Materials and Prestressing Methods

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Concrete Materials

- Short-term Properties
  - Strength (compression, tension and shear)
  - Stiffness (modulus of elasticity)
- Long-term Properties
  - Shrinkage
  - Creep
Compressive Strength

Concrete Stress-Strain in Compression
Concrete in Tension

Tensile strength of concrete is approximately 10 to 20% of its compressive strength.

Creep

Age of Concrete

Compressive Stress

Tensile Stress

Strain

$\epsilon_c$

$\epsilon_{el}$

$\Delta \epsilon_c$
**Shrinkage**

- **Concrete strength**: 4000 psi, 28 MPa
- **Concrete strength**: 6000 psi, 41.5 MPa

Graph showing creep strain (millions per psi) vs. age (days) for different ages of loading: 28, 90, 180, 28 (sealed), and 360 days.
Steel Reinforcement

- Deformed Mild Reinforcing Steel
- Prestressing Steel
  - Seven-wire strand
  - Bar
  - Wire
- Welded Wire Reinforcement
**Stress-Strain of Reinforcement**

![Stress-Strain of Reinforcement Diagram]

**Stress-Strain of Prestressing Strands**

![Stress-Strain of Prestressing Strands Diagram]

GUTS - “Guaranteed Ultimate Tensile Strength”
Relaxation of Stress in Prestressing Strand with Time

Figure is based on data for Stress-Relieved Strand from test data published in 1964 (Collins and Mitchell 1991)

Tendons or Strands
Methods of Prestressing

Pre-Tensioning

- Tendons are stretched between external anchorages before concrete is placed.
- When concrete hardens it bonds to steel.
- When concrete reaches the required strength the tendons are cut and the force in the tendons is transferred through bond from the steel to concrete.
- Tendons used are primarily in the form of multiple wire stranded cables.
Pre-Tensioning

- Strand extension and jacking force are measured
- High early strength concrete and steam curing often used to accelerate hardening
- Prestress force transferred by bond at the ends of the beam (no special anchors (cost savings))
- Standardization thru long line method and reusable forms
Pre-Tensioning
Post-Tensioning

- Tendons are stressed after concrete has hardened
- Jacking done against the concrete member itself
- Tendon profile can be varied and can be made to follow moment diagram shape for greater effectiveness
- Hollow conduits containing unstressed tendons are placed in the forms to the desired profile before pouring concrete
Post-Tensioning

- Tendon is gauged by measuring both jacking pressure and elongation of steel
- Tendons are normally grouted in their conduits after stressing using cement grouts
- Grout bonds tendon and inner conduit wall and thus improves ultimate strength
- In certain cases de-bonding of tendons is necessary (e.g. thin slabs)
  - Wrapped with asphalt paper
  - Encased in plastic sheathing
TENSA 14990 kN jack (108 strands)

TENSA 2980 kN jack (15 strands)

TENSA Control records stressing pressure and elongation and stores data

TENSA 289 kN jack (monostrand)