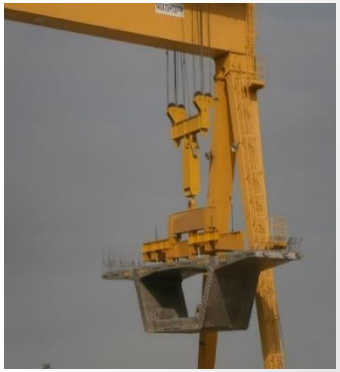



HiSCS
engineering experts

LMK
Post Tensioning System







Highway Special Construction Systems

With more than 25 years of international experience and expertise, **HiSCS** is a technical company that provides a full range of services for high demand applications in the design and construction of technical projects such as:

- **SUPPLY AND APPLICATION** of materials for specialized applications such as post-tensioning in bridges and buildings.
- **LMK POST-TENSIONING SYSTEM** with production, management & quality assurance by HiSCS.
- **PROVISION OF TECHNICAL ADVISOR SERVICES** for post-tensioning applications in infrastructure projects and in all kind of industrial and building projects.
- **INSPECTION, MAINTENANCE & BUILDING REPAIR** (specialized applications for repair-strengthening, supervision, repairs and inspections).



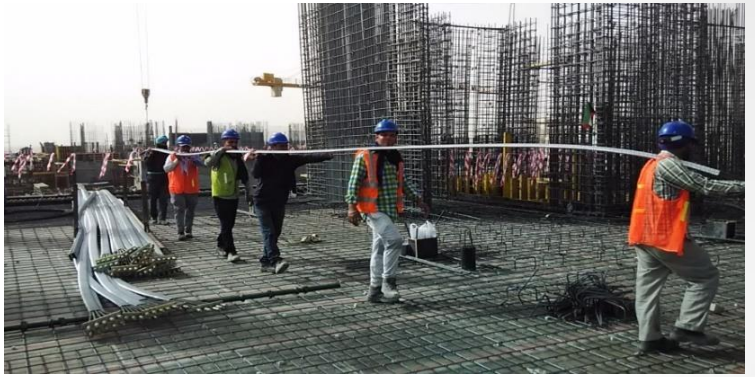

HiSCS – Domestic and International Experience

In recent years, HiSCS has participated in dozens of high quality construction projects both in Greece and abroad.

Post-tensioning studies and applications in buildings, bridges and other constructions in (Kuwait, Saudi Arabia, Iran, Malaysia, Indonesia, UAE etc.) with post-tensioning steel totaling over +10,000 tones and +45,000 pieces of different types of anchorage.

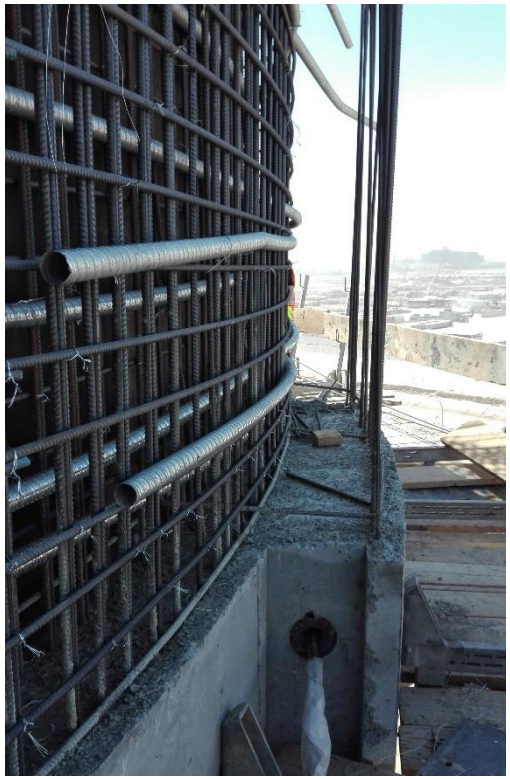
Post-tensioning applications in buildings

Tamdeen Square, Towers A-B-C, Kuwait City - State of Kuwait:



Post-tensioning applications in special projects

Cement Factory, Cement Silos 1 & 2, State of Kuwait:



Post-tensioning applications in special projects

Residential Towers Al-Asfour, Ground Floor, State of Kuwait:

