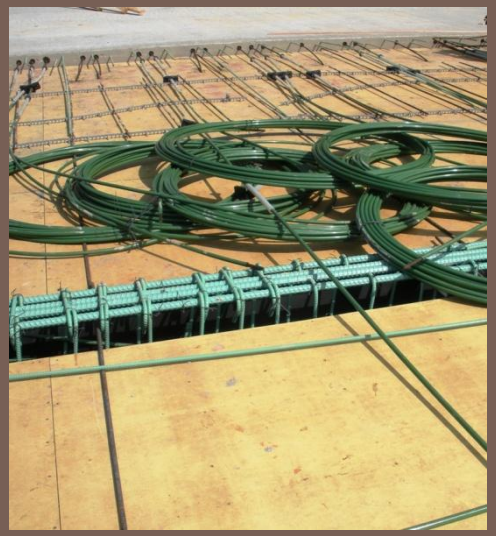
POST-TENSIONED CONCRETE

INFORMATION SESSION



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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

Click this icon to view video in presentation

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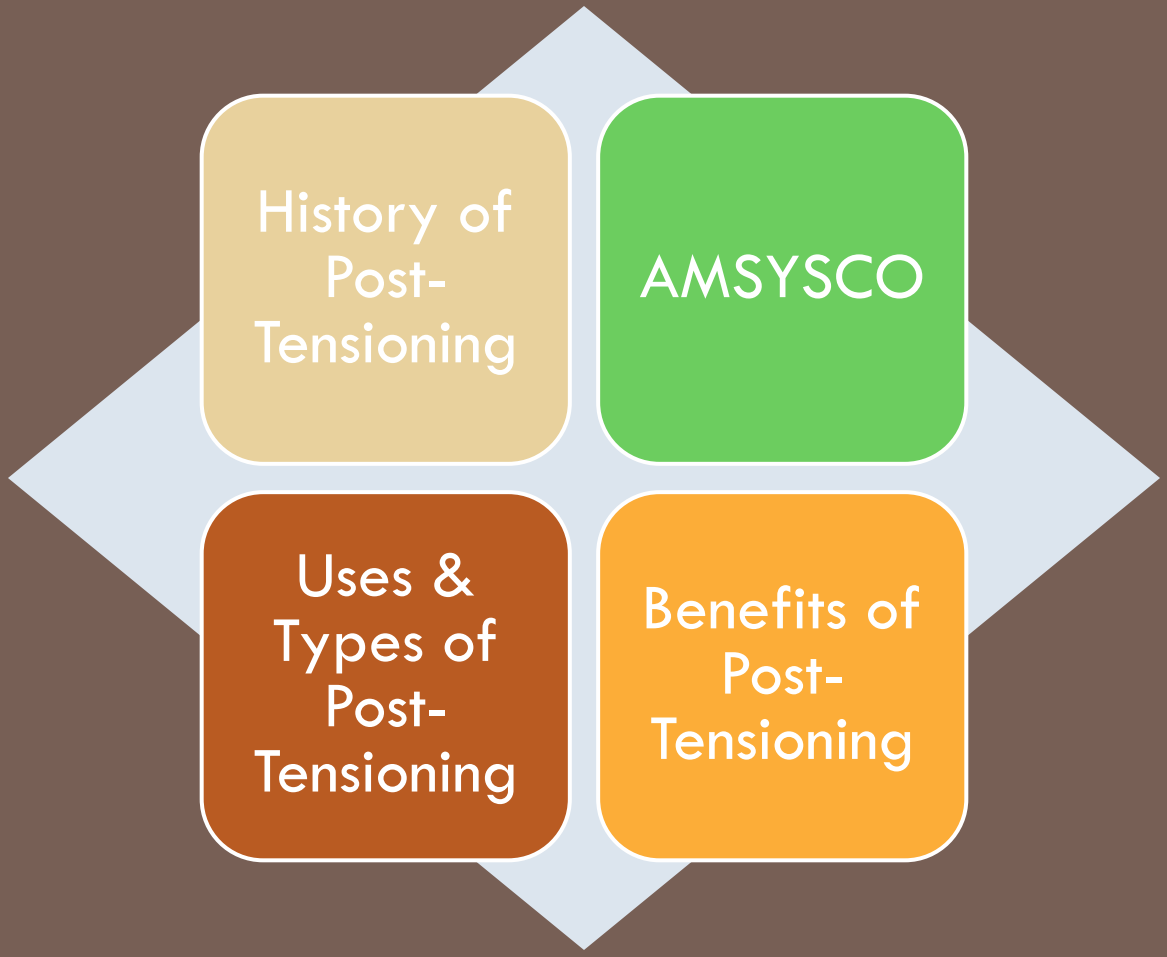

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1. INTRO to POST-TENSIONING

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.

POST-TENSIONING INSTITUTE

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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)

AMSYSCO, Inc.
1200 Windham Parkway
Romeoville, IL 60446

P: 630-296-8383
F: 630-296-8380
www.amsyscoinc.com

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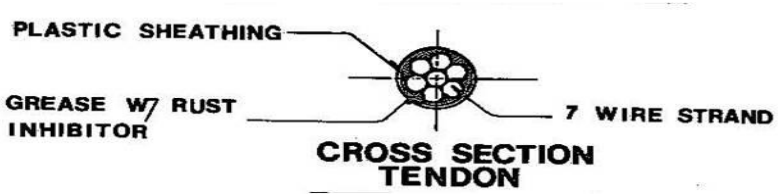
1.3.1 Types of Post-Tensioning

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.

