INTRODUCTION TO PRESTRESSING SYSTEMS

PRESTRESSING SYSTEMS

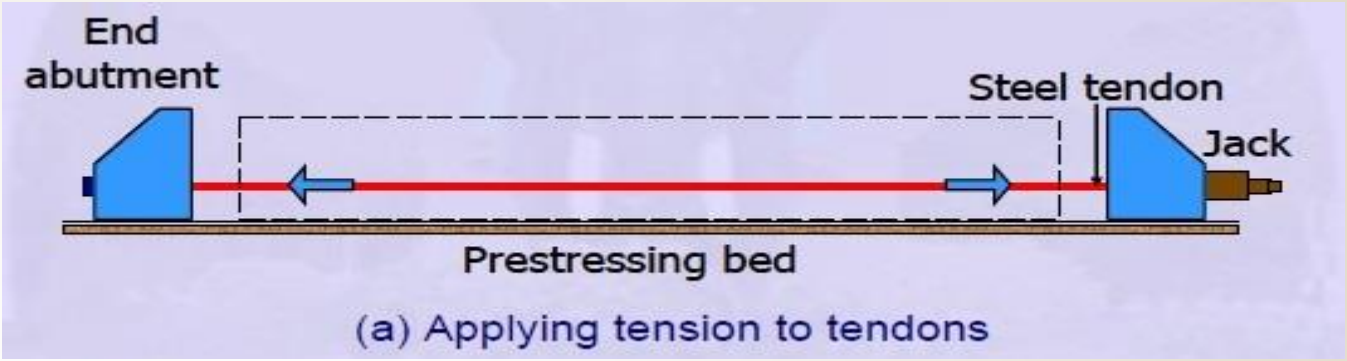
- PRE-TENSIONING SYSTEMS
- POST-TENSIONING SYSTEMS

PRE-TENSIONING

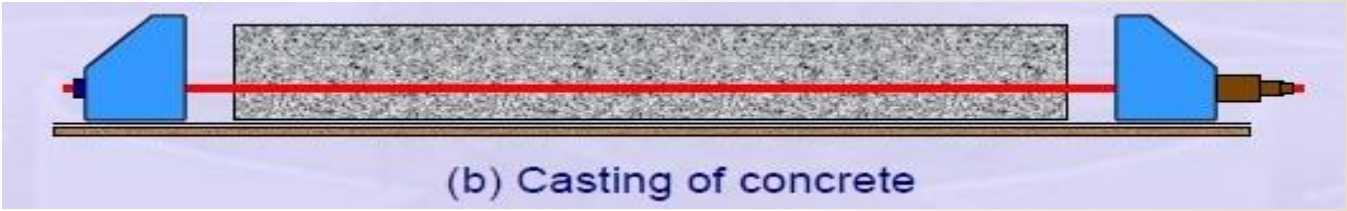
- In pre-tensioning system, the high-strength steel tendons are pulled between two end abutments (also called bulkheads) prior to the casting of concrete.
- Abutments are fixed at the ends of a prestressing bed.
- Once the concrete attains the desired strength for prestressing, the tendons are cut loose from the abutments.
- Prestress is transferred from tendons to concrete, due to bond between them.
- Member undergoes elastic shortening.
- Transmission Length
- Eccentric Tendon - Camber

