CE 414
Prestressed Concrete

Introduction and Types of Prestressing

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Introduction

Prestressed concrete: Concrete in which there have been introduced internal stresses of such magnitude and distribution that the stresses resulting from given external loadings are counteracted to a desired degree.

In reinforced concrete members the prestressed is commonly introduced by tensioning the steel reinforcement.

Advantages of PC over RC

Advantages :

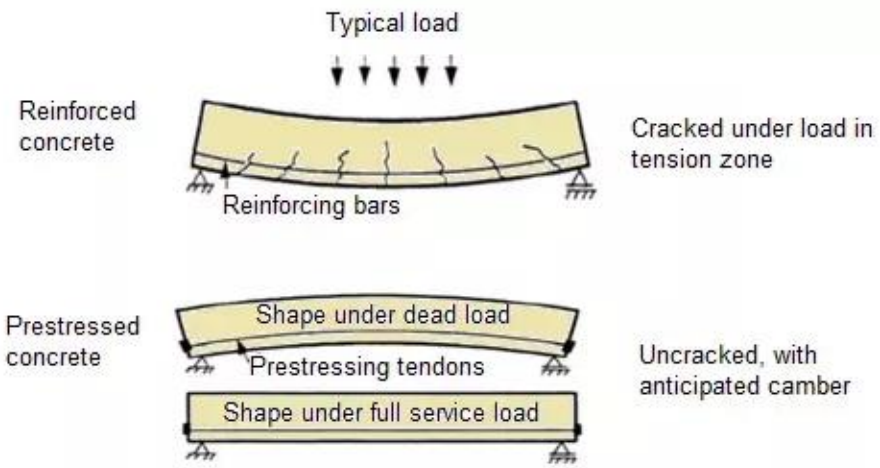
- Take full advantages of high strength concrete and high strength steel
- Need less materials
- Smaller and lighter structure
- No cracks
- Use the entire section to resist the load
- Better corrosion resistance
- Good for water tanks and nuclear plant
- Very effective for deflection control
- Better shear resistance

Disadvantages of PC

Disadvantages compared to RC:

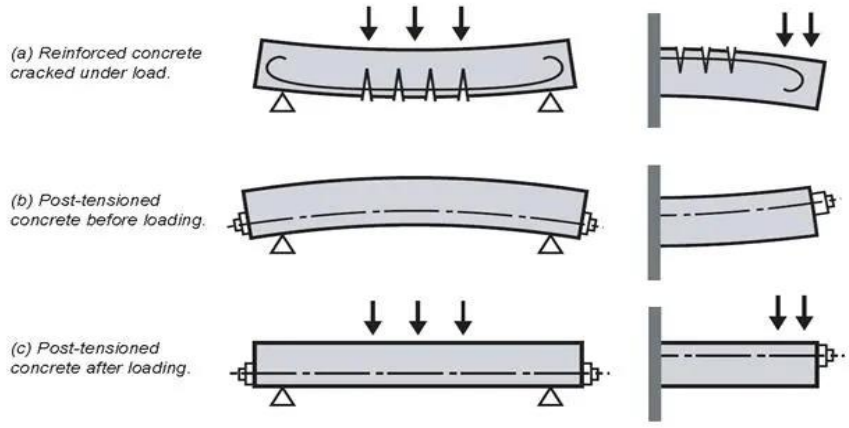
- Need higher quality materials
- More complex technically
- More expensive
- Harder to re-cycle

Normal Reinforced Concrete vs Prestressed concrete



Normal Reinforced Concrete vs Prestressed concrete

- Prestressing prevents the occurrence of shrinkage cracks which could conceivably destroy the shear resistance.



Example of PC structures

ICC tower, Hong Kong
484m 2010

Guoco Tower, Singapore
290m 2016

Sydney Opera House
1973

Example of PC structures

Gateway Bridge
Brisbane, Aust.

Incheon Bridge
South Korea

Autobahn A73
Itz Valley, Germany

Example of PC structures

CN Tower
Toronto, Canada

LNG tanks
South Hook, Wales

Ringhals nuclear plant
Videbergshamn, Sweden

Example of PC structures

Mohakhali Flyover
Bangladesh

Padma Multipurpose Bridge
Bangladesh

Types of Prestressing

- Pretensioning and posttensioning
- Externally or Internally prestressed
- Linear or circular prestressing
- Bonded or Unbonded tendons
- End-anchored or Non-end-anchored tendons
- Partial or Full prestressing
- Electrical Prestressing and Chemically Prestressing
- Precast, Cast in situ and Composite construction

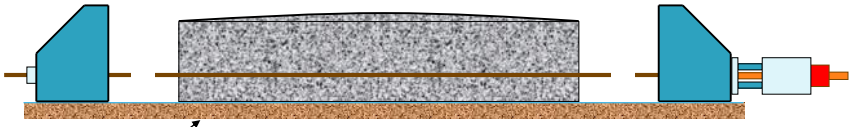
Pretensioning

Pre-tensioned members

- In these, the tendons are tensioned even before casting the concrete.
- One end of the reinforcement (i.e. tendon) is secured to an abutment while the other end of the reinforcement is pulled by using a jack and this end is then fixed to another abutment.
- The concrete is now poured. After the concrete has cured and hardened, the ends of the reinforcement are released from the abutments.
- The reinforcement which tends to resume its original length will compress the concrete surrounding it by bond action.
- The prestress is thus transmitted to concrete entirely by the action of bond between the reinforcement and the surrounding concrete.