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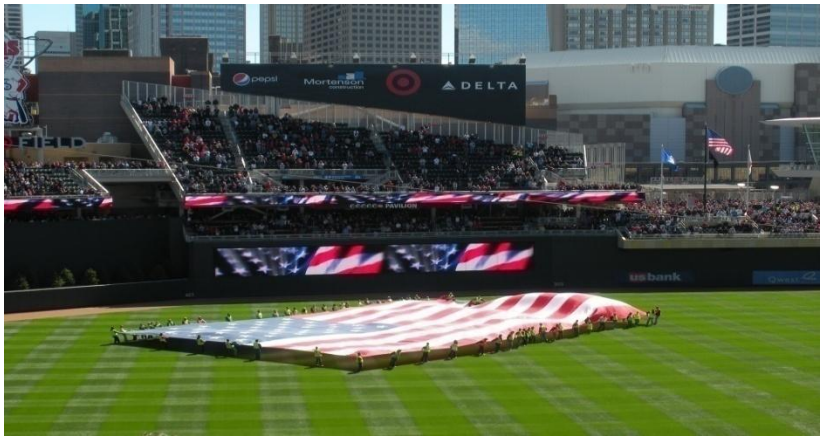
1.3.2 Uses of Post-Tensioning

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



- Bridges
- Stadiums
- Tennis Courts
- Water Tanks / Silos
- Nuclear Plants
- Repair & Restoration

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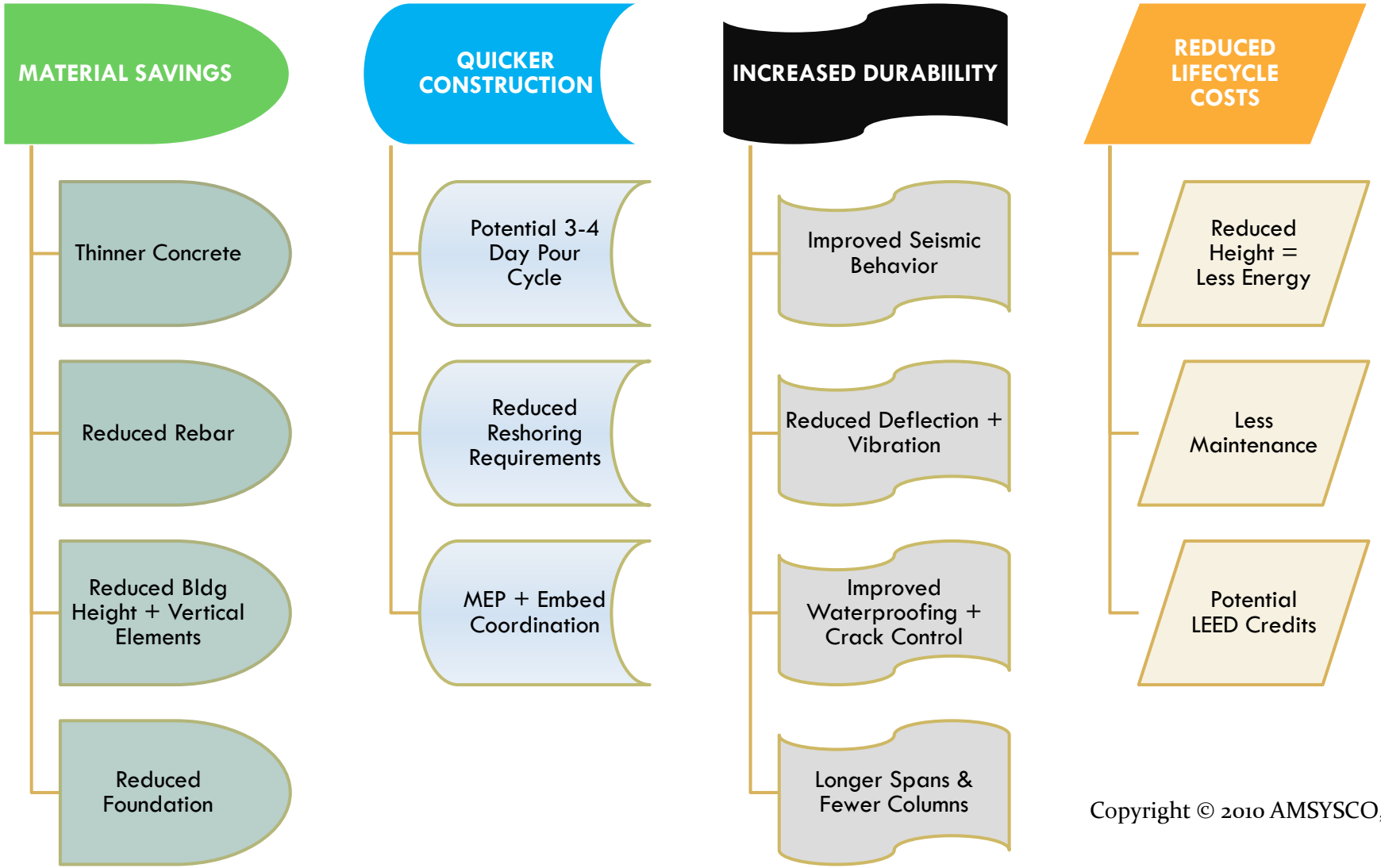
1.4 Benefits of Unbonded Post-Tension



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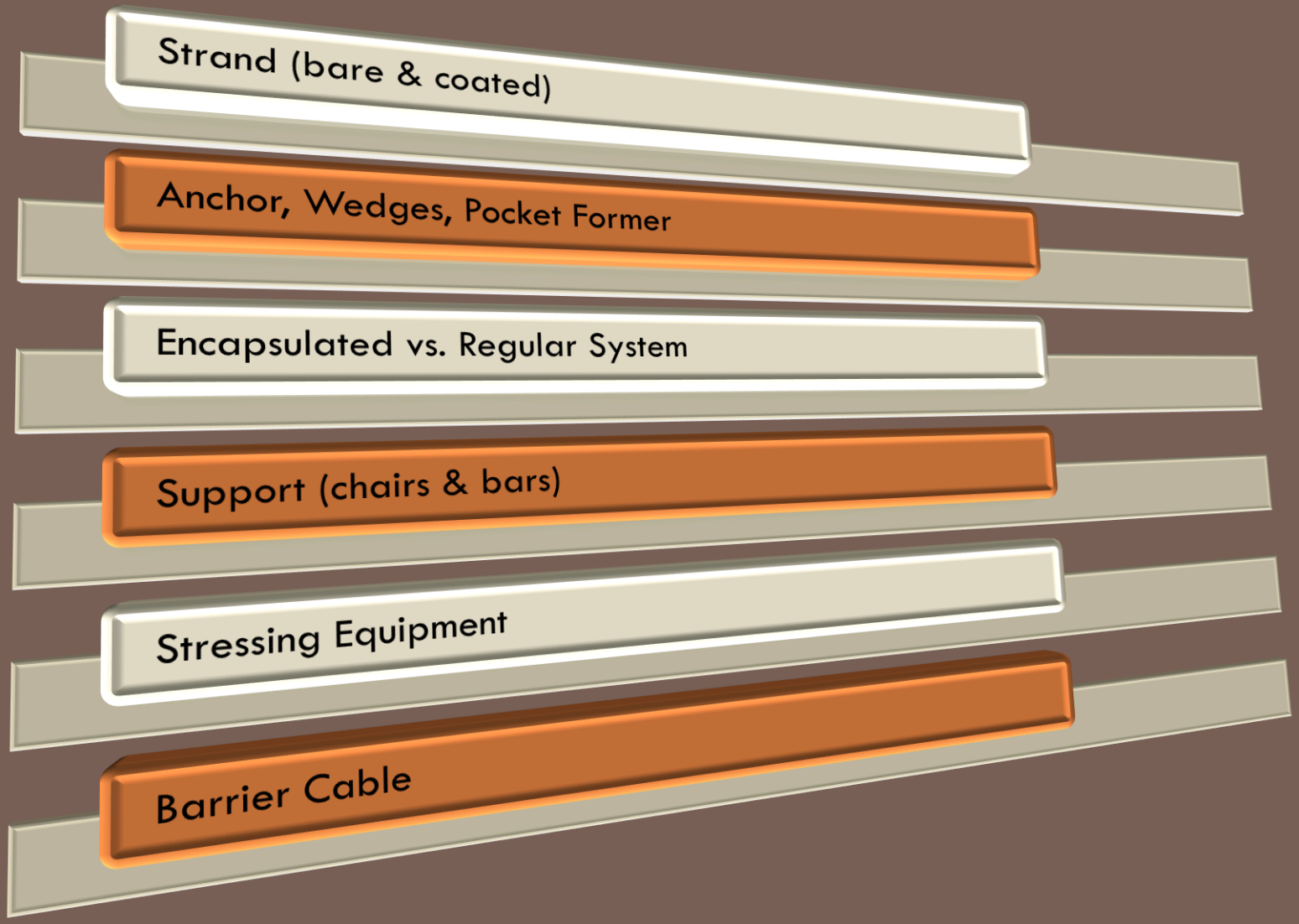

