

Prestressed Concrete

Part 2

(Prestressing Techniques)

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Prestressing Techniques

Prestressing is introduced by prestressing reinforcement

Two different technologies:

- **Pre-tensioned prestress concrete**
- **Post-tensioned prestressed concrete**



Prestressing Techniques

- ◆ Pre-tensioning is accomplished in a precasting plant before arriving at the job site.
- ◆ Post-tensioning is usually performed at the building site, especially when the structural units are too large to transport from factory to site.



Pretensioning

- ◆ Prestresses a concrete member by stretching the reinforcing *tendons* before the concrete is cast.

Pretensioning



- Steel tendons are first stretched across the casting bed between two abutments until a predetermined tensile force is developed.

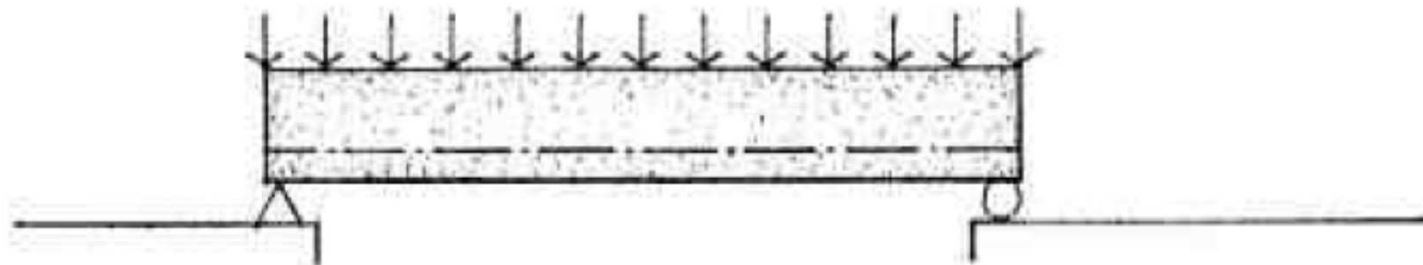


- Concrete is then cast in formwork around the stretched tendons and fully cured. The tendons are placed eccentrically in order to reduce the maximum compressive stress to that produced by bending alone.

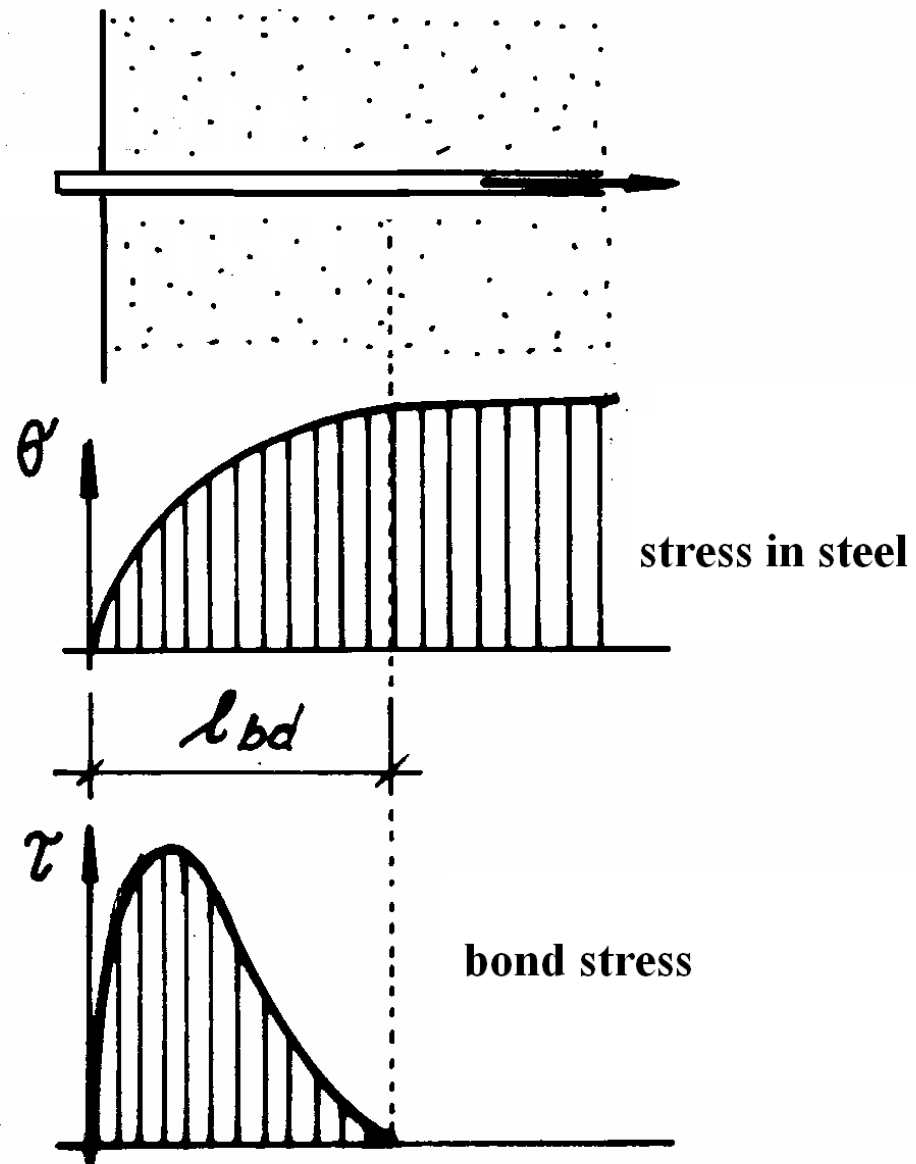
Pretensioning (cont)

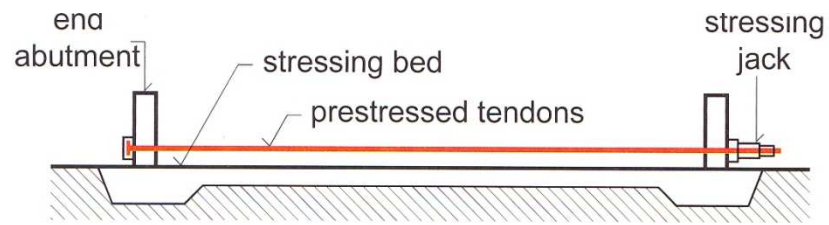


- When the tendons are cut or released, the tensile stresses in the tendons are transferred to the concrete through bond stresses. The eccentric action of the prestressing produces a slight upward curvature or camber in the member.

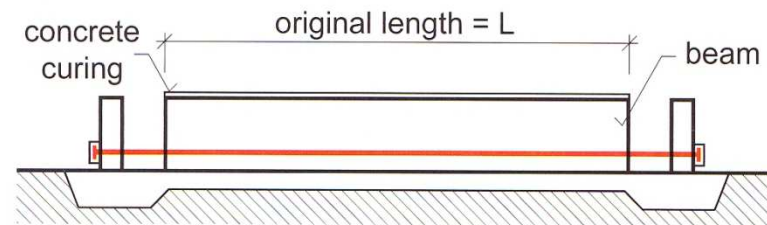


- The deflection of the member under loading tends to equalize its upward curvature.

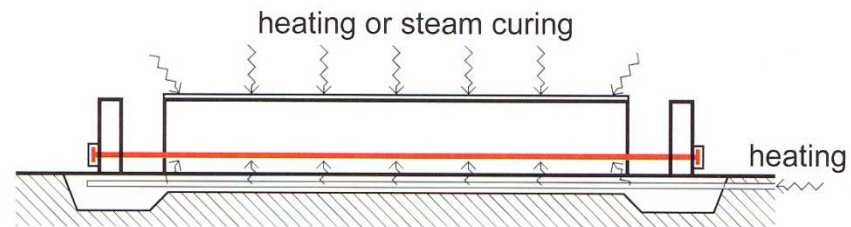




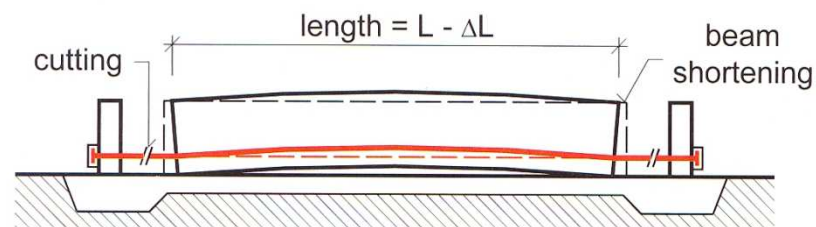
(a) stressing of of high-strength tendons between abutments



