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REINFORCED CONCRETE

8- Principle of Reinforced Concrete

The principles of reinforced concrete applied to construction elements such as: foundations - columns - beams - slabs - balconies, etc., Result from:

- criteria for economy and safety.
- the conditions for the proper functioning of structures,
- the characteristics of concrete and steel,

REINFORCED CONCRETE

8- Principle of Reinforced Concrete

8-1- Economic and Functional Criteria:

- Concrete primarily balances compressive forces in the compressed zones of reinforced concrete structures.
- Steel primarily balances tensile forces; it is placed in tension zones.

8-2-Conditions for Proper Operation of Structures:

- Concrete and steel are combined through the mutual adhesion of materials

REINFORCED CONCRETE

8-Principle of Reinforced Concrete

8-3- Safety Criteria:

- The tensile strength of concrete is not considered in calculations.
- Safety factors are applied to the potential strengths of concrete and steel.

9- Application

Beams and lintels

The flexural beam is subjected to both:

- a compressive force (at the top)
- a tensile force (at the bottom)

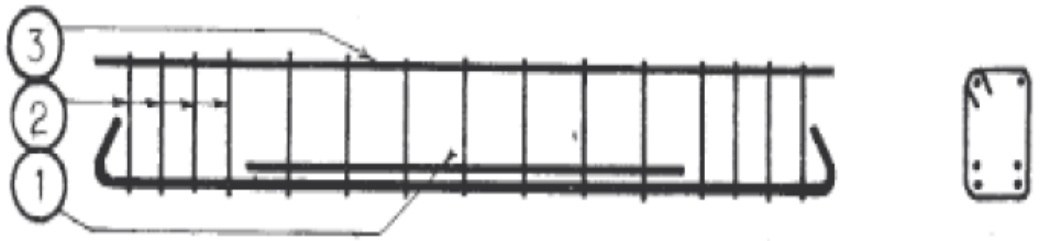
REINFORCED CONCRETE

9- Application

• an oblique shear due to vertical actions of

opposite directions: support

- action directed upwards load
- action directed downwards



To address this, it is necessary to have:

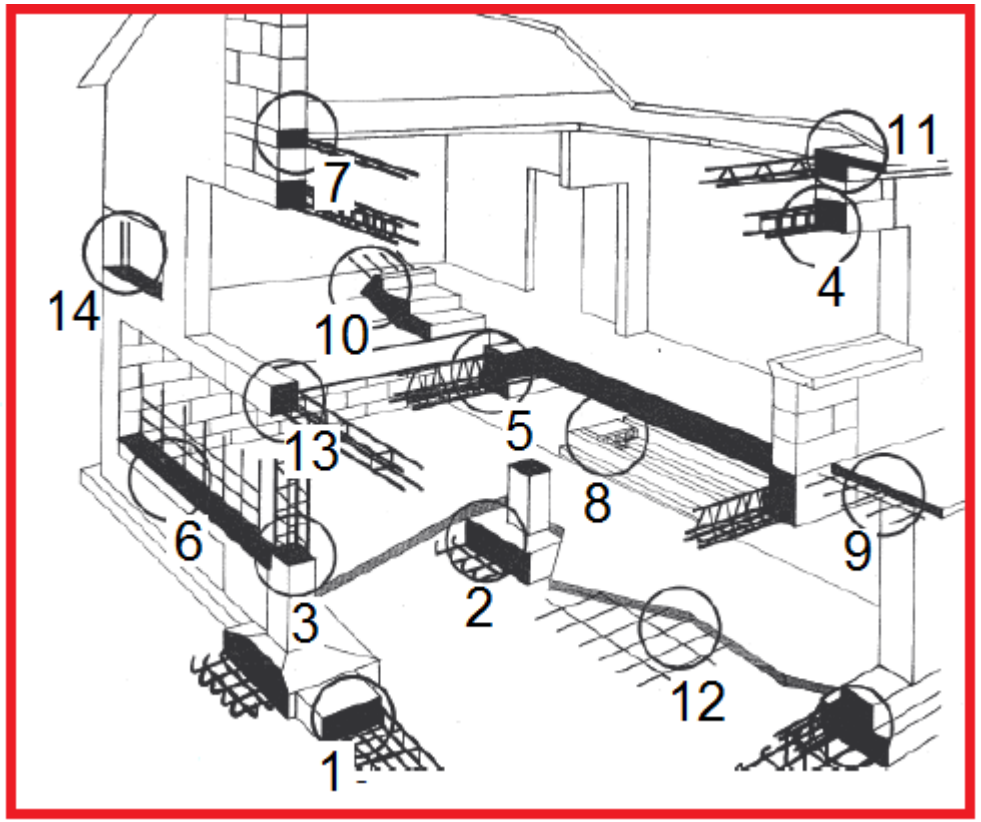
1. main steel bars (longitudinal reinforcements)
2. frames or stirrups (transverse reinforcements)
3. installation bars