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2. COMPONENTS of Post-Tension

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.*

Strand	0.5"	0.6"	Units
Weight	0.525	0.740	lbs per ft
Ultimate Stress	270	270	ksi
Cross-sectional area	0.153	0.217	sq.in.
MUTS = ksi x sq.in.	41.3	58.6	kips
Jacking Force = 80% MUTS	33	46.8	kips
Avg. Final Effective Force	~27.5	~38.0	kips
Elongation = approx. 8" per 100'-0 tendon length			inches

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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

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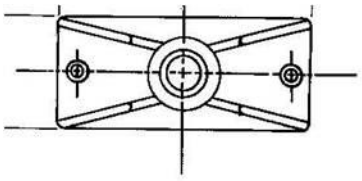
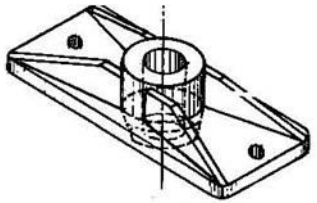
2.2 Anchor, Wedges, Pocket Former

- **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.



TOP VIEW - ANCHOR



ISOMETRIC VIEW - ANCHOR

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2.3 Encapsulated vs. Regular

Component	ENCAPSULATED	REGULAR
Plastic Sheathing	50 ML	40 or 50 ML
Anchors	Plastic-Coated Metal	Uncoated Metal
Pocket Formers	**YES**	**YES**
Snap Caps	**YES**	NO
Wedges	**YES**	**YES**
Translucent Sleeves	**YES**	NO
- filled with grease	**YES**	N/A
Positive Mechanical Connection	**YES**	NO
Seal Plugs	**YES**	NO
Protection during shipping	**YES**	*Depends on spec.*

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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.**

- **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.*

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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.)

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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.

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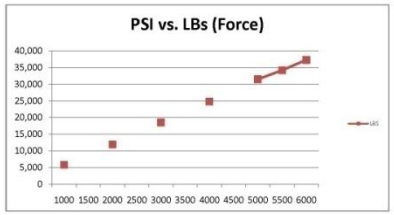
STRESSING JACK CALIBRATION RECORD 0.5"

CONTRACTOR INFO	PROJECT INFO	JOB #
ABC CONSTRUCTION	PROJECT X	

Initial ■ Repaired □ Replacement □ Extra □ Other □ Dead End Seater □

Date Calibrated:	7/27/2010
Strain Indicator #	51006
Load Cell #	1101
Stressing Jack #	2005-078
Gauge #	167
Pump #	328680
Hand Seating Tools:	1
Seating Tool must be returned with the jack & pump at the end of the project.	

Gauge Pressure	Strain Indicator reading: Actual Force
PSI	LBS
1000	5,800
2000	11,900
3000	18,500
4000	24,800
5000	31,500
5500	34,200
6000	37,300



Actual for 5000-5500: 5278

Actual for 5500-6000: 5306

Gauge Pressure (PSI) for stressing @33,000 lbs: 5300

5% Overstressing: 5565

Stressing Barrier Cable: varies 800 psi to 1100 psi

Notes:
1. The gauge pressure reading is rounded to the nearest hundred for convenience.
2. CAUTION: Do NOT use this gauge pressure for Barrier Cable (it should be much lower). Call PT Supplier for gauge pressure.
3. If you need to overcome higher friction losses, you can stress to a gauge pressure which is 5% higher than required. Please get the Structural Engineer's approval prior to overstressing. We suggest overstressing tendons less than 35'-0.
4. Great care has been taken to calibrate the equipment. Re-calibration will be at the cost of others. Please return complete sets of jacks, pumps and gauges in proper working condition.
5. The rental period for the stressing equipment is referenced in our proposal. Rental over this will be charged accordingly.
6. Our pump is limited to a gauge pressure of 6000 psi or 37,300 lbs (below the point of yielding/breaking the strand).
7. DO NOT USE this equipment for products not provided by AMSYSCO, Inc.
8. Stressing operations should be done by a PTI Certified Level 2 Superstructure Ironworker and monitored by a Level 2 Inspector.

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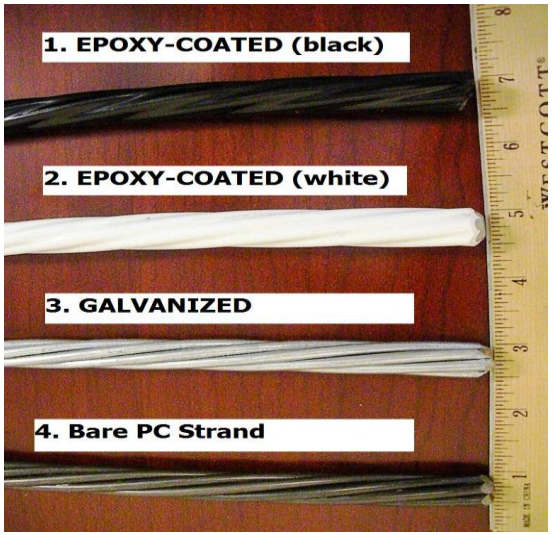
2.6 Barrier Cable

- 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.



