# Session 17


## Bret Pilstick

Eisman & Russo Consulting Engineers.


## *Improved Durability of Post-Tensioned Bridges*

### Topic Description

A paper will be presented discussing the problems and solutions developed in Florida in response to recent external tendon failures in post-tensioned bridges.

### Speaker Biography

Mr. Pielstick Graduated with a Bachelor of Science in Civil Engineering in 1984 from Brigham Young University, Provo, Utah and has Twenty One (21) years experience in heavy construction, primarily in the construction of segmental bridges. He is currently a Senior Vice President and Principle at Eisman & Russo Consulting Engineers. Brett is active in several Professional Society Technical Committees here in the United States and in Europe and has been presented and been published many times in his career. He is a license Professional Engineer in six states and serves in the Stake Presidency of the Jacksonville East State of the Church of Jesus Christ of Latter-day Saints and works closely with the Boy Scout of America. Brett has been married twenty three (23) years and has four children.

# Florida DOT efforts with AASHTO/ASBI toward improving Post Tension durability

## Article by William Nickas
## Presented by Brett Pielstick

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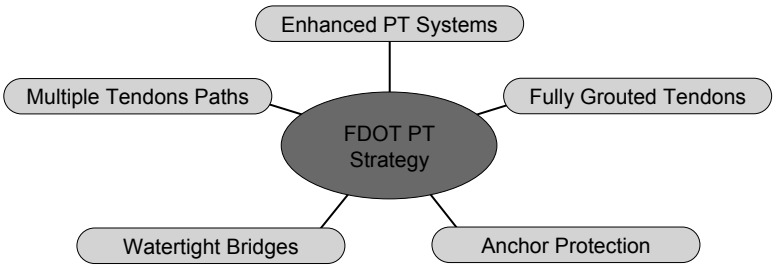
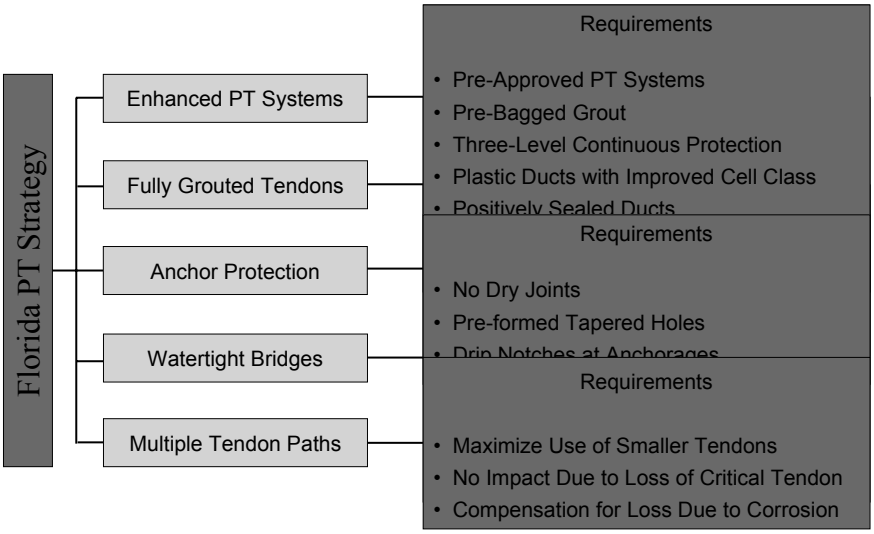
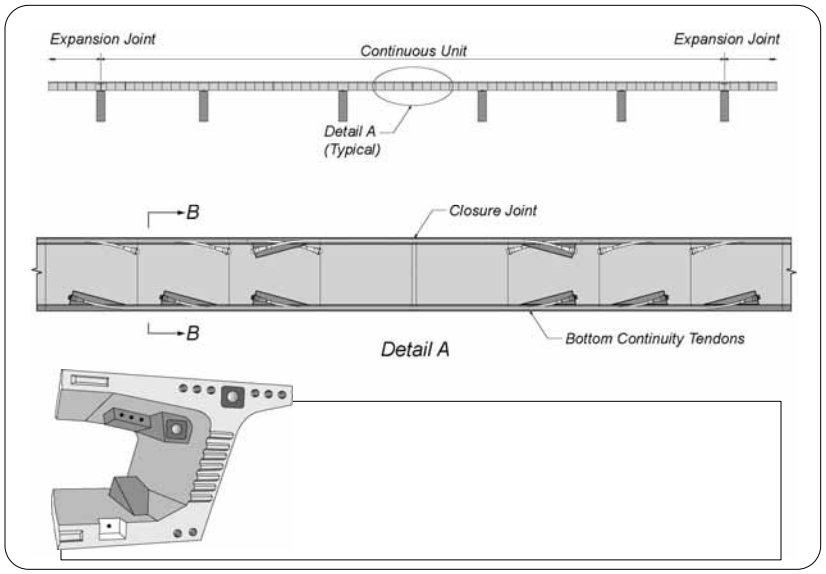
## Post-Tensioning Strategies






## Balanced Cantilever Construction



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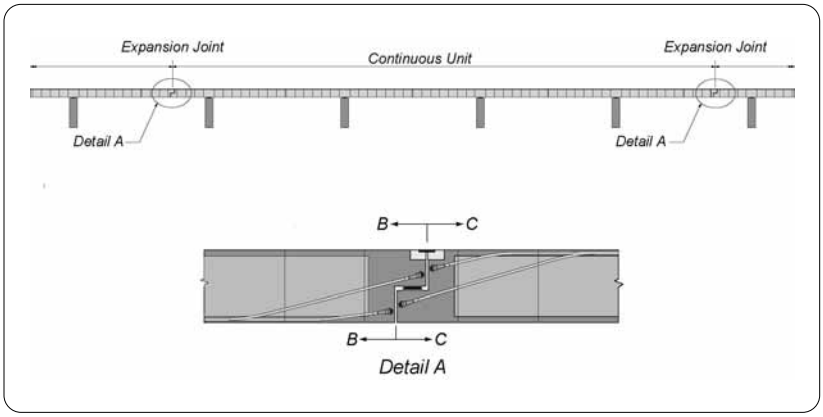


## Critical Nature of Tendons

- Type of Construction
  - CIP on Falsework
  - CIP Balanced Cantilever
  - P/C Balanced Cantilever
  - P/C Span-By-Span
  - P/C Beam w/ CIP Slab
- Structural Purpose
  - Superstructure
  - Substructure
  - Construction vs. Permanent
  - Bonded vs. Unbonded
- Tendon Protection System
  - Mat'ls – Duct, Anchor, Grout
  - Wet vs. Dry Joints
  - Risk of Exposure
- Maintainability
  - Access to inspect components
  - Applicability of test methods
  - Ability to be replaced
- Redundancy
  - External
  - # & Distribution of Tendons

Florida Department of Transportation

**New Directions for Florida Post-Tensioned Bridges**

**Volume 2 of 5: Design and Detailing of Post-Tensioning in Florida Bridges**

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Tallahassee, Florida 32308
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February 18, 2002

Contents

- Precast Balanced Cantilever
- Precast Span-by-Span
- Spliced I-Girders
- CIP Balanced Cantilever
- CIP on Falsework
- Substructures
- Transverse Superstructure

POST-TENSIONING STANDARD DETAILS

# *More Specifically FDOT POST-TENSIONING STANDARDS FOR SEGMENTAL AND GIRDER POST-TENSIONED BRIDGES*

POST-TENSIONING STANDARD DETAILS

# OBJECTIVE

**TO PROVIDE CONSISTENCY AND UNIFORMITY IN THE DESIGN, DETAILING, AND CONSTRUCTION OF POST-TENSIONED STRUCTURES IN ORDER TO PROVIDE A HIGHER QUALITY PRODUCT WITH A MINIMUM COST INCREASE**

POST-TENSIONING STANDARD DETAILS

# OBJECTIVE

**MORE SPECIFICALLY, TO IMPROVE THE QUALITY OF PT HARDWARE, GROUTING, AND ANCHOR PROTECTION IN ORDER TO REDUCE THE INCIDENCES OF RECHARGE AND CORROSION IN POST-TENSIONED STRUCTURES**

POST-TENSIONING STANDARD DETAILS

# OBJECTIVE IMPLEMENTATION

## STRATEGIES IMPLEMENTED

- STRATEGY 1
  - ENHANCED POST-TENSIONING SYSTEMS
  - SEALING OF GROUT PORTS, VENTS AND DRAINS
- STRATEGY 2
  - FULLY GROUTED TENDONS
  - ACCESSIBLE ANCHORS
  - GROUTING OF TENDONS / GENERAL PROCEDURES