REINFORCED CONCRETE

9- Application

Use of reinforcements:

1. Continuous footing
2. Isolated footing
3. Column
4. Lintel
5. Cast-in-place beam
6. Wall
7. Horizontal tie
8. Floor slab
9. Balcony
10. Staircase
11. Cornice
12. Floor slab
13. Precast lintel
14. Vertical tie



PRE-STRESSED CONCRETE

Summary

Definition

Principle of Prestressed Concrete

Methods of implementing prestressing:

1.Inflation of jacks resting on fixed abutments:

2.Tensioning of steel cables by jacks supported on the concrete of the piece to be prestressed:

3.Prestressing by bonded tendons:

4.Pre-stressing Methods

- -1Pre-tension: cables tensioned before concrete casting
- -2Post-tension: cables tensioned after concrete casting

1. Pre-stressing by Pre-tension

- **General Steps of Execution**

Post-tensioning Prestressing

- **General steps of implementation:**
- **Prestressing Equipment**

The domains of prestressing application:

1. Post-tensioning

2.Pre-tensioning

PRE-STRESSED CONCRETE

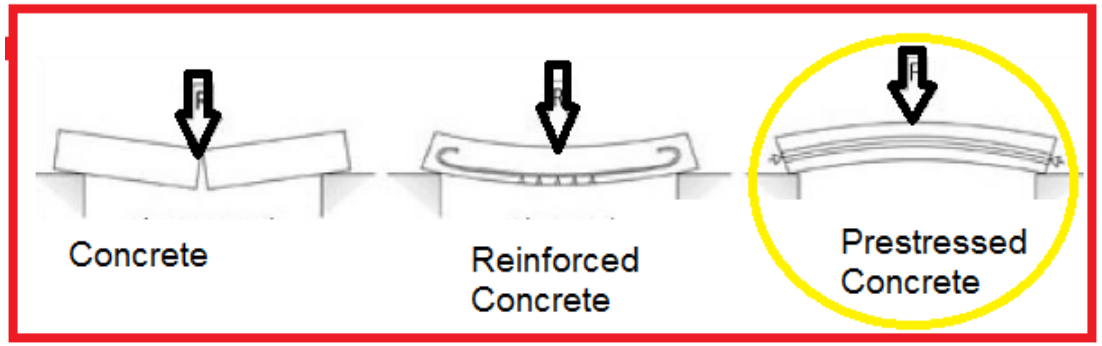
Definition

Pre-stressed concrete stems from the following reasoning: concrete is currently the most economical construction material. Although it exhibits excellent compressive strength, its tensile strength is very low. Therefore, it is necessary to construct using concrete while avoiding excessive tension that could lead to cracks. To achieve this, it is necessary to artificially and continuously compress it in areas subjected to external tensile forces, so that the concrete remains overall compressed (or slightly tensed to avoid cracks) and thus resistant to loads.

PRE-STRESSED CONCRETE

Definition

The intentionally applied compressive force for this purpose is called pre-stressing force (or simply pre-stress). Consequently, our structure is active from the outset as it is subjected to pre-tensioning efforts even before being loaded. In 1928, its inventor, Eugène Freyssinet, defined pre-stress in this manner.



PRE-STRESSED CONCRETE

Principle of Prestressed Concrete

Let's consider, for example, a reinforced concrete beam resting on two simple supports. When subjected to a load, it deforms. The cross-section at the point of application of the load is compressed on the upper fiber and stretched on the lower fiber. When the load becomes too high, cracks form at the bottom of the beam.

In this beam, let's suppose that the traditional tensile reinforcement is removed and replaced with a curved duct following the beam's deformation, containing prestressed cables. By pulling on the cables, we compress the beam. Thus, in the cross-section, the upper fiber stretches and the lower fiber compresses.

PRE-STRESSED CONCRETE

Principle of Prestressed Concrete

When a load is applied, the tensile forces neutralize the compressive forces created by the prestressing, and all fibers remain compressed. This pre-compressed beam will withstand without damage the loads that would cause the rupture of a reinforced concrete beam of the same dimensions and span.