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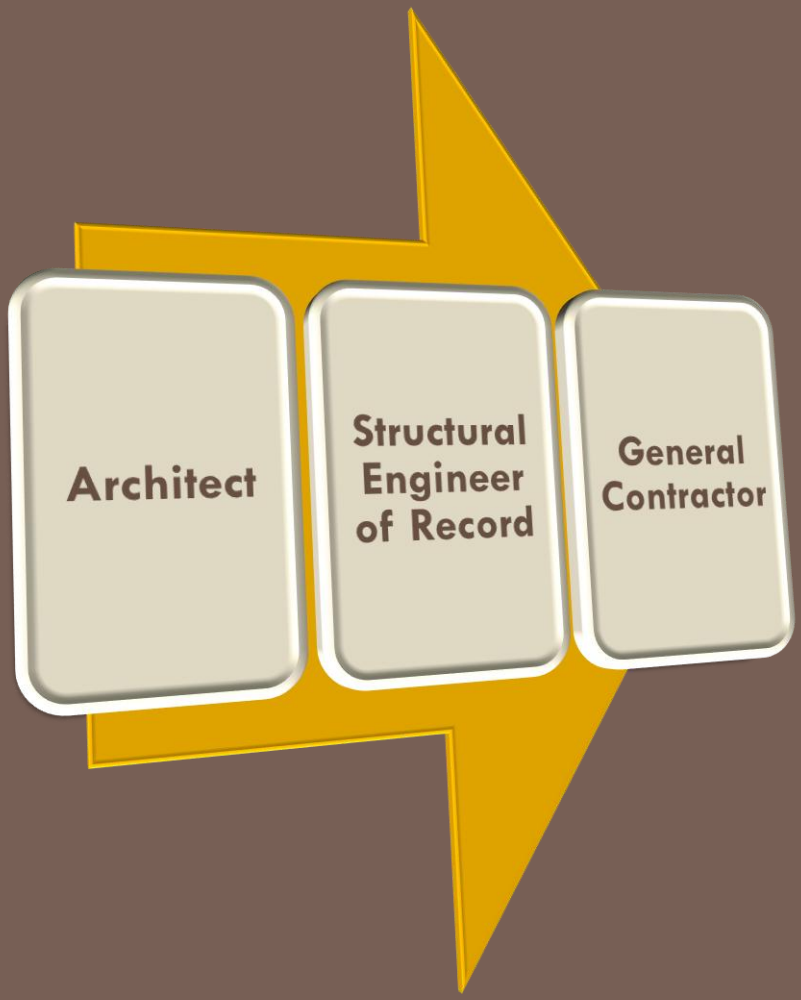

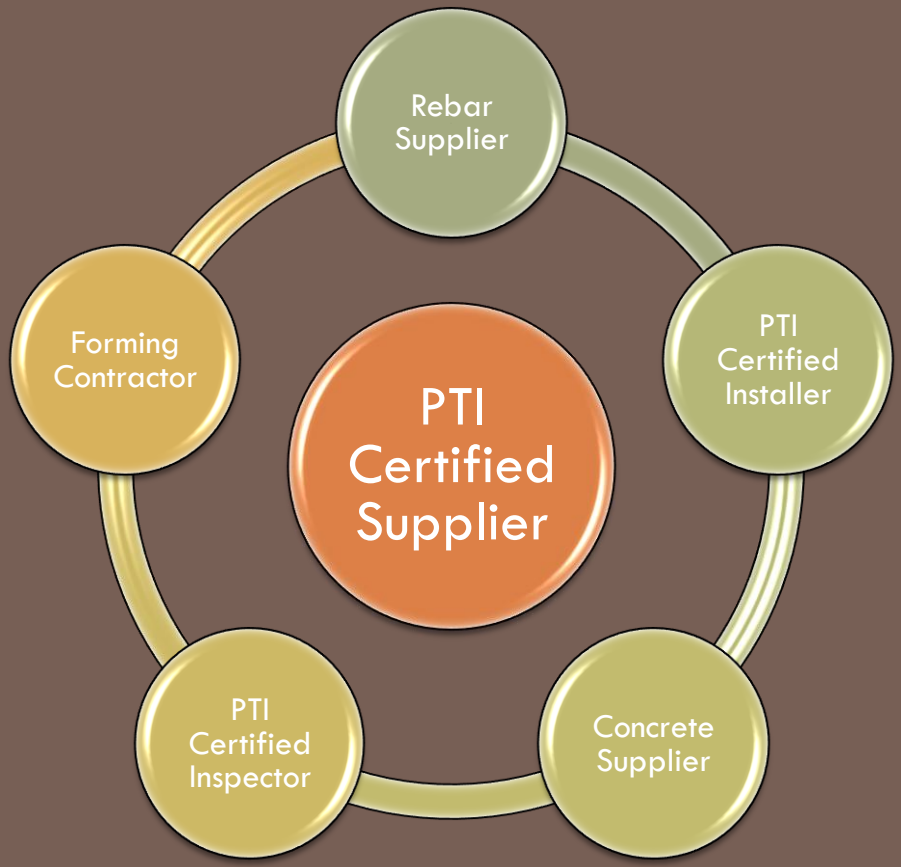

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3. CONSTRUCTION TEAM

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.

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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

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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.

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3.4 Post-Tension Installer

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

- For safety reasons, individuals operating stressing equipment must have <u>experience</u> in stressing and basic maintenance.
- Should keep a copy of the PTI '*Field Manual*' onsite.

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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.

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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.