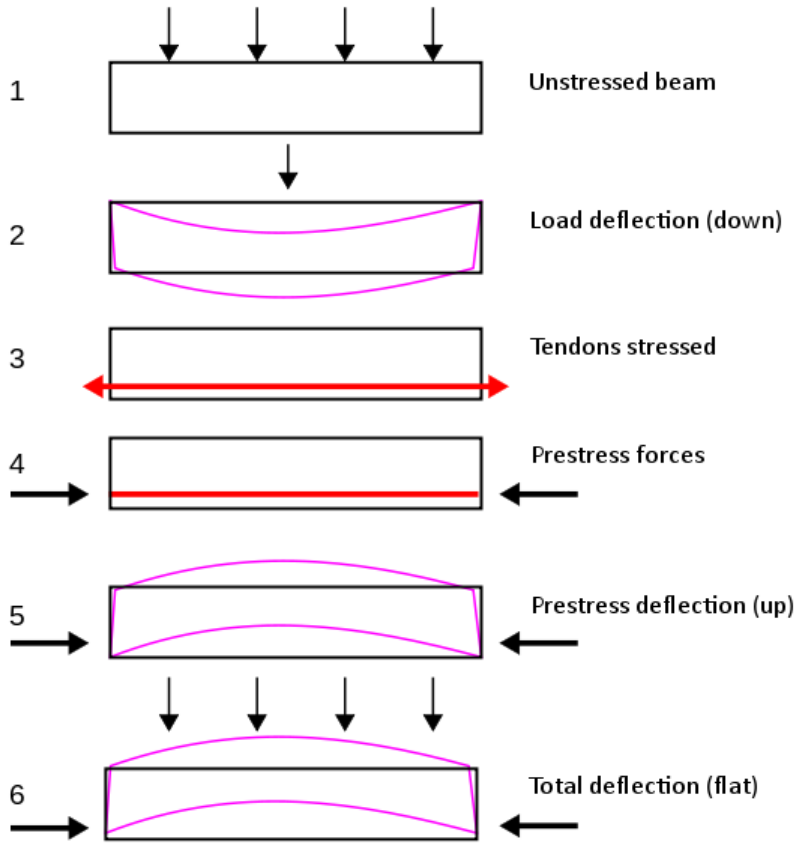
Post-tensioning – general data

Post-tensioning signifies *the imposition of an additional, deliberate and appropriately designed compressive load* which aims to improve the static operation of the structural frame by maximally exploiting the compressive strength of the concrete.

Given the plate's thickness, the deflection is a function of basic parameters:

- The characteristics of the materials,
- The length of the opening,
- The applied loads.

- Concrete Compressive strength: approximately **15 times more** that the tensile.
- Tendons: **4 times more durable** than common steel.
- Post tensioning plate: Load capacity **4 to 5 times bigger** compared to a conventionally reinforced plate.



The post-tensioning solution in buildings

Post-tensioned concrete slabs and beams:

A widespread worldwide solution with a wide range in the **conventional building construction**.

It offers significant **technical** and **economic** advantages.

By exploiting the solution of post-tensioned slabs in construction, the designer is able to cope with a number of problems and limitations such as:

- Cases with **sparse arrangement of columns**,
- Limitations of **static height** of beams,
- Issues related to increased **self-weight**,
- Issues related to **large imposed loads**,
- Issues related to **high deflections by imposed loads**,
- Issues related to **local cracking**.

Why shall we use post-tensioning?

Since advanced expertise makes it an **equally accessible** method to conventional reinforced concrete construction. It also offers significant technical and economic advantages:

- ***minimizing the propagation of cracks***
- ***increase in strength and safety*** of construction
- ***dimensional decrease*** of structural members
- ***reducing the total weight*** of the structure
- ***reducing the total cost*** of construction

Post-tensioned Slabs: When can we apply them?

In general, instead of conventionally reinforced slabs, in all cases where **increased lengths** are desired with simultaneous limitation of the deflections and the thickness of the plate.

Specifically, in cases where the design specifies demanding layouts with unfavorable thickness ratios and openings, such as:

- Cantilevers having **increased length** and **limited thickness**,
- Constructions with large distances between columns and **increased load requirements** (multi-storey carparks, industrial warehouses, pools - water tanks at the superstructure),
- Other cases where **limited beam height** is required.

