Prestressed Concrete

Notes by-

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PRESTRESSED CONCRETE

"Drawing is the language of Engineer"

Prestressed Concrete:- A concrete in which internal stresses of a suitable magnitude & distribution are introduced so that the stresses resulting from external loads are counteracted to a desired degree.

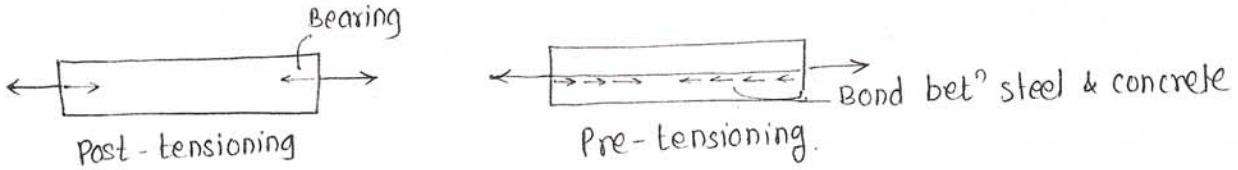
* Need of high strength steel & concrete:-

The normal loss of ~~pre~~stress in steel is about 100 - 240 N/mm^2, while working stress of MS is only 120 N/mm^2. As the loss of prestress should be very small than working stress, initial stress in the steel should be high about 1200 - 2000 N/mm^2. This high range of stress is possible only with use of high strength steel.

High strength concrete is necessary in prestressed concrete, as it offers high resistance in tension, shear, bond & bearing. In the zone of anchorage the bearing stresses are higher. ~~So~~ and also, high strength concrete is less liable to shrinkage cracks, & has a higher E, smaller creep strain resulting smaller loss of stress in steel. With a reduced DL of matl. longer spans becomes technically & economically practicable.

* Pretensioning:- A mtd. of prestressing by tensioning the tendons ~~against~~ before placing ~~hardened~~ concrete. In this mtd, prestress is imparted to concrete by bond bet^n steel & concrete.

* Post-tensioning:- A mtd. of PSC by tensioning against hardened concrete. The prestress is imparted by concrete by bearing.



Post-tensioning Pre-tensioning.

* Advantages of Prestressed concrete:-

In case of PSC ~~bea~~ section, which is free from tensile stresses under all stages of loading. The c/s is more efficiently utilised when compaired with RCC section which is cracked under working load.

② Absence of cracks in concrete gives higher capacity of str. to resist -
- i) Reversal of stresses
- ii) Impact, vibration, shocks,
- iii) Shear
- iv) Less chance of rusting of steel.

③ PSC beam can be designed in such a way that, DL is practically neutralised. Hence reaction reqd. at support is much smaller than RCC beam. Thus reduced wt. of str. results in saving the cost of found^n.

④ Because of use of High strength ~~st~~ concrete & no crack improves under aggressive envt.

⑤ Use of curved tendon & precompression of concrete helps to resist shear.
⑥ Quantity of steel reqd. is $1/3^{rd}$ that of RCC
⑦ Many of PSC member can be precast blocks / elements. Hence this saves cost of shuttering & centring for major projects.
⑧ PSC beam gives less deflection as compared to RCC for same span.
⑨ PSC can be used more efficiently where tension develops, as concrete is weak in tension. eg. Tie member
Suspender for bridges.
Railway sleepers.
Electric poles.
u/s face of gravity dam.

* Disadvantages of PSC :-

① Due to high strength concrete, consumption of cement is more. use of high grade steel is 3 times costlier than that used in RCC.
② It requires complicated & costlier tensioning equipment & anchoring devices which are usually covered under patented rights.
③ Const^{n} of PSC str. requires perfect supervision at all stages of loading.

Diff. bet^{n} Prestressed Concrete & RCC.

PSC	RCC
① High strength matls. are used. eg: Concrete grade :- M30, M35 – Post-tensioning M40 - Pre-tensioning. steel :- Yield stress = 1000 - 2000 MPa.	② Low strength matls. are used. eg: concrete grades : M15, M20 steel grade : Fe250, Fe415, Fe500.
② Entire c/s becomes effective in PSC	① The c/s above NA is effective & c/s below NA is non effective
③ considerable smaller section will be reqd. to resist BM & SF, as curved tendon, helps to carry some SF & also pre-compressed concrete increases shear strength & reduces principal tension.	③ size of c/s will be more to resist same BM & SF
④ High strength matl. are economical for longer spans & mass production.	⑤ Use of high grade concrete gives smaller c/s but steel requirement is increases which in turns uneconomical.
⑤ Serviceability :- Being thin/small sect^{n} is gives less deflection & uncracked section. & due to this less corrosion of steel occurs for same cover.	