POST-TENSIONING STANDARD DETAILS

# OBJECTIVE

## STRATEGY 3

- MULTI-LEVEL ANCHOR PROTECTION
- ANCHORS AT EXPANSION JOINTS / INSIDE BOXES / BLISTERS
- EMBEDDED ANCHORS

- STRATEGY 4
  - WATERTIGHT BRIDGES: Double Face Epoxy
  - ACCESS, LIFTING HOLES
  - DRIP NOTCHES

POST-TENSIONING STANDARD DETAILS

## DRAWING INDICES

- INSTRUCTIONAL NOTES
- POST-TENSIONING VERTICAL PROFILES
- POST-TENSIONING ANCHORAGE PROTECTION
- POST-TENSIONING ANCHORAGE AND GROUTING DETAILS

POST-TENSIONING STANDARD DETAILS

## INSTRUCTIONAL NOTES

- DESIGNER TO PROVIDE TENDON PROFILE AND ANCHOR PROTECTION TYPE FOR EACH TYPE OF TENDON
- TENDON PROFILE AND ANCHOR PROTECTION TYPE TO BE INCLUDED IN THE PT SCHEDULE

POST-TENSIONING STANDARD DETAILS

# INSTRUCTIONAL NOTES

- TENDON PROFILES MAY BE AMENDED BY THE ENGINEER
- EOR RESPONSIBLE FOR REVIEWING THE CONTRACTORS GROUTING PLAN (SHOP DRAWINGS)
- DEVIATIONS FROM THE STANDARDS SHALL BE APPROVED BY THE FDOT

POST-TENSIONING STANDARD DETAILS

# POST-TENSIONING VERTICAL PROFILES

- TYPICAL PROFILES FOR POST-TENSIONING TENDONS USED IN
  - SUPERSTRUCTURE
    - GIRDER
    - SEGMENTAL
  - SUBSTRUCTURE
    - HAMMERHEADS
    - STRADDLE BENTS
  - VERTICAL APPLICATIONS

POST-TENSIONING STANDARD DETAILS

# TYPICAL TENDON PROFILES

POST-TENSIONING STANDARD DETAILS

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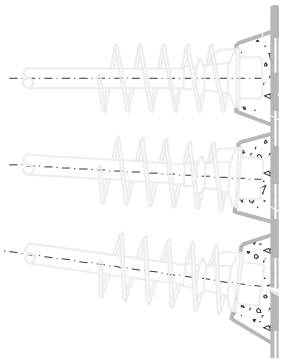
POST-TENSIONING STANDARD DETAILS

# SUBSTRUCTURE VERTICAL PROFILES

- SUBSTRUCTURE
  - ELEVATION OF BASE OF TENDON SHALL BE A MINIMUM OF
    - 5'-0" FOR SUBSTRUCTURES OVER LAND
    - 12'-0" FOR SUBSTRUCTURES OVER OR NEAR WATER

POST-TENSIONING STANDARD DETAILS

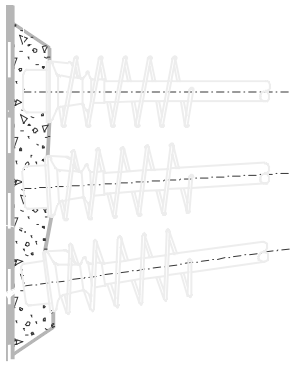
# ANCHORAGE PROTECTION



**EXPOSED SURFACES AND EXPANSION JOINTS**

POST-TENSIONING STANDARD DETAILS

# ANCHORAGE PROTECTION



**EXPOSED SURFACES AND EXPANSION JOINTS**

POST-TENSIONING STANDARD DETAILS

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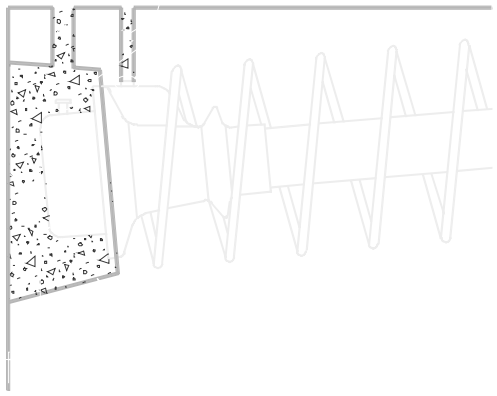
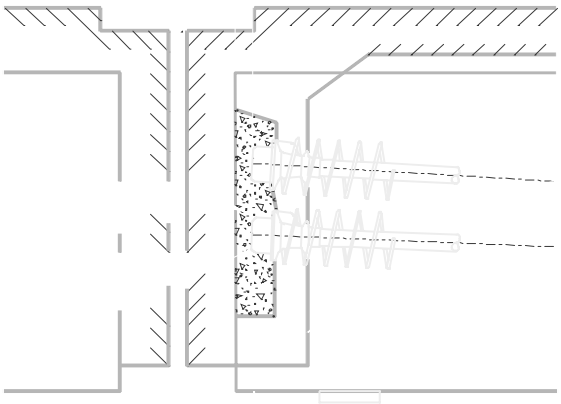


## CANTILEVER TENDONS

POST-TENSIONING STANDARD DETAILS

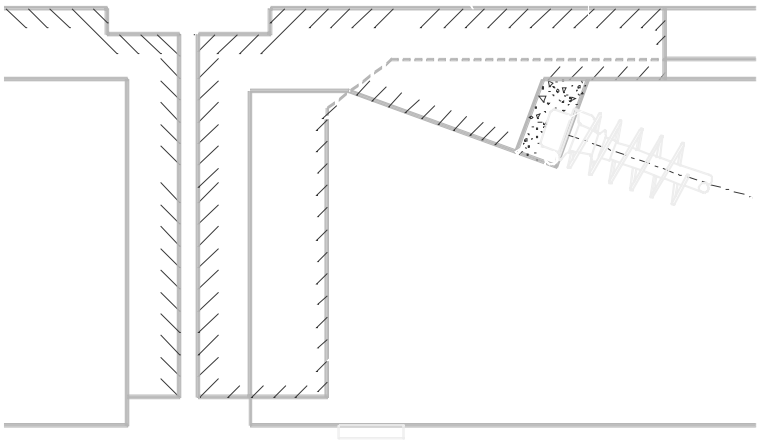
# ANCHORAGE PROTECTION



## PT GIRDERS AND BULB-T'S

POST-TENSIONING STANDARD DETAILS

# ANCHORAGE PROTECTION



PT GIRDERS AND BULB-T'S

POST-TENSIONING STANDARD DETAILS

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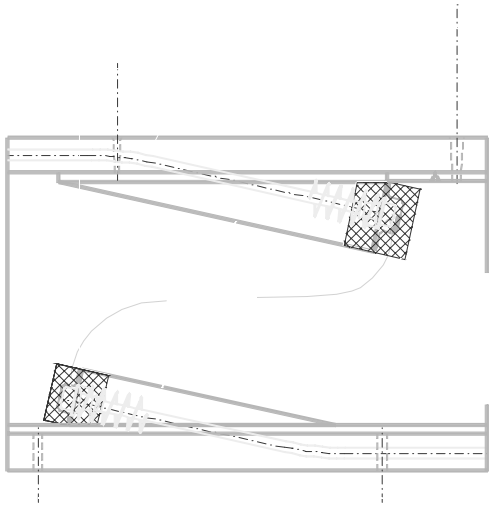
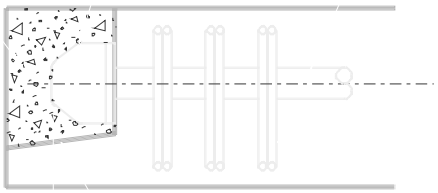