(b) casting and curing of concrete

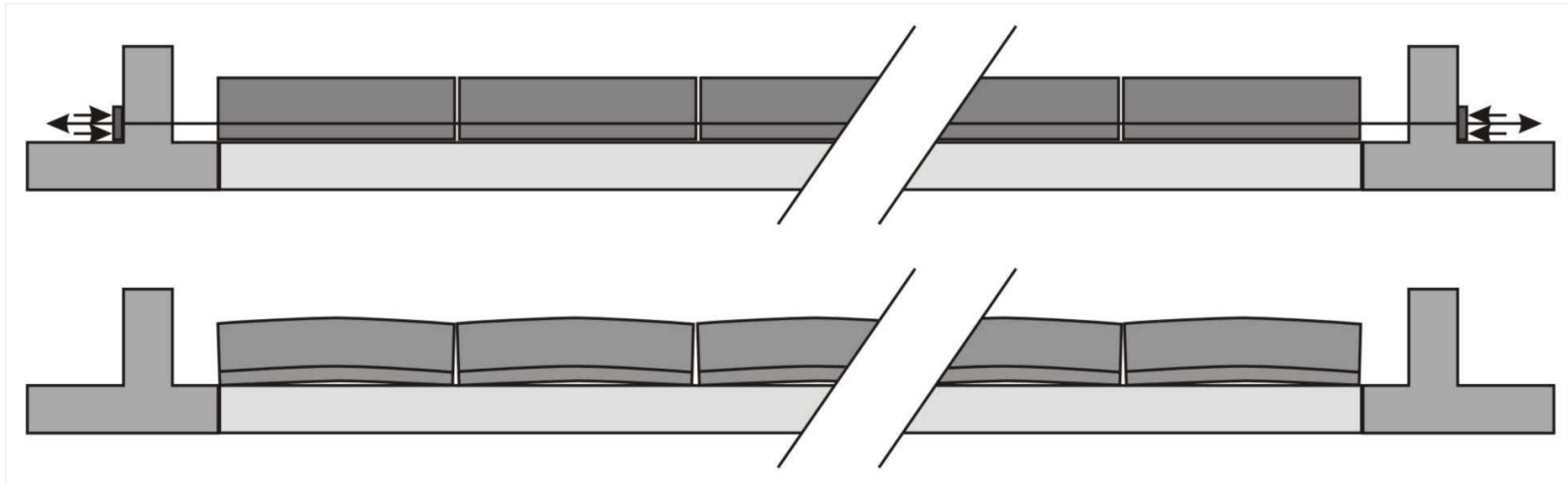


(c) acceleration of hardening of concrete

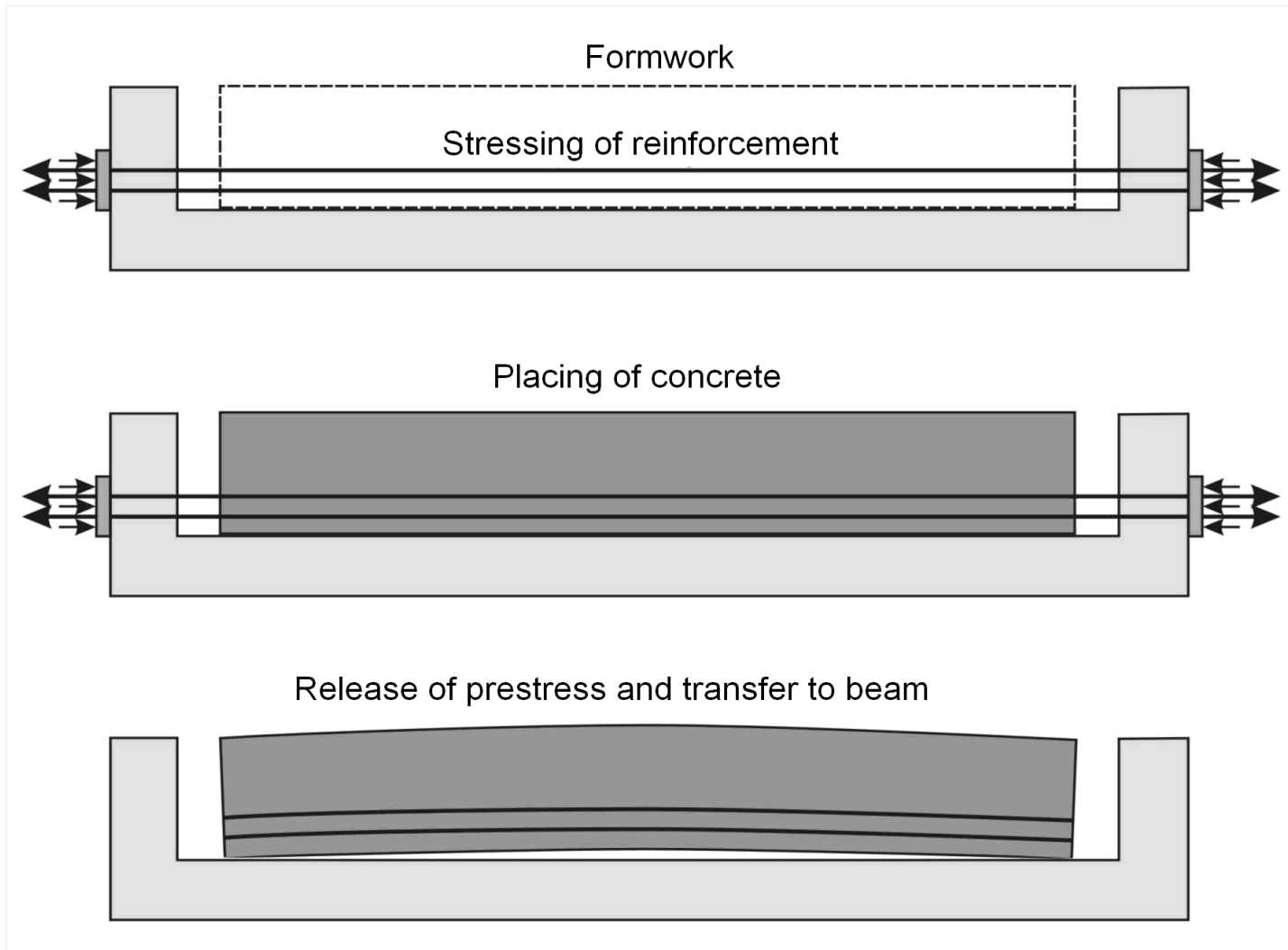


(d) transfer of prestressing into hardened concrete

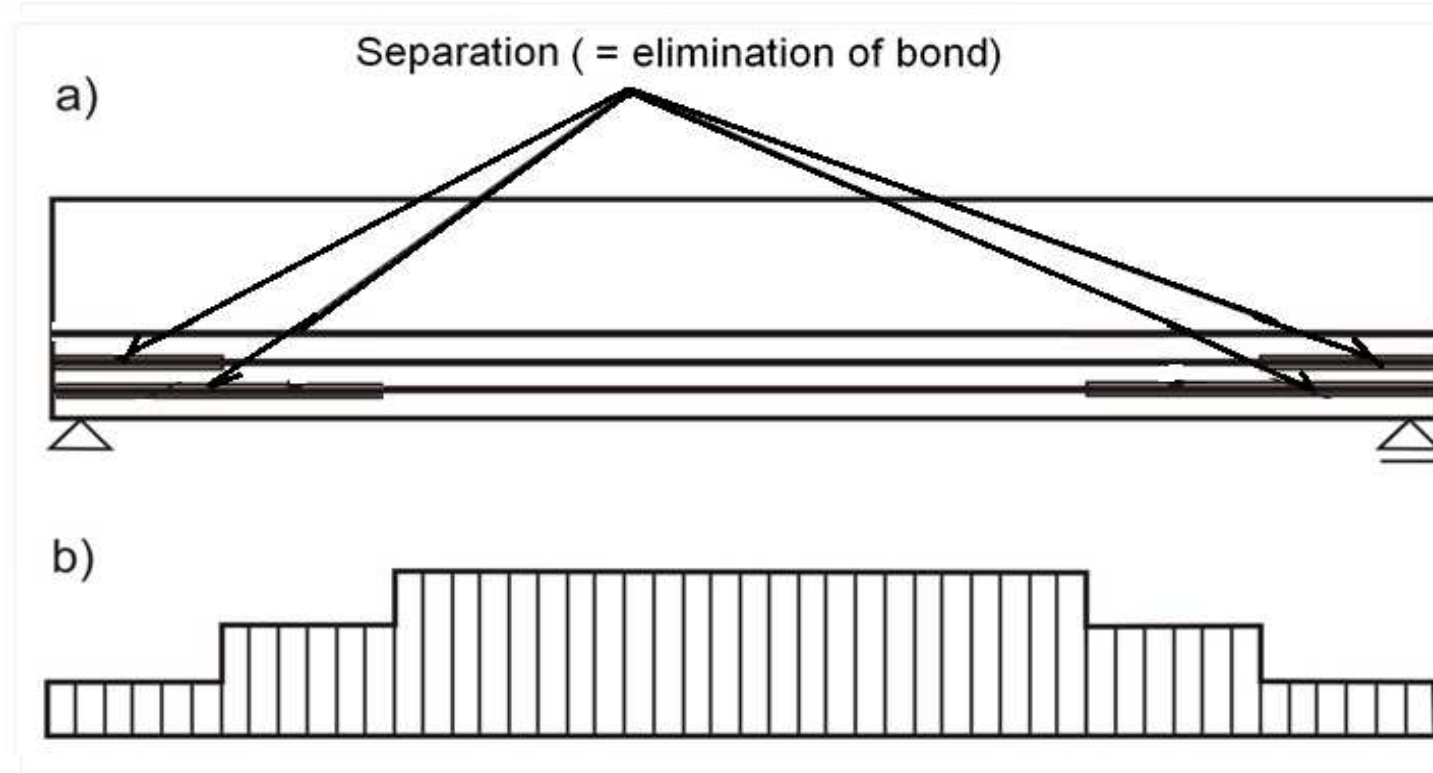
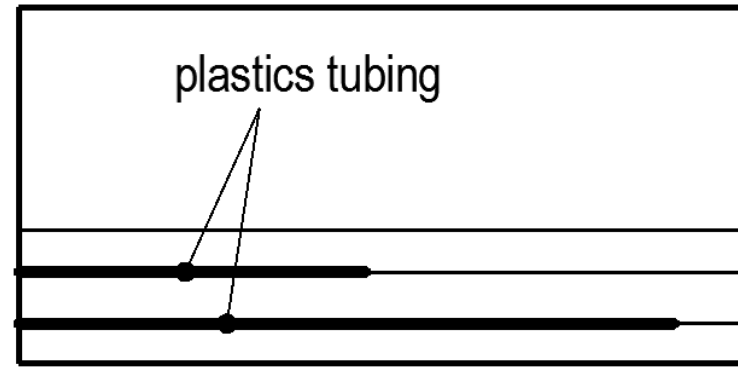
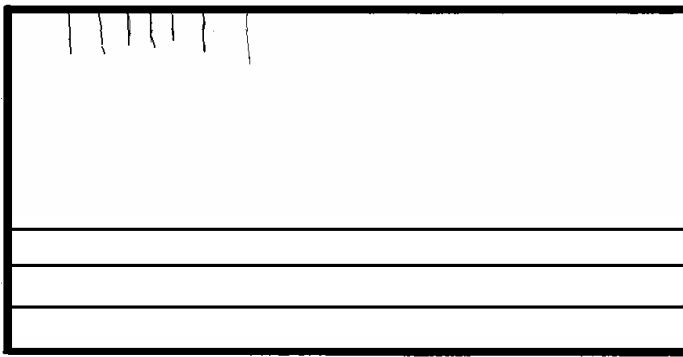
Principle of production of pretensioned concrete



Principle of pretensioning – long stressing bed



Pretensioning- steel rigid mould





Casting of SPIROLL hollow-core slabs.



Casting PARTEK hollow core slab



Cutting PARTEK hollow core slab

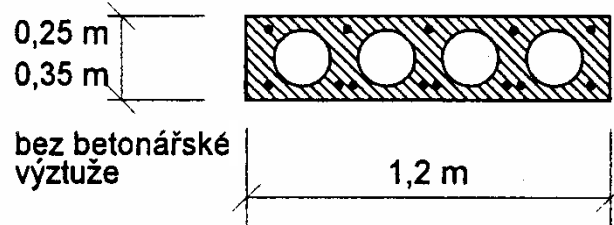
Prestressed concrete - prefabrication

Beams RC: $h \cong (1/10 - 1/15) l$

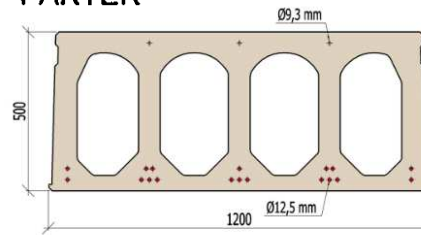
PC: $h \cong (1/15 - 1/30) l$

l – span of the beam

SPIROLL

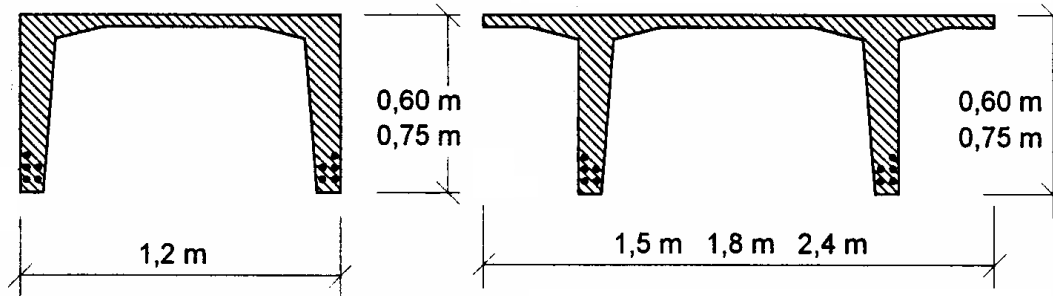


PARTEK

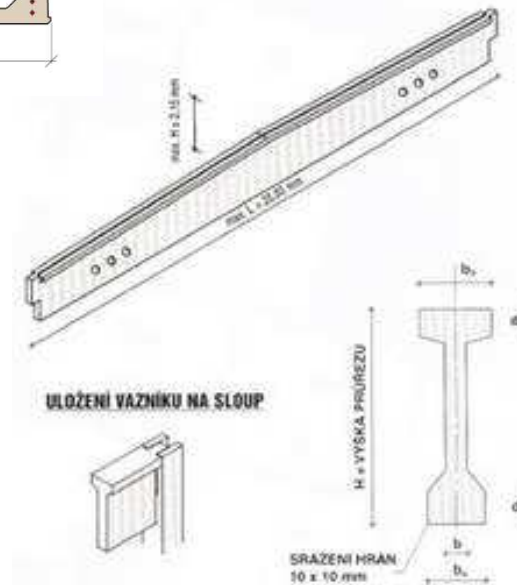


prvky TT

rozpětí 12 až 18 m, pro střechy až 24 m



roof, floor precast panels



roof girder



Hollow core slabs - Partek



Pretensioned I beams



Post-tensioning



- ◆ Is a method of reinforcing (strengthening) concrete or other materials with high- strength steel strands or bars, typically referred to as *tendons*.
- ◆ Applications include office and apartment buildings, parking structures, slabs- on- ground, bridges, sports stadiums.
- ◆ In many cases, post- tensioning allows construction that would otherwise be impossible due to either site constraints or architectural requirements.



Rebar vs Tendons

- ◆ **Rebar** is what is called “passive” reinforcement however; it does not carry any force until the concrete has already deflected enough to crack.
- ◆ **Post- tensioning tendons**, on the other hand, are considered “Active” reinforcing.
 - Because it is prestressed, the steel is effective as reinforcement even though the concrete may not be cracked.
- ◆ Post- tensioned structures can be designed to have minimal deflection and cracking, even under full load.