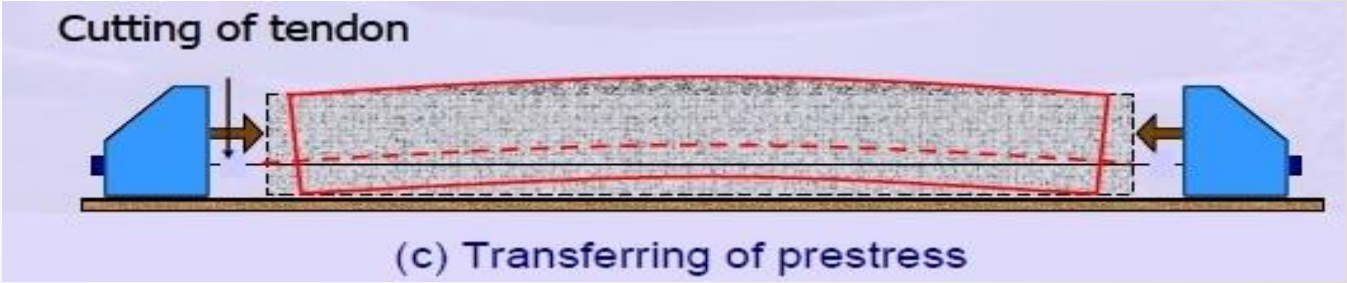
STAGES OF PRE-TENSIONING

- Anchoring of tendons against the end abutments
- Placing of jacks
- Applying tension to the tendons
- Casting of concrete
- Cutting of the tendons



(a) Applying tension to tendons


(b) Casting of concrete



(c) Transferring of prestress

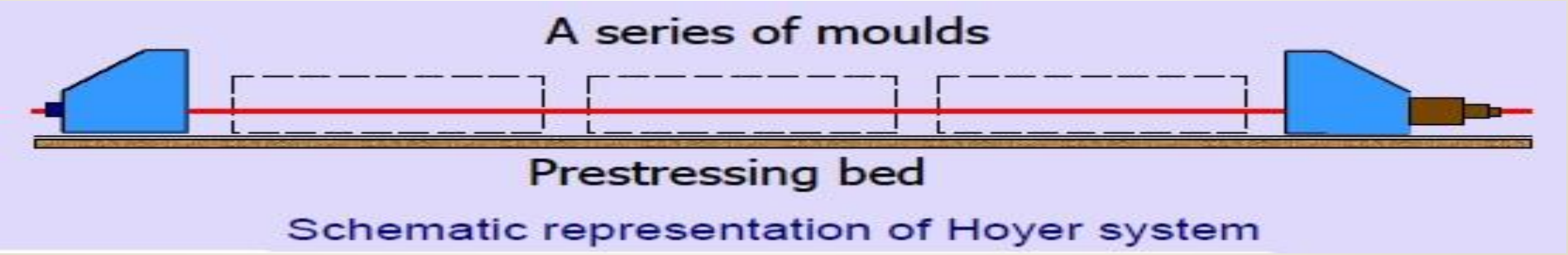
ADVANTAGES & DISVANTAGES OF PRE-TENSIONING

Advantages of Pre-tensioning

- Suitable for precast members produced in bulk.
- No requirement of large anchorage devices.

Disadvantages of Pre-tensioning

- A prestressing bed is required.
- There is a waiting period in the prestressing bed, before the concrete attains sufficient strength.
- There should be good bond between concrete and steel over the transmission length.