It is possible to determine the necessary prestressing force to keep the beam always compressed, regardless of the applied load

PRE-STRESSED CONCRETE

Methods of implementing prestressing:

1.Inflation of jacks resting on fixed abutments:

In this method, jacks are placed between the abutments and the concrete piece cast between them. The inflation of the jacks shortens the piece, compressing it accordingly. Wedges are then inserted between the abutments and the piece to keep it compressed. This method is cost-effective when the abutments are affordable, typically when natural rock formations can replace them. Otherwise, the two abutments can be connected by a tie, often a steel cable, to prevent them from moving apart during the action of the jacks.

PRE-STRESSED CONCRETE

Methods of implementing prestressing:

2.Tensioning of steel cables by jacks supported on the concrete of the piece to be prestressed:

In this method, steel cables are tensioned by jacks resting on the concrete of the piece to be prestressed. Under the action of the jack, the cable elongates and stretches, exerting a compressive force on the concrete equal to the prestressing force. Once tensioned, the cable is anchored to the concrete, ensuring the permanence of compression. This operation is performed after the concrete has been poured and has sufficiently hardened to withstand the prestressing force, which is called post-tensioning.

PRE-STRESSED CONCRETE

Methods of implementing prestressing:

3.Prestressing by bonded tendons:

This method, also known as pretensioning, involves first tensioning the tendons between two fixed abutments. Then, concrete is poured around the tendons, and once it has sufficiently hardened, the tension in the tendons is released. Their shortening is hindered within the piece by bond, which significantly reduces tension loss in the steel and ensures the compression of the concrete. This method is primarily used for the factory prefabrication of series of identical pieces, typically with straight tendons.

PRE-STRESSED CONCRETE

Pre-stressing Methods

To carry out the prestressing operation, there are two possibilities:

- Pre-tension: cables tensioned before concrete casting
- Post-tension: cables tensioned after concrete casting

1. Pre-stressing by Pre-tension

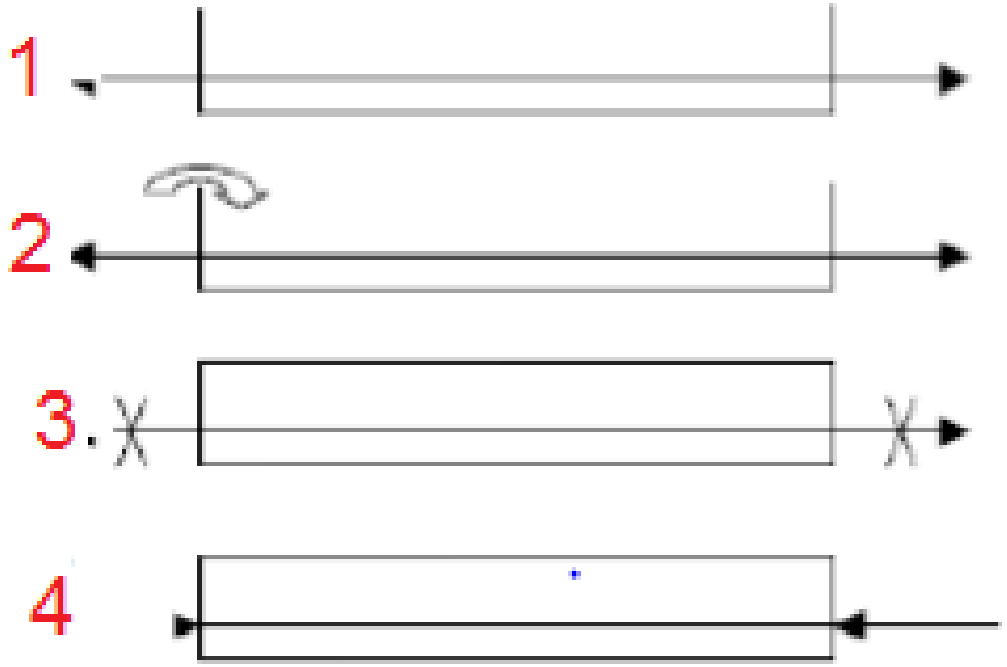
In this process, the prestressing cables are tensioned between two firmly anchored blocks before the concrete is poured .This technique is mainly used on prefabrication benches to produce repetitive elements.

PRE-STRESSED CONCRETE

1. Pre-stressing by Pre-tension

General Steps of Execution

1. Tensioning of the cables.
2. Pouring of the concrete.
3. Releasing of the cables after the concrete has hardened.
4. Through adhesion, the compressiv prestress is transferred to the concrete.