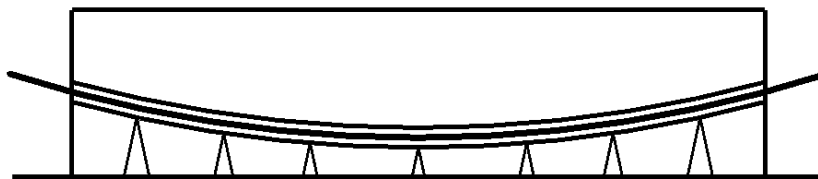
Post-tensioning



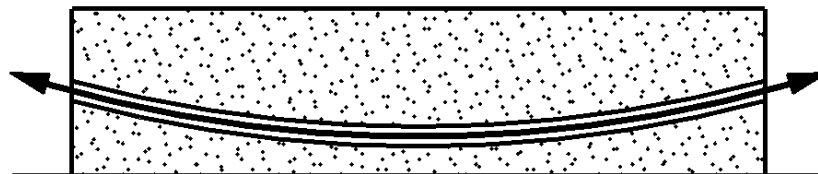
- ◆ Done almost entirely on the job site
- ◆ High-strength steel strands (tendons) are covered with a steel or plastic tube to prevent them from bonding with the concrete
- ◆ The prestressing of a concrete member by tensioning the reinforcing tendons after the concrete has set.
- ◆ **"Tendon"** is defined as a complete assembly consisting of the anchorages, the prestressing strand or bar, the sheathing or duct and any grout or corrosion-inhibiting coating (grease) surrounding the prestressing steel.

Prestressing Techniques

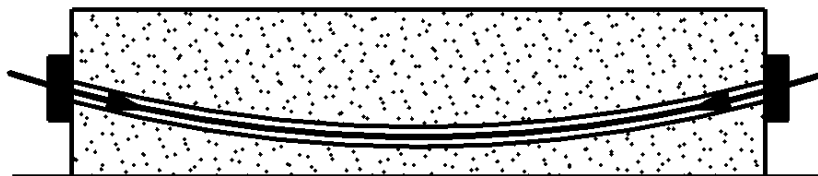
◆ Post-tensioning



Tendon in duct (tube)
Tendon in plastic sheath
Casting

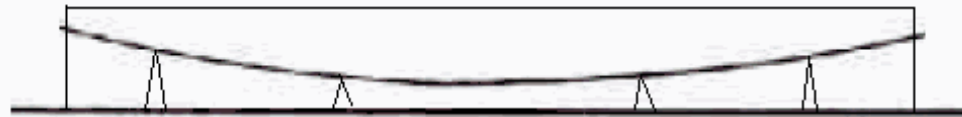


Reinforcement is stressed



Anchored by anchorage devices
Protection from corrosion

Post-tensioning

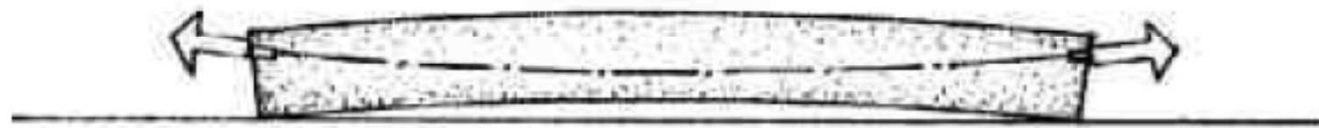


- Unstressed steel tendons, draped inside the beam or slab form, are coated or sheathed to prevent bonding while the concrete is cast.

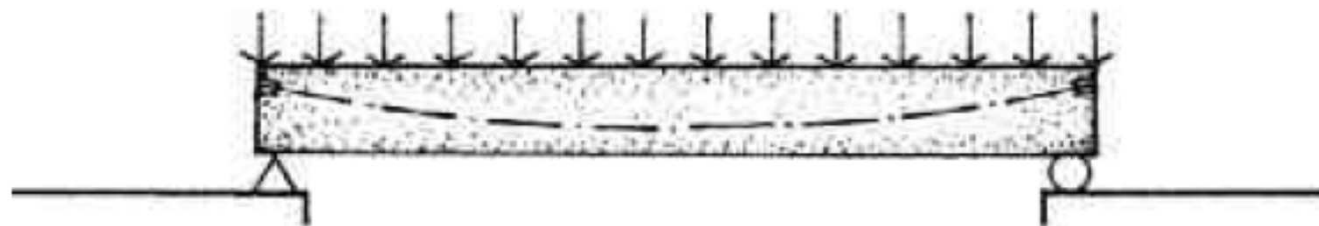


- After the concrete has cured, the tendons are clamped on one end and jacked against the concrete on the other end until the required force is developed.

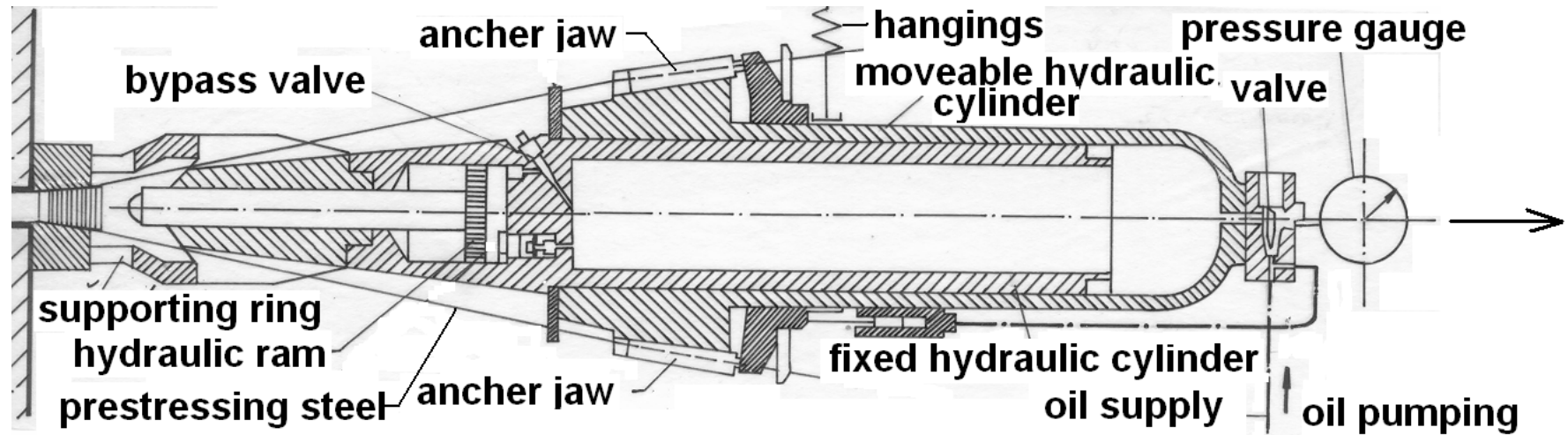
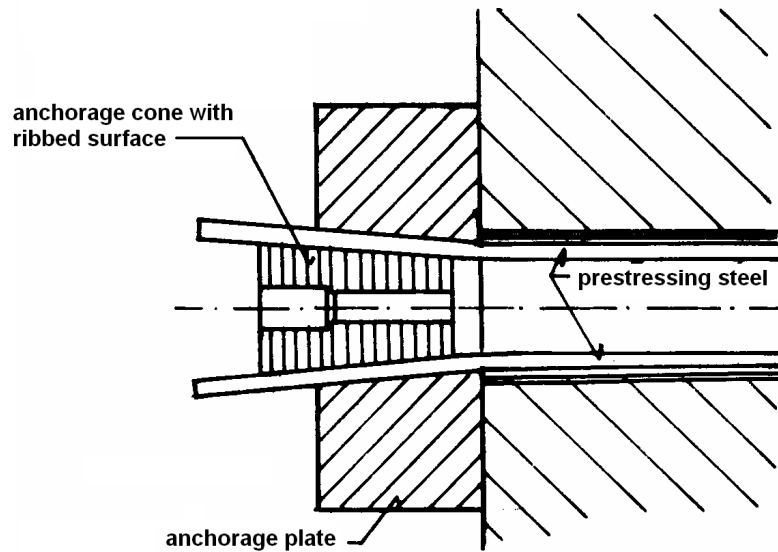
Post-tensioning



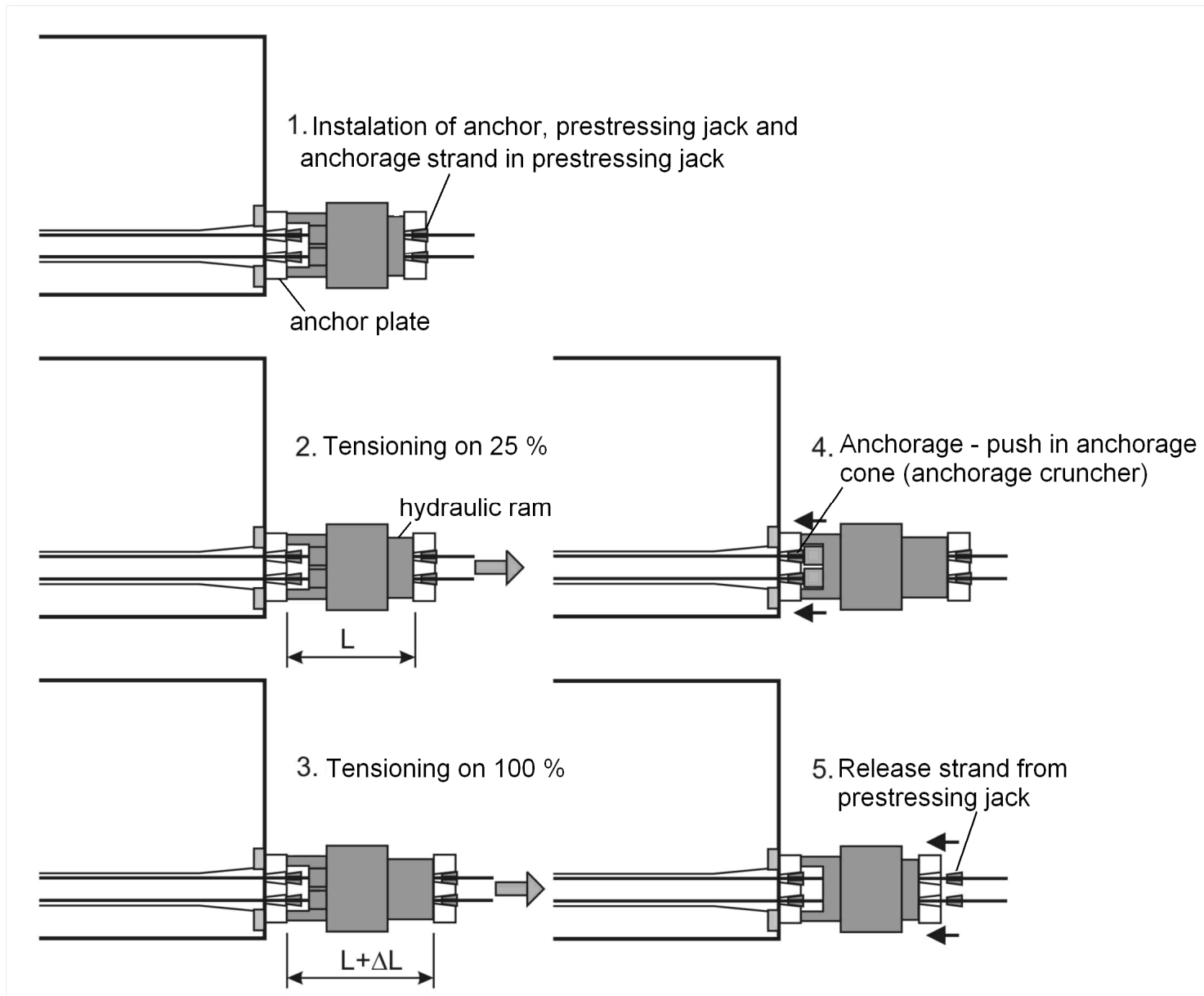
- The tendons are then securely anchored on the jacking end and the jack removed. After the posttensioning process, the steel tendons may be left unbonded, or they may be bonded to the surrounding concrete by injecting grout into the annular spaces around the sheathed strands.



- The deflection of the member under loading tends to equalize its upward curvature.