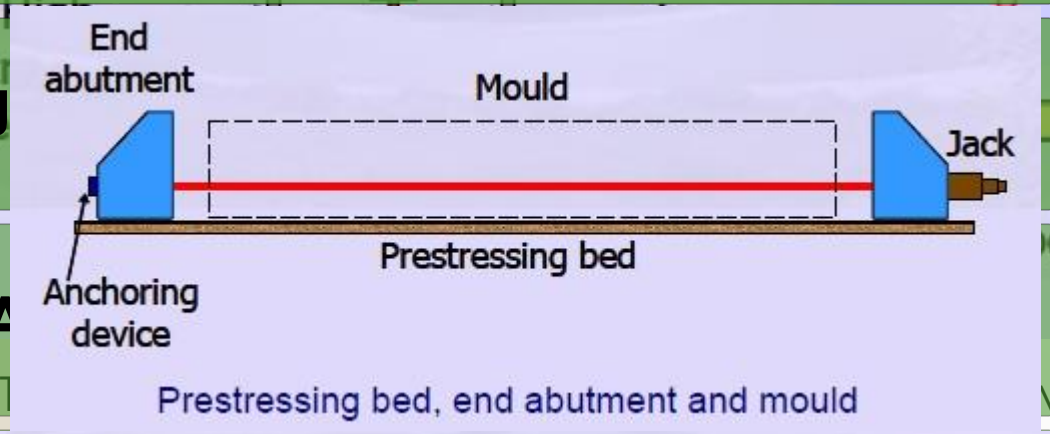


Schematic representation of Hoyer system

DEVICES IN PRE-TENSIONING SYSTEMS

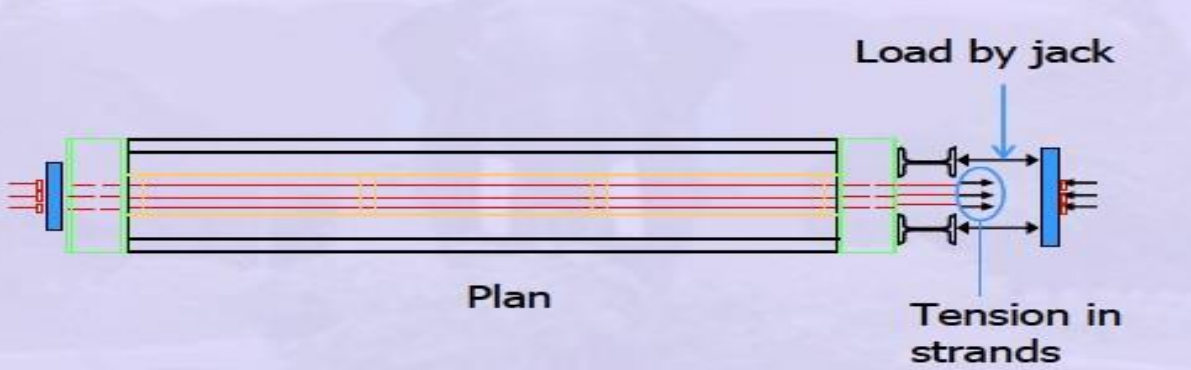
Prestressing bed with end abutments

Shuttering / Mould



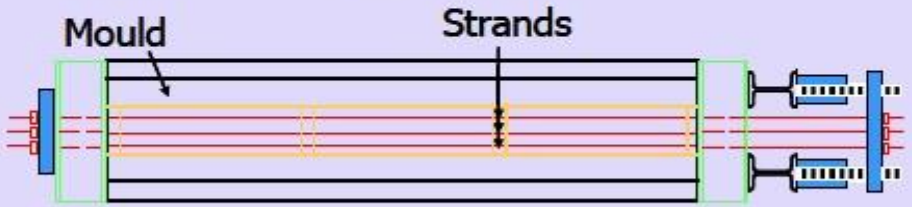
Prestressing bed, end abutment and mould

OPT ertical)