~~Pretensioning~~ Post	~~Post tensioning~~ Pre
① A mtd. of prestressing in which tendon is tensioned after the concrete has been hardens & tendons are properly anchored at ends.	② A mtd. of ~~post tensioning~~ PSC in which tendon is tensioned ~~after~~ before placing the concrete.
② Prestressing force is imparted to concrete by bond bet^n steel & concrete. & bearing. PRE	Post ② Prestressing force is imparted by concrete by bearing.
③ Used for short member & mass production.	③ Used for long span members.
④ Maintaining the cable profile is difficult.	④ Maintaining the cable profile is easy.
⑤ Less labour reqd. for placing, stressing, grouting etc.	⑤ More labours are reqd.
⑥ Anchorages are not reqd. for each member.	⑦ Two anchorages are reqd. for each member.
⑦ Usually used in precast member	⑧ Used for cast-in-situ elements

Materials used in Prestressing:-

Grade of concrete : M30 onwards - Post-tensioning
M40 onwards - Pre tensioning.

Steel : Fy 1500
Fy 2100.

Reason for use of high strength matls. in PSC:-
① It offers high resistance in tension, shear, bond, bearing.
② To resist high bursting force developed at end block.
③ Less liable to shrinkage cracks.
④ High value of E - due to which creep reduces & less of loss of prestress.
⑤ To achieve smaller c/s area.

Max. Grade of concrete for PSC = M60.

Because :- ① More cost involved in mix design plant.
② Special supervision reqd.
③ Control on mixing, placing, vibration, curing.
④ No use of strength of concrete beyond M60.

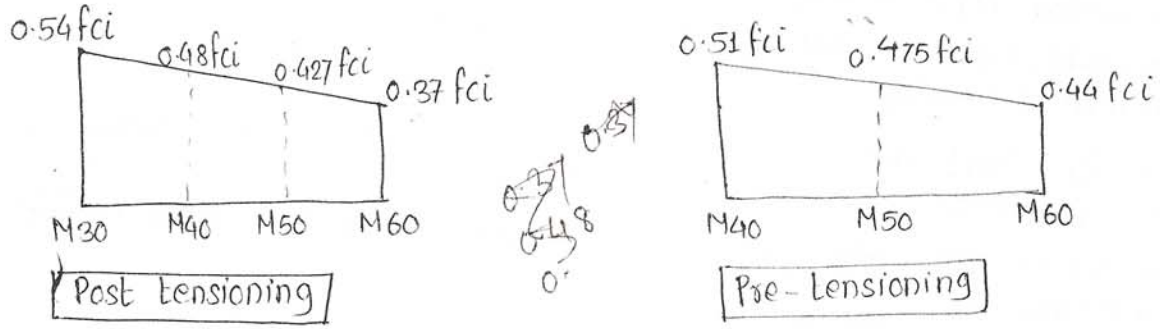
① In case of steel, loss of prestress is about 300 MPa. So ordinary steel have very small strength in tension is available after loss of prestress.
② In case of high strength steel, "high ultimate elongation" is given which is reqd. to develop high PS force.

Permissible stresses

I a) Concrete: Cl. 22.8/54

* Max. bending stress (σ_{bc}) in ~~compre~~ flexure of concrete is,

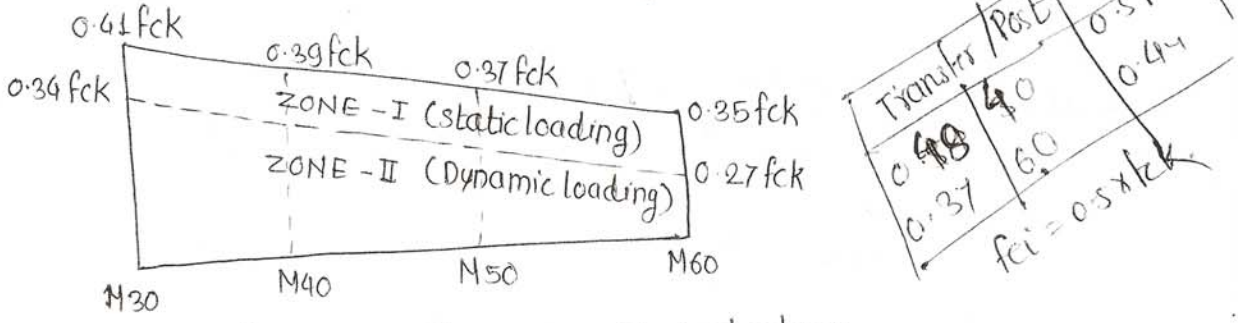
a) At transfer / Initial stage



Where, $f_{ci} = \frac{f_{ck}}{2}$

For direct compression, $\sigma_{ac} \leq 0.8\,\sigma_{bc}$ .... as obtained above.

b) At Service / Working / Design / Final stage :-



For axial comp., $\sigma_{ac} \leq 0.8\,\sigma_{bc}$ ... as obtained above.

II] Steel :-

Max. initial prestress (f_{pi}) $\leq 0.8\,f_y$ ... ultimate tensile strength.

$$f_{pi} = 0.8\,f_y$$

Stages of Loading

① ~~Initial / Transfer stage : When member is subjected to PS force, but no~~
② ~~external load is applied.~~

~~This st~~

Stage I] At transfer of Prestress
Stage II] Handling & erection
Stage III] At service or design load
Stage IV] At appearance of first crack
Stage V] At failure.