POST-TENSIONED CONCRETE

INFORMATION SESSION

AMSYSSCO, INC.
OUTLINE of INFO SESSION

PART ONE
1. Introduction to Post-Tension
2. Components of Post-Tension
3. Construction Team
4. Submittals

PART TWO
5. Pre-Installation
6. Installation Management
7. Post-Concrete Placement

PART THREE
8. Troubleshooting

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1. INTRO to POST-TENSIONING

- History of Post-Tensioning
- AMSYSCO
- Uses & Types of Post-Tensioning
- Benefits of Post-Tensioning
1.1 History of Post-Tensioning

- **Post-Tensioning** is a method of prestressing. Concrete is weak in tension. PT increases concrete’s ability to perform under tensile stresses. Tendons are tensioned after the concrete is poured.

- **1928**: Modern Prestressed Concrete “invented.”

- **1946**: Post-Tensioning gained momentum in Europe due to steel shortage.

- **1951**: 1st PT bridge constructed in U.S.

- **1963**: Prestressed Concrete incorporated into ACI Code.

- **1976**: Post-Tensioning Institute (PTI) founded.
1.2 AMSYSCO, Inc.

- 1981: AMSYSCO, Inc. founded by Rattan Khosa
- 1984: Joined PTI
- 1985: Installed extrusion line equipment
- 1989: Became PTI Plant Certified
- 1990: Rattan Khosa elected to PTI Executive Committee
- 1999: Rattan Khosa became President of PTI (2yrs)
- 2000: Completed 400th unbonded PT project
- 2003: Neel Khosa joined AMSYSCO
- 2007: Moved headquarters to Romeoville, IL
- 2008: Awarded PTI Project of the Year (Guthrie)
- 2009: Completed Target Field (MN Twins)
1.3.1 Types of Post-Tensioning

PRESTRESSING STEEL TENDONS

- **Mono-Strand** = One single strand per tendon.
- **Multi-Strand** = Multiple strands per tendon.
- **Unbonded**: Tendon encased in plastic sheathing. Does not bond to concrete. Force transferred by the anchorage only.

- **Bonded**: Tendon installed in ducts that are pumped with grout after stressing. Bonds to concrete.
1.3.2 Uses of Post-Tensioning

- Commercial High-Rise
- Multi-Family Housing
- Residential Housing (SOG)
- Parking Structures
- Stadiums / Theaters

- Bridges
- Stadiums
- Tennis Courts
- Water Tanks / Silos
- Nuclear Plants
- Repair & Restoration
1.4 Benefits of Unbonded Post-Tension

**MATERIAL SAVINGS**
- Thinner Concrete
- Reduced Rebar
- Reduced Bldg Height + Vertical Elements
- Reduced Foundation

**QUICKER CONSTRUCTION**
- Potential 3-4 Day Pour Cycle
- Reduced Reshoring Requirements
- MEP + Embed Coordination

**INCREASED DURABILITY**
- Improved Seismic Behavior
- Reduced Deflection + Vibration
- Improved Waterproofing + Crack Control
- Longer Spans & Fewer Columns

**REDUCED LIFECYCLE COSTS**
- Reduced Height = Less Energy
- Less Maintenance
- Potential LEED Credits

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2. COMPONENTS of Post-Tension

- Strand (bare & coated)
- Anchor, Wedges, Pocket Former
- Encapsulated vs. Regular System
- Support (chairs & bars)
- Stressing Equipment
- Barrier Cable
2.1.1 Strand – Bare

- **Strand**: High-strength steel wire. 6-wires twist around 7th central “king”-wire. Typical diameters are 0.5” and 0.6”.
- **Tendon**: Strand that is encased with a layer of corrosive-inhibitor (grease) and plastic sheathing.

<table>
<thead>
<tr>
<th>Strand</th>
<th>0.5”</th>
<th>0.6”</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>0.525</td>
<td>0.740</td>
<td>lbs per ft</td>
</tr>
<tr>
<td>Ultimate Stress</td>
<td>270</td>
<td>270</td>
<td>ksi</td>
</tr>
<tr>
<td>Cross-sectional area</td>
<td>0.153</td>
<td>0.217</td>
<td>sq.in.</td>
</tr>
<tr>
<td>MUTS = ksi x sq.in.</td>
<td>41.3</td>
<td>58.6</td>
<td>kips</td>
</tr>
<tr>
<td>Jacking Force = 80% MUTS</td>
<td>33</td>
<td>46.8</td>
<td>kips</td>
</tr>
<tr>
<td>Avg. Final Effective Force</td>
<td>~27.5</td>
<td>~38.0</td>
<td>kips</td>
</tr>
<tr>
<td>Elongation = approx. 8” per 100’-0 tendon length</td>
<td></td>
<td></td>
<td>inches</td>
</tr>
</tbody>
</table>
2.1.2 Strand – Coated