Free body diagram of stress bench

Elevation



Plan

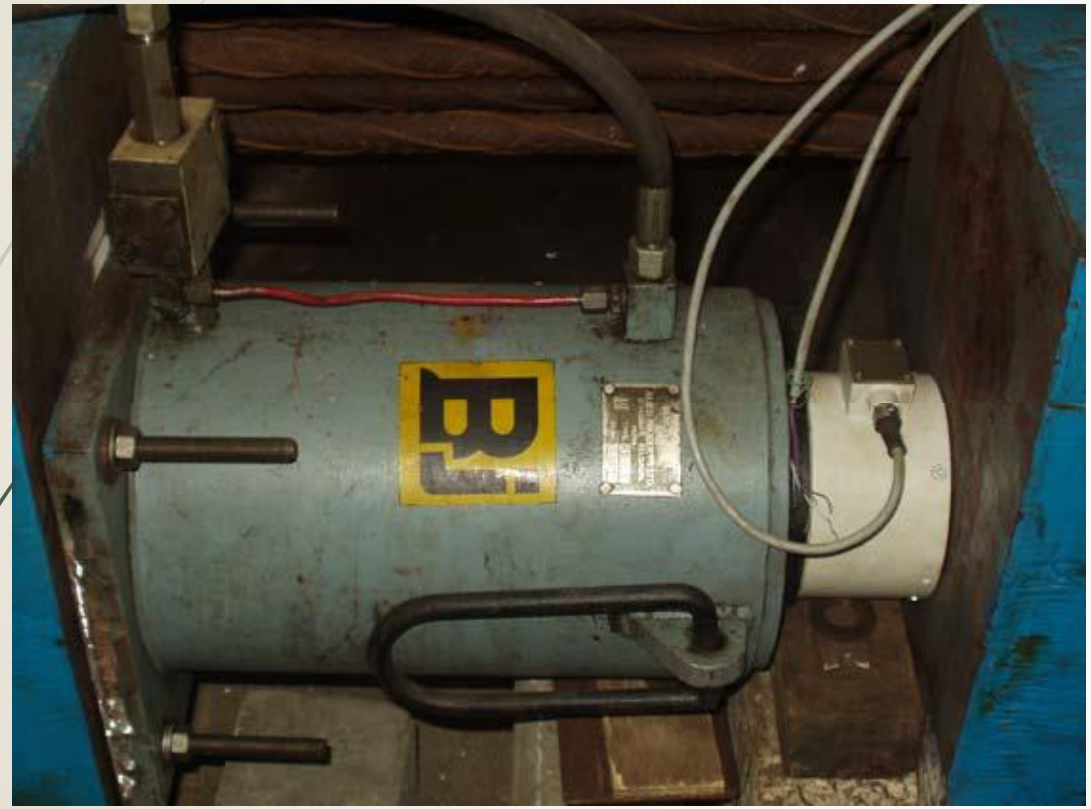
Stress bench – Self straining frame

Elevation

Plan

The stress bench after casting concrete

JACK



A double acting hydraulic jack with a load cell

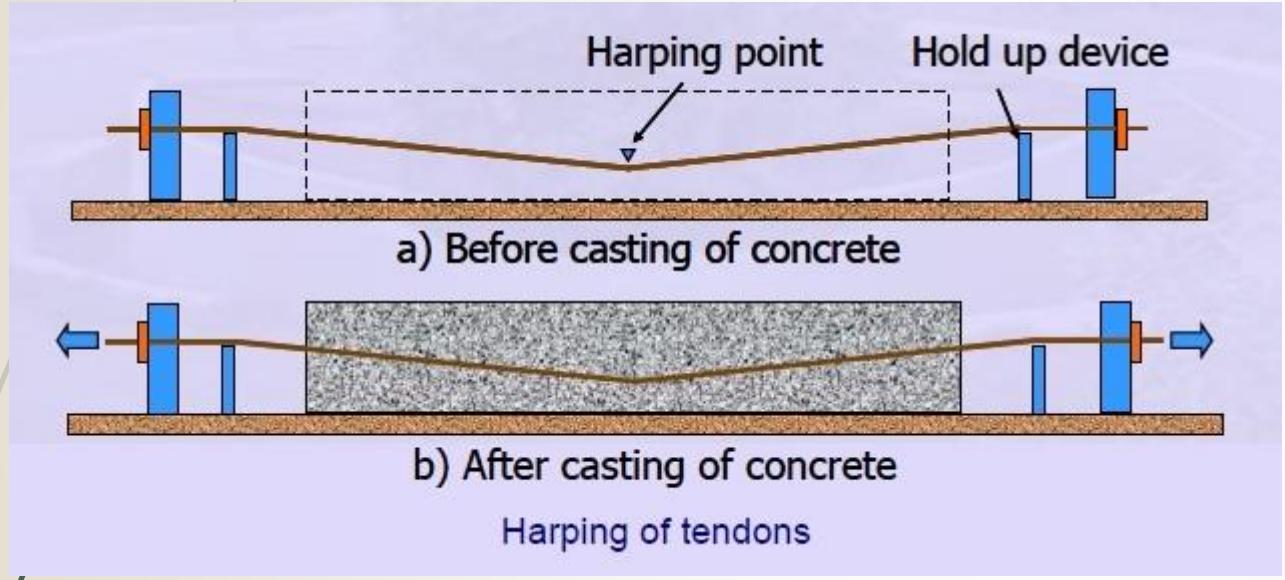
Single acting jack

Double acting jack

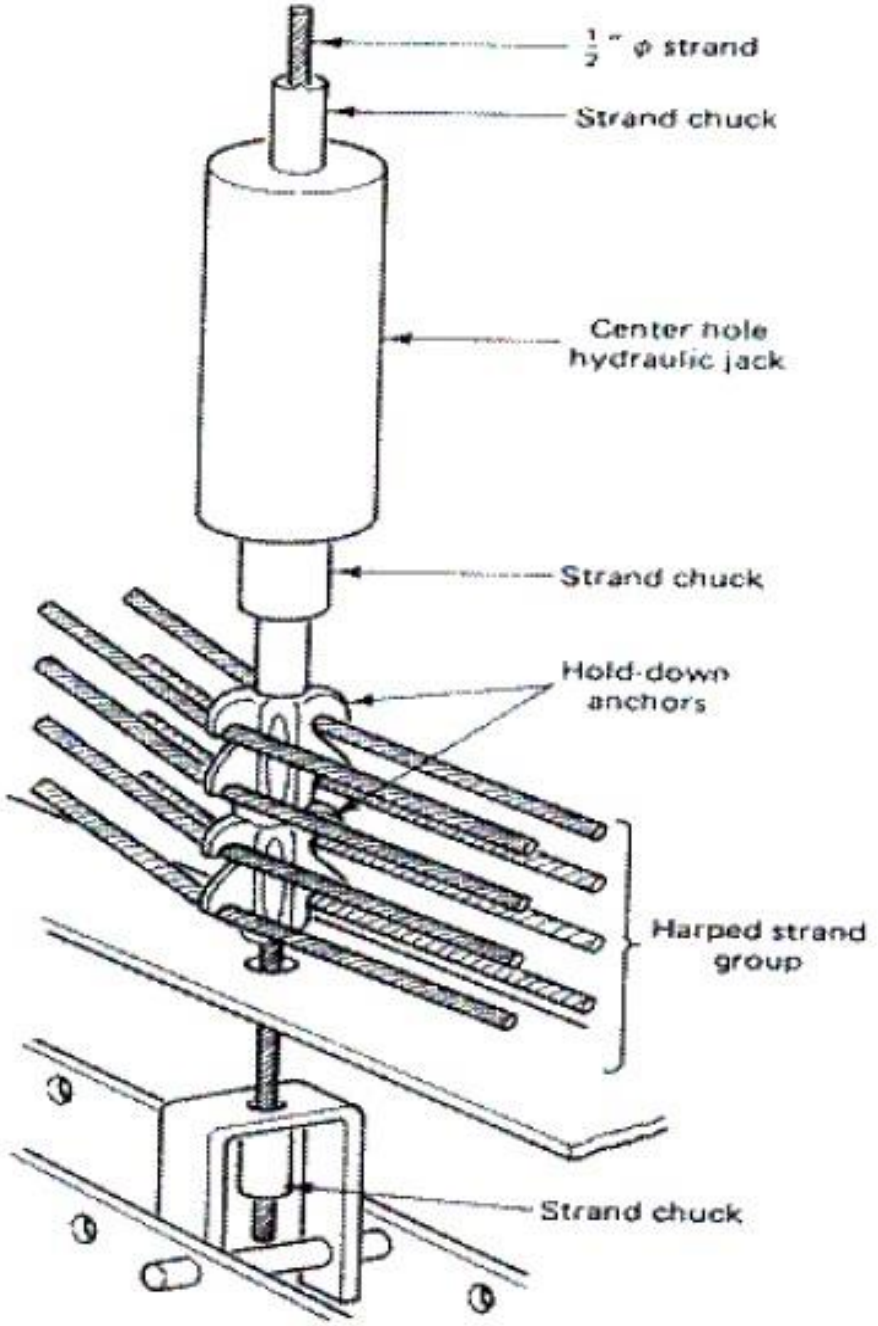