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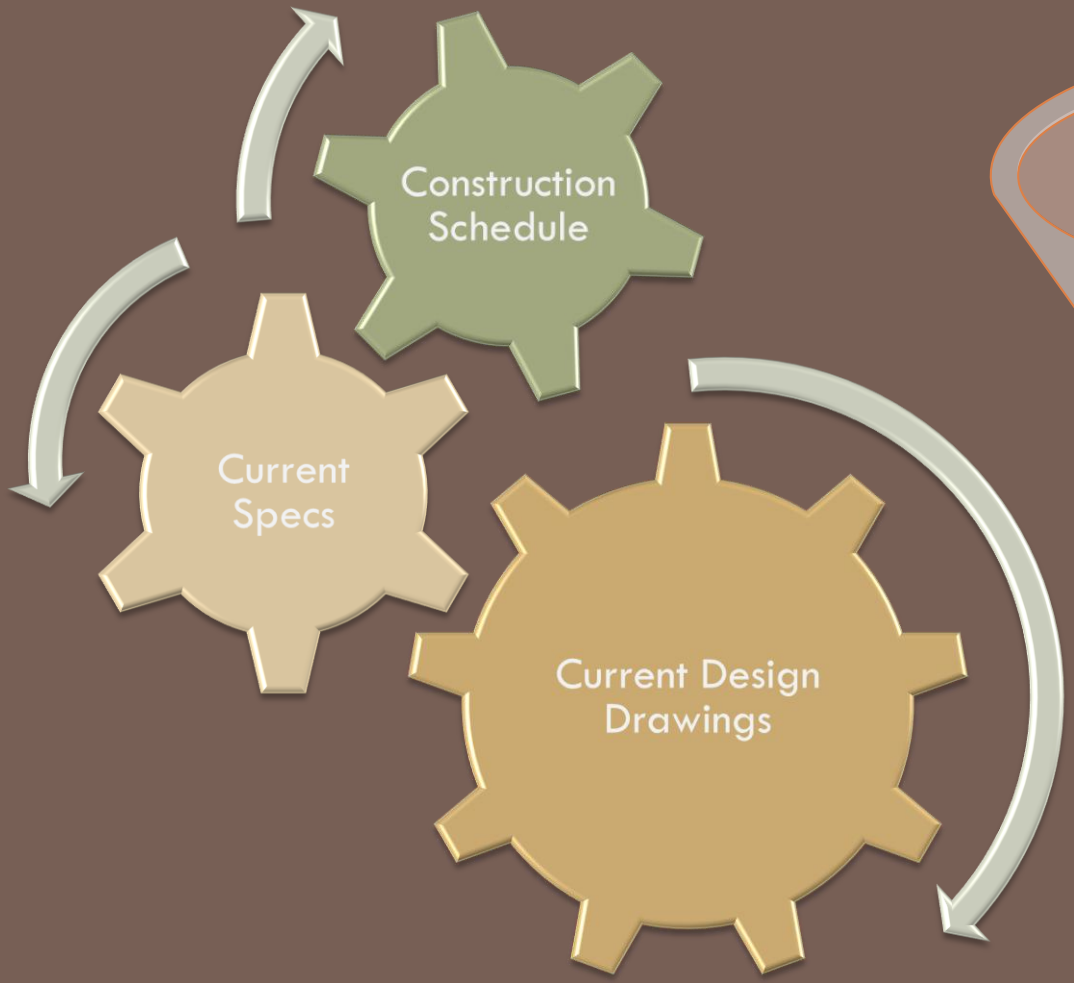

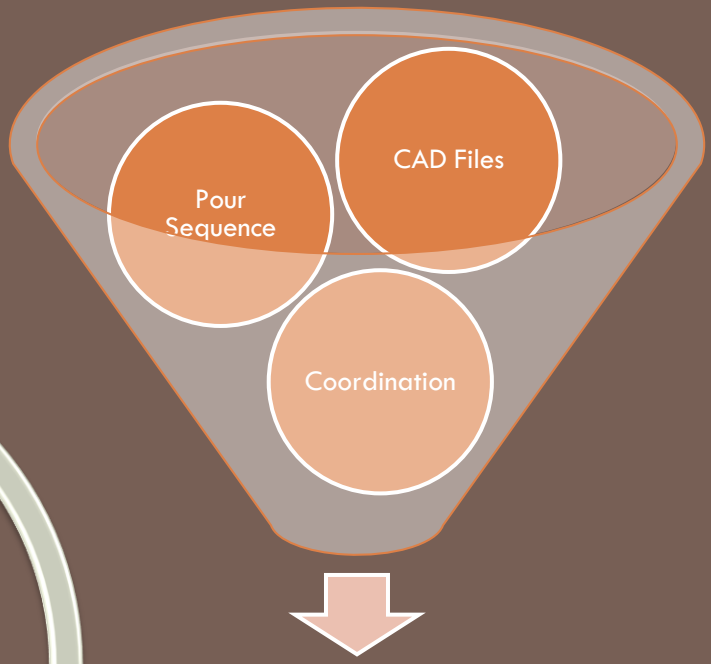

PT SUBMITTALS

1. Installation Drawings
2. Friction Calcs
3. Product Data
4. Samples

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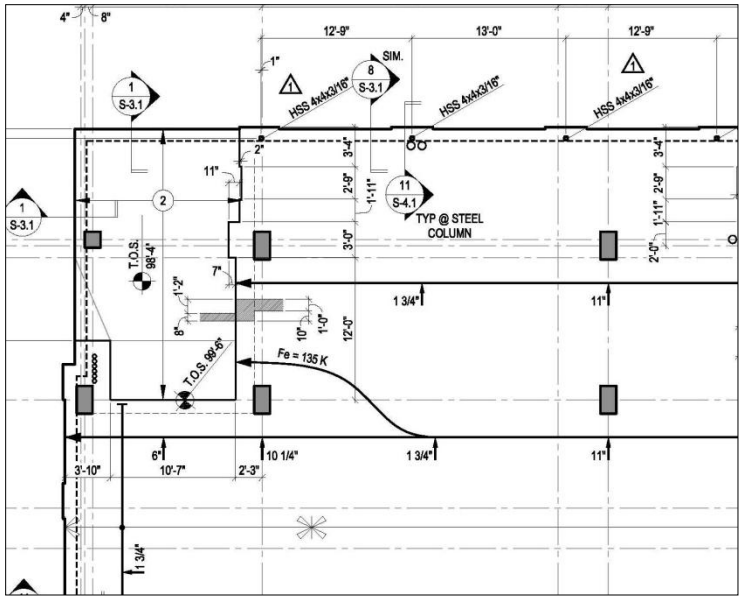
4. SUBMITTALS

4.1 Construction Documents

- Drawings
  - Structural
  - Architectural
- Specifications
  - Post-Tensioning (Division 3)
  - Barrier Cable (Division 5)
- Construction Schedule
  - Forming, Delivery, Installation and Stressing dates



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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)

