SECTION 2

PT SYSTEMS

DEVELOPED BY THE PTI EDC-130 EDUCATION COMMITTEE
OUTLINE

- Unbonded and Bonded Post-Tensioning Comparison
- Unbonded Post-Tensioning:
  - Systems and equipment
  - Function of the coated tendon
  - Construction
- Bonded Post-Tensioning:
  - Various systems, components and equipment
  - Function of the grouted tendon
  - Construction
- Post-Tensioning Applications
UNBONDED AND BONDED PT COMPARISON

- **Unbonded Post-Tensioning (PT)**
  - Tendon is not bonded to the surrounding concrete
  - PT force is transmitted to the structure by means of the anchorages.

- **Bonded Post-Tensioning (PT)**
  - Tendon is bonded to the concrete
  - Bond is achieved throughout the length of the tendon by a cementitious matrix called grout.
  - Bond between the strand and the concrete is achieved through the duct after grouting
  - PT force at every section is a function of the deformation of the concrete (strain compatibility)
UNBONDED AND BONDED PT COMPARISON

- Applications: both systems are used in building and civil structures (bridges, containment structures, etc...)
  - In USA, unbonded is more common in buildings
  - Bonded is more common in civil structures
  - Both systems can be used as external post-tensioning
- Performance and durability: both systems provide comparable satisfactory results
- Selection of a system depends on:
  - Availability
  - Economics
  - Specific needs of each project
## MAJOR CONSTRUCTABILITY DIFFERENCES

<table>
<thead>
<tr>
<th></th>
<th>Unbonded</th>
<th>Bonded</th>
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<tbody>
<tr>
<td>Fabrication of tendons in plant</td>
<td>Necessary</td>
<td>Not necessary but possible</td>
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<tr>
<td>(extrusion &amp; cutting to specific</td>
<td></td>
<td></td>
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<tr>
<td>length)</td>
<td></td>
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<tr>
<td>Placement</td>
<td>Very practical and</td>
<td>Very practical and flexible.</td>
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<td></td>
<td>flexible. Easy to handle</td>
<td>Depending on application and</td>
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<td></td>
<td>and does not necessitate</td>
<td>system used, may require heavy</td>
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<tr>
<td></td>
<td>heavy equipment</td>
<td>equipment and reduced flexibility</td>
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<tr>
<td>Grouting</td>
<td>Not Applicable</td>
<td>Necessary</td>
</tr>
<tr>
<td>Stressing</td>
<td>Single strand stressing</td>
<td>Typically multi-strands with high</td>
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<td></td>
<td></td>
<td>stressing forces. Single strand</td>
</tr>
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<td></td>
<td></td>
<td>stressing in specific systems</td>
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<tr>
<td>Demolition</td>
<td>Requires special care</td>
<td>Straight forward (similar to regular</td>
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<td>reinforcement)</td>
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UNBONDED SYSTEMS

- Monostrand PT systems:
  - Coated strand
  - Coated anchors
  - Encapsulation accessories
  - Wedges
UNBONDED PT COATED STRAND

- The process of coating the strand is called extrusion
- Coated strand
  - 7-wire PC strand: ultimate strength $f_{pu} = 270 \text{ ksi}$
  - Plastic sheathing: High Density Polyethylene (HDPE) or Polypropylene (PP)
  - PT coating: Corrosion inhibiting grease
UNBONDED PT ANCHORAGE

- Encapsulated anchorage
  - Prevent water infiltration and corrosion
- Monostrand steel anchor coated with corrosion protection
- Lockable encapsulation sleeves
- Encapsulation cap to cover strand tails (ends)
- Plastic pocket former
STEEL WEDGE

- Wedges are responsible of locking the strand after stressing so it holds the force
- Wedges are made of steel and have ductile core to adjust to strand shapes
FUNCTION OF STRAND COATING

• Function of the PT coating
  – Allow a bond free movement of the strand inside the sheathing.
  – Increase protection against corrosion and provide a non-conductive environment for corrosion
  – Reduce friction between the strand and sheathing
• Function of the sheathing
  – Provide corrosion protection to the strand
  – Provide encasement against damage and moisture penetration
UNBONDED PT STRESSING EQUIPMENT

Monostrand Stressing Jack

Stressing Pump

Gauge
UNBONDED PT CONSTRUCTION

- Tendon fabrication (PTI certified plants)
- Site installation
- Inspection and concrete placement
- Stressing operation
UNBONDED PT FABRICATION