- **PT Coating or Tendon Grease**
  - Reduces friction during stressing
    - *Less friction means more force per tendon.*
  - Eliminates rifling in plastic sheathing
  - Protects Strand from corrosion

- **PT Sheathing or Plastic Sheathing**
  - Extruded HDPE
  - Acts as bond breaker to enable stressing
  - Contains PT Coating
  - Acts as additional corrosion barrier
2.2 Anchor, Wedges, Pocket Former

- **Anchor**: Casting which houses **wedges** used to transfer prestressing force to concrete.
  - Fixed Anchor – installed in supplier’s plant
  - Intermediate Stressing – located at construction joints
  - Stressing Anchor – where jacking force is applied

- **Wedges**: Tapered high-strength steel with teeth.

- **Pocket Former**: Temporary device that creates opening/pocket in concrete to allow for stressing.

*Images of anchor and pocket former diagrams*
2.3 Encapsulated vs. Regular

<table>
<thead>
<tr>
<th>Component</th>
<th>Encapsulated</th>
<th>Regular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic Sheathing</td>
<td>50 ML</td>
<td>40 or 50 ML</td>
</tr>
<tr>
<td>Anchors</td>
<td>Plastic-Coated Metal</td>
<td>Uncoated Metal</td>
</tr>
<tr>
<td>Pocket Formers</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Snap Caps</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Wedges</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Translucent Sleeves</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>- filled with grease</td>
<td>YES</td>
<td>N/A</td>
</tr>
<tr>
<td>Positive Mechanical Connection</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Seal Plugs</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Protection during shipping</td>
<td>YES</td>
<td>Depends on spec.</td>
</tr>
</tbody>
</table>
2.4.1 Supports — Definitions

- **C.G.S.** = Center of Gravity of Steel
- **C.G.C.** = Center of Gravity of Concrete
- **AT ANCHORAGES:** C.G.S. = C.G.C.

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- **Profile / Drape:** Tendon elevation inside concrete.
  - Slab-On-Ground has no drape in slab (not in beams).
- **High Point:** Control point at column supports.
- **Low Point:** Control point at mid-span.
2.4.2 Supports – Function

- Maintains tendon drape & Reduces tendon wobble.
- Stabilizes tendon during concrete placement.

- **Support Chair**: Plastic supports used in slabs.
- **Support Bar**: #4 Bar.
- **Slab Bolster**: Used at slab midspans. No bar required.
- **Beam Supports**: Attach U-bars to stirrups.

- Maximum 48” spacing (U.N.O.)
2.5 Stressing Equipment

- Hydraulic Jack/Ram and Electric Pump with Gauge.
- Needs 110V, 30 amps power with cords that are 3-wire, 12-gauge and less than 100 feet long.
2.6 Barrier Cable

- Used for pedestrian and/or vehicular restraint.
- Same as 0.5” Post-Tensioning strand.
  - Except for galvanization or epoxy coating.
- Anchorage devices may be different also.
3. CONSTRUCTION TEAM
3.1 Architect & Structural Engineer

- **ARCHITECT**
  - Provides building dimensions and layout.
  - Provides barrier cable design.

- **STRUCTURAL ENGINEER**
  - Provides structural design for post-tensioning, etc.
  - Provides concrete mix design requirements.
  - Adherence to building and seismic codes (IBC, etc.)
  - General and special requirements.
3.2 General Contractor

- Provides latest design documents to PT Supplier.
- Approves pour sequence.
- Coordinates post-tensioning with other trades (embeds, stairs, openings etc.) that may affect the access to stressing tendons.
- Manages post-tensioning process.

**Should obtain from PT Supplier:**
- Bare and Gross weight of PT
- # of Holes in bulkhead to stress
- # Pockets to grout
- Support/Backup bar tonnage (epoxy)
- Pour Sequence
3.3 Post-Tension Supplier

- Must ship material from a PTI Certified Plant.