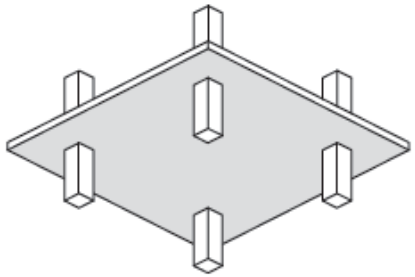
In any other case where flexibility is required in the ground plan combined with efficient use of **demanding materials and techniques**:

- Sensitive mortars with low adhesion and limited elasticity (avoiding defects & micro-cracking)

Design Approach

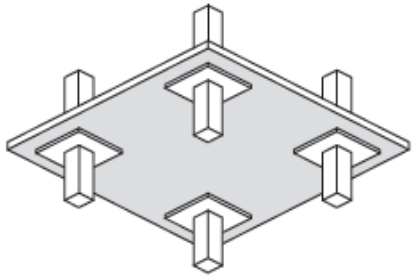
Basic types of slabs:

Solid Flat Slab



- Spans of about equal dimensions
- Relatively small service loads
- Houses, offices, hotels, hospitals, parking stations
- **Spans 5 – 12m**

Solid Flat Slab with Drop Panels

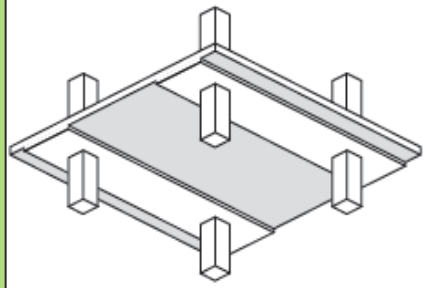


- As above
- **Spans up to 16m**

Design Approach

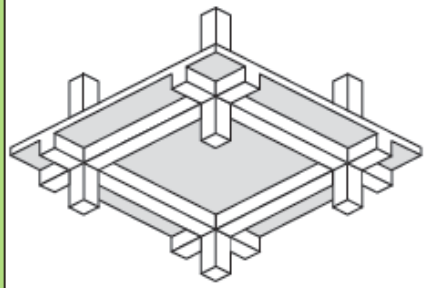
Basic types of slabs:

Banded Flat Slab



- One-way span structures
- Moderate service loads
- Malls, schools, parking stations
- **Spans up to 16m**

Slab and Beam

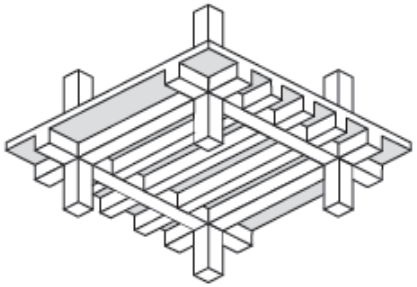


- Equal spans at both directions
- Moderate service loads
- Commercial buildings, hotels, parking stations
- **Spans 10-20m**

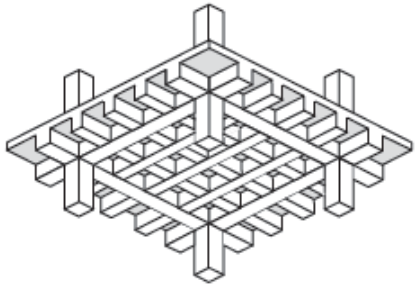
Design Approach

Basic types of slabs:

Ribbed Slab



Waffle Slab



- Significant service loads
- Storage areas, factories, airport buildings
- **Spans 10-20m**