INTERIOR ANCHORS IN CELLULAR BOXES

POST-TENSIONING STANDARD DETAILS

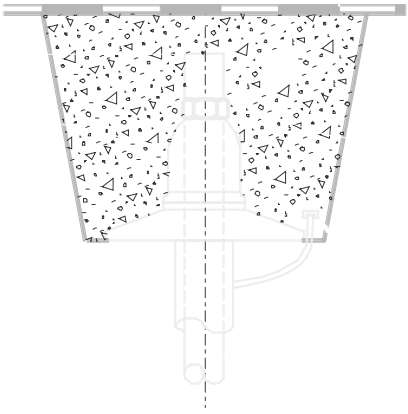
# ANCHORAGE PROTECTION



## TRANSVERSE TENDONS

POST-TENSIONING STANDARD DETAILS

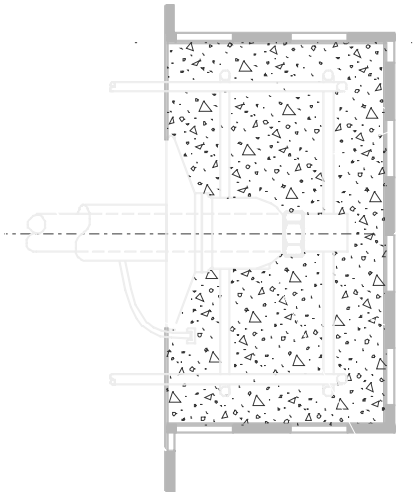
# ANCHORAGE PROTECTION



## POST-TENSIONING BARS

POST-TENSIONING STANDARD DETAILS

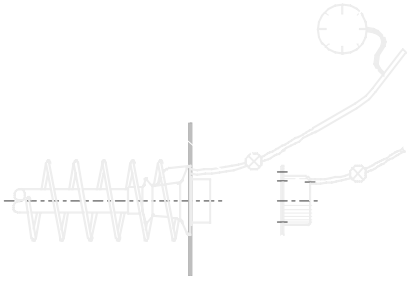
# ANCHORAGE PROTECTION



**POST-TENSIONING BARS**

POST-TENSIONING STANDARD DETAILS

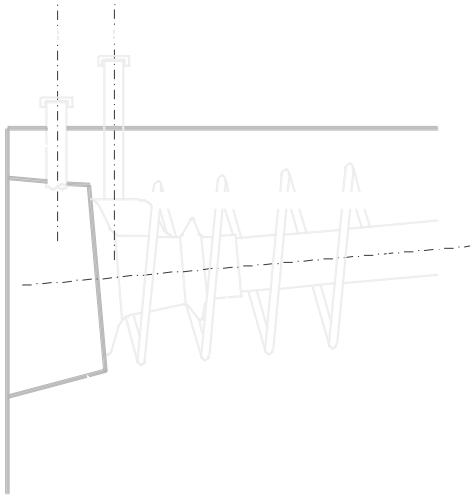
# ANCHORAGE & GROUTING DETAILS



**FACE INSPECTED ANCHOR WITH GROUT INLET**

POST-TENSIONING STANDARD DETAILS

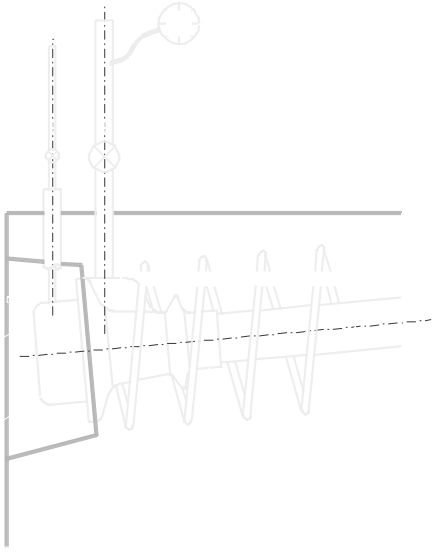
# TOP INSPECTED ANCHOR



## STEP 1- INSTALLATION & SHIPPING

POST-TENSIONING STANDARD DETAILS

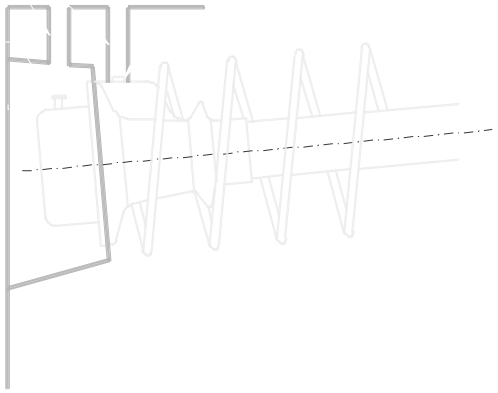
# TOP INSPECTED ANCHOR



## STEP 2 - GROUTING

POST-TENSIONING STANDARD DETAILS

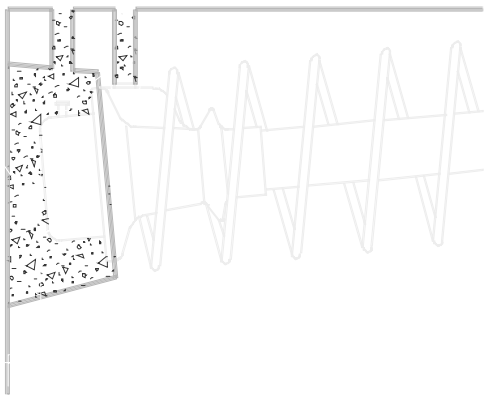
# TOP INSPECTED ANCHOR



## STEP 3 - INSPECTION

POST-TENSIONING STANDARD DETAILS

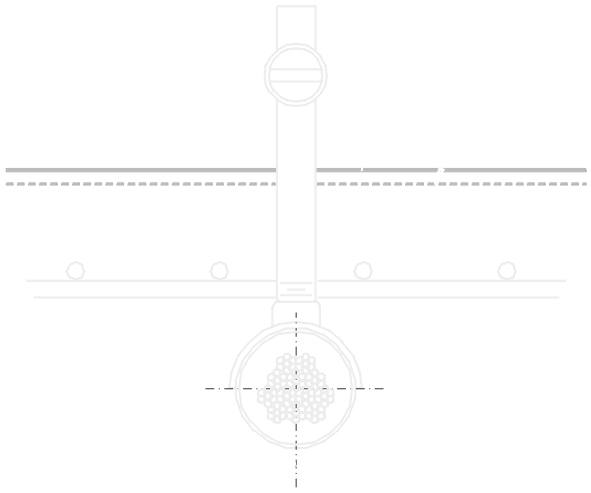
# TOP INSPECTED ANCHOR



## STEP 4 - PROTECTION

POST-TENSIONING STANDARD DETAILS

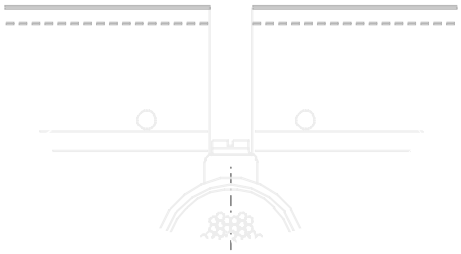
# HORIZONTAL SURFACES



REMOVAL OF GROUT PIPE

POST-TENSIONING STANDARD DETAILS

# HORIZONTAL SURFACES



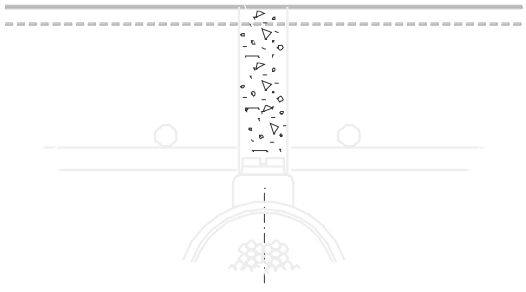
REMOVAL OF GROUT PIPE

POST-TENSIONING STANDARD DETAILS

# HORIZONTAL SURFACES

POST-TENSIONING STANDARD DETAILS

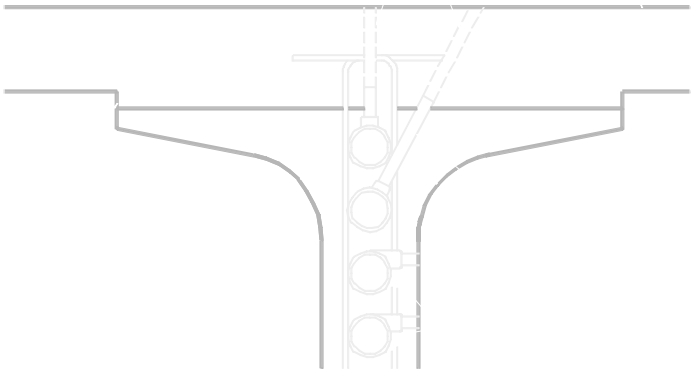
# HORIZONTAL SURFACES



## FILLING GROUT PIPE POCKETS

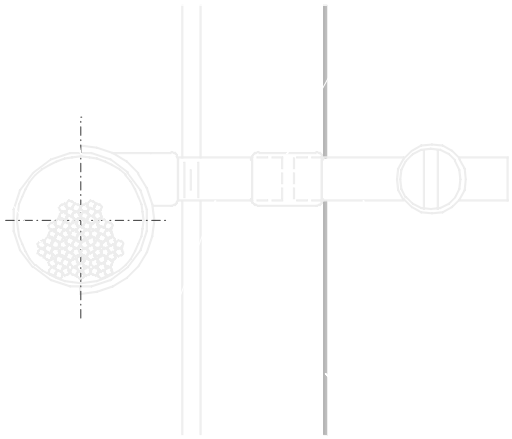
POST-TENSIONING STANDARD DETAILS

# HIGH POINT INSPECTION GROUT OUTLET



POST-TENSIONING STANDARD DETAILS

# VERTICAL SURFACES



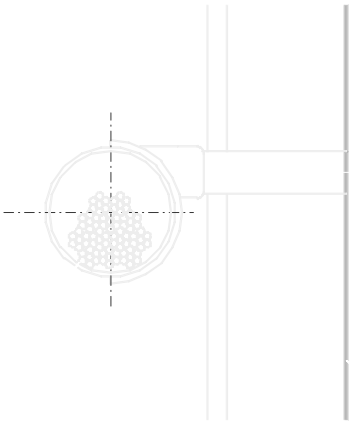
## GROUT OUTLET CONNECTION TO TENDON

POST-TENSIONING STANDARD DETAILS

# VERTICAL SURFACES

POST-TENSIONING STANDARD DETAILS

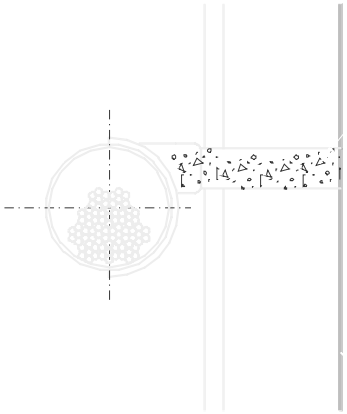
# VERTICAL SURFACES



## INSPECTION & POCKET PREPARATION

POST-TENSIONING STANDARD DETAILS

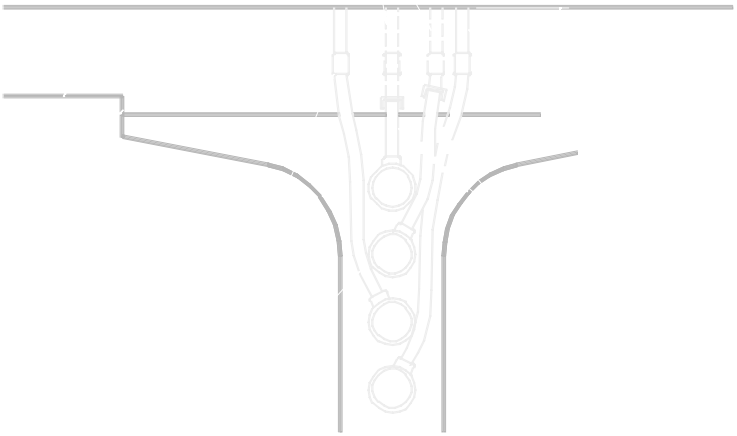
# VERTICAL SURFACES



FILLING POCKET WITH EPOXY GROUT

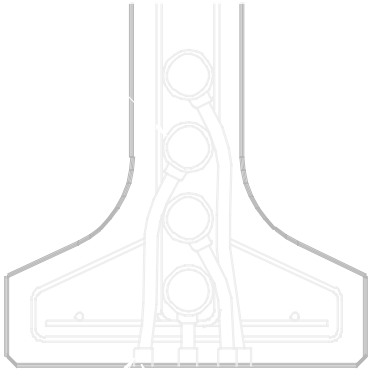
POST-TENSIONING STANDARD DETAILS

# GROUT OUTLET – 3 TO 6 FT FROM HIGH POINTS



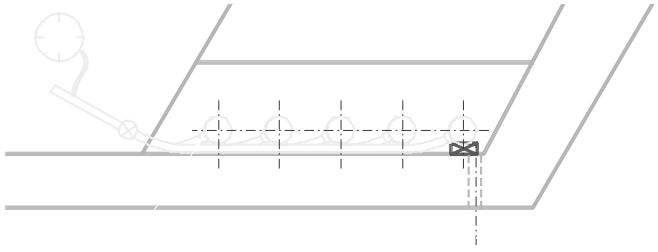
POST-TENSIONING STANDARD DETAILS

# GROUT INLET / OUTLET – AT LOW POINTS OF TENDON



POST-TENSIONING STANDARD DETAILS

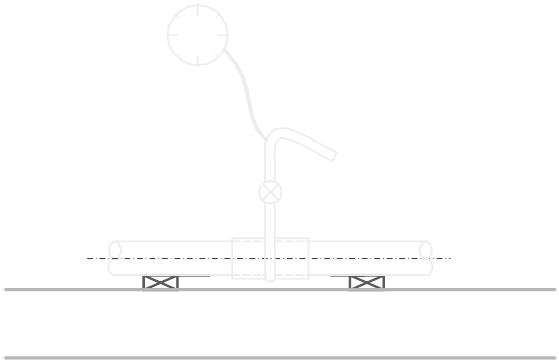