- Responsibilities include:
  - Provide installation shop drawings and calcs that meet requirement in structural design drawings.
  - Furnish post-tensioning tendons and accessories to meet structural specifications.
  - Certify calibrated stressing equipment.
  - Assist in solving preconstruction and field issues related to post-tensioning.
  - Provide theoretical elongation ranges.
3.4 Post-Tension Installer

- Should be PTI Certified – Level 2 Ironworker (or equal).

- For safety reasons, individuals operating stressing equipment must have experience in stressing and basic maintenance.

- Should keep a copy of the PTI ‘Field Manual’ onsite.
3.5 Post-Tension Inspector

- Should be PTI Certified – Level 2 Inspector.
- Independent party from PT Supplier and Installer.

Responsibilities include:
- Check tendon profiles.
- Monitor stressing operations.
- Measure elongations after stressing.
- Compare measured to theoretical elongations.
- Make elongation report for Str. Engineer’s approval.
3.6 Other Subcontractors

- **Rebar Supplier** – needs bar list for support steel.
- **Forming Contractor** – needs pour sequence.
- **Concrete Supplier** – mix design to ensure adequate concrete strength at time of stressing.
- **MEP Trades** – coordinate openings for office/residential.
- **Trades with Embeds** –
  architectural precast, curtain-wall, railings, etc.
4. SUBMITTALS

PT SUBMITTALS
1. Installation Drawings
2. Friction Calcs
3. Product Data
4. Samples
4.1 Construction Documents

- **Drawings**
  - Structural
  - Architectural

- **Specifications**
  - Post-Tensioning (Division 3)
  - Barrier Cable (Division 5)

- **Construction Schedule**
  - Forming, Delivery, Installation and Stressing dates
4.2 Pre-Detailing

- CAD Files
- Pour Sequence
  - Construction Joints
  - Pour Strips
  - Stressing Restrictions
- Scope review
  - Special requirements
- Coordination with other trades
  - Openings (MEP, crane) & Embeds (precast, curtainwall)
4.3 Post-Tensioning Submittals

- Installation Drawings
  - Tendon Plan
  - Support Plan
  - Beam End View Details
- Friction Calculations
- Product / Test Data
- Bar List (support/backup)
- Mill Certificates
- Samples

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5. PRE-INSTALLATION
5.1 PTI Certified Plant

- Fabrication
  - Raw Materials
  - PT Coating/Grease
  - Plastic Sheathing
  - Corrosion Protection

- Delivery
  - Mill Certs
  - Bill of Lading
  - Cutting Lists
  - Jack Calibration
5.2 Jobsite

- Unloading & Handling without damaging PT
- Storage to protect from corrosion.
- Organization of post-tension inventory.
- **Safety** during installation and stressing.
6. JOBSITE INSTALLATION

- Anchors
- One-Way Slab
- Two-Way Slab
- Slab-On-Ground
- Concrete Placement
6.1 PTI Field Procedures Manual

- Published by Post-Tensioning Institute

- Provides procedures and details for post-tensioned concrete installation.

- Introduction
- Document Control
- Delivery, Acceptance, Handling and Storage
- Installation Concrete Placement
- Tendon Stressing
- Elongation
- Tendon Finishing
- Encapsulation
- Jobsite Troubleshooting
- Appendix
6.2 Anchor Types

A. **Fixed / Dead End** – Anchor attached on one end of tendon. Installed by PT supplier.

B. **Intermediate Anchor** – Anchor placed on tendon by PT supplier. Moves freely until it is installed at construction joint by PT installer.

C. **Stressing / Live End** – Anchor attached on one or two end(s) of tendon. Installed by PT installer. Stressing occurs after concrete reaches specified strength.
6.3 One-Way Slab

- **Beam Tendon** – Group of tendons placed inside a beam. Supported by rebar. (similar to girders, joists).

- **Slab Tendon** – Tendons or Bundles of Tendons placed in the slab that run perpendicular to the beam. Supported by chair and/or rebar.

- **Temperature Tendon** – Tendons placed in the slab that run parallel to the beam. Installed for crack-control. Supported by chair/rebar and/or on main tendons.
6.4 Two-Way Slab

- **Banded Tendon** – Group of tendons placed together in a narrow strip along the column line.

- **Uniform / Distributed Tendon** – Tendons or Bundles of Tendons spaced uniformly that run perpendicular to the banded tendons.
6.5 Slab-On-Ground

- Used mainly in residential housing foundation, industrial floors or grade-level parking areas.

