SECTION 1
INTRODUCTION TO POST-TENSIONED CONCRETE
DEVELOPED BY THE PTI EDC-130 EDUCATION COMMITTEE
NOTE: MOMENT DIAGRAM CONVENTION

• In PT design, it is preferable to draw moment diagrams to the tensile face of the concrete section. The tensile face indicates what portion of the beam requires reinforcing for strength.

• When moment is drawn on the tension side, the diagram matches the general drape of the tendons. The tendons change their vertical location in the beam to follow the tensile moment diagram. Strands are at the top of the beam over the support and near the bottom at mid span.

• For convenience, the following slides contain moment diagrams drawn on both the tensile and compressive face, denoted by (T) and (C), in the lower left hand corner. Please delete the slides to suit the presenter's convention.
REVIEW:
FUNDAMENTALS OF PRESTRESSED CONCRETE

NEW:
DIFFERENCES BETWEEN PRE-TENSIONING AND POST-TENSIONING
REVIEW OF REINFORCED CONCRETE

Critical Point for Cracking

Stages of Behavior

Uncracked

Cracked (~Elastic)

Ultimate

$\sigma$

$\sigma$

$\sigma$

$\sigma$
Large deflections due to cracking

Steel is not engaged until after cracking
Reinforcement is \textit{Passive}

Steel crosses cracks, but does not prevent them
QUESTION TO PONDER

Suppose a R/C beam has too much cracking and too much deflection. How might you propose to fix it? (i.e. not replace it)

Tension (bending) + Compression (“squeezing”) = Net Zero Stress

“Squeezed” Before Loading (Pre-compressed):
Pre-Compression (“prestressing”) + Tension (bending) = Net Zero Stress
HOW TO BUILD IT?

1. Pre-Tensioning: Steel tensioned before concrete is placed
2. Post-Tensioning: Steel tensioned after concrete is hardened

Prestressing is ACTIVE – can prevent cracks from forming
PRE-TENSIONING

1. Tension Strands
2. Cast Concrete – Bond strands to concrete
3. Cut Strands – Transfer force to concrete
POST-TENSIONING

1. Cast Concrete with Duct
2. Feed Strands through Duct
3. Tension Strands
4. Grout Duct (or other corrosion protection)
POST-TENSIONING

• Post-tensioning can take on any profile
• Draped configurations are much more common than straight tendons
  • Why?
Force Transfer by Steel-Concrete bond

**PRE-TENSIONING**

Force Transfer at end anchor

**Post-Tensioning**

Strain Compatibility and Force Equilibrium:

Steel held at length longer than it “wants” to be: Tension

Concrete compressed shorter than it “wants” to be: Compression
- Pre-Tensioned elements are often *precast* in a factory and shipped to the site.

- Post-Tensioned elements can be cast and tensioned in the final location (*cast-in-place*). They can also be precast.
PRE-TENSIONING
INSTALL PRESTRESSING STRANDS
PRE-TENSIONING
TENSION STRANDS
PRE-TENSIONING

STRANDS AFTER TENSIONING
PRE-TENSIONING
INSTALL MILD REINFORCEMENT
PRE-TENSIONING
INSTALL INSERTS AND ASSEMBLIES
PRE-TENSIONING
PLACE CONCRETE
PRE-TENSIONING

REMOVE GIRDER FROM CASTING BED
PRE-TENSIONING
MOVE GIRDER TO STORAGE
PRE-TENSIONING
TRANSPORT TO JOBSITE
PRE-TENSIONING
POST-TENSIONING

Ducts for Post-Tensioning
POST-TENSIONING
POST-TENSIONING
POST-TENSIONING
POST-TENSIONING
POST-TENSIONING

Stressing Strands:

Single Strand: Monostrand

Multiple Strands: Multistrand
HOW ARE STRANDS ANCHORED?

Cast against concrete at end of beam

STANDARD TENDON
HOW ARE STRANDS ANCHORED?

Concrete

Duct

Strand

Anchor cast in concrete
POST-TENSIONING:

Bonded System (at high point)

Unbonded System

Grout

“PT Coating” (grease)
POST-TENSIONING
STRUCTURAL EFFECT OF PRESTRESSING

True for Pre- and Post-Tensioning

\[ \text{Pre-Stressing} + \text{Applied Load} = \text{Total Stress} \]

Stress Limits
STRUCTURAL EFFECT OF PRESTRESSING
True for Pre- and Post-Tensioning

Pre-Stressing

Applied Load

Total Stress

Service

Transfer

\[ \text{Total Stress} = \text{Pre-Stressing} + \text{Applied Load} \]
ECCENTRIC PRESTRESSING

Eccentricity in prestressing:
- Desirable at midspan
- Not productive, even detrimental, at end of span

Strategies for pre-tensioned systems:
- Draped / harped profiles
  Temporarily held in place before concrete is hardened
- Debonding
  Not all strands are active at end of span

Strategies for post-tensioned systems:
- Install ducts in desired profile
COMMON CONFIGURATIONS

Pre-tensioning:
- Draped
- Debonded

Post-tensioning:
PROBLEM FOR THOUGHT...
Where should the prestressing be placed?
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Where should the prestressing be placed?

Option 1

Good:
• Efficient at midspan
• Easy to construct

Bad:
• Counter-productive over support
PROBLEM FOR THOUGHT...
Where should the prestressing be placed?

Option 1

Good:
• Efficient at midspan
• Easy to construct

Bad:
• Counter-productive over support
PROBLEM FOR THOUGHT...
Where should the prestressing be placed?

Option 2

Good:
- Efficient over support
- Easy to construct

Bad:
- Counter-productive at midspan

(T)
PROBLEM FOR THOUGHT...
Where should the prestressing be placed?

Option 2

Moment Diagram

Good:
• Efficient over support
• Easy to construct

Bad:
• Counter-productive at midspan
PROBLEM FOR THOUGHT...
Where should the prestressing be placed?

Option 3

Good:
- Efficient over support
- Efficient at midspan

Bad:
- Difficult to construct

(T)
PROBLEM FOR THOUGHT...
Where should the prestressing be placed?

Option 3

Good:
- Efficient over support
- Efficient at midspan

Bad:
- Difficult to construct
PROBLEM FOR THOUGHT...
Where should the prestressing be placed?

Option 4

Requires post-tensioning; very difficult to achieve by pre-tensioning

(T)
PROBLEM FOR THOUGHT...
Where should the prestressing be placed?

Option 4

Requires post-tensioning; very difficult to achieve by pre-tensioning

(C)
SUMMARY: PRESTRESSED CONCRETE

- Efficient use of materials – concrete maintained in compression, crack control
- Smaller deflections/thinner members
- Longer spans
- Corrosion resistance
- Less material; reduced environmental impact