PRE-STRESSED CONCRETE

- **Pre-stressing by Pre-tension**

In a more detailed manner, the pre-tensioning prestressing method follows the following cycles:

- Cleaning of the molds;
- Application of form release oil on the molds;
- Unrolling of the active reinforcements and securing them at the ends in plates;
- Placement of passive reinforcements;
- Placement of the molds in their final position;
- Installation of any deflectors;
- Tensioning of the reinforcements by hydraulic jacks;

PRE-STRESSED CONCRETE

- **Pre-stressing by Pre-tension**

In a more detailed manner, the pre-tensioning prestressing method follows the following cycles:

- Placement of concrete using overhead crane or gantry crane;
- Smoothing of the upper part;
- Vibration of the concrete;
- Curing or heating of the concrete;
- Stripping of the molds;
- Relaxation of the active reinforcements;
- Cutting of the wires between two prefabricated elements;
- Handling and storage.

PRE-STRESSED CONCRETE

Post-tensioning Prestressing

This process involves tensioning the prestressed cables after pouring and hardening of the concrete, using the structure as a compression member . This technique is employed for significant structures and is typically implemented on-site.

Post-tensioning prestressing comes in two forms:

- Internal post-tensioning prestressing
- External post-tensioning prestressing

PRE-STRESSED CONCRETE

Post-tensioning Prestressing

General steps of implementation:

- Placement of ducts (sheaths) in the formwork.
- Pouring of concrete.
- After the concrete has hardened, tensioning of the cables.
- Blocking is achieved using various systems of wedges on a fretted concrete area.
- Injection of a cement grout.

Injection is an extremely important operation as it serves a dual role:

1. Protection of prestressed reinforcements against corrosion.
2. Enhancement of the bond between reinforcements and ducts.

PRE-STRESSED CONCRETE

Post-tensioning Prestressing

Prestressing Equipment

The complete set of prestressing equipment typically includes the following elements :

1) **Anchoring Device:** Two main types of anchoring are distinguished:
Active anchoring, located at the end where tensioning occurs.
Passive anchoring (dead anchorage), situated at the opposite end to the tensioning.

2) **Couplers:** Devices allowing for the extension of reinforcements.

3) **Tensioning Equipment:** Hydraulic jacks, injection pumps, jack feeding pumps, etc.

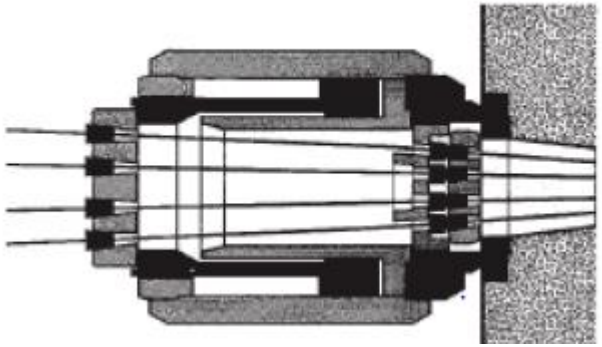
4) **Accessories:** Ducts, injection tubes, etc.

PRE-STRESSED CONCRETE

Post-tensioning Prestressing
Prestressing Equipment

Couplers

Multi-strand active anchorages



A hydraulic jack

sheaths

PRE-STRESSED CONCRETE

The domains of prestressing application:

1. Post-tensioning

The initial applications, which later expanded, primarily focused on medium to long-span bridges:

- The cable-stayed bridge of Barrios de Luna spans 440 meters. More commonly, lightweight concrete cores and the use of external prestressing allow spans ranging from 50 to 250 meters.
- Prestressing also facilitates the construction of reservoirs. Some hydrocarbon reservoirs reach capacities of 100,000 m3; water reservoirs and silos, with more modest volumes, also extensively utilize prestressing.

PRE-STRESSED CONCRETE

The domains of prestressing application:

1. Post-tensioning

- Additionally, prestressing is employed in offshore platforms, nuclear reactor containment structures, and the use of external prestressing in the repair of bridges or dams. In the realm of building construction, post-tensioning prestressing, although less common, is utilized for long-span beams or relatively thin-section floor slabs in comparison to their spans: parking structures, industrial or commercial buildings.

PRE-STRESSED CONCRETE

The domains of prestressing application:

2.Pre-tensioning

This technique is primarily used for standardized prefabricated elements, where it is justified by the concept of mass production.

The building industry constitutes the most common field of application for these elements: beams, floor beams , precast slabs, hollow core floor slabs, or large-sized cladding panels (10 to 15 meters in length) for industrial, commercial, or agricultural buildings.

Pre-tensioning is also employed for various types of poles (telegraph or electrical poles, fences, etc.) or railway sleepers.