Original prestressing system by Freyssinet



Post-tensioned prestressed concrete – procedure of tensioning

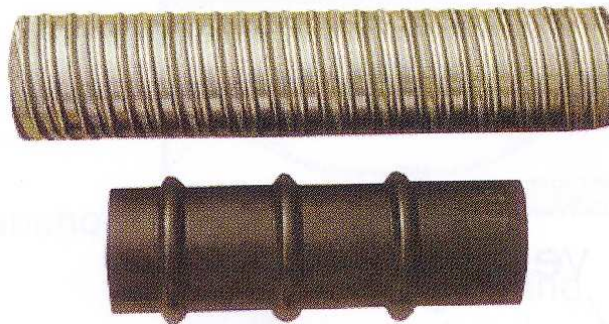


Types of Post-Tensioning

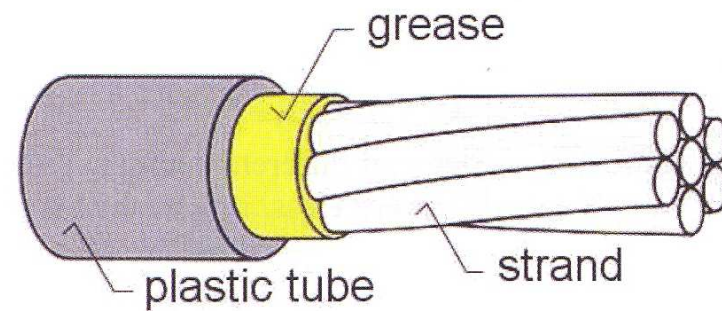
- ◆ There are two main types of post-tensioning:
 - *Unbonded*
 - *Bonded (grouted)*

Post-tensioning Process

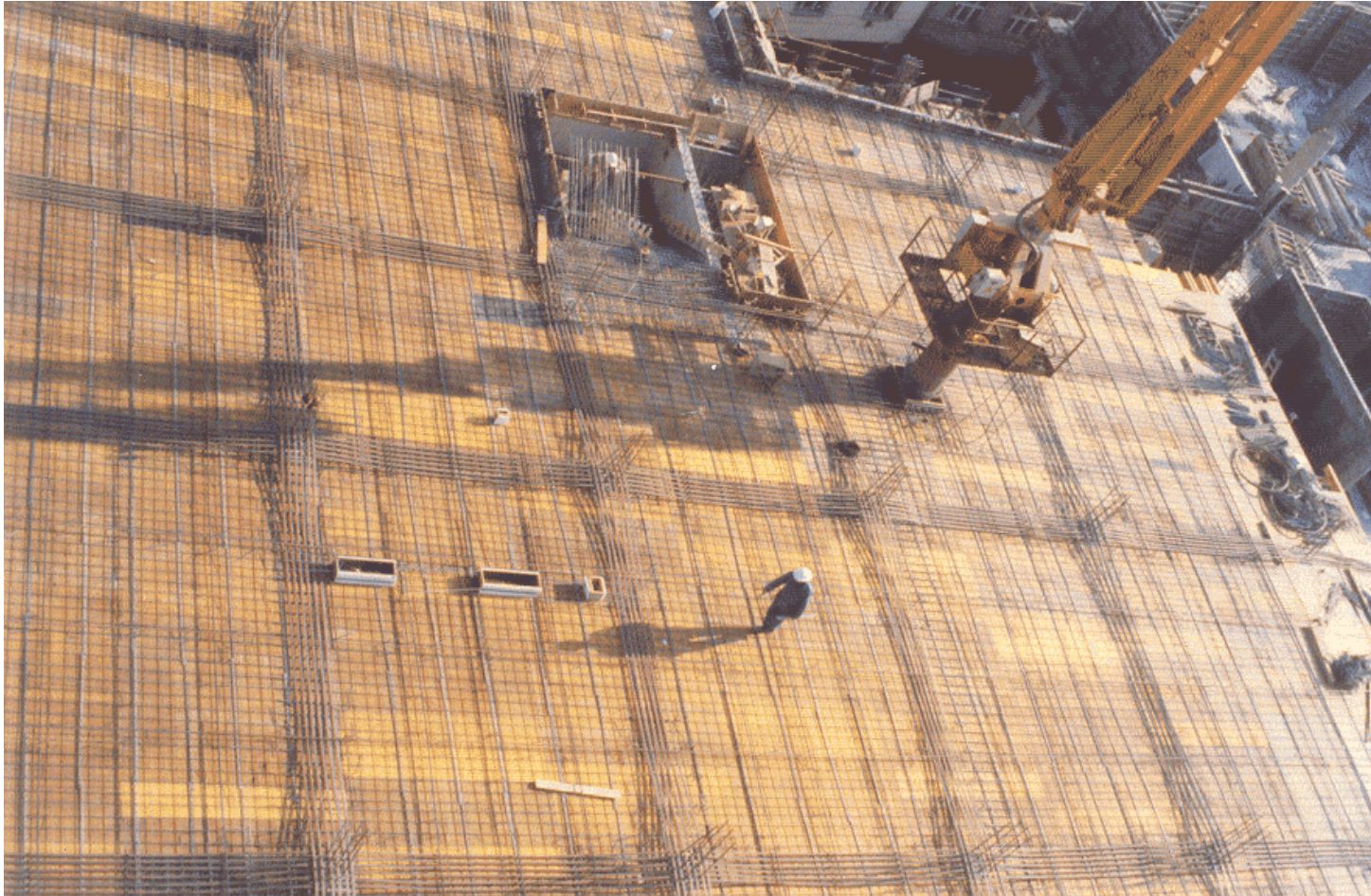
- ◆ Abutments are not needed.
- ◆ Tendons may be left *unbonded* or if in a steel tube *bonded* with a injected grout.
- ◆ Most are unbonded.



Tendon ducts



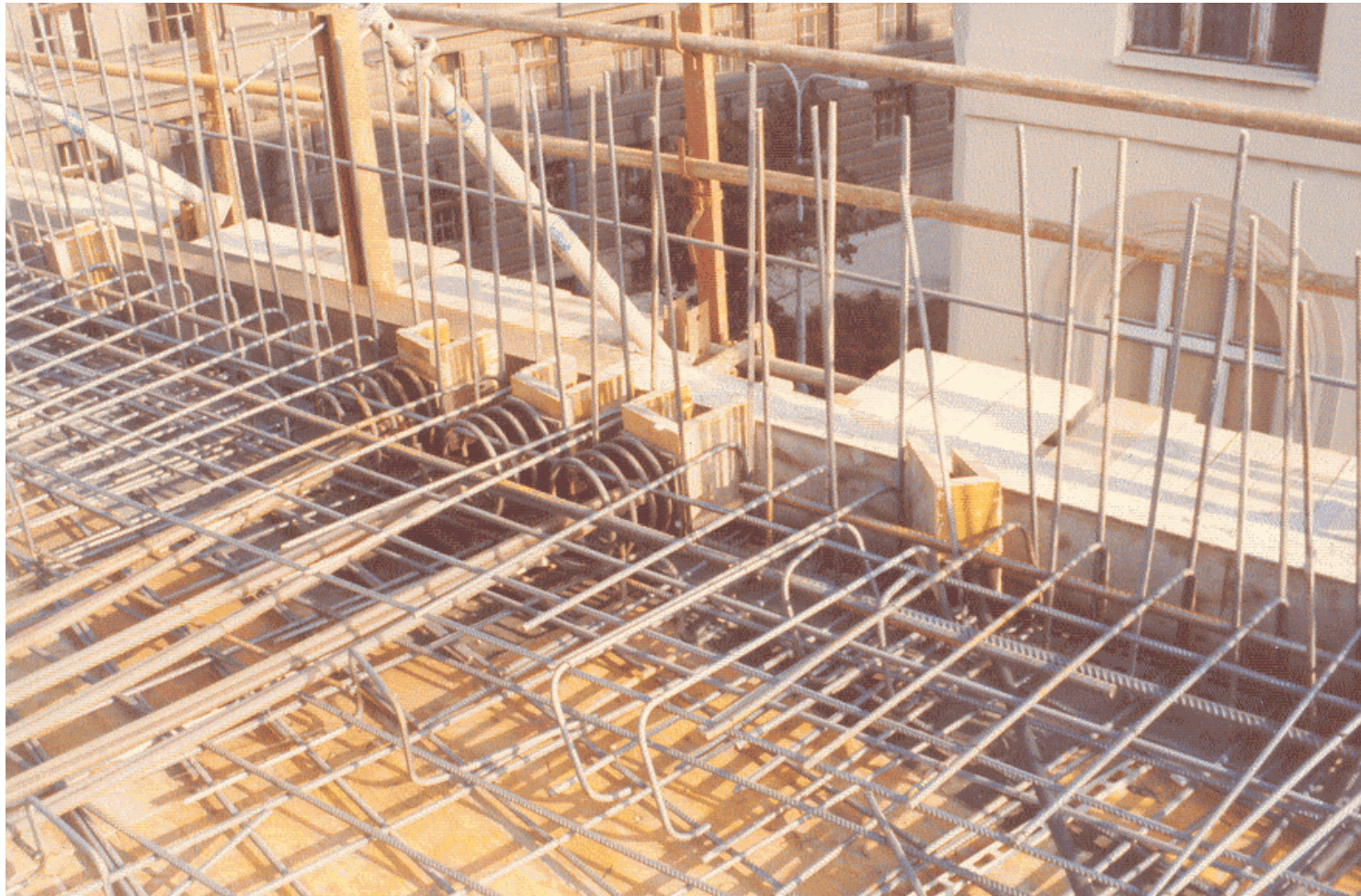
Unbonded prestressing strand



Post-tensioned slab



Lift-up tendons over the support

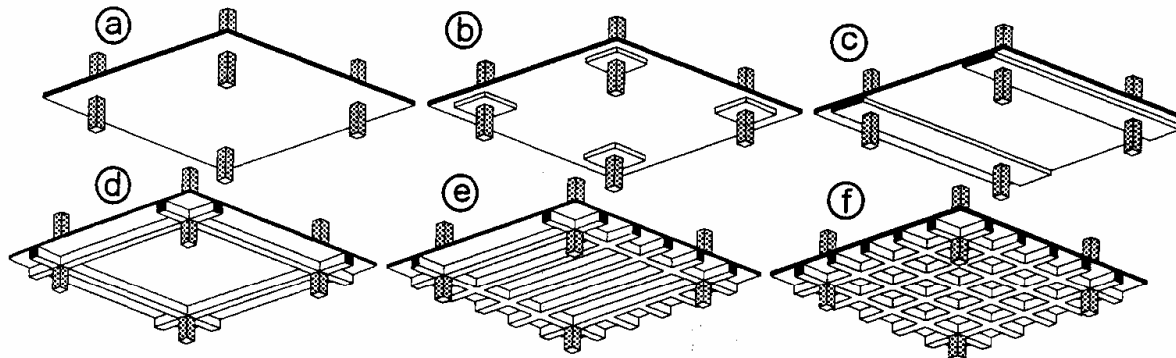


Anchorage devices

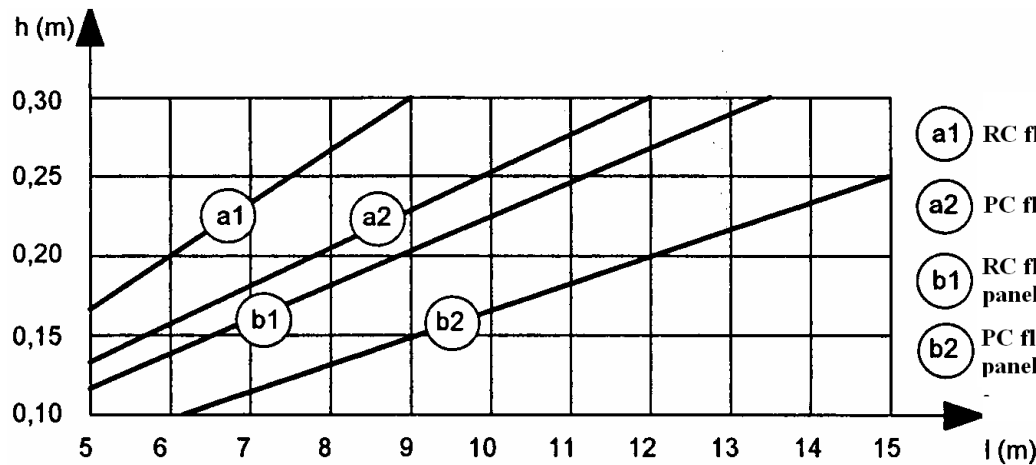
Prestressed post tensioned concrete slabs – reinforcement without bond