# ANCHORAGE & GROUTING DETAILS



**GROUTING AT LOW POINTS**
**SPAN X SPAN CONSTRUCTION**

POST-TENSIONING STANDARD DETAILS

# ANCHORAGE & GROUTING DETAILS



## GROUTING AT LOW POINTS
## SPAN X SPAN CONSTRUCTION

POST-TENSIONING STANDARD DETAILS

# BLOCK-OUTS AND TEMPORARY ACCESS HOLES

POST-TENSIONING STANDARD DETAILS

**Reminder Details are great but one must always…**

**INTEGRATE STRATEGIES INTO THE CONSTRUCTION AND MATERIALS SPECIFICATIONS**

**"One gets what he INSPECTS not what he EXPECTS"**

POST-TENSIONING STANDARD DETAILS

**POST-TENSIONING SYSTEM example items**

- **INSPECTABLE ANCHORS**
- **BAR COUPLERS**
- **PERMANENT GROUT CAPS**
- **INLETS AND OUTLETS**
- **DUCT SCHEDULE 40 STEEL OR PLASTIC**
- **POLYPROPYLENE CORRUGATED DUCT**
- **POLYETHYLENE SMOOTH DUCT (DR 17)**
- **PRESSURE TESTING COMPONENTS WITH SYSTEM**

POST-TENSIONING STANDARD DETAILS

## PLASTIC DUCT AND CONNECTIONS example issues

- ALL COMPONENTS ASSEMBLED INTO PRESSURE TESTED SYSTEMS
- POLYPROPYLENE CORRUGATED DUCT FOR INTERNAL TENDONS GREATER STIFFNESS WITH LESS HEAT GAIN
- POLYETHYLENE DUCT THICK WALL WITH PRESSURE PIPE CHEMISTRY
- IN-PLACE TESTING FOR LEAKS BEFORE GROUTING

POST-TENSIONING STANDARD DETAILS

## Education is Critical

POST-TENSIONING STANDARD DETAILS

# Why not always use Plastic Duct ?

POST-TENSIONING STANDARD DETAILS

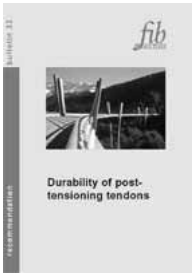
## Assessment and Rehabilitation of Post-tensioning Tendons

1. Introduction
2. Assessment of post-tensioning tendons
3. Rehabilitation of post-tensioning tendons
4. Summary

POST-TENSIONING STANDARD DETAILS

## 1. Introduction

**Results of the IABSE / fib Workshop on "Durability of pt-tendons" at Ghent (Belgium), November 2001 and then in Zurich (Switzerland) November 2005:**




- **The majority of prestressed concrete structures and their pt-tendons show excellent durability behaviour**
- **In a minority of cases, however, minor to very severe corrosion problems exists**
- **Durability of post-tensioning tendons Recommendation (76 pages, ISBN 2-88394-073-8, December 2005)**

POST-TENSIONING STANDARD DETAILS

POST-TENSIONING STANDARD DETAILS

**Failures of pc-bridges in Europe due to corrosion of the pt-tendons:**

- **1967: 2 pedestrian bridges (UK)**
- **1985: Ynis-y-Gwas Bridge (UK)**
- **1992: Bridge over the Melle River (B)**
- **1999: San Stefano Bridge (I)**