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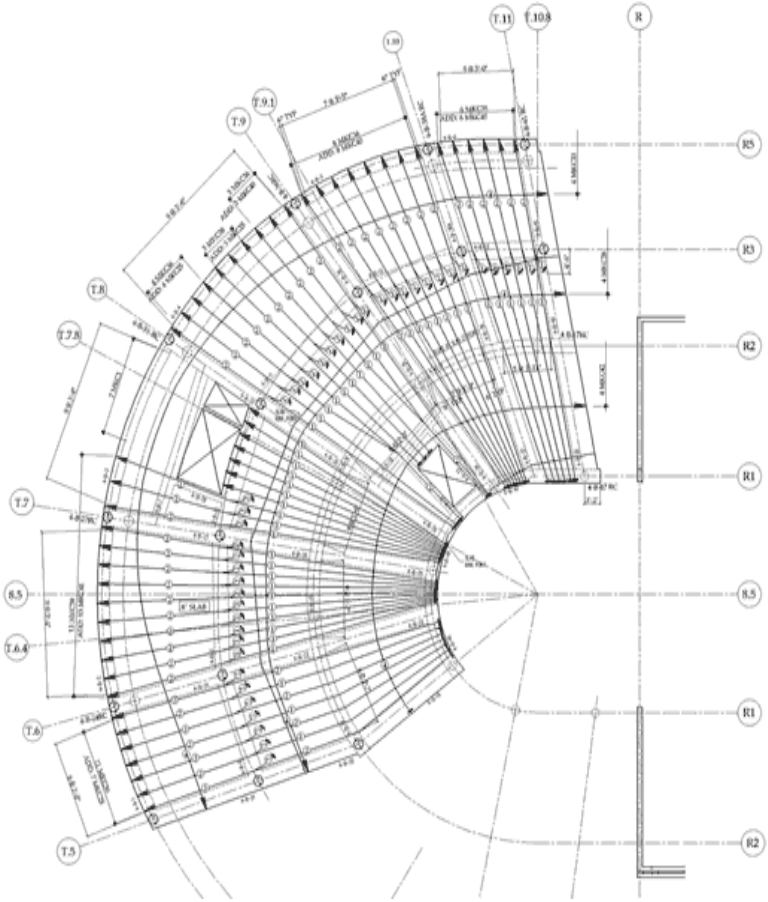
4.3 Post-Tensioning Submittals

- 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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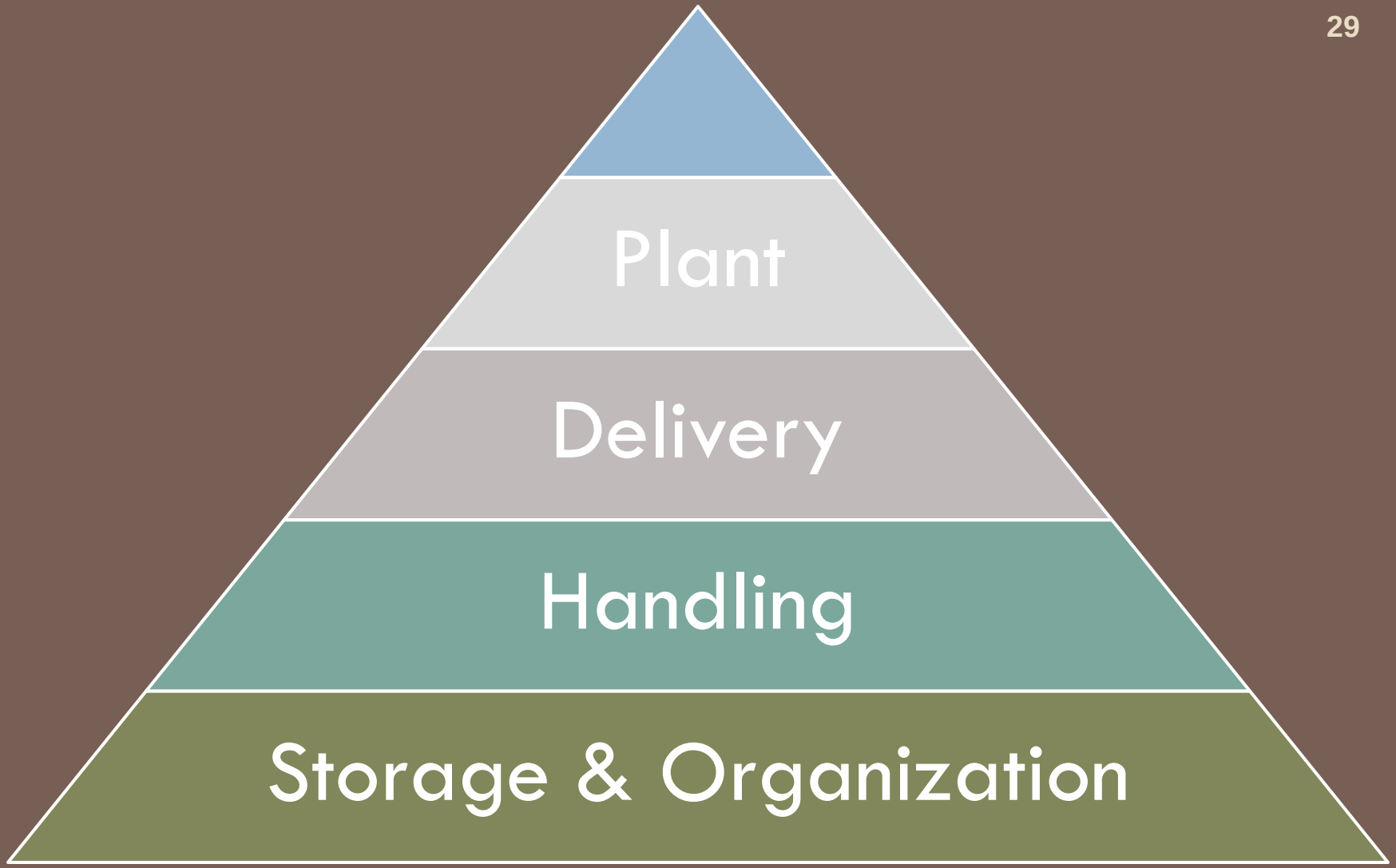

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5.1 PTI Certified Plant

- Fabrication
  - Raw Materials
  - PT Coating/Grease
  - Plastic Sheathing
  - Corrosion Protection
- Delivery
  - Mill Certs
  - Bill of Lading
  - Cutting Lists
  - Jack Calibration

