax at the factory
- Fast installation on site
- Easy stressing, restressing, exchange and force control
- ETA 07/0186

## Installation on site



- pulling the prefabricated tendons from the coil
- no interference with other works on the site
- No wax injection on site





**start strengthening before its too late....**





Thank you for your attention!



Contact: [Werner.Brand@dywidag-systems.com](mailto:Werner.Brand@dywidag-systems.com)