

PRESTRESSING METHOD IN MULTI-STORIED BUILDING FRAME

History of Pre-stressing

The art of pre-stressing concrete evolved over many decades and from many sources, but we can point to a few select instances in history that brought about this technology.

In the United States, engineer John Roebling established a factory in 1841 for making rope out of iron wire, which he initially sold to replace the hempen rope used for hoisting cars over the portage railway in central Pennsylvania. Later, Roebling used wire ropes as suspension cables for bridges, and he developed the technique for spinning the cables in place.

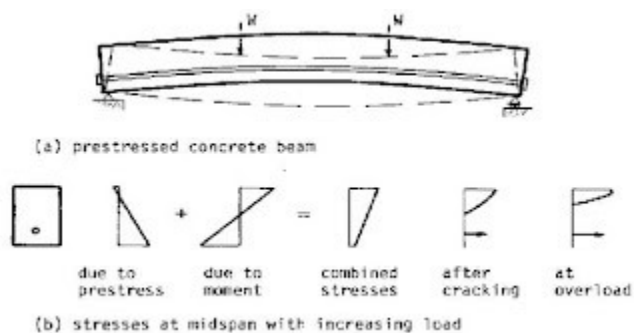
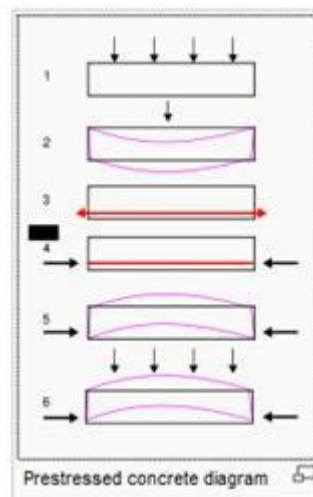
During the 19th century, low-cost production of iron and steel, when added to the invention of portland cement in 1824, led to the development of reinforced concrete. In 1867, Joseph Monier, a French gardener, patented a method of strengthening thin concrete flowerpots by embedding iron wire mesh into the concrete. Monier later applied his ideas to patents for buildings and bridges.

Swiss engineer Robert Maillart's use of reinforced concrete, beginning in 1901, effected a revolution in structural art. Maillart, all of whose main bridges are located in Switzerland, was the first designer to break completely with the masonry tradition by putting concrete into forms technically appropriate to its properties – yet visually surprising. His radical use of reinforced concrete revolutionized masonry arch bridge design.

PRE-STRESSED CONCRETE

Pre stressed concrete, like reinforced concrete, is a composite material which uses to advantage the compressive strength of concrete, whilst circumventing its weakness in tension. Pre stressed concrete is made from structural concrete, usually of high strength, and high strength steel tendons which may or may not be grouped together. Prior to external loading the tendons are tensioned in one of two ways. With pretensioning the tendon are tensioned prior to the casting of the concrete and using post tensioning techniques the tendons are tensioned after the concrete has hardened. Some ordinary reinforcing steel is also often included both as subsidiary longitudinal reinforcement and as transverse stirrups to resist shear.

Pre-stressed concrete is a method for overcoming concrete's natural weakness in tension. It can be used to produce beams, floors or bridges with a longer span than is practical with ordinary reinforced concrete. Pre-stressing tendons (generally of high tensile steel cable or rods) are used to provide a clamping load which produces a compressive stress that offsets the tensile stress that the concrete compression member would otherwise experience due to a bending load. Traditional reinforced concrete is based on the use of steel reinforcement bars, inside poured concrete. The basic purpose of pre-stressing is to improve the performance of concrete members and this is achieved by inducing in the beam initial deformation and stresses which tend to counteract those produced by the service loads.



Since concrete is weak in tension in normal reinforced concrete construction cracks develop in the tension zone at working loads and therefore all concrete in tension is ignored in design.

Pre-stressing involves inducing compressive stresses in the zone, which will tend to become tensile under external loads. This compressive stress neutralizes the tensile stress so that no resultant tension exists, (or only very small values, within the tensile strength of the concrete). Cracking is therefore eliminated under working load and all of

the concrete may be assumed effective in carrying load. Therefore lighter sections may be used to carry a given bending moment, and pre-stressed concrete may be used for longer span than reinforced concrete.

The pre-stressing force also reduces the magnitude of the principal tensile stress in the web so that thin-webbed I - sections may be used without the risk of diagonal tension failures and with further savings in self-weight.

The pre-stressing force has to be produced by a high tensile steel, and it is necessary to use high quality concrete to resist the higher compressive stresses that are developed. As the name itself suggests pre-stressing is the technique of stressing a structural member prior to loading to resist excessive tensile stresses.

The advantages of pre-stressed concrete as a construction material in multi storied frame can be listed as follows:

- Maximum utilization of provided section of the member.
- Provision of slender member for long span beams as compared to RCC.
- Use of high strength materials contribute to the durability of the structure.
- Pre-stresses concrete has considerable resilience and impact resistance.
- Proves to be economical only in long span beam-column frames compared to other materials.
- The intermediate distance between the columns can be increased by using pre-stressed concrete as compared to reinforced cement concrete.
- Architectural design provisions and specifications can be achieved using pre-stressed concrete.
- Dead weight of concrete is reduced to a higher rate using pre-stressed concrete.