Pretensioning

Operation of pre-tensioning through various stages by animation

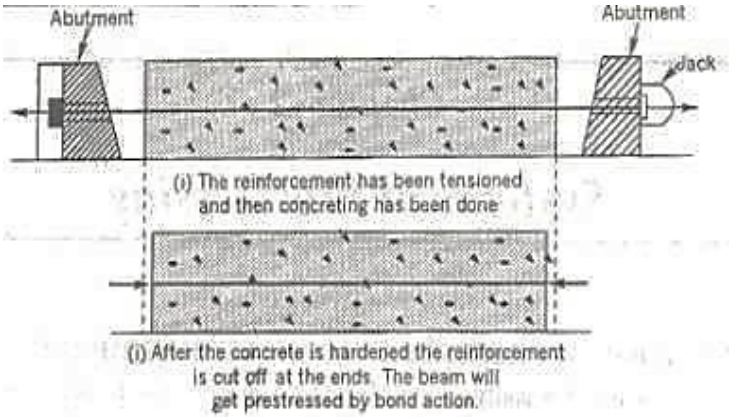


Prestressing bed

Pre-tensioning of a member

Pretensioning

Pre-tensioned members



Posttensioning

Post-tensioned member

- It is one in which the reinforcement is tensioned after the concrete has fully hardened.
- The beam is first cast leaving ducts for placing the tendons.
- The **ducts** are made in a number of ways–by leaving corrugated steel tube in the concrete, by providing steel spirals, sheet metal tubing, rubber have or any other duct forming unit in the form work.
- When the concrete has hardened and developed its strength, the tendon is passed through the duct.

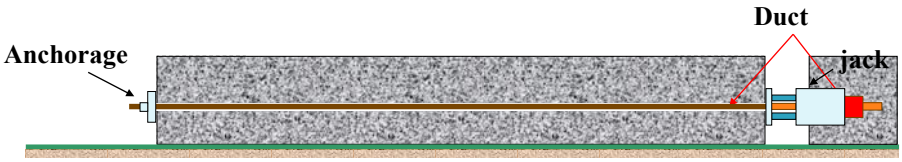
Posttensioning

Post-tensioned member

- One end is provided with an anchor and is fixed to one end of the member.
- Now, the other end of the tendon is pulled by a jack which is butting against the end of the member.
- The jack simultaneously pulls the tendon and compresses the concrete.
- After the tendon is subjected to the desired stress, the end of the tendon is also properly anchored to the concrete.
- To avoid crushing of concrete due to excessive bearing stress, a distribution plate is provided at each end.

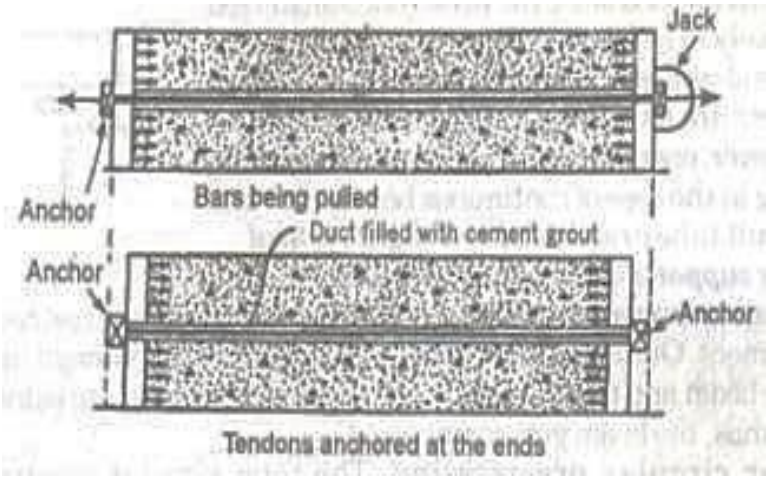
Posttensioning

Operation of post-tensioning through various stages by animation



Post-tensioning of a member

Posttensioning



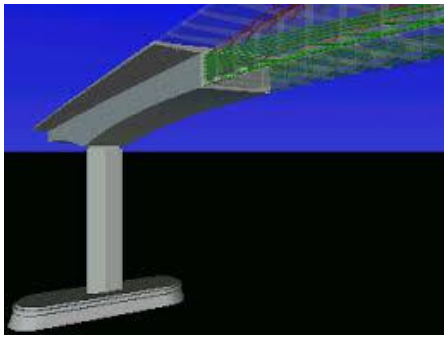
Externally Prestressed

- In External Prestressing, the member is prestressed by external reaction offered by rigid abutments.
- In this, the necessary prestressing force can be applied by compressing the member by jacking against abutments.
- A sliding surface may be provided underneath the beam.
- After the prestressing is over, the space between the end of the beam and the abutment may be packed with concrete and the jack recovered.