POST-TENSIONING STANDARD DETAILS

**San Stefano Bridge (I):**

POST-TENSIONING STANDARD DETAILS

**San Stefano Bridge (I):**

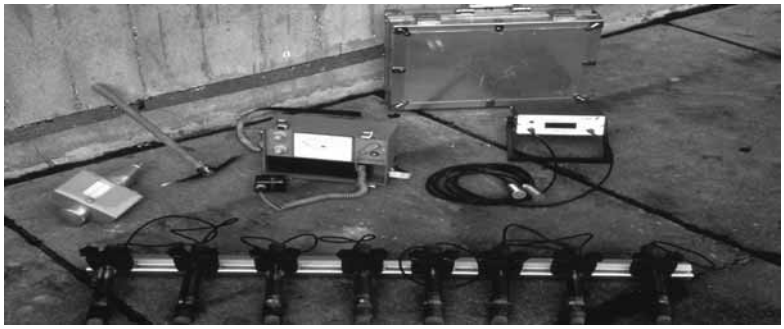
POST-TENSIONING STANDARD DETAILS

## 2. Assessment of pt-tendons

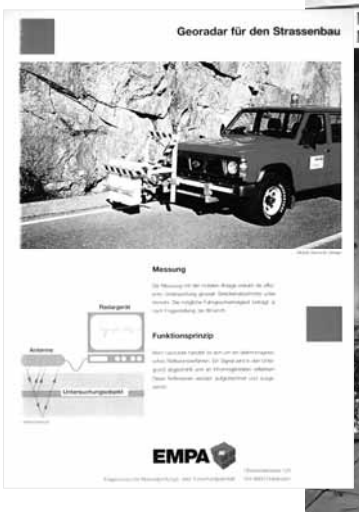
### 2.1 Inspection methods (NDT)

- Georadar and Covermeter
- Potential Mapping
- Impact-Echo Method
- Remanent Magnetism Method
- Radiography
- Reflectometrical Impulse Measurement
- Ultrasonic Methods
- Acoustic Monitoring
- Thermography
- Tomography

POST-TENSIONING STANDARD DETAILS



POST-TENSIONING STANDARD DETAILS




POST-TENSIONING STANDARD DETAILS

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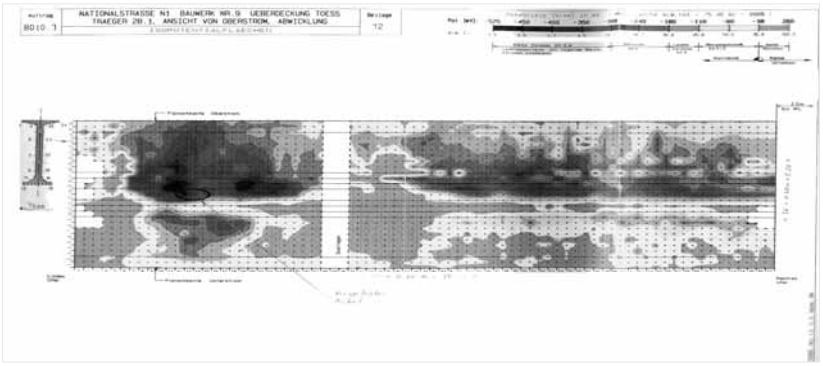

## POST-TENSIONING STANDARD DETAILS

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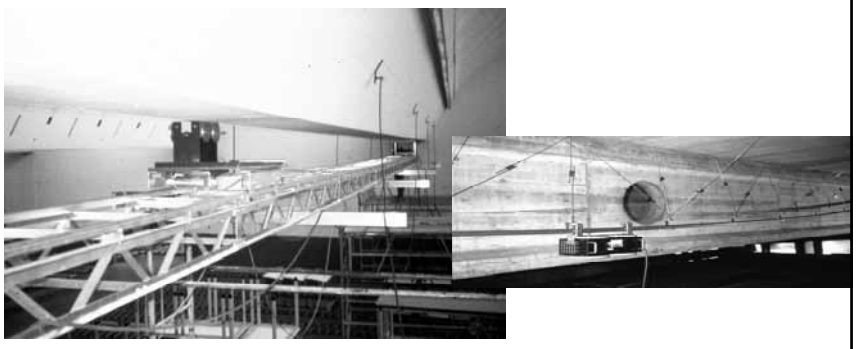
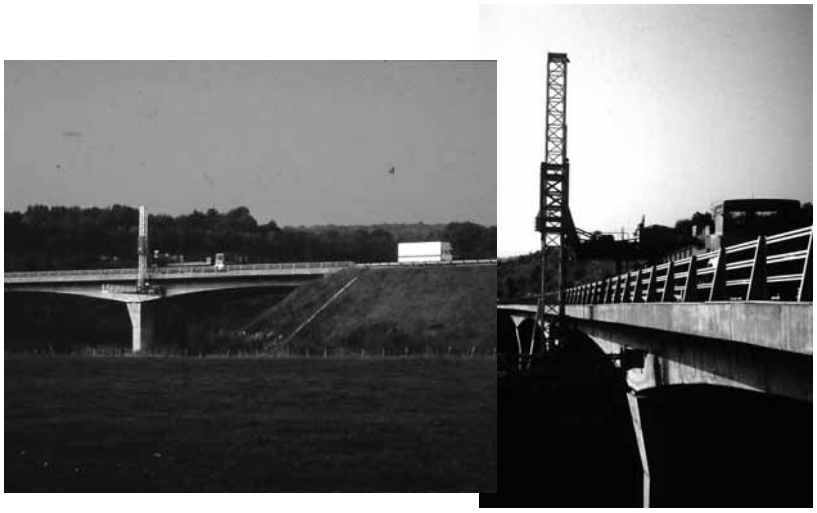
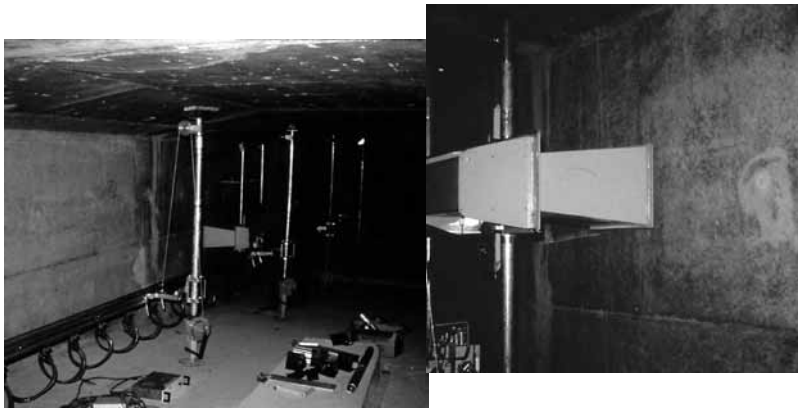


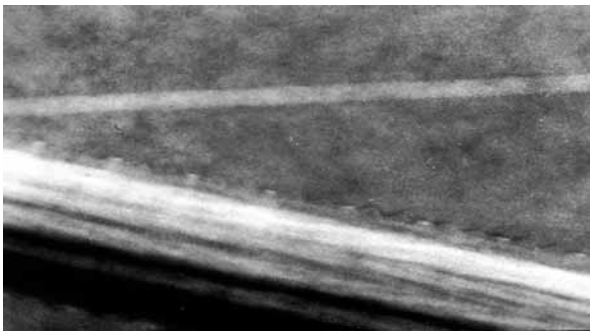
## POST-TENSIONING STANDARD DETAILS



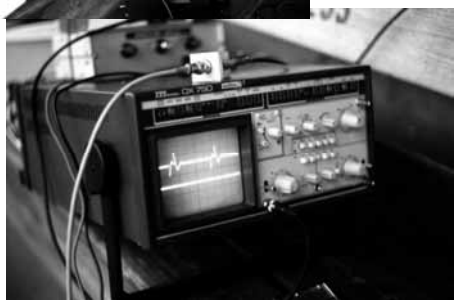
## POST-TENSIONING STANDARD DETAILS



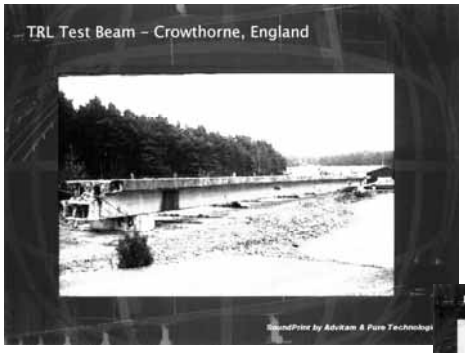
POST-TENSIONING STANDARD DETAILS



POST-TENSIONING STANDARD DETAILS

POST-TENSIONING STANDARD DETAILS





POST-TENSIONING STANDARD DETAILS

**Conclusions:**

- **None of the presented NDT-Methods can provide a complete and meaningful assessment of pt-tendons in existing structures.**
- **Some methods however provide partial results in accessible areas.**

POST-TENSIONING STANDARD DETAILS

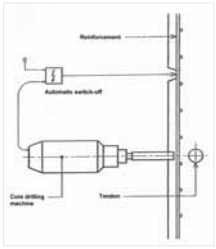
## 2.2 The Engineer's approach to tendon inspection

**The method that overall still rates best in terms of information and interpretation:**

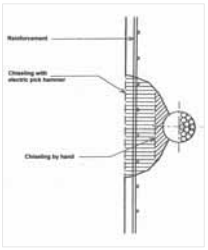
**To provide access to the tendons by carefully drilling or chiseling.**