Slabs RC: $h \cong (1/10 - 1/20) l$

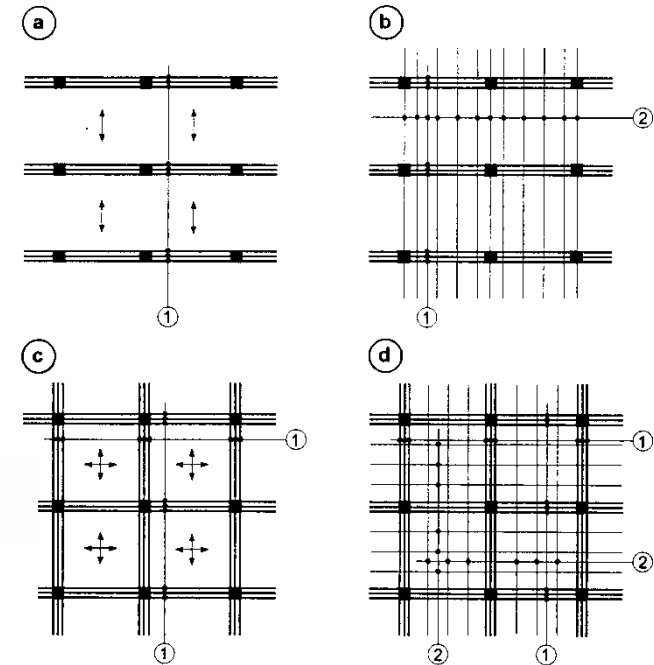
PC: $h \cong (1/15 - 1/30) l$



- a - $l_{max} = 12$ m
- b - $l_{max} = 14$ m
- c - $l_{max} = 15$ m
- d - $l_{max} = 20$ m
- e - $l_{max} = 20$ m
- f - $l_{max} = 22$ m



- (a1) RC flat slab
- (a2) PC flat slab
- (b1) RC flat slab with drop panels
- (b2) PC flat slab with drop panels





Bridge from the composite postensioned beams



Composite bridge postensioned beam (slab cast in situ)





Cantilevered construction of the bridge







ADVANTAGES/APPLICATIONS

- ◆ Allows longer clear spans, thinner slabs, fewer beams
- ◆ Thinner slabs mean less concrete is required.
- ◆ Post- tensioning can thus allow a significant reduction in building weight versus a conventional concrete building with the same number of floors.
- ◆ Post- tensioning is the system of choice for parking structures since it allows a high degree of flexibility in the column layout, span lengths and ramp configurations.



Bonded post-tension systems

- ◆ More commonly used in bridges, both in the superstructure (the roadway) and in cable-stayed bridges, the cable-stays.
- ◆ In buildings, they are typically only used in heavily loaded beams such as transfer girders and landscaped plaza decks where the large number of strands required makes them more economical.



Unbonded tendon

- ◆ Is one in which the prestressing steel is not actually bonded to the concrete that surrounds it except at the anchorages.
- ◆ The most common unbonded systems are monostrand (single strand) tendons, which are used in slabs and beams for buildings, parking structures and slabs- on-ground.
- ◆ A monostrand tendon consists of a seven- wire strand that is coated with a corrosion- inhibiting grease and encased in an extruded plastic protective sheathing.



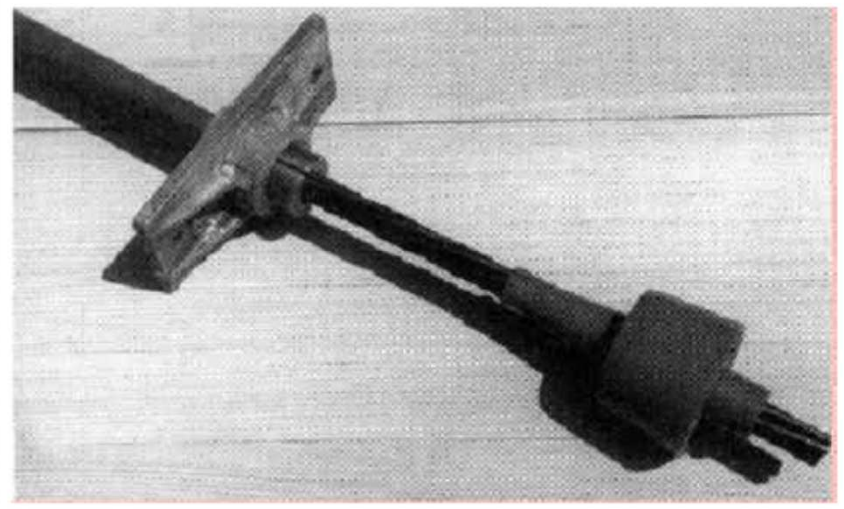
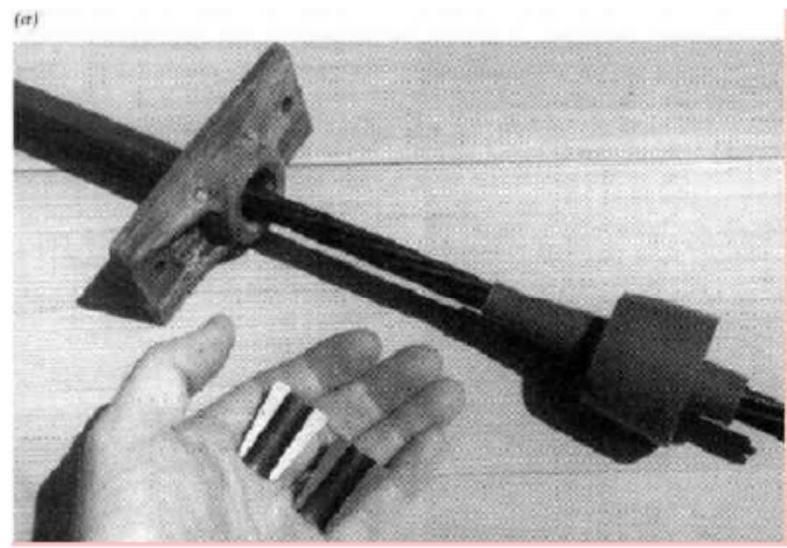
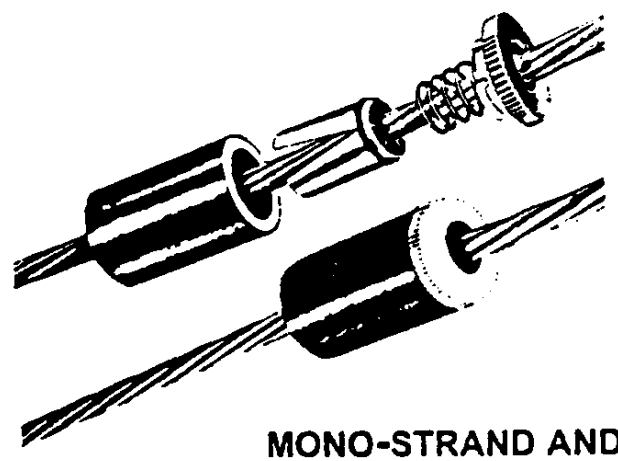
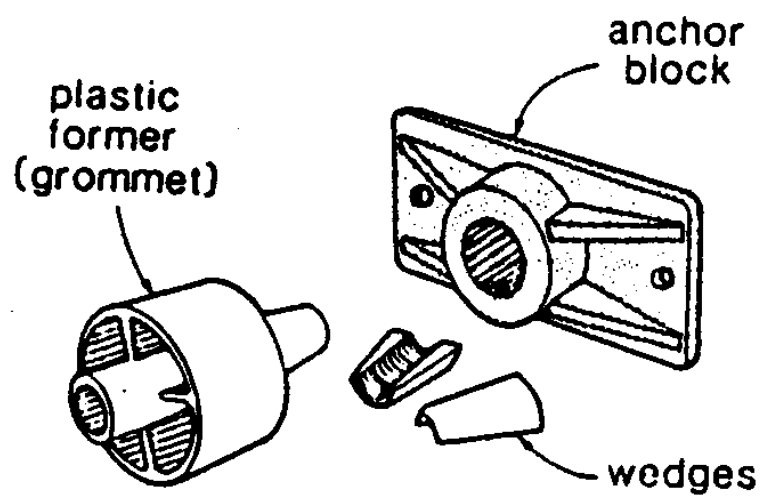
Anchorage in Post-Tensioning

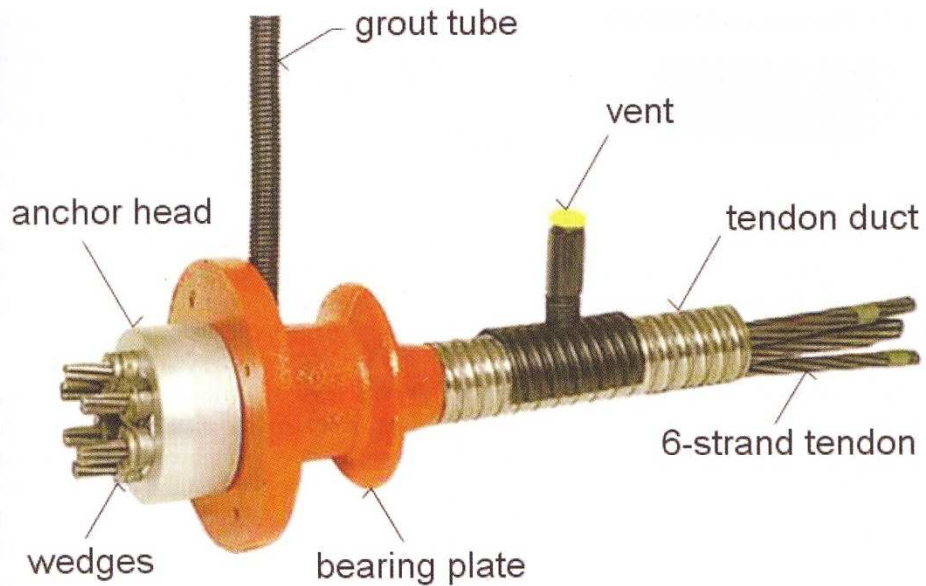
- ◆ Anchorages are a critical element, particularly in unbonded systems.
 - After the concrete has cured and obtained the necessary strength, the wedges are inserted inside the anchor casting and the strand is stressed.
 - When the jack releases the strand, the strand retracts slightly and pulls the wedges into the anchor.
 - This creates a tight lock on the strand. The wedges thus maintain the applied force in the tendon and transfer it to the surrounding concrete.



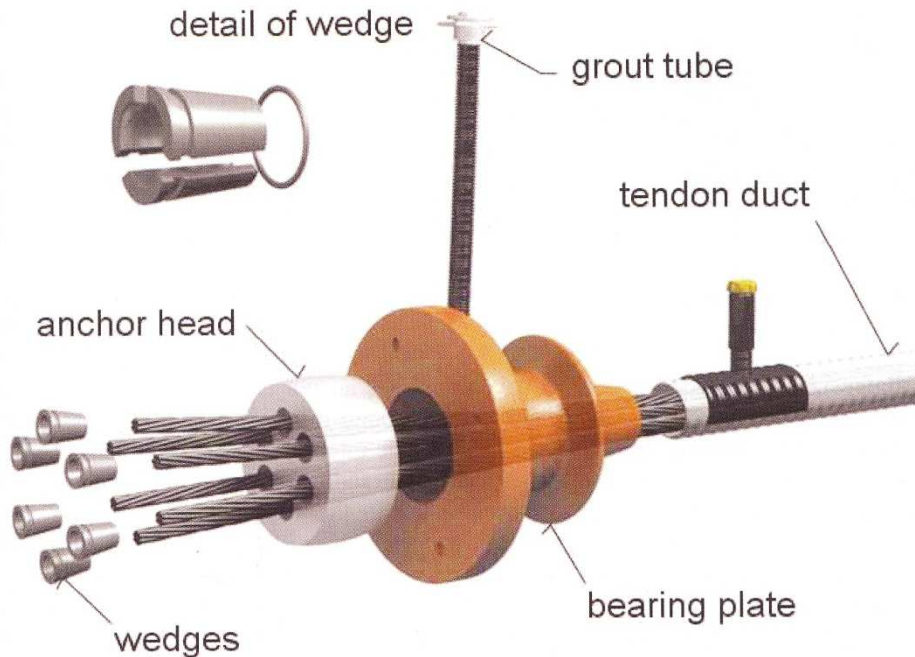
Post-tensioning

- ◆ **Anchorage device and numerous other details - prestressing technology**
- ◆ **Prestressing system is marketed by different companies, e.g. DYWIDAG, VSL, Freyssinet, BBR etc.**