PRINCIPLE OF PRESTRESSING

The function of pre-stressing is to place the concrete structure under compression in those regions where load causes tensile stress. Tension caused by the load will first have to cancel the compression induced by the pre-stressing before it can crack the concrete. Figure (a) shows a plainly reinforced concrete simple-span beam and fixed cantilever beam cracked under applied load. Figure (b) shows the same unloaded beams with pre-stressing forces applied by stressing high strength tendons. By placing the pre-

stressing low in the simple-span beam and high in the cantilever beam, compression is induced in the tension zones; creating upward camber.

Figure (c) shows the two pre-stressed beams after loads have been applied. The loads cause both the simple-span beam and cantilever beam to deflect down, creating tensile stresses in the bottom of the simple-span beam and top of the cantilever beam. The structural Designer balances the effects of load and pre-stressing in such a way that tension from the loading is compensated by compression induced by the pre-stressing. Tension is eliminated under the combination of the two and tension cracks are prevented. Also, construction materials (concrete and steel) are used more efficiently; optimizing materials, construction effort and cost.

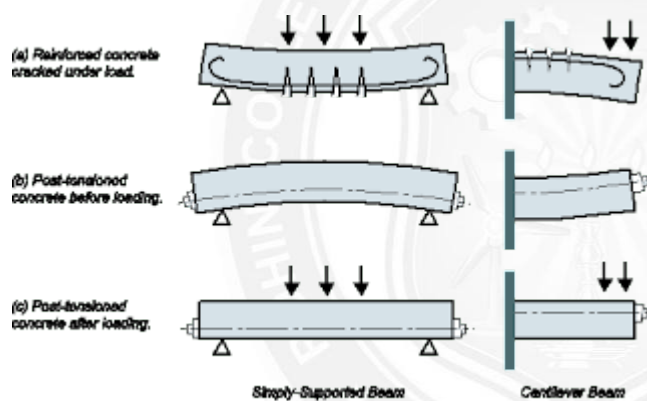


Fig 1. - Comparison of Reinforced and Prestressed Concrete Beams

Pre-stressing can be applied to concrete members in two ways, by pre-tensioning or post-tensioning. In pre-tensioned members the pre-stressing strands are tensioned against restraining bulkheads before the concrete is cast. After the concrete has been placed, allowed to harden and attain sufficient strength, the strands are released and their force is transferred to the concrete member. Pre-stressing by post-tensioning involves installing and stressing pre-stressing strand or bar tendons only after the concrete has been placed, hardened and attained a minimum compressive strength for that transfer.

METHODS AND SYSTEM OF PRE-STRESSING

There are two methods of pre-stressing concrete: -

- 1) Pre-cast Pre-tensioned
- 2) Pre-cast Post-tensioned

Both methods involve tensioning cables inside a concrete beam and then anchoring the stressed cables to the concrete.

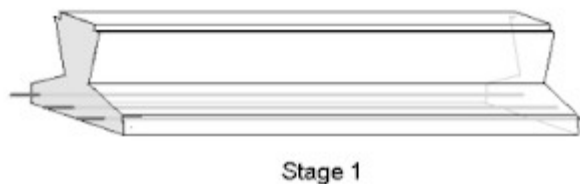
Pre-cast Pre-tensioned: -

Pre-tensioning is a method of pre-stressing in which the steel tendons are tensioned before the casting of the member. In this method the tendons are tensioned using hydraulic jacks, which bear on strong abutments between which the moulds are placed. After the concrete attains full strength the tendons are released and the stress is transferred to the concrete by bond action.

Procedure of precast pre-tensioned concreting

Stage 1

Tendons and reinforcement are positioned in the beam mould.



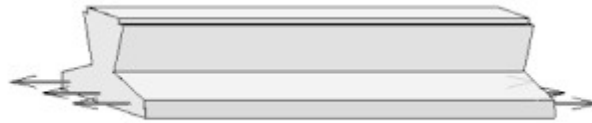
Stage 2

Tendons are stressed to about 70% of their ultimate strength.



Stage 3

Concrete is cast into the beam mould and allowed to cure to the required initial strength.



Stage 3

Stage 4

When the concrete has cured the stressing force is released and the tendons anchor themselves in the concrete.



Stage 4

Pre-cast Post-tensioned: -

Post-tensioning is a method of pre-stressing in which the steel tendons are tensioned after the casting of the member. In this method ducts or sheaths are placed in the required profile in the mould and the tendons are passed through the ducts. After the concrete had attained sufficient strength the tendons are tensioned using hydraulic jacks which bear on the member itself. The stress is transferred to the concrete by bearing action of tendons which are anchored using suitable anchorages. Finally the ducts are grouted and the anchor plates concealed by cement mortar.

Procedure of precast post-tensioned concreting

Stage 1

Cable ducts and reinforcement are positioned in the beam mould. The ducts are usually raised towards the neutral axis at the ends to reduce the eccentricity of the stressing force.



Stage 1

Stage 2

Concrete is cast into the beam mould and allowed to cure to the required initial strength.



Stage 2

Stage 3

Tendons are threaded through the cable ducts and tensioned to about 70% of their ultimate strength.



Stage 3

Stage 4

Wedges are inserted into the end anchorages and the tensioning force on the tendons is released. Grout is then pumped into the ducts to protect the tendons.



Stage 4