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5.2 Jobsite

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

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

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6. JOBSITE INSTALLATION

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

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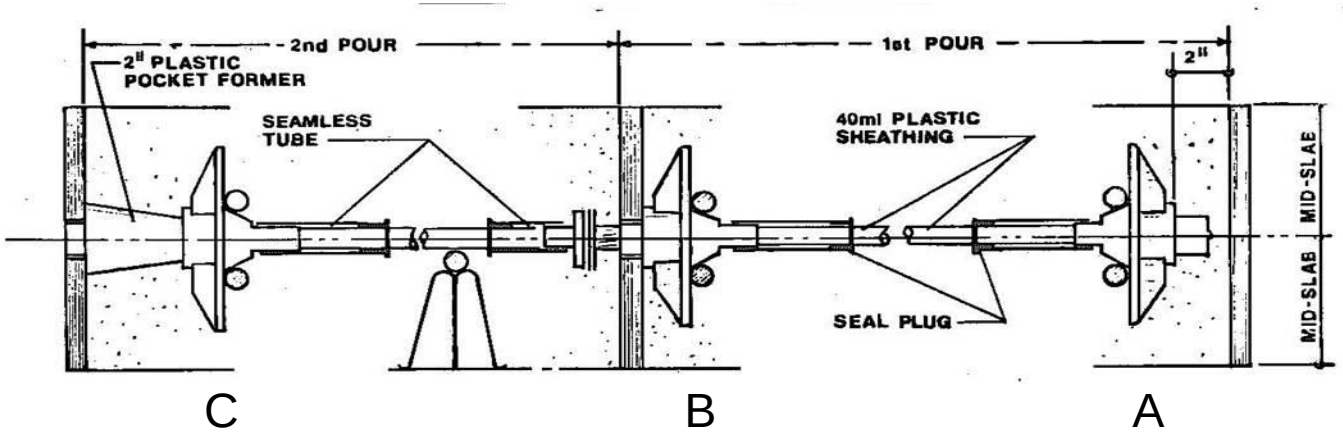
6.2 Anchor Types



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.

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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.

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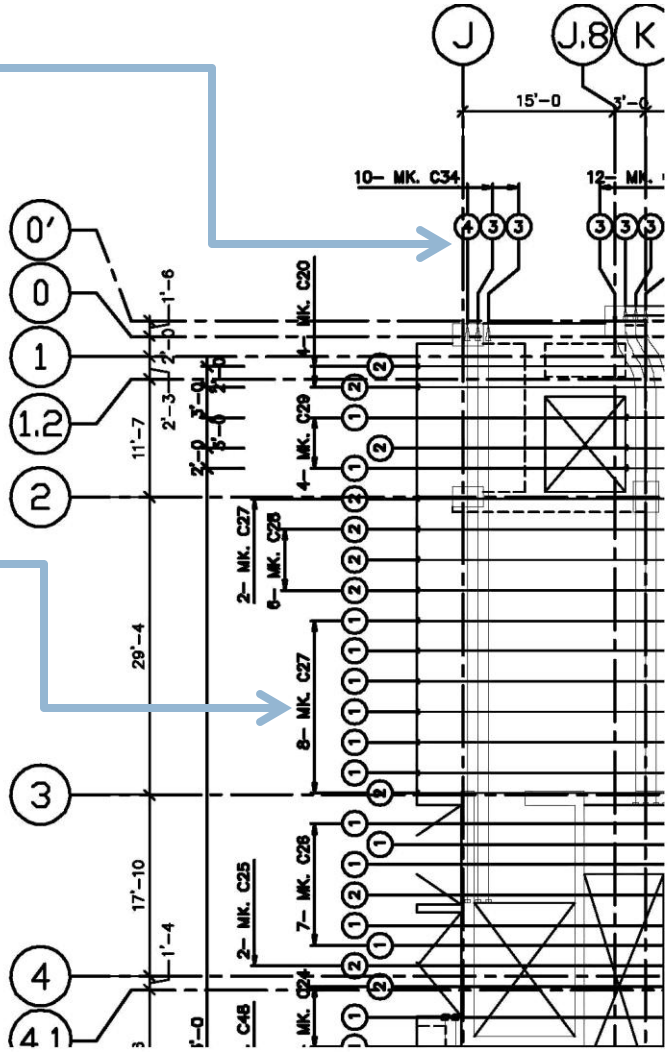
6.4 Two-Way Slab

- **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.



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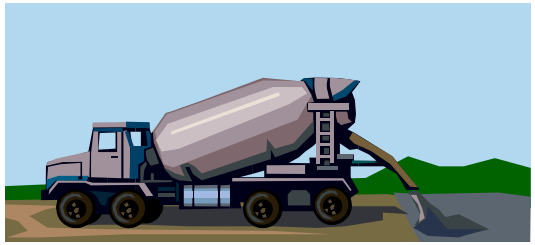
6.5 Slab-On-Ground

- 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.

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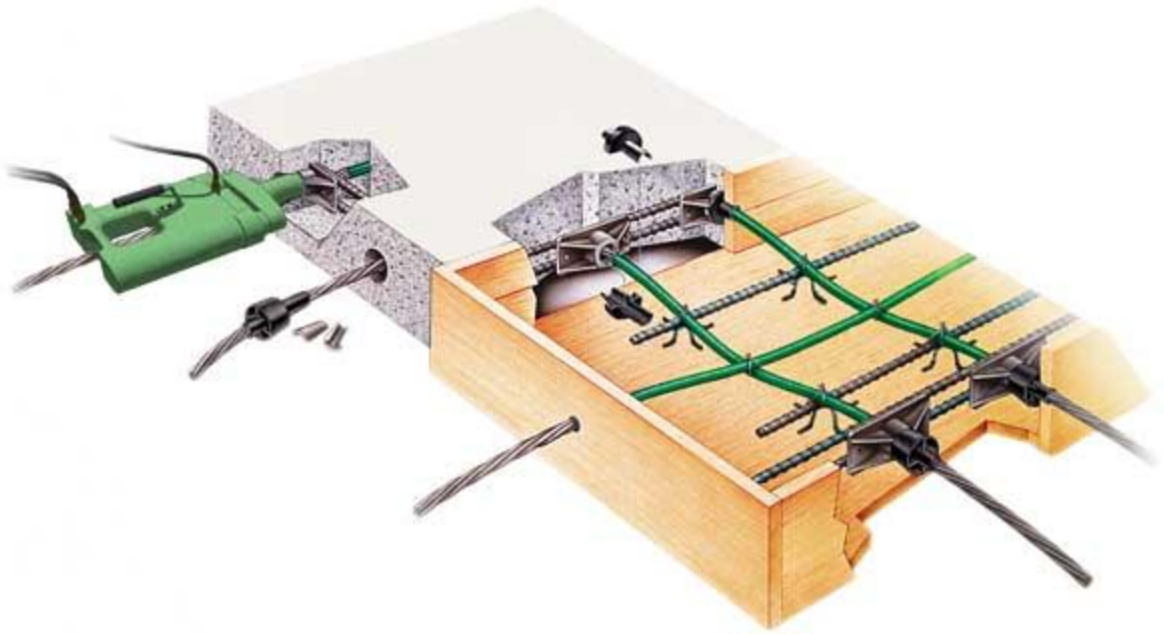
6.6 Concrete Placement

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



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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.