Advantages in the application of post-tensioned slabs

Advantages during study

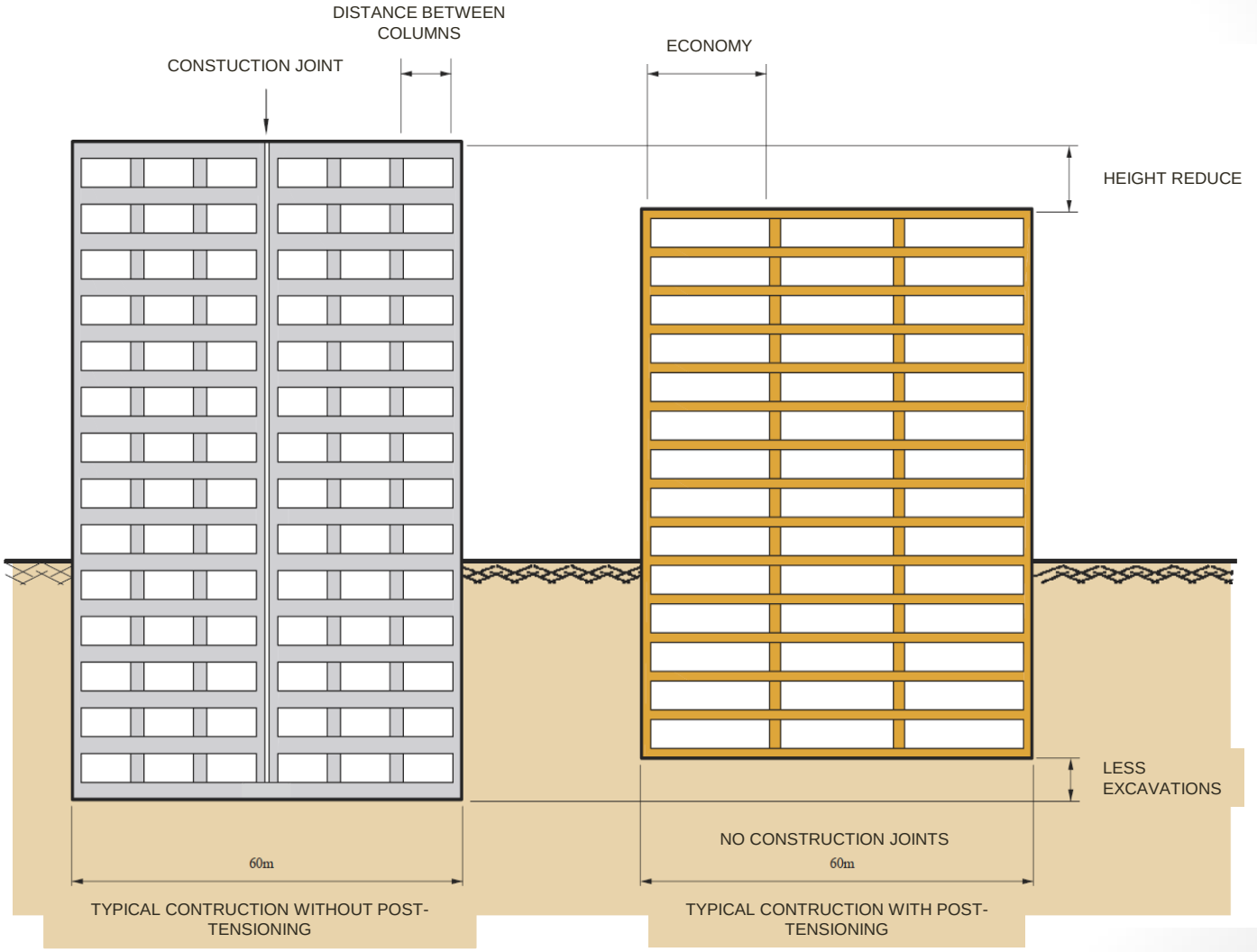
Direct advantages	Indirect advantages
• Reduction of plate thickness.	• Economy in the total height of the building. • Economy in total construction costs. • Reduction of required excavations. • Reduce the energy required for heating and cooling. • Ability to build longer joints in length.
• Larger openings.	• Reduce the number of columns. • Increase available space, • Increased freedom of architectural design,
• Reduction of dead weight on each floor.	• Saving on columns and foundations, • Decreased building mass - better seismic behavior,
• Radical reduction of cracks.	• Improving security, functionality and aesthetics.
• Significant reduction of static height and deflections.	• Ideal solution for buildings requiring large openings (amphitheaters, cinema halls, etc.) and for buildings with extensive parking spaces.

Advantages in the application of post-tensioned slabs

Advantages during construction

Direct advantages	Indirect advantages
• Reduction of the rainforcement and simplification of its layout.	• Easier handling and placement of materials.
• Faster removal of scaffolding (immediately after post-tensioning)	• Faster construction due to reduced construction time on each floor.
• High repeatability from floor to floor / fast switching of molds.	• Reduction of construction time, • Reduction of time for scaffolding, • Improvements in buildup.

