INTRODUCTION TO PRESTRESSING

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SESSION OVERVIEW

Content
• Reinforcement Review
  • Purpose of Reinforcement
  • Types of Reinforcement
• Strand Properties
• Prestressing vs. Reinforcement bars

PURPOSE OF REINFORCEMENT
**COMPRESSIVE FORCES ON CONCRETE**

Concrete can withstand compression

**CONCRETE UNDER COMPRESSION**

This 2” X 2” cube of concrete withstands a 4000 psi compressive force

**TENSILE FORCES ON CONCRETE**

Without reinforcement, concrete will fail in tension
CONCRETE IN TENSION

A 2" X 2" cube of concrete fails under a 400 psi tensile force.

FLEXURAL FORCES ON CONCRETE

Without reinforcement, the bottom side will fail in tension.

NON-REINFORCED CONCRETE BEHAVIOR
REINFORCED CONCRETE BEHAVIOR

Initial condition

Loaded condition

PRESTRESSING VS. REBAR

PRESTRESSED CONCRETE BEHAVIOR

Initial condition

Loaded condition
CONVENTIONAL V. PRESTRESSED

Concretely reinforced concrete beam

Prestressed concrete beam

TYPES OF REINFORCEMENT

• Reinforcement Bar
• Fibers
• Strand
  • Prestressing
  • Post-tensioning
PRESTRESSING STRAND

STRAND PROPERTIES

• Strand refers to seven-wire, stress-relieved or low relaxation steel strand
  • ASTM A416 - Stress relieved, Grades 250 and 270
  • ASTM A416, Supplement 1 - Low relaxation

STRAND PROPERTIES

• Strand refers to seven-wire, stress-relieved or low relaxation steel strand
  • ASTM A722 - High Strength Steel Bars
• Strand chucks, vises, and barrels must be designed and manufactured to withstand the stress imposed by the strand at 100% of its ultimate strength.
**Basics of Prestressing**

**Intro to Prestressing**

- Prestressing Defined
  - Method of applying compression to concrete prior to loading
  - Process
    - Strands of steel cable are stretched in the casting bed prior to concrete placement
    - Steel bonds to concrete as concrete cures
    - Strands are released after specified concrete strength gain

**Prestressing Video**
CONVENTIONAL V. PRESTRESSED

- The load carrying capacity of prestressed concrete members is directly related to the force applied to the strands.

ELASTIC PROPERTY OF PRESTRESSING STRAND

ELASTIC V. INELASTIC RANGES
Elastic vs. Inelastic Ranges

**Strand Properties**

- Yield Point
  - The expiration of the elastic zone
  - The point beyond which the steel will no longer spring back to its original shape
  - Usually characterized by "necking"

**Necking**
ELASTIC V. INELASTIC RANGES

- Necking
  - Increased length of strand

Before After

ELASTIC V. INELASTIC RANGES

- Necking
  - Decreased diameter of strand
  - Inability to carry load

Before After

ELASTIC V. INELASTIC RANGES

- As long as the strand is in its elastic range, it can take on loads repeatedly.

- It is critically important to maintain the strand within its elastic zone in order to calculate the correct stress and elongation
ELONGATION CALCULATIONS

ELONGATION

• The basic elongation calculation is relatively straight-forward and simple
• Elongation is inversely proportional to the Modulus of Elasticity

MODULUS OF ELASTICITY

\[ E = \frac{\delta}{\varepsilon} \]

Always given by mill certificate
ELONGATION FORMULA

The basic equation for the calculation of elongation (e) in a prestressing strand is:

\[ e = \frac{P \times L}{A \times E} \]

where:

\( P \) = load applied to the strand (lb.)
\( L \) = length of strand between anchorages (in.)
\( A \) = area of strand (sq. in.)
\( E \) = modulus of elasticity of strand (psi)

TYPICAL TENSIONING LAYOUT

CALCULATION OF STRESSING VALUES

• An initial tension load of between 5% and 25% of the final load is applied to the strands to take out slack and establish an initial point for the measurement of elongation.

• The final strand force (measured as gauge pressure) is obtained from the shop drawings or plant engineering.
CALCULATIONS

• Refer to handout

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FIG. AA  
Given: \( \frac{1}{2}'' \) (13 mm) dia., 270 ksi (1860 MPa), low relaxation strand  
\( A = 0.153 \text{ sq. in. (100 mm}^2\)  
\( E = 28,000,000 \text{ psi (193,000 MPa)} \)  
Initial Force = 4,000 lb (18 kN)  
Final Force = 30,000 lb (130 kN)
FIG. BB  Given: ½” (13 mm) dia., 270 ksi (1860 MPa), low relaxation strand
A = 0.153 sq. in. (100 mm²)  Initial Force = 4,000 lb (18 kN)
E = 29,900,000 psi (206,000 MPa)  Final Force = 28,000 lb (125 kN)