ANCHORAGE DEVICE

Anchorage Devices

HARPING DEVICE



Harping of tendons



Hold-down anchor for harping of tendons

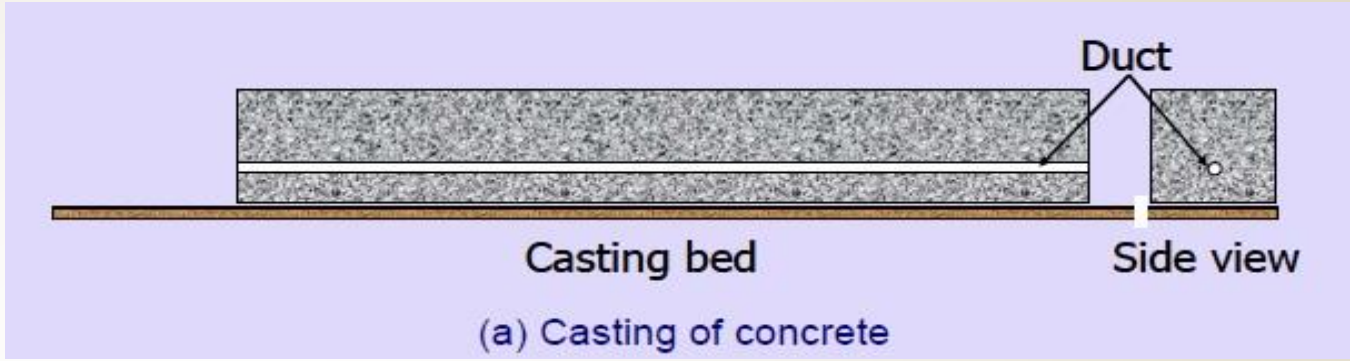
Harping Device

POST-TENSIONING

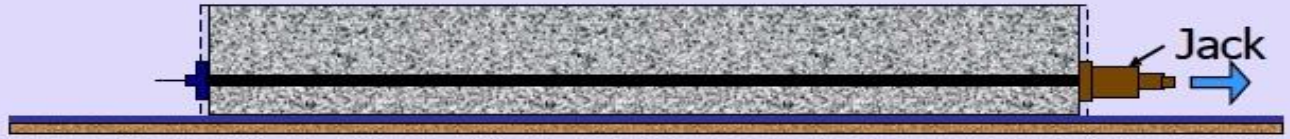
- Ducts for the tendons (or strands) are placed along with the reinforcement before the casting of concrete.
- Tend
- Duct s during the tensi
- Unlik ction acting agai
- If the -tensioning.
- Unbo
- Duct

STAGES OF POST-TENSIONING

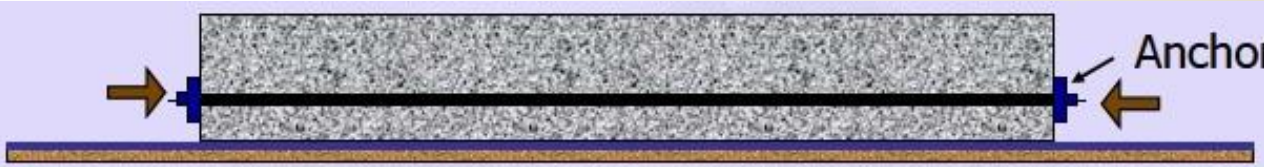
- Casting of concrete
- Placement of the tendons
- Placement of the anchorage block and jack
- Applying tension to the tendons
- Seating of the wedges
- Cutting of the tendons