- Distributed tendons supported by chairs at each intersection. Profile at mid-depth of slab (unless there is a grade-beam).

- Tendons equally spaced, each way.
6.6 Concrete Placement

- Important to have proper strength before stressing.
- Stressing should occur within 3-4 days of pour.
- Dependant on 28 day strength and project specs.
7. POST-CONCRETE PLACEMENT
7.1 Safety

- Proper installation and storage affects safety
- Equipment O&M Manuals

- Stressing by qualified personnel
  - Controlled Access Area: No one allowed along entire length of tendon.
  - Recommend placing sand bags on top of Fixed End and Stressing End in case of blowouts.
  - Listen and watch equipment and concrete.
Before stressing:

- Concrete reach proper strength (typically 3000 psi)
- Clean anchor cavity with WD-40
- Install wedges, check alignment.
- Cross-Check equipment (automatic-seater)

Stressing Video on AMSYSCO website
7.3 Elongations

- Paint Markings
- Proper Measuring
- Use metal object
- Stressing Record

- Approved by Structural Engineer
- “Negative” elongation is slippage
7.4 Cutting

- Different methods of cutting tendon tails:
  - Oxyacetylene Torch (recommend fire-watch/welder)
  - Hydraulic Shear
  - Plasma Cutter
  - Abrasive Wheel

- Enough tail has to be cut to install snap cap.
  - Abrasive wheel not recommended for this reason.
7.5 Grouting

- Non-shrink, Non-chloride, Non-corrosive.
- Reach required strength.
- Clean anchor cavity prior to grouting.
- Spray resin in pocket to produce better grout cap.
- Grout within 1-2 days of approved stressing.
8. TROUBLESHOOTING

PRE-INSTALLATION
- Missing Tendons
- Damaged Tendons
- Short Tendon Length
- Missing Accessories
- Plastic Sheathing
- Rebar Congestion

EQUIPMENT
- Jack
- Pump
- Gauge

FIELD
- Concrete Issues
- Strand Breakage
- Elongation

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8.1 Pre-Installation Issues #1

- **Missing Tendons**
  - Check packing slips
  - Check color coding
  - Check other bundles

- **Short Length Tendons**
  - Splice Coupler and piece of tendon
  - Or Replace tendon

- **Damaged Tendons**
  - Anchor damage (replace anchor)
  - Kink in strand (replace tendon)
8.1 Pre-Installation Issues #2

- **Missing Accessories**
  - Support Chairs
  - Anchors
  - Wedges
  - Pocket Formers
  - Snap Caps, etc.

- Which Pours were shipped? Compare to packing slips.

- **Plastic Sheathing Issues**
  - Cuts (use repair tape)
  - Shrinkage at anchors (use repair tape/split-tubing or replace tendon).

- **Rebar congestion**
  - Beam anchor detail
  - Allow for concrete consolidation.
8.2 Equipment Issues #1

- **Hydraulic Jack (Ram)**
  - Grippers
  - Leaking
- **Electric Pump**
  - Tripping breakers
- **Gauge**
  - Needle jumps/stalls
- **Hoses (10,000 psi)**
  - Pressure buildup
8.2 Equipment Issues #2

- **Tips for Jack (Ram)**
  - Tighten screws for tendon-gripper.
  - Remove concrete, etc. in nose-piece and grippers.

- **Tips for Electric Pump / Gauge / Hoses**
  - Check rating and length of electric cord / generator.
  - Check whether gauge starts at 0 psi.
  - Tighten hose fittings and check for cuts in hoses.
  - Check oil reservoir.

- **DO NOT stress in rain/snow.**

- **Tie equipment off for fall-safety.**

- **DO NOT kick or drag equipment.**
8.3 Field Issues #1

- **Concrete Issues:**
  - Blowouts
  - Honeycombing
  - Voids
  - How to repair???

- **Installation Issues:**
  - Excessive tendon curves (w/o hairpins) can cause issues.
  - Jobsite damage to material.
8.3 Field Issues #2

- **Elongations (± 7%)**
  - Over-elongation means more force provided than anticipated.
  - Under-elongation is means less force provided than anticipated.
  - Check mill certs, EL range, tendon length, equipment, anchor cavity

- **Strand Breakage or Drilled Tendons**
  - PT Supplier can run force calc to find out remaining force.
  - Replace or Abandon.
  - Approval by Engineer of Record.
  - **Contact PT Supplier**
THANK YOU!

AMSYSCO’s Online Network

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