- Tendon extrusion and cutting to length
- Tendon bundling
- Tendon color coding & labeling
- Loading and shipping to site
UNBONDED PT INSTALLATION

- Placing of formwork
- Fixing of anchors to side formwork
- Installing chairs to profile heights shown on PT drawings
- Installing reinforcement and PT tendons
UNBONDED INSPECTION AND CONCRETE CASTING

- Inspect reinforcement and PT installation according to drawings
- Cast concrete
  - Thorough vibration around anchorages
  - Avoid damaging PT tendons
  - Proper curing
UNBONDED PT STRESSING

- Remove edge formwork
- Prepare tendons for stressing
- Check achieved concrete strength
- Stress tendons using calibrated monostrand equipment
- Fill out elongation records
- Approve elongations
- Seal tendons and patch pockets
Several systems exist with main components being:
- Bare Strands or Bars
- Steel Anchorage Assemblies (bearing plates and wedge plates); proprietary designs
- Plastic or Galvanized Metal Ducts
- Steel Wedges
- Typically multistrands encased in grouted duct
- Bonded systems also known as grouted systems
FUNCTION OF GROUTED DUCTS

• Function of the duct
  – Maintain a voided path for strands during construction
  – Transfer the bond between the grout & the concrete
  – Act as additional corrosion protection against penetration of moisture and chemicals

• Function of the grout
  – Provide a continuous bond between the strand and the duct
  – Increase protection against corrosion
  – Provide a non-conductive environment for corrosion
BONDED PT SYSTEMS

- High capacity multistrand systems used in civil structures and transfer beams or slab construction
- Main components
  - Bare strands
  - Multistrand anchorage assembly
  - Round corrugated duct
  - Grout accessories (cap, shut-off valves, vents, etc...)
  - Wedges
BONDED PT SYSTEMS

• Flat systems used typically in thin concrete elements and slab construction
• Main components
  – Bare strands
  – Multistrand anchorage assembly
  – Flat corrugated duct
  – Grout accessories (cap, vent tubes, etc.)
  – Wedges

Duct
Deviation Cone (Optional)
Bearing Plate
Wedge Plate
Anchorage Assembly
Wedges
BONDED PT SYSTEMS

- Bar systems:
  - PT bar
  - Steel anchor
  - Duct
  - Grout accessories
- Monostrand grouted system
  - Single strand anchor
  - Round duct
  - Wedge
  - Grout accessories
BONDED PT
STRESSING EQUIPMENT

Stressing Jack

Strand Pusher

Stressing Pump

Grouting Machine
BONDED PT CONSTRUCTION

- Installation
- Inspection and concrete placement
- Stressing operation
- Grouting operation
BONDED PT SYSTEMS INSTALLATION

- Placing of formwork and side shutter
- Fixing of bearing plates
- Placing of ducts and reinforcement
- Profiling ducts according to drape specified on PT installation drawings
- Placement of strands inside duct (can be done before or after casting of concrete)
INSPECTION AND CONCRETE PLACEMENT

- Inspect reinforcement and PT installation according to placement drawings
- Cast concrete
  - Thorough vibration around bearing plates
  - Avoid damaging PT tendons
  - Proper curing
BONDED PT SYSTEMS STRESSING

- Remove edge formwork
- Prepare tendons for stressing
- Check achieved concrete strength
- Stress tendons using calibrated equipment
- Fill up elongation records
- Approve elongations
BONDED PT SYSTEMS
GROUTING

- Check ducts for blockage
- Grout and seal tendons
- Record grouting results
- Check vents for grout adequacy
PT APPLICATIONS:
2-WAY SLABS

Photo Courtesy of Seneca Structural Engineering Inc.
PT APPLICATIONS: TWO-WAY SLABS
PT APPLICATIONS: SLABS-ON-GROUND
PT APPLICATIONS: SLABS-ON-GROUND

Uniform Thickness Foundation
PT APPLICATIONS: MAT FOUNDATIONS
PT APPLICATIONS: INDUSTRIAL FLOORS
PT APPLICATIONS: PARKING STRUCTURES
PT APPLICATIONS: GROUND ANCHORS
PT APPLICATIONS: STORAGE STRUCTURES
PT APPLICATIONS: BARRIER CABLE
PT APPLICATIONS: STRENGTHENING
PT APPLICATIONS: SPLICED GIRDERS