POST-TENSIONING STANDARD DETAILS

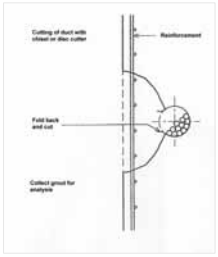
**a) Core drilling (with automatic switch-off)**



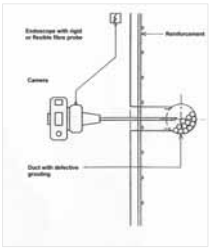

**b) Chiseling**




**c) Opening of the duct**

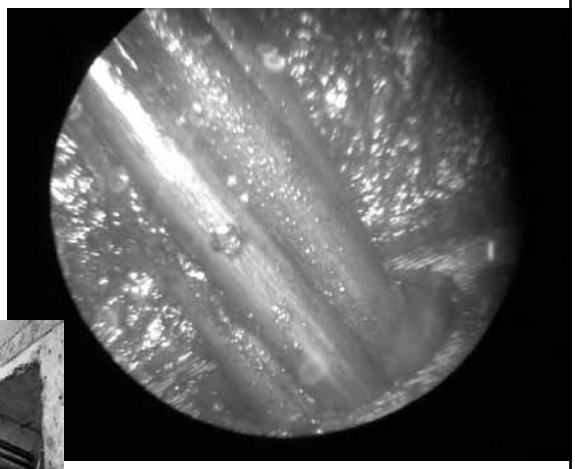



**d) Investigation of duct with endoscope**



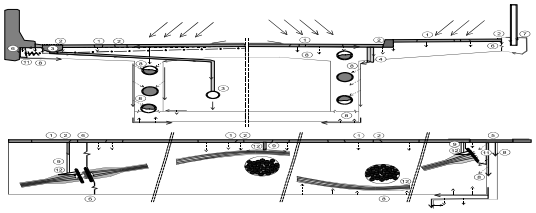

**Getting access to the tendon**

POST-TENSIONING STANDARD DETAILS



POST-TENSIONING STANDARD DETAILS

**Hazard scenarios for prestressing steel in a typical box girder bridge: Indication of potentially "weak points" where water (possibly contaminated with chlorides) can gain access to the tendons and cause corrosion.**



POST-TENSIONING STANDARD DETAILS

**Non-structural elements:**

1 Defective wearing course (e.g. cracks)

2 Missing or defective waterproofing membrane incl. edge areas

3 Defective drainage intakes and pipes

4 Wrongly placed outlets for the drainage of wearing course and waterproofing

5 Leaking expansion joints

6 Cracked and leaking construction or element joints

7 Inserts (e.g. for electricity)

**Corrosion protection system:**

8 Defective concrete cover

9 Partly or fully open grouting in- and outlets (vents)

10 Leaking, damaged metallic ducts mechanically or by corrosion

11 Cracked and porous pocket concrete

12 Grout voids at tendon high points

POST-TENSIONING STANDARD DETAILS

**Opening location is determined by desk study (drawings etc.) and a thorough visual inspection:**

- Water flow, wet or moist areas
- Discoloration (e.g. rust stains)
- Spalling, delamination
- Cracks
- Honey-combing
- Concrete deterioration by freezing and freezing-thawing
- Joint leakage
- etc.

POST-TENSIONING STANDARD DETAILS

## 3. Rehabilitation of pt-tendons

**Possible defects and degradations:**

- **Defective grouting (e.g. grout voids, grout segregation) and water access to the prestressing steel.**
- **Corrosion of the metallic duct, the prestressing steel, anchorages and couplers due to the ingress of water possibly contaminated by de-icing salts.**
- **Fretting corrosion of the prestressing steel due to fatigue.**
- **Corrosion of the prestressing steel due to stray currents.**

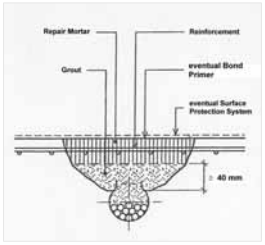
POST-TENSIONING STANDARD DETAILS

**Rehabilitation / repair methods, e.g.:**

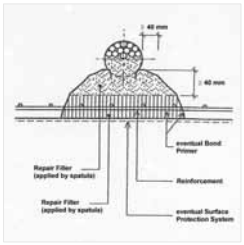
- **Grouting of existing voids (internal and external tendons):**
  - **large voids ⇨ grouting (generally vacuum grouting)**
  - **small voids ⇨ patching with suitable mortar**
- **Replacement of the tendon pipe (external tendons)**

POST-TENSIONING STANDARD DETAILS

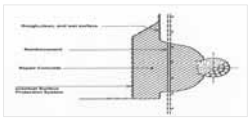
a) Access to tendon from above



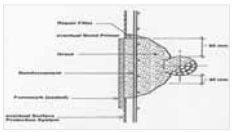

b) Access to tendon from below




c) Access to tendon from side



d) Concrete pour back



Closing of tendon opening

POST-TENSIONING STANDARD DETAILS

## 4. Summary

- Non- or low-destructive inspection and monitoring methods have their limitations. None allows a full assessment of pt-tendons.
- The Engineer's approach to determine the locations with likely corrosion problems and to carefully open and inspect a tendon still rates best (to be used restrictively).

POST-TENSIONING STANDARD DETAILS

- **For pc-structures in aggressive environment or for inaccessible structural elements, tendon monitoring during the service life is justified, e.g. by using electrically isolated tendons (other options need more development to be feasible in practice).**

  **and finally**

- **Prestressing is not a commodity; experienced personnel is needed to achieve durability.**

POST-TENSIONING STANDARD DETAILS

## FHWA Scan of European Segmental and Cable-Stay Bridges – 1999

**Scan of October 1999**

POST-TENSIONING STANDARD DETAILS

## FHWA Scan Team

**Federal and State Representatives**

| | |
|---|---|
| ■ Dr. Walter Podolny (DC) | FHWA |
| ■ Jonathan Hooks (DC) | FHWA |
| ■ Doug Edwards (FI) | FHWA |
| ■ Majid Madani | Caltrans |
| ■ Dr. Mohsen Shahawy | Florida DOT |
| ■ Randy Cox | Texas DOT |

POST-TENSIONING STANDARD DETAILS

## FHWA Scan Team

**Private Sector Representatives**

| | |
|---|---|
| ■ Maury Miller | HNTB |
| ■ Brett Pielstick | Eisman & Russo |
| ■ Man Chun Tang | T.Y.Lin - DRC |
| ■ Kent Montgomery | Figg Eng. Group |
| ■ Alan Moreton | (Author) FEG |

POST-TENSIONING STANDARD DETAILS

## EU Countries Visited / Met

- Switzerland - visited
- Germany - visited
- Denmark - visited
- Norway Rep - met
- France - visited
- United Kingdom - representative - met

POST-TENSIONING STANDARD DETAILS

## Salginatobel - Switzerland, Maillart 1927

POST-TENSIONING STANDARD DETAILS

## Salginotobel

- Reinforced concrete arch rehabilitated by cleaning, sealing and coating
- Recognized in 1991 by ASCE as an International Historic Civil Engineering Landmark

POST-TENSIONING STANDARD DETAILS

## Hosts and Guests - FHWA Scan 1999

POST-TENSIONING STANDARD DETAILS

## Acknowledgements

- Switzerland - Federal Institute of Technology (ETH)
- Germany - Federal Highway Research Institute
- Denmark - Road Directorate, Ministry of Transport
- Norway - Norwegian Road Directorate
- France - Service d'Etudes des Routes et Autoroutes
- United Kingdom - Highways Agency
- Various other authorities, private firms and individuals

POST-TENSIONING STANDARD DETAILS

## Overall Impression

- Excellent exchange of ideas, understanding
- Insights far greater than learned through normal daily business, conferences, internet
- Focussed effort = well worth time and cost
- Engineering and administration in EU is different to US but experiences and technology are the same or similar - so -
- EU and US progress in same direction

POST-TENSIONING STANDARD DETAILS

## EU Performance Seg'l and Cable Stay

- European average 10 years older than US
- First segmental bridges - from 1960's
- First modern cable-stay - c. 1962 (Swiss)
- Overall performance is good - Europeans are well satisfied and continue to build them
- "Old-issues" c. 1970's (e.g. excess creep deflection, etc.) solved by standards and practice introduced in 1975. All now O.K.