(a) Casting of concrete



(b) Tensioning of tendons



(c) Anchoring the tendon at the stretching end

ADVANTAGES & DISVANTAGES OF POST-TENSIONING

Advantages of Post-tensioning

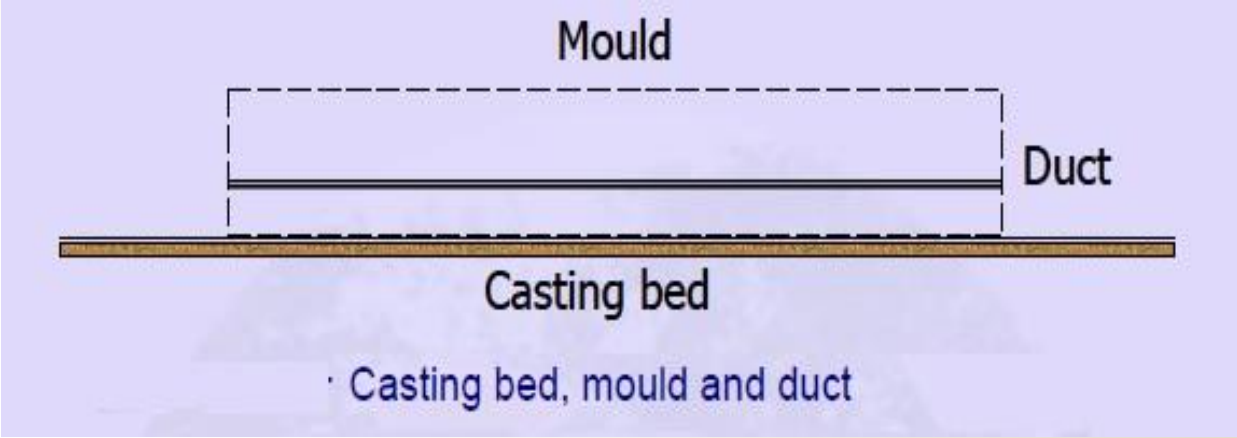
- **Post-tensioning is suitable for heavy cast-in-place members.**
- **The waiting period in the casting bed is less.**
- **The transfer of prestress is independent of transmission length.**

Disadvantages of Post-tensioning

- **Requirement of anchorage device and grouting equipment.**

DEVICES IN POST-TENSIONING SYSTEMS

- Casting bed
- Shuttering / Mould
- Ducts
- Anchoring Devices
- Jacks
- Couplers (optional)
- Grouting equipment (optional)



· Casting bed, mould and duct

ANCHORAGE DEVICES

- Anchorage devices are based on following actions:

1) Wedge action (frictional grip)

2) Direct bearing

3) Looping the wires

Anchorage by looping the wires in a slab

COUPLERS

- The couplers are used to connect strands or bars.
- They are located at the junction of the members, for example at or near columns in post-tensioned slabs, on piers in post-tensioned bridge decks.
- The couplers are tested to transmit the full capacity of the strands or bars.

GROUTING

- Grouting can be defined as the filling of duct, with a material that provides an anti-corrosive alkaline environment to the prestressing steel and also a strong bond between the tendon and the surrounding grout.
- The major part of grout comprises of water and cement, with a water-to-cement ratio of about 0.5, together with some water-reducing admixtures, expansion agent and pozzolanas.

VARIOUS TYPES OF DEVICES USED FOR TENSIONING

1. **Mechanical**

- **Mechanical devices generally include weights with or without lever transmission, geared transmission in conjunction with pulley blocks, screw jacks with or without gear drives and wire-winding machines.**
- **Mainly used for prestressing structural concrete components produced on a mass scale in factories.**

VARIOUS TYPES OF DEVICES USED FOR TENSIONING

2. Hydraulic

- Hydraulic jacks can produce large pr forces and are extensively used as tensioning devices.
- Several commonly used jacks are Freyssient, Magnel, Gofford Udall and Baur-Leonhardt for the range of 5-100 tonnes.
- Large hydraulic jacks for forces in the range of 200-600 tonnes have also been developed by Baur-Leonhardt.
- It is important that during the tensioning operation the force applied should be accurately measured.
- In most of the jacks, calibrated pressure gauges directly indicate the magnitude of force developed during the tensioning.

VARIOUS TYPES OF DEVICES USED FOR TENSIONING

3. Electrical (Thermal)

- Electrical devices have been successfully used in erstwhile USSR since 1958 for tensioning of steel wires and deformed bars.
- The steel wires are electrically heated and anchored before placing concrete in the moulds.
- The method is often referred to as 'thermo-electric pretsressing'.

VARIOUS TYPES OF DEVICES USED FOR TENSIONING

4. Chemical

- In the chemical method, expanding cements are used and the degree of expansion is controlled by varying the curing conditions.
- Since the expansive action of cement while setting is restrained, it includes tensile forces in tendons and compressive stresses in concrete.

TERMINOLOGIES

- **Tendon**

A stretched element used in a concrete member of structure to impart prestress to the concrete. Generally, high-tensile steel wires, bars cables or strands are used as tendons.

- **Anchorage**

A device generally used to enable the tendon to impart and maintain prestress in the concrete. The commonly used anchorages are the Freyssinet, Magnel Blaton, Gifford-Udall, Leonhardt-Baur, LeeMcCall, Dywidag, Roebling and B.B.R.V. systems.