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7.2 Stressing

- 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 

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7.3 Elongations

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

- Approved by Structural Engineer
- "Negative" elongation is slippage

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Tel.: 630-296-8383 Fax: 630-296-8380

AMSYSCO™

STRESSING RECORD

	TENDON MARK	TYPE	MIN ELONG	MAX ELONG	GAUGE READING	ACTUAL ELONGATION 1ST	ACTUAL ELONGATION 2ND	TOTAL ELONG	REMARKS
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

Project:
Customer:
Pour No.
Jack No.
Pump No.

Ram Area:
Gauge Reading (Min):
Gauge Reading (Max):
Stressing Operator:
FORM FILED BY OTHERS

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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.

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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.

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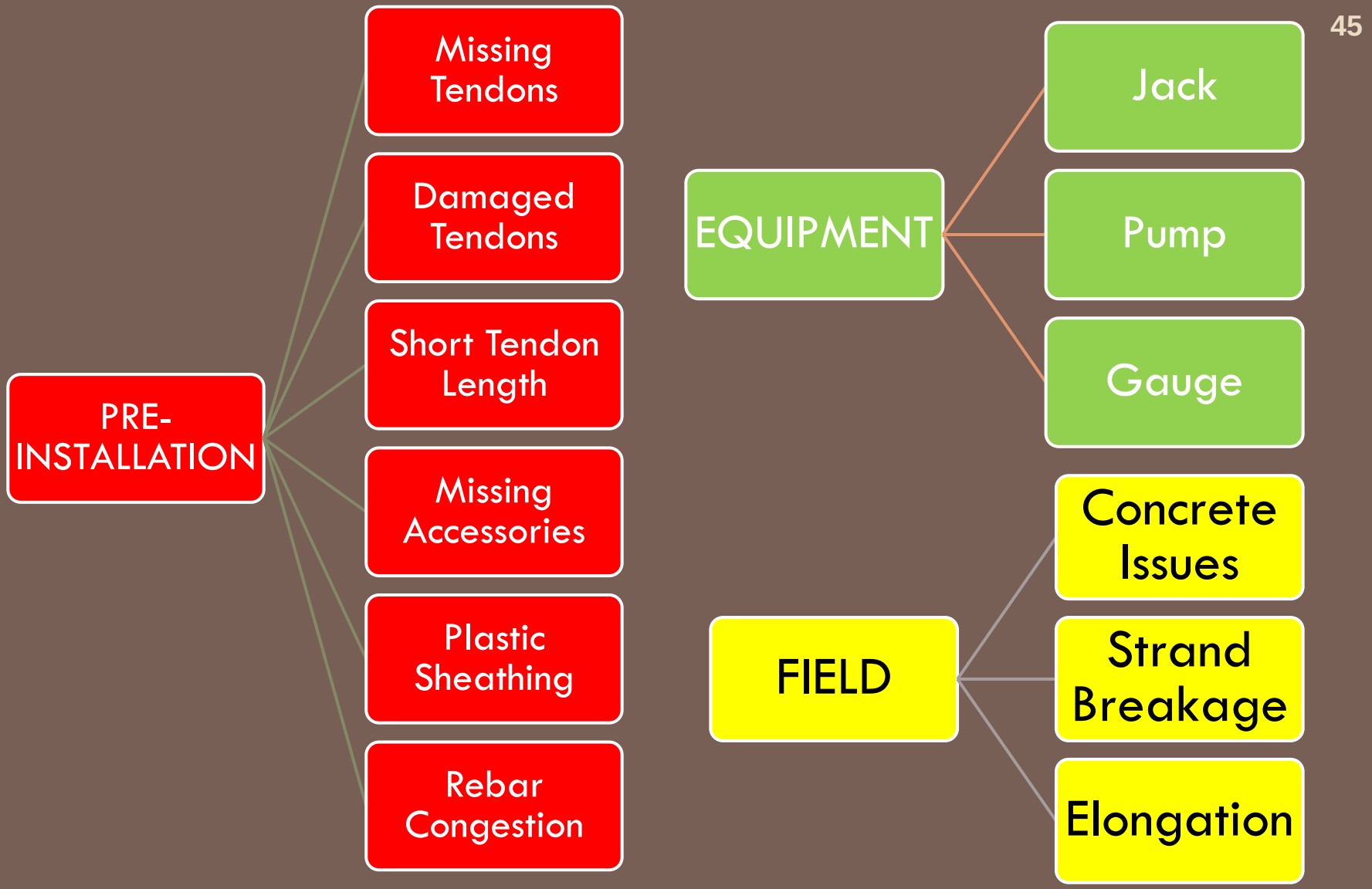

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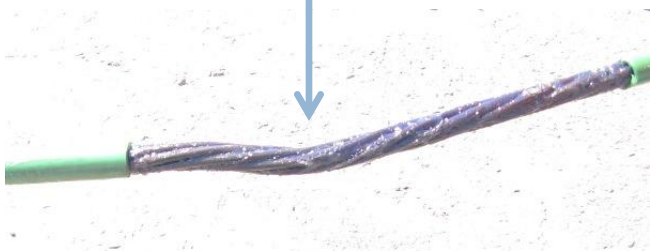
8.1 Pre-Installation Issues #1

- 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)



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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.

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8.2 Equipment Issues #1

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

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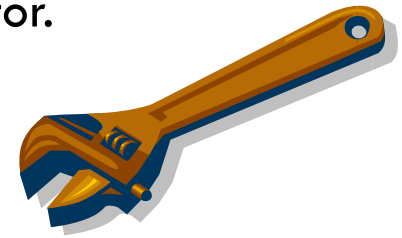
8.2 Equipment Issues #2

- 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.



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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.

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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

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