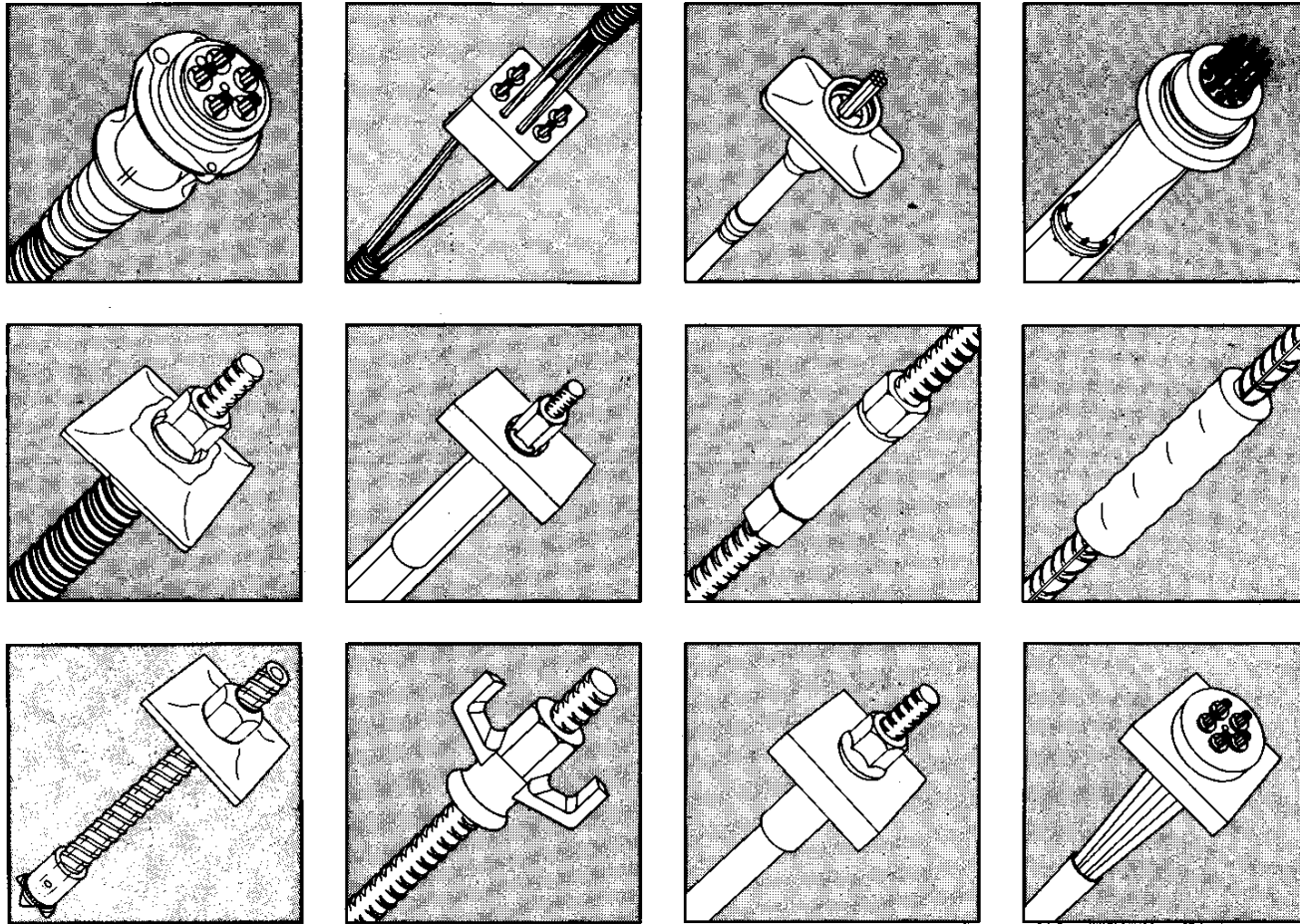


(a) photography, courtesy of SKANSKA DS



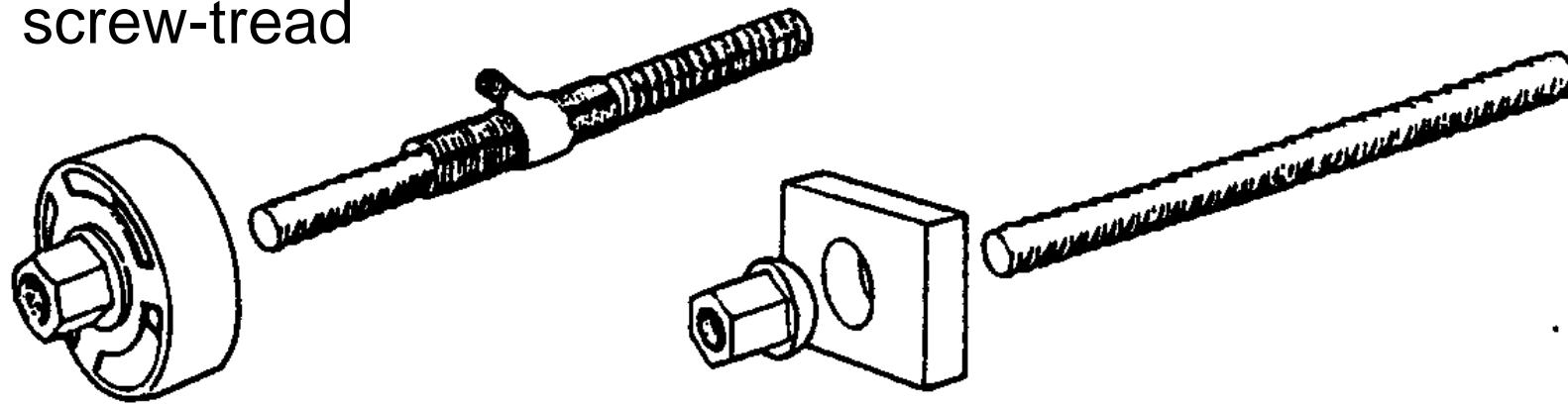
(b) translucent visualisation

Prestressing
SOLO
system for
6 Ø Lp 15,5



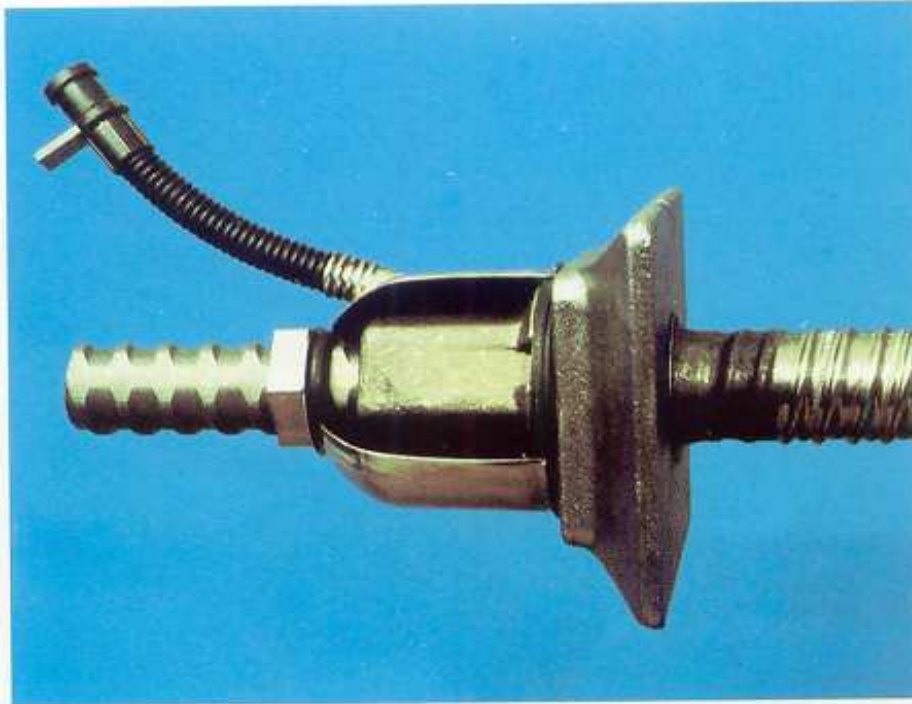
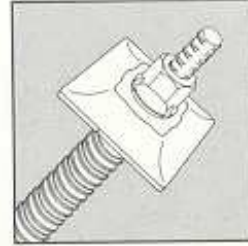
DYWIDAG ANCHORAGE SYSTEM