Advantages in the application of post-tensioned slabs

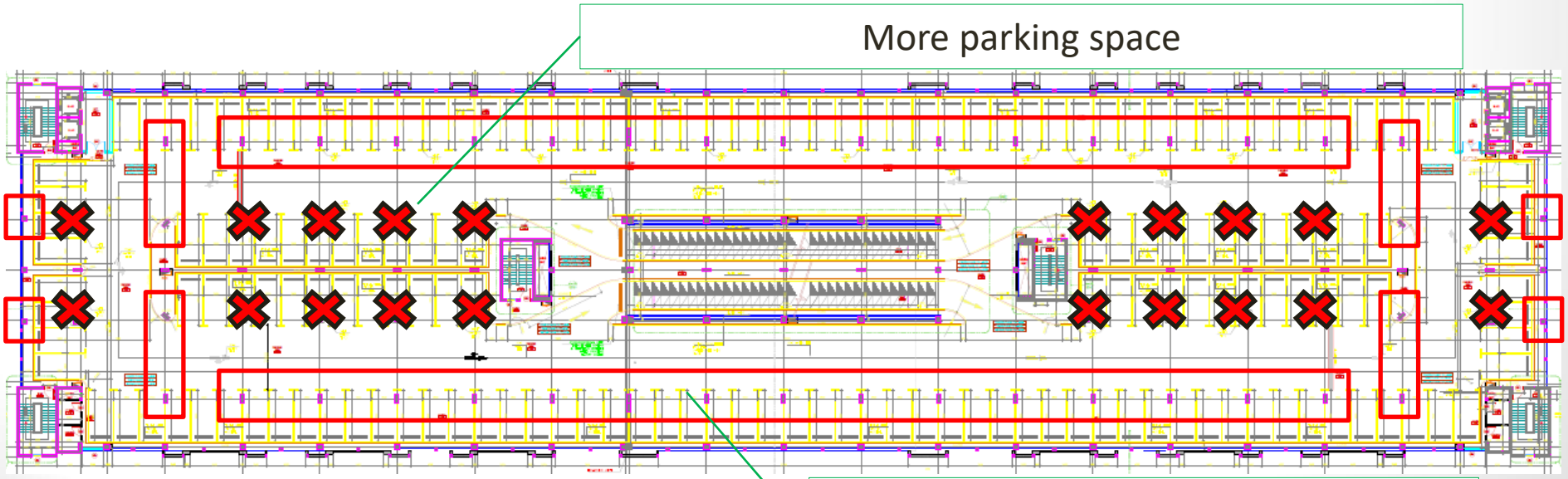


Advantages in the application of post-tensioned slabs

Example of post-tensioning in a car park building

Benefits resulting from the elimination of intermediate columns due to the application of post-tensioning:

- More parking spaces. (on 5 floors, gain of 100 parking spaces)
- Reduced construction costs and construction time.
- Reduced total height per floor. (on 5 floors, gain up to 2.5 meters → one extra floor [20-50cm per floor])



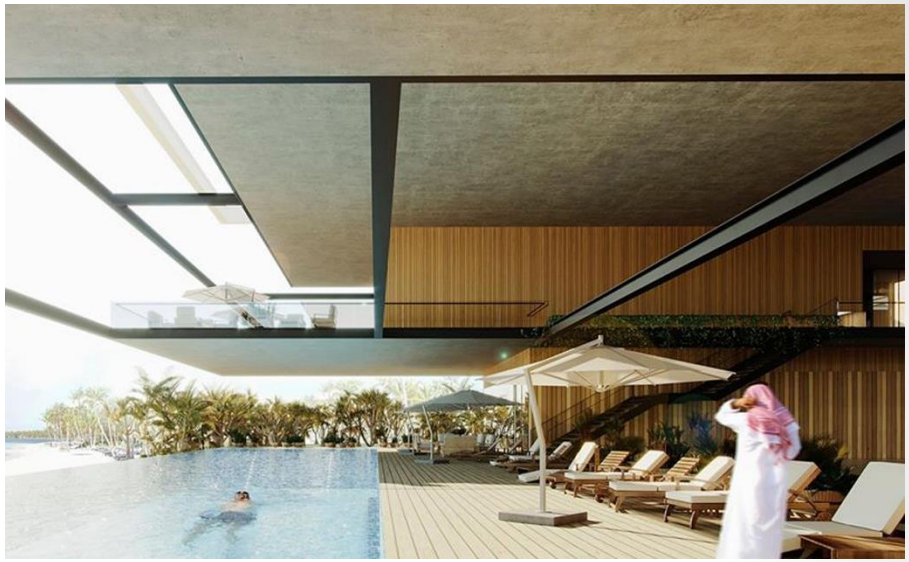
Innovative Architectural Design using post-tensioning