POST-TENSIONING STANDARD DETAILS

## Sunniberg Bridge, Switzerland, 1999

POST-TENSIONING STANDARD DETAILS

**Sunnigberg, Switzerland, FHWA Scan 1999**

POST-TENSIONING STANDARD DETAILS

## Rehab of 1st Generation - (pre 1970's)

- **Chillon Viaduct (Switzerland)**
  - **Added PT to cantilevers with mid-span hinges**
  - **No corrosion - good waterproofing / overlay**
- **Autobahn Bridges (various - Germany)**
  - **Cracks at 1/4 span joints with coupled tendons**
  - **Add external grease and sheath mono-strand**
- **Corbeil Bridge (France)**
  - **Added external longit PT to midspan - with**
  - **Transverse PT to bottom slab / internal frames**

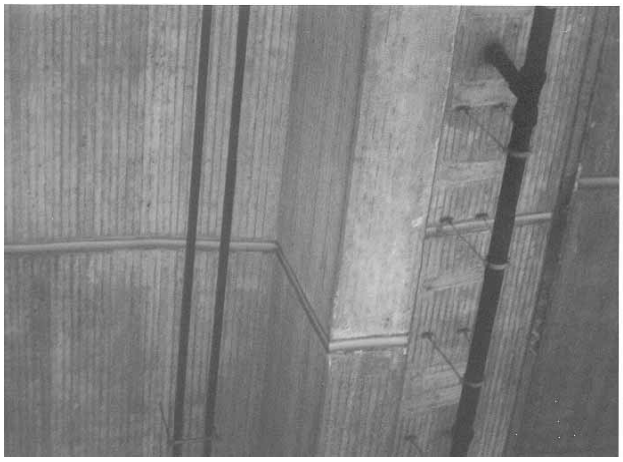
POST-TENSIONING STANDARD DETAILS

## Chillon Viaduct, Switzerland, built 1967

- Continuous
- Midspan hinges
- Deflection
- External PT added
- Waterproof deck - no corrosion of tendons

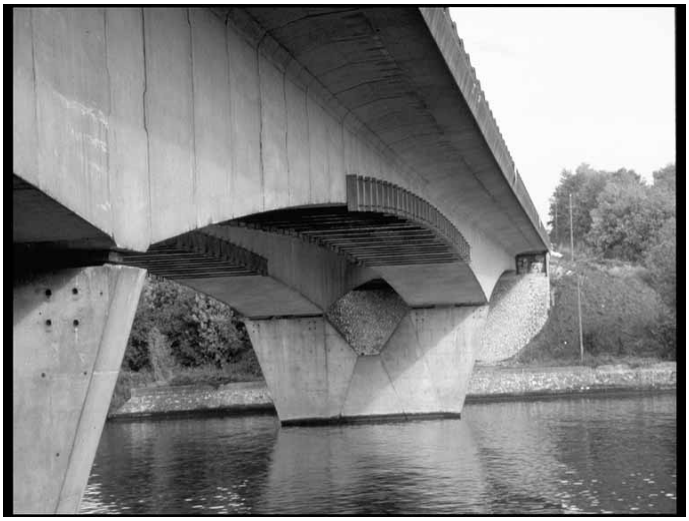
POST-TENSIONING STANDARD DETAILS

## Rehab. of "Coupling Joint" - Koln, 1999



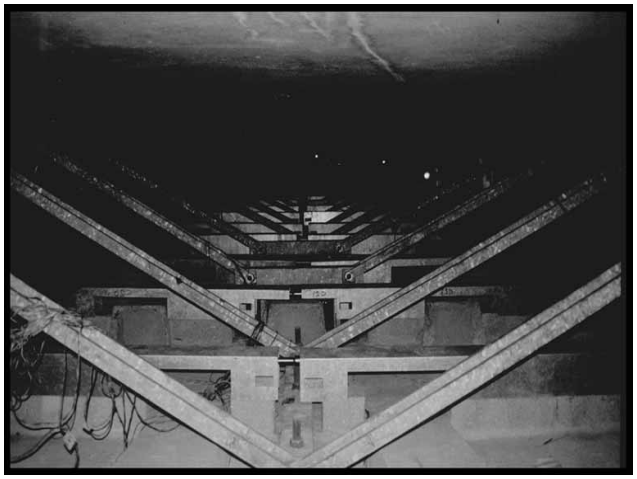
POST-TENSIONING STANDARD DETAILS

## Corbeil Bridge rehabilitation, France



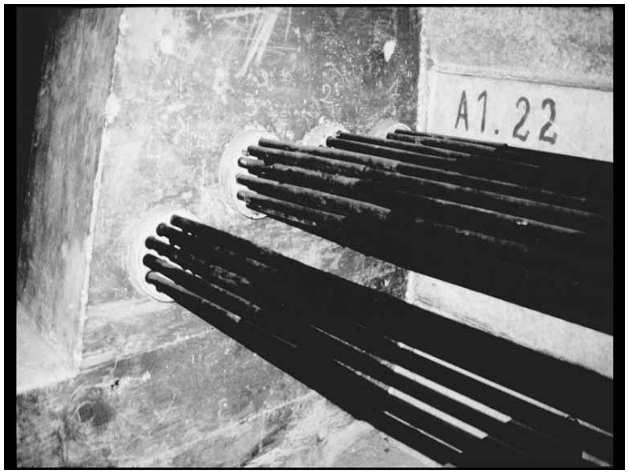
POST-TENSIONING STANDARD DETAILS

## Internal transverse frames and PT



POST-TENSIONING STANDARD DETAILS

## Ext. PT - Greased and sheathed strands




POST-TENSIONING STANDARD DETAILS

## Anchors of ext. PT grouted and capped

POST-TENSIONING STANDARD DETAILS

## EU Structure Protection

- Little or selective use of epoxy-rebar (some for salt splash barrier face)
- Stainless steel rebar is becoming cost effective for similar applications
- Less use of aggressive de-icing salts
- Cover = same as USA approximately
- Sealers (silanes/siloxanes) use as in US
- Coatings (epoxy/p'urethane) use as in US
- Buried surfaces are coated with bitumen

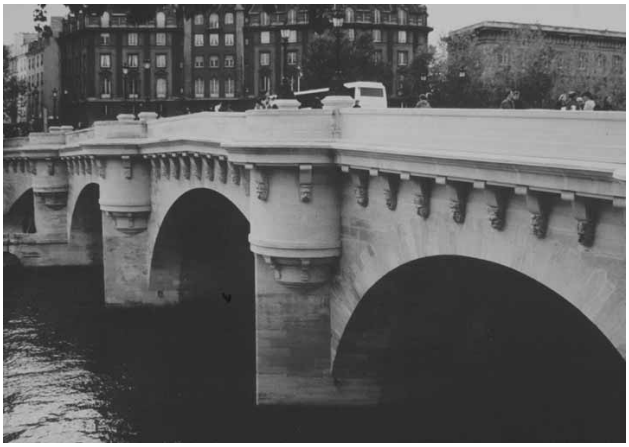
POST-TENSIONING STANDARD DETAILS

## EU Maintenance Policy

- All EU countries perform regular inspections or condition checks
- Generally, pro-active repair is implemented as soon as any damage found
- Bridge Management Systems vary according to country, resources and and needs but most are similar to those in the US
- Maintenance funds may meet "half" of need (compare to US where only 10 to 20%)

POST-TENSIONING STANDARD DETAILS

## Pont Neuf, Paris - natural stone cleaned



POST-TENSIONING STANDARD DETAILS

## EU Concrete

- Concrete is similar to US with similar strengths and allowable stresses with zero tension or 1.5N/mm^2 (200psi) comp.
- Corrosion resistance is enhanced through low w/c, air entrainment, fly-ash, micro-silica, other additives etc. - but practice varies
- Calcium nitrite not effective ("washes out")
- Increased strength is by-product of drive to improved durability - but is not "used" .

POST-TENSIONING STANDARD DETAILS

## EU Performance - Post-Tensioning

- All EU report some corrosion of rebar in all types of construction (concrete beams, cast-in-place, precast and steel decks)
- PT corrosion caused by grout voids, bleed, and/or honeycombed concrete allowing access of water, oxygen, chlorides
- New rules on good installation of grout, details, vents, no voids or bleed
- Grout material is not issue - but is improved

POST-TENSIONING STANDARD DETAILS

## EU Internal and External Tendons

- Internal grouted tendons are now allowed only in slabs - i.e. not placed in webs
- External grouted allowed everywhere
- External greased and sheathed popular
- Combinations of internal and external tendons are allowed
- New "robust" PT ducts under development
- External tendons (grouted or greased and sheathed) are used for repairs / retrofit.