screw-tread

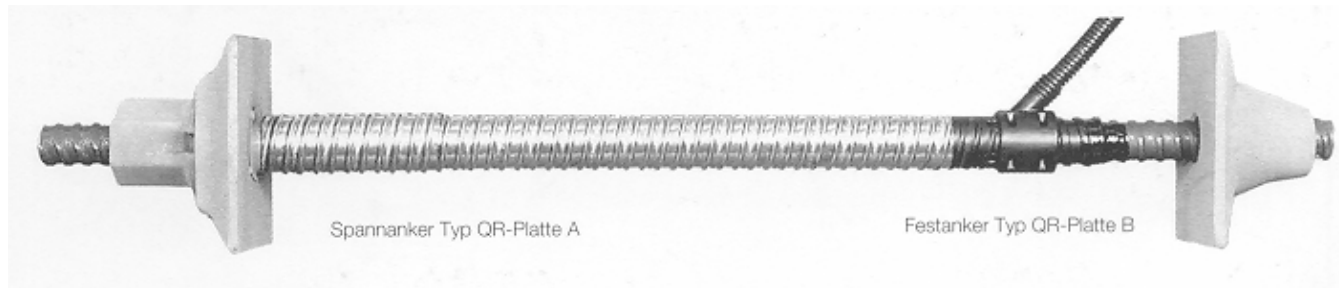


Anchorage plate,
female screw - nut

DYWIDAG bell and plate anchoring system

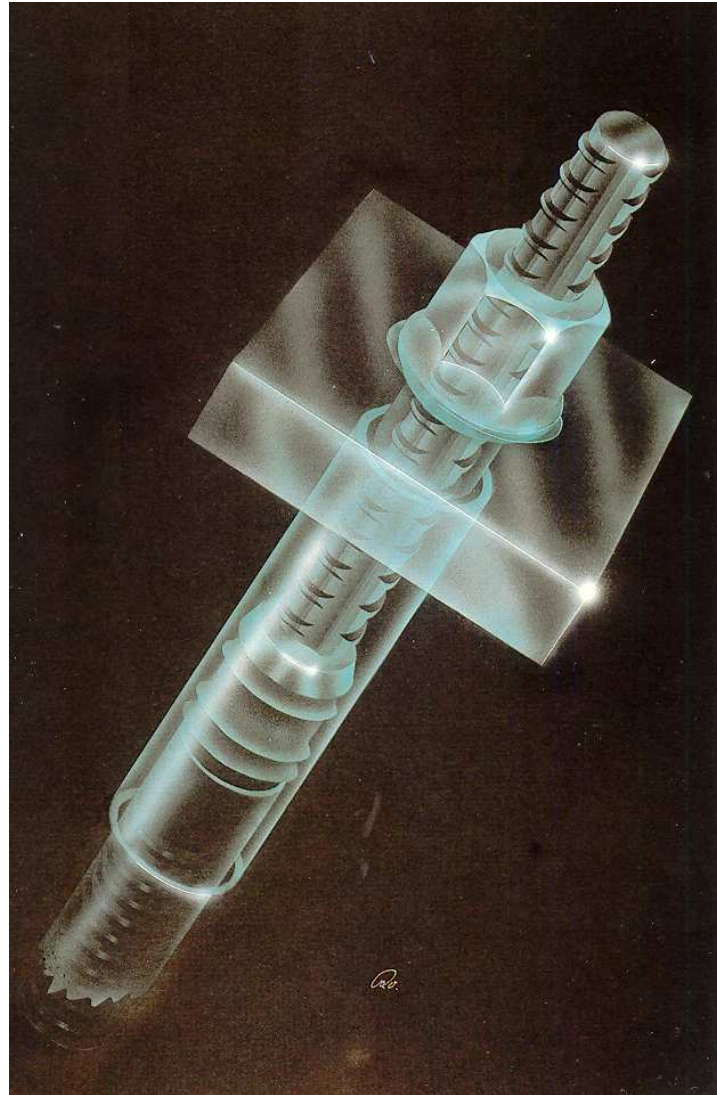


DYWIDAG



Spannanker Typ QR-Platte A

Festanker Typ QR-Platte B



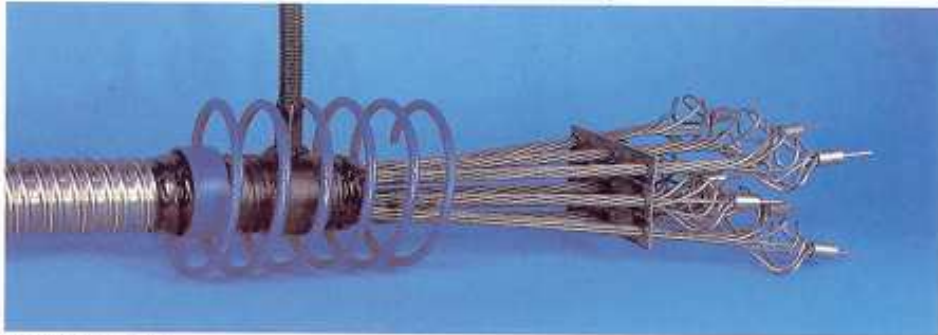
DYWIDAG ANCHORING PLATE SYSTEM



Mehrfächenverankerung MA
Multiplane Anchorage MA



SD-Plattenverankerung
Plate Anchorage SD

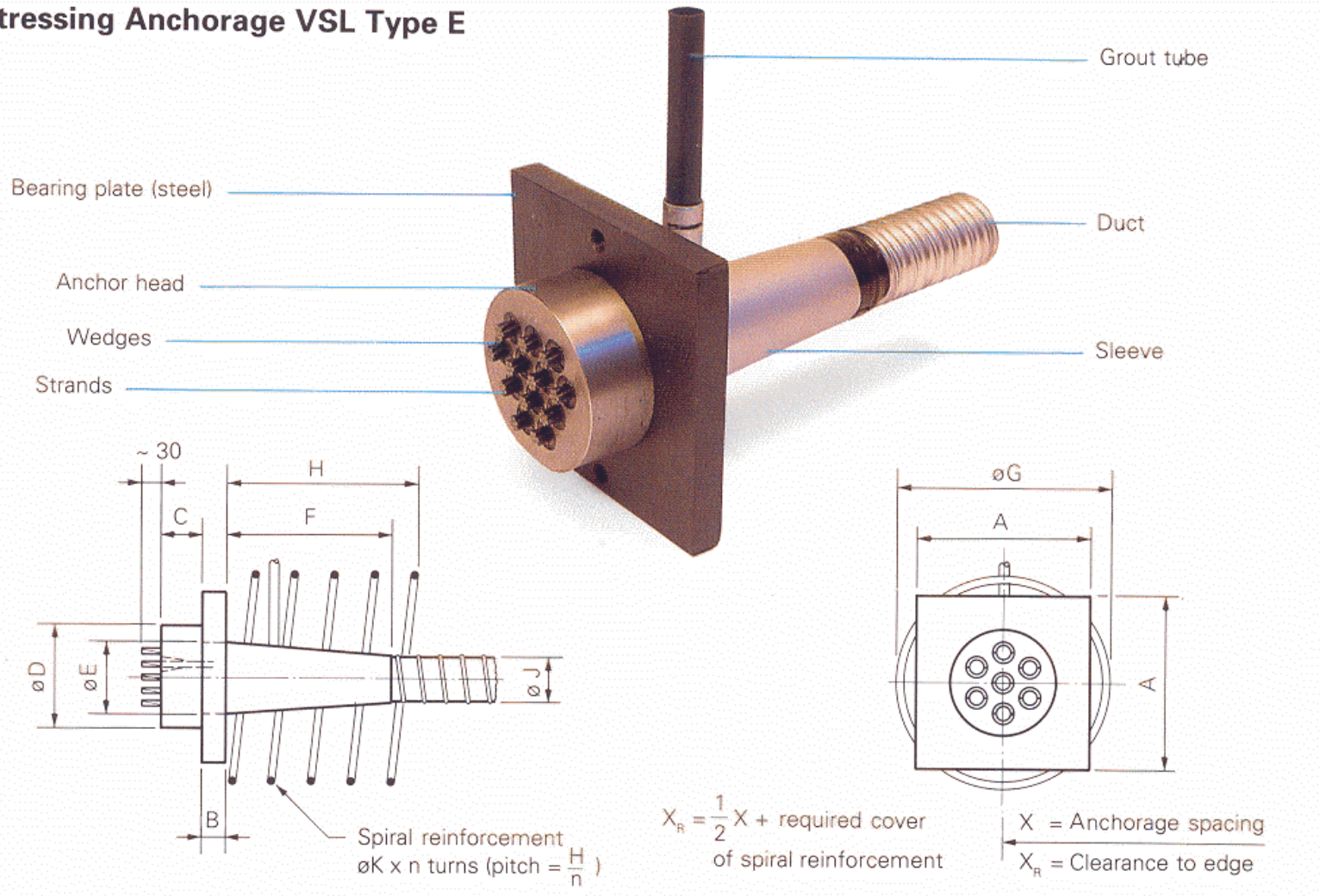


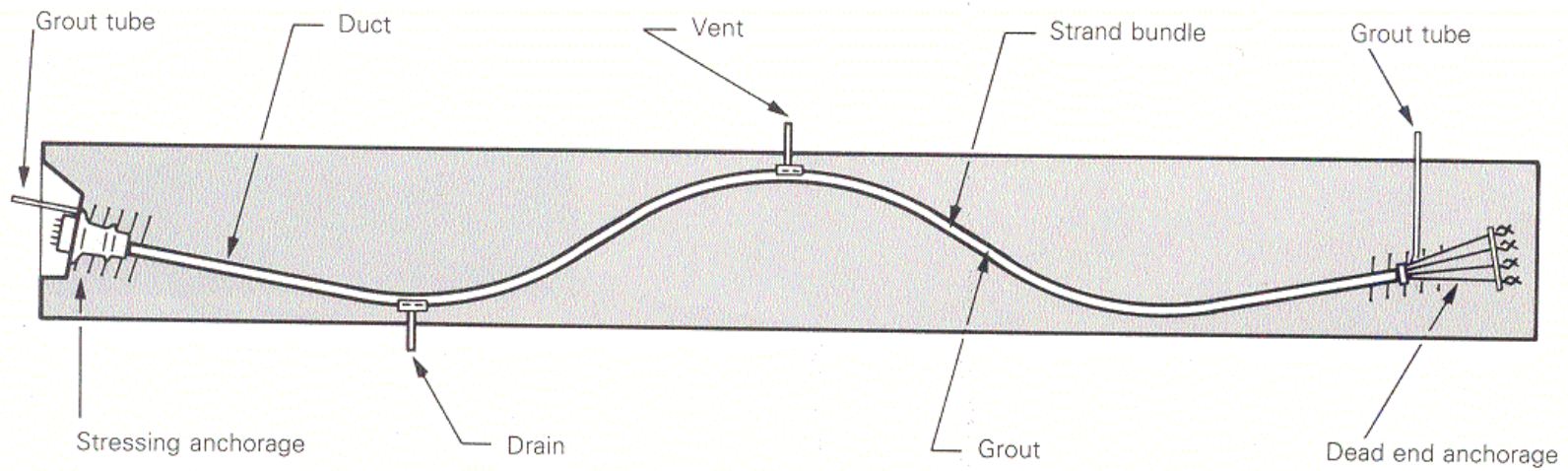
Verbundanker ZF/ZR
Bond Head Anchorage



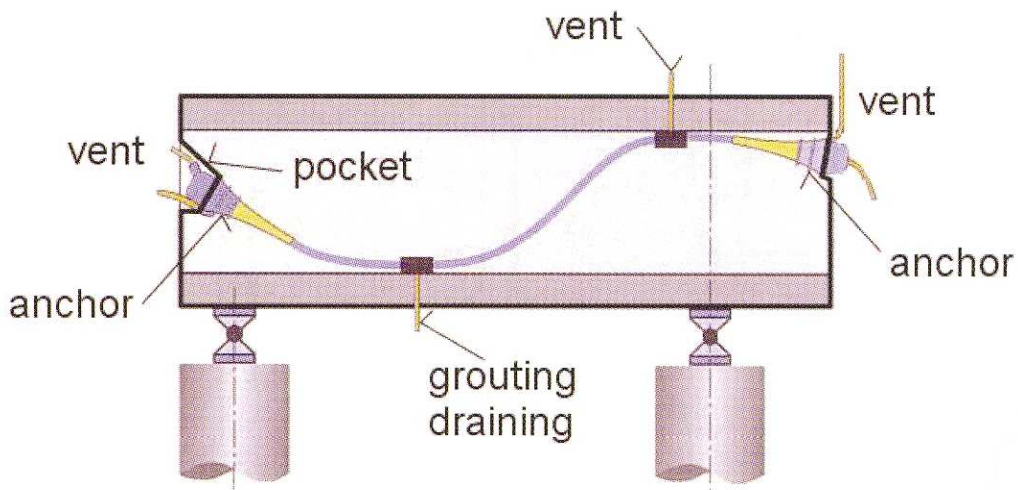
DYWIDAG post tensioning system using strands

Stressing Anchorage VSL Type E

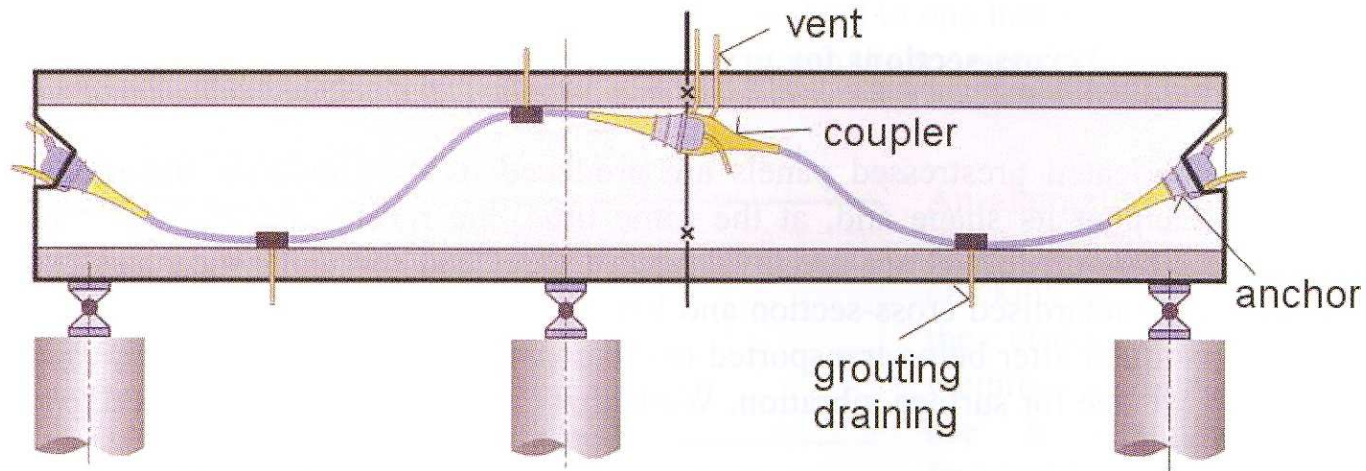




VSL Multistrand system



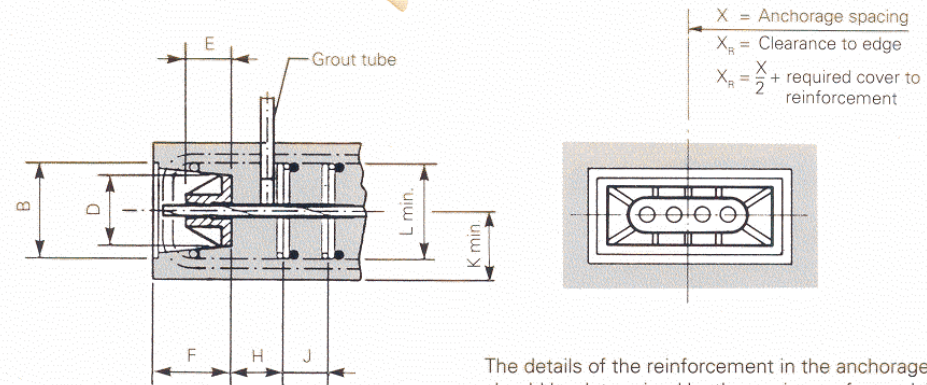
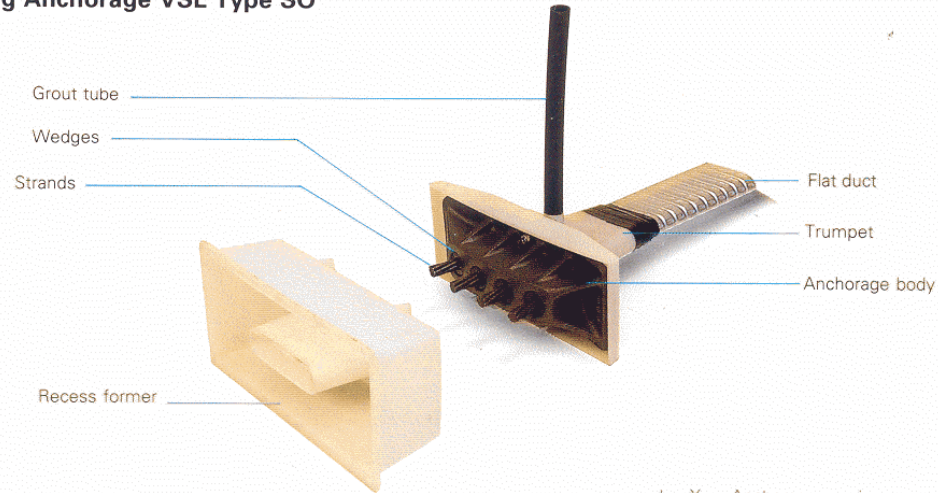
1. construction stage