The usual restrictions imposed to architectural study are now diminished. Indicatively:

Possibility to manufacture **long cantilevers** (5m long balconies with post-tensioned slab 30cm thick)

Large length openings:

- Openings up to 12m without intermediate beams.
- Post-tensioned beams with a total height of 60cm for openings up to 20m.
- Post-tensioned beams with a total height of 100cm for openings up to 30m.
- Reduction of the total number of columns by **up to 50%**.



Post-tensioning and Repair-Strengthening

Applying external post-tensioning in **structural rehabilitations**:

- Great flexibility of the post-tensioning system layout, which induces a large number of solutions.
- Crucial factors are the geometry of the assembled member and the choice of anchorage positions.

The required increase in bearing capacity is achieved by post-tensioning:

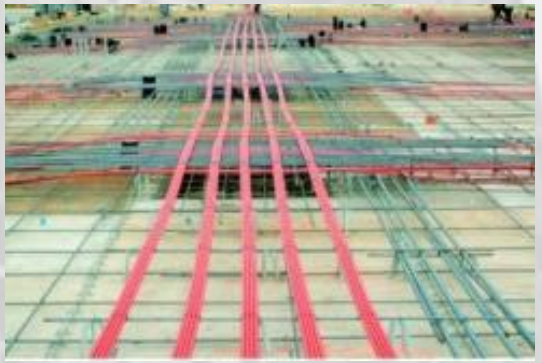
→ No increase in the cross-section of the assembled member is required.

AVAILABLE TYPES OF POST–TENSIONED SLABS

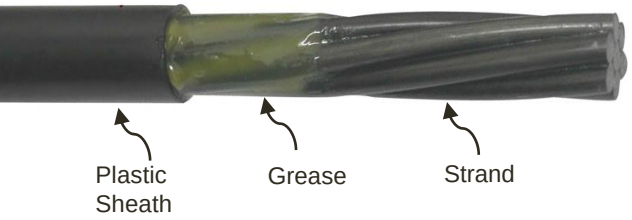
WITHOUT BONDING

Tendons coated with anticorrosive grease inside a watertight plastic tube.

- The tendons are not grouted and remain free in the concrete.
- Flexible features: Ease of required geometry near bores and other plate shape changes.
- Not applying grouting will speed up the whole process.



Unbonded Applications



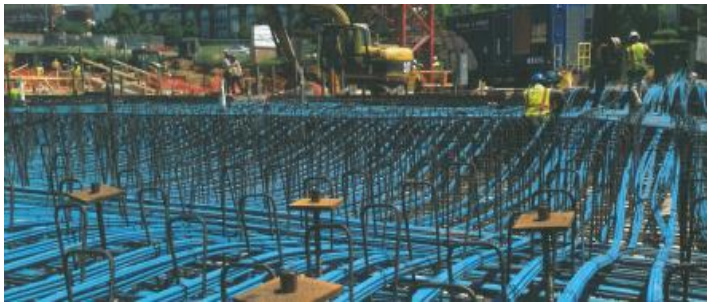
Without bonding

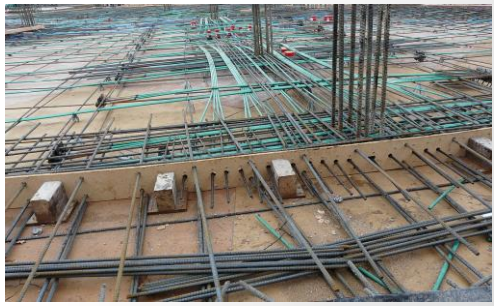
Advantages-without ponding

<u>Cost effective solution:</u>
-No PT ducts
-No grouting
-Faster/Easier installation, thus erection
-Best protection of strand

Disadvantages-without bonding

-Higher cost of strand
-Loss 100% of PT force in case of failure … (redundancy)





Unbonded Applications

The **unbonded** application in slabs ε πλάκες allows the recovery of its elastic deformation. **Strands have strength > 3 times the strength of typical reinforcement** (braking load 1860 N/mm^2 -vs- 550 N/mm^2).