POST-TENSIONING STANDARD DETAILS

## External Strands

- Greased and Sheathed mono-strands are used for rehabilitation
- Grouted at end anchors
- Special deviator saddles used at diaphragms

POST-TENSIONING STANDARD DETAILS

## UK Moratorium on Post-Tensioning

- UK moratorium is still in effect for "internal, grouted tendons with discontinuous (poorly sealed) ducts" - which is (mis)interpreted to mean "no internal tendons with precast joints" (i.e. use all external PT) - but open to new ideas
- Performance spec. requires proof test of joint system for internal tendons in precast construction (i.e. discontinuous ducts)
- Otherwise segmental is OK - however,
- Few new bridges = no UK segmental industry

POST-TENSIONING STANDARD DETAILS

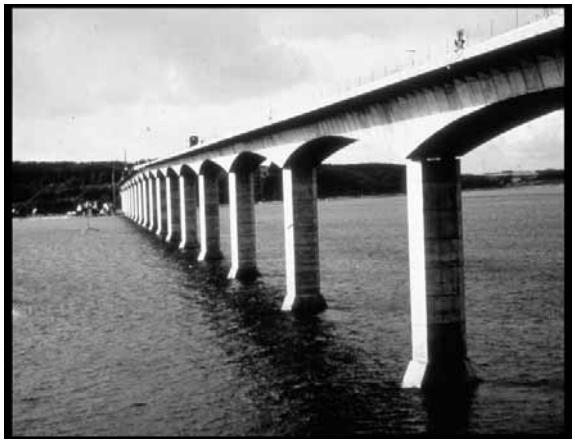
## EU - Epoxy Joints - Recent Findings

- Good (20+yr) performance with no signs of corrosion of internal PT in major cantilever bridges at;
  - Sallingsund Fjord Bridge (Denmark - 1979)
  - M180 River Trent Bridge (England - 1979)
- Both of precast match cast segments with similarly sealed epoxy joints plus,
- Waterproof membranes and asphalt overlays

POST-TENSIONING STANDARD DETAILS

## Sallingsund, Denmark (opened 1979)

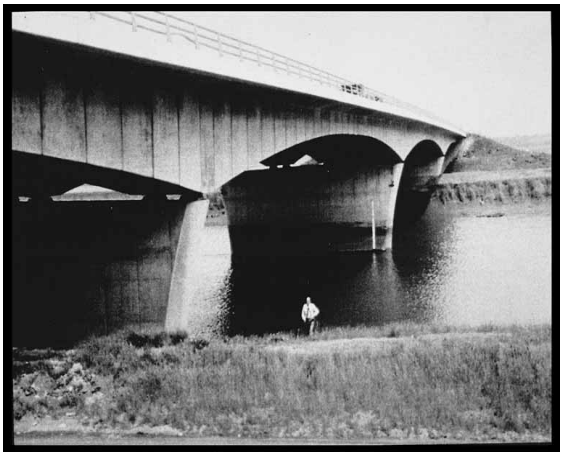
- Epoxy sealed joints
- Deck membrane and overlay
- No corrosion



POST-TENSIONING STANDARD DETAILS

## M180, Trent Bridge, UK, (opened 1979)

- Epoxy Sealed Joints
- Deck membrane and overlay
- No corrosion



POST-TENSIONING STANDARD DETAILS

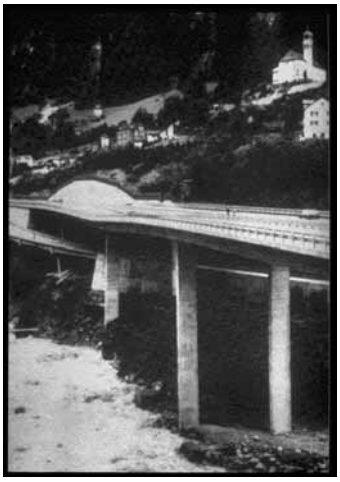
## Integrity of PT Structures

- Reusbrucke Wassen, Switzerland, 1987
- Undermined by flash floods
- Severe loss of support and deflection > 1m.
- Superstructure jacked back up, repaired and pier underpinned.
- Re-opened 1988

POST-TENSIONING STANDARD DETAILS

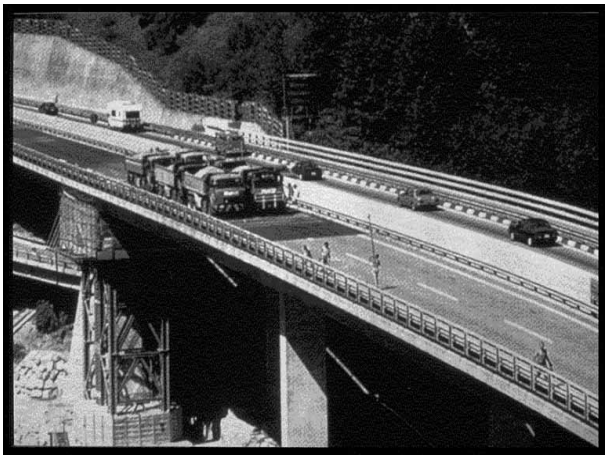
## Reussbrucke Wassen, Switzerland

- PT concrete box
- 1987 flash floods undermined pier
- Over 1m. Deflection
- Bridge remained intact



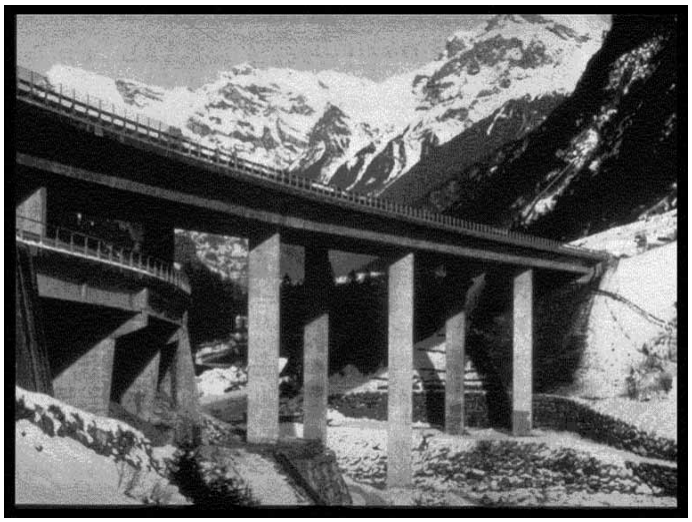
POST-TENSIONING STANDARD DETAILS

## Reussbrucke - post underpin load test



POST-TENSIONING STANDARD DETAILS

## Reussbrucke - reopened 1988



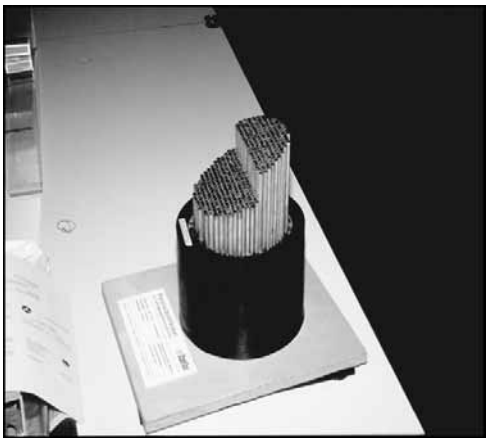
POST-TENSIONING STANDARD DETAILS

## Sunnibergbrucke - Switzerland

POST-TENSIONING STANDARD DETAILS

## Sunnigbergbrucke - Cable Stay

- Parallel wires
- In inert matrix
- Thick wall PE pipe
- All stays prefabricated to length at factory



POST-TENSIONING STANDARD DETAILS

## Non-Destructive Evaluation (NDE)

EU and US methods for old tendons and stays:

- gammagraphy
- x-ray
- ultra-sonic
- georadar
- magnetic perturbation
- electrical resistance... etc

all only partially useful = no “magic bullet”

POST-TENSIONING STANDARD DETAILS

## Demolition or Deconstruction

- EU: some (non-segmental) PT structures have been replaced for traffic inadequacy
- FR: dismantled segmental cantilever in reverse sequence to erection - saw cut at joints. (Also, “reverse launch” of beams)
- EU in general, for deconstruction, all countries require an “engineered” solution with supporting calculations by experienced and knowledgeable engineers

POST-TENSIONING STANDARD DETAILS

## Demolition or Deconstruction

POST-TENSIONING STANDARD DETAILS

## FHWA European Scan - Conclusions

- "Major Problems" are things of the past - (many resolved by 1977 FHWA scan)
- Tendon protection (grouting) is now being addressed through new codes and practices
- Likewise for protection of cable-stays - now require a "multi-barrier" system (like PTI)
- Enhanced concrete performance and deck waterproofing / protection add durability

POST-TENSIONING STANDARD DETAILS

## FHWA European Scan - Conclusions

- In general, segmental and cable-stay bridges in Europe are performing well
- They comprise important technology and are still being designed and built.
- The Scan found no new dramatic revelations
- In general, US and EU head in same direction - thus confirming current practice

POST-TENSIONING STANDARD DETAILS

POST-TENSIONING STANDARD DETAILS

# QUESTIONS / ANSWERS

**www.dot.state.fl.us/structures**