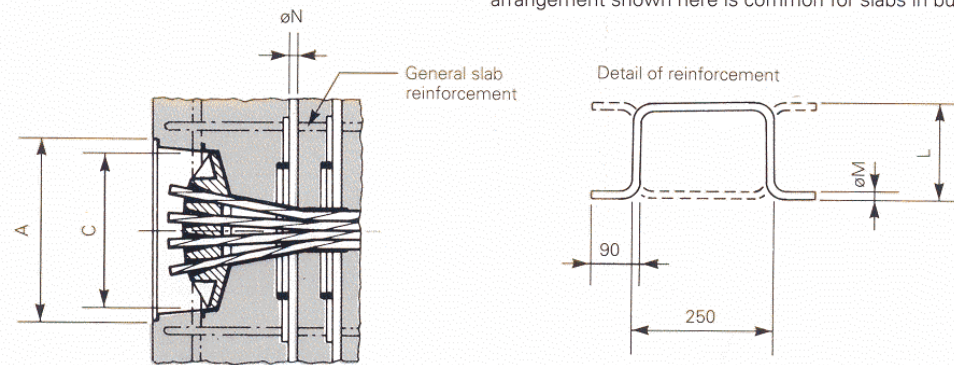
2. construction stage

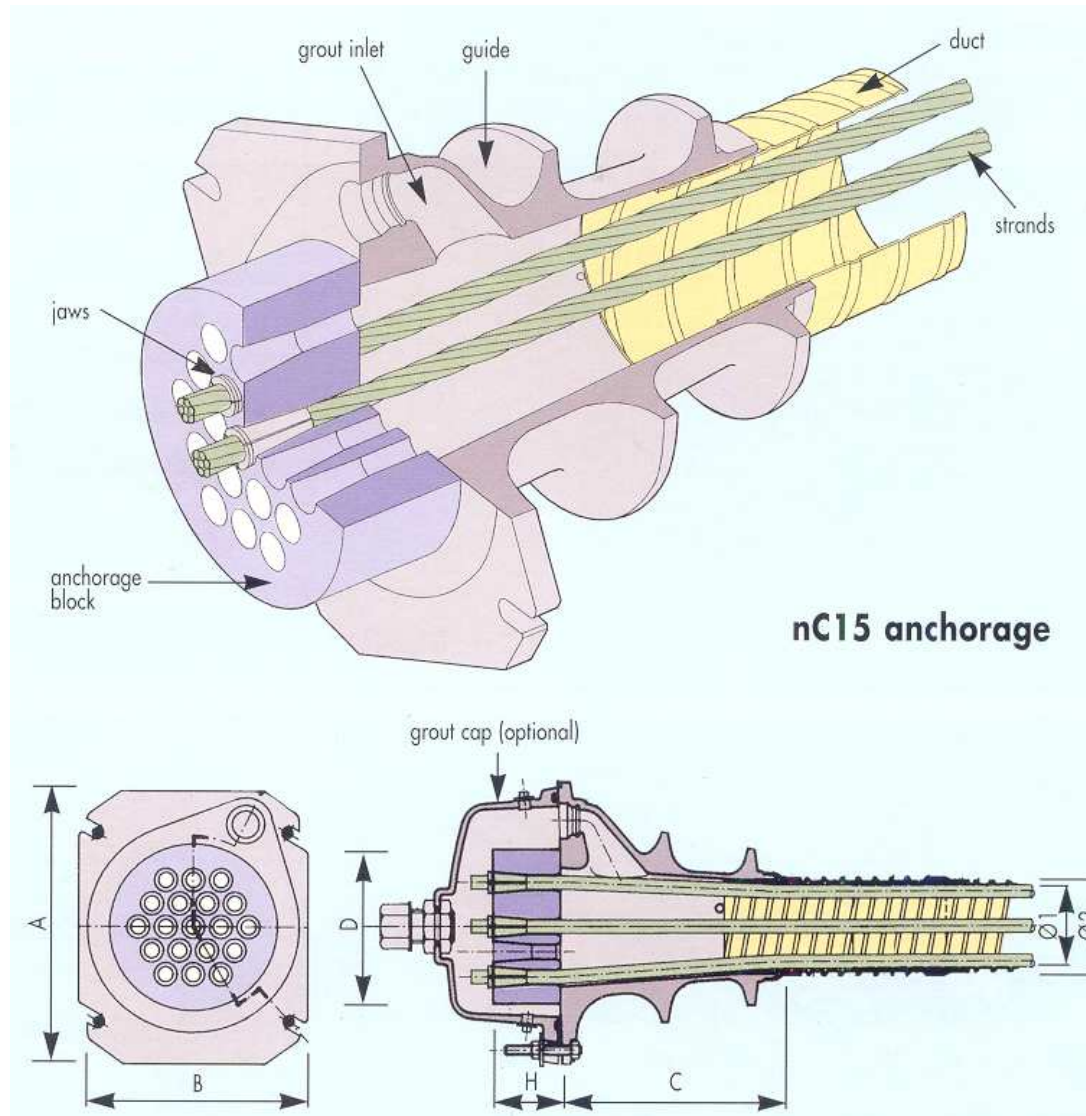
Main components of multi-strand prestressing systems, modified data of DYWIDAG

Stressing Anchorage VSL Type SO

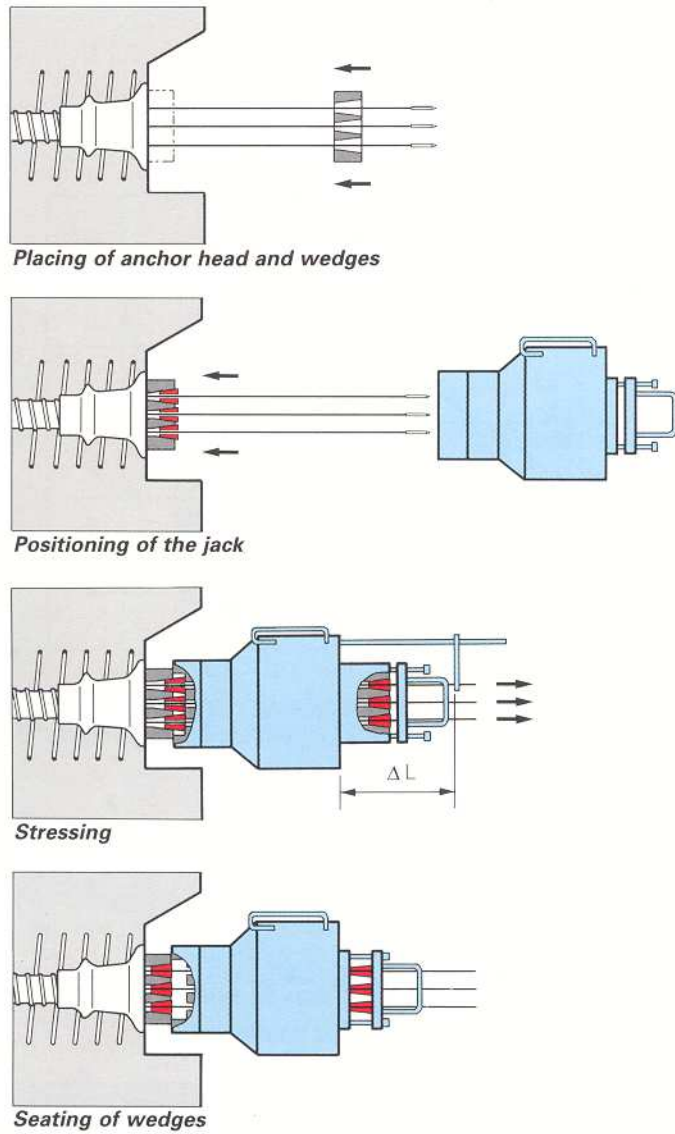


The details of the reinforcement in the anchorage zone should be determined by the engineer of record. The arrangement shown here is common for slabs in buildings.





Freyssinet post tensioning system



Placing of anchor head



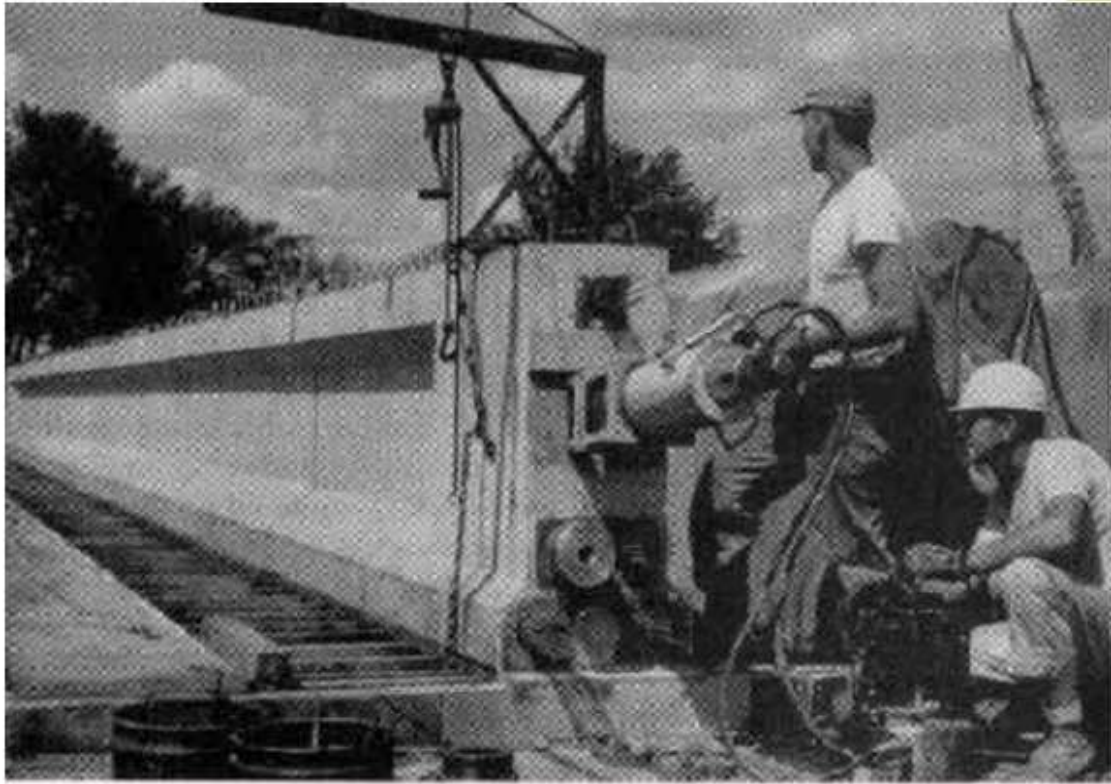
Positioning of jack



Stressing, measuring, seating of wedges

Stressing procedure VSL

Hydraulic Jack (Ram)



Smaller Hydraulic Jack