It has been observed in tests that an unbonded slab has a load capacity of **4-5 times > from the failure load of the concrete** (after the failure the slab cables act as suspension bridge cables) **and this means an additional safety**.

AVAILABLE TYPES OF POST–TENSIONED SLABS

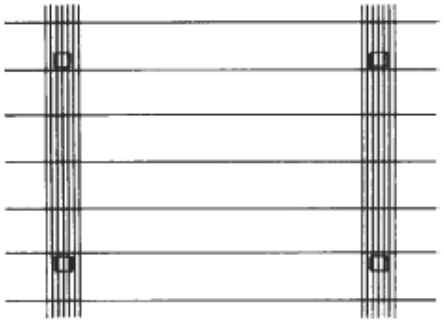
WITH BONDING

Using bare tendons in metal or plastic flat hose and fitting of anchorages at the ends. Filling with grout to achieve bonding.

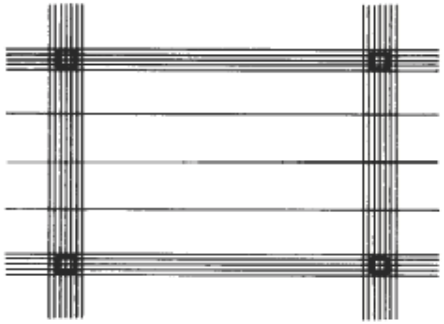
- By achieving bonding, the slab and the post-tensioning tendons operate as a joined system.
- Curved geometry of the tendons for increased system performance.
- Minimum values must be met concerning:
  - Overlaps
  - Distances
  - Eccentricity

Post-tensioned slab solution

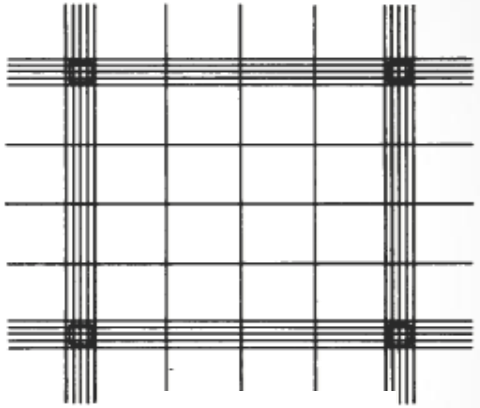
Some typical tendon patterns without bonding:



Pattern A



Pattern B



Pattern C

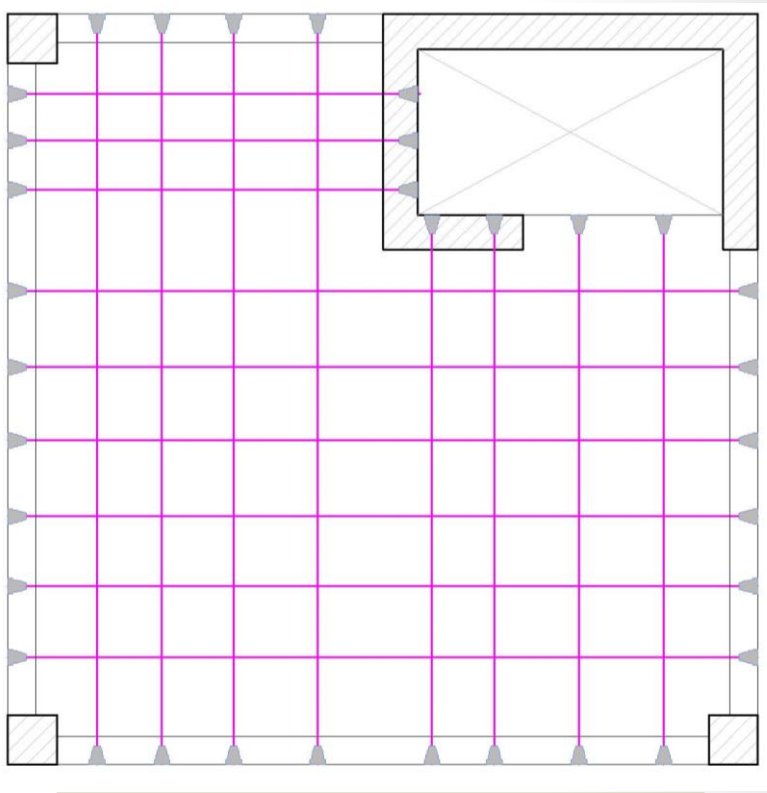
Bores in post-tensioned slabs can be implemented with relative ease but should be defined by the study phase.