TERMINOLOGIES

- **Pre-tensioning**

A method of prestressing concrete in which the tendons are tensioned before the concrete is placed. In this method, the prestress is imparted to concrete by bond between steel and concrete.

- **Post-tensioning**

A method of prestressing concrete by tensioning the tendons against hardened concrete. In this method, the prestress is imparted to concrete by bearing.

- **Bonded Prestressed Concrete**

Concrete in which prestress is imparted to concrete through bond the tendons and surrounding concrete. Pre-tensioned members belong to this group.

TERMINOLOGIES

- **Non-bonded Prestressed concrete**

A method of construction in which the tendons are not bonded to the surrounding concrete. The tendons may be placed in ducts formed in the concrete members or they may be placed outside the concrete section.

- **Full presrressing**

Prestressed concrete in which tensile stresses in the concrete are entirely obviated at working loads by having sufficiently high prestress in the members.

- **Limited or partial prestressing**

The degree of prestress applied to concrete in which tensile stresses to a limited degree are permitted in concrete under working loads. In this case, in addition to tensioned steel, a considerable proportion of untensioned reinforcement is generally used to limit the width of cracks developed under service loads.

TERMINOLOGIES

- **Moderate prestressing**

In this type no limit is imposed upon the magnitude of the tensile stresses at working loads. According to Leonhard, this form of construction is not really prestressed concrete but is to be regarded reinforced concrete with reduced cracking and the sections should be analyzed according to the rules of reinforced concrete, as a case of bending combined with axial force.

- **Axial presrressing**

Members in which the entire cross-section of concrete has a uniform compressive prestress. In this type of prestressing, the centroid, of the tendons coincides with that of the concrete section.

TERMINOLOGIES

- **Eccentric prestressing**

A section at which the tendons are eccentric to the centroid, resulting in a triangular or trapezoidal compressive stress distribution.

- **Concordant prestressing**

Prestressing of members in which the cables follow a concordant profile. In the case of statically indeterminate structures, concordant prestressing does not cause any change in the support reactions.

- **Non-distortional prestressing**

In this type the combined effect of the degree of prestress and the dead-weight stresses is such that the deflection of the axis of the member is prevented. In such cases, the moments due to prestress and dead-weight exactly balance resulting only in an axial force in the member.

TERMINOLOGIES

- **Uniaxial, biaxial and triaxial prestressing**

The terms refer to the cases where concrete is prestressed (i) in only one direction, (ii) in two mutually perpendicular directions and (iii) in three mutually perpendicular directions.

- **Circular preslressing**

The term refers to prestressing in round members, such as tanks and pipes.

- **Transfer**

The stage corresponding to the transfer of prestress to concrete. For pretensioned members, transfer takes place at the release of prestress from the bulk- heads; for post-tensioned members, it takes place after the completion of the tensioning.

TERMINOLOGIES

- **Supplementary or untensioned reinforcement**

Reinforcement in prestressed members not tensioned with respect to the surrounding concrete before the application of loads. These are generally used in partially prestressed members.

- **Transmission length**

The length of the bond anchorage of the prestressing Wire from the end of a pre-tensioned member to the point of full steel stress.

- **Cracking load**

The load on the structural element corresponding to the first visible crack.

TERMINOLOGIES

- **Creep in concrete**

Progressive increase in the inelastic deformation of concrete under sustained stress component.

- **Shrinkage of concrete**

Contraction of concrete on drying.

- **Relaxation in steel**

Decrease of stress in steel at constant strain.

- **Proof stress**

The tensile stress in steel which produces a residual strain of 0.2 percent of the original gauge length on unloading.

TERMINOLOGIES

- **Creep-coefficient**

The ratio of the total creep strain to elastic strain in concrete.

- **Cap cable**

A short curved tendon arranged at the interior supports of a continuous beam. The anchors are in the compression zone, while the curved portion is in the tensile zone.

- **Degree of prestressing**

A measure of the magnitude of the prestressing force related to the resultant stress occurring in the structural member at working load.

- **Debonding**

Prevention of bond between the steel wire and the surrounding concrete.