Externally prestressed

Internally prestressed

- In Internal Prestressing tendon is provided from which the prestress can be applied.

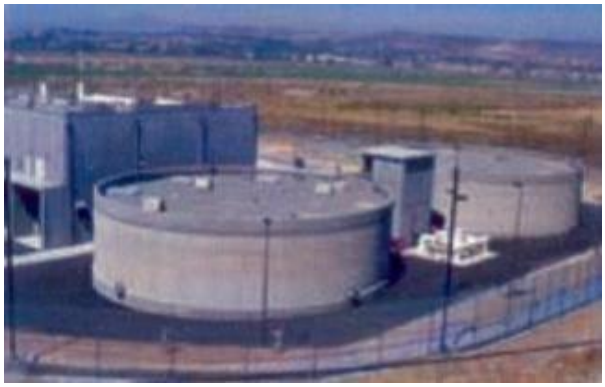


Linear prestressed

- Linear prestressing is a term applied to prestressing straight members like beams and slabs.
- The prestressing tendons are not necesserily straight; they can be either bent or curved, but they do not go round and round in circles as in circular prestressing.

Circular prestressed

The term circular prestressing is applied to prestressing circular structures like cylindrical tanks, silos and pipes. In this case, the prestressing tendons are provided in the form of rings.



Bonded or Unbonded Tendons

Bonded tendons denote those bonded throughout their length to the surrounding concrete.

- Non-end-anchored tendones are necessarily bonded.
- Bonding is accomplished by grouting

Unbonded tendons are those which are not bonded to the surrounding concrete.

- End-anchored tendones may be either bonded or unbonded to the concrete.
- Typically the unbonded tendon is greased and wrapped with paper or plastic to prevent bonding with concrete.

End-anchored and Non-end anchored

End-Anchored: In Posttensioning, tendons are anchored at their ends using mechanical devices to transmit the prestress to concrete; , therefore, it is end-anchored. (Grouting or not is irrelevant)

Non-End-Anchored: In Pretensioning, tendons transfer the prestress through the bond actions along the tendon; therefore, it is non-end-anchored □

Partial and full prestressing

Fully prestressed: When a member is designed so that under the working load there are no tensile stresses in it then the concrete is said to be fully prestressed.

Partial prestressed: If some tensile stresses will be produced under the working load then the concrete is termed as partially prestressed.

- For partially prestressing, additional mild-steel bars are frequently provided to reinforce the portion under tension.
- Sometimes partially prestressed concrete (PPC) is used to control camber and deflection, increase ductility, and save costs.

Electrical and Chemical Prestressing

Electrical Prestressing: In this method, reinforcing bars is coated with thermoplastic material such as sulphur or low melting alloy and buried in the concrete. After the concrete is set, electric current of low voltage but high amperage is passed through the bar. Electric current heats the bar and the bar elongates. Bars provided with threads at the other end are tightened against heavy washers, after required elongation is obtained. When the bar cools, prestress develops and the bond is restored by resolidification of the coating.

Chemical Prestressing: Chemical prestressing is done using expanding cement. Prestressing can be applied by embedding steel in concrete made of expanding cement. Steel is elongated by the expansion of the concrete and thus gets prestressed. Steel in turn produces compressive stress in concrete.

Precast, Cast-in-situ & Composite

Precast

Precast prestressed concrete is a form of concrete that is prepared, cast and cured off-site, usually in a controlled factory environment, using reusable molds.

- Precast concrete elements can be joined to other elements to form a complete structure.
- It is typically used for structural components such as; wall panels, beams, column, floors, staircases, pipes, tunnes and so on.

Precast, Cast-in-situ & Composite

Cast-in-situ

Cast-in-situ prestressed concrete is a concreting technique which is undertaken in situ or in the concrete component's finished position.

Cast-in-situ concrete is the preferred choice for concrete slabs and foundations, as well as components such as beams, columns, walls, roofs, and so on.

Composite construction

Composite construction consists of providing monolithic action between precast reinforced or prestressed concrete and Cast-in-situ concrete. This method is found to provide a greater structural efficiency compared with the conventional methods of construction.