- Small bores (smaller than 300 x 300 mm) can generally be placed anywhere on the slab between the tendons without any particular requirement.
- Larger bores are formed by locally arranging the tendons perimetrically of the bore.

Post-tensioned slab solution

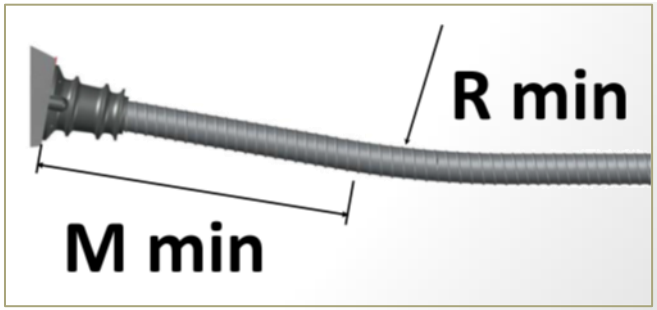
Tendon arrangement with consistency:

- **Bores** can be treated in the study phase by predicting the proper trajectory of the tendons.
- **Big bores** can also be shaped thanks to the variable positioning of the anchorages.



Minimum requirements must be met related to:

- The assigned geometry (circular arc diameters in curved segments).
- The tendons distances the from the edges of the plate and between them.



Flat Anchorages

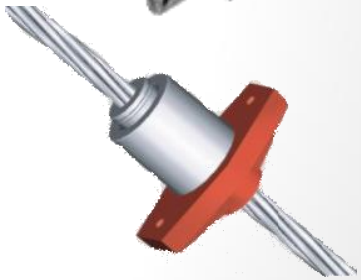
Cast iron bearing plates *ASTM A48/35 – EN1563*

Anchor heads & couplers of machined steel

ASTM A29-5140 – EN-ISO-683-2/10083

Wedges

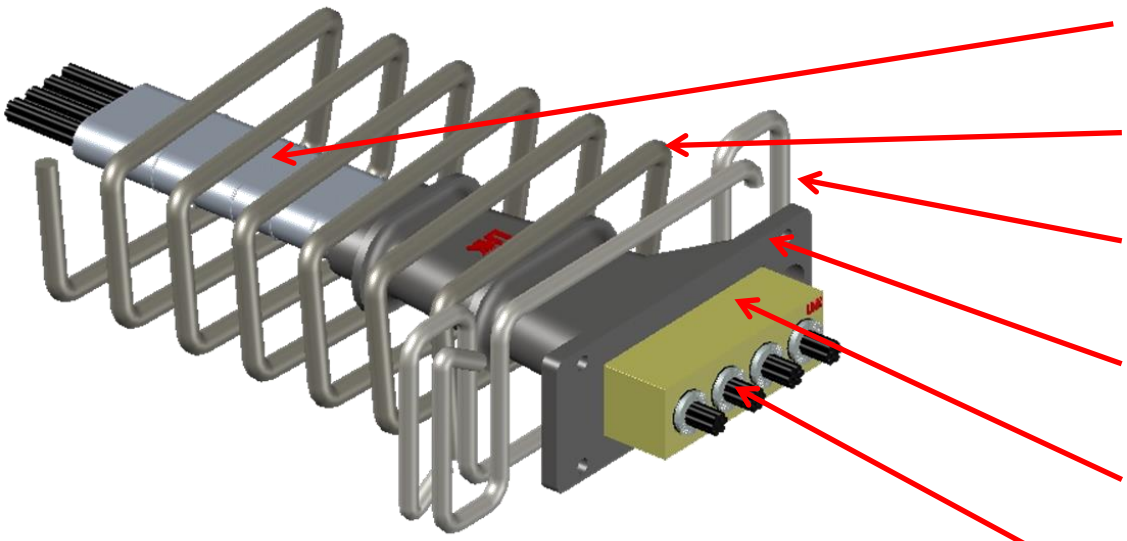
ASTM A29-4121 – EN-ISO-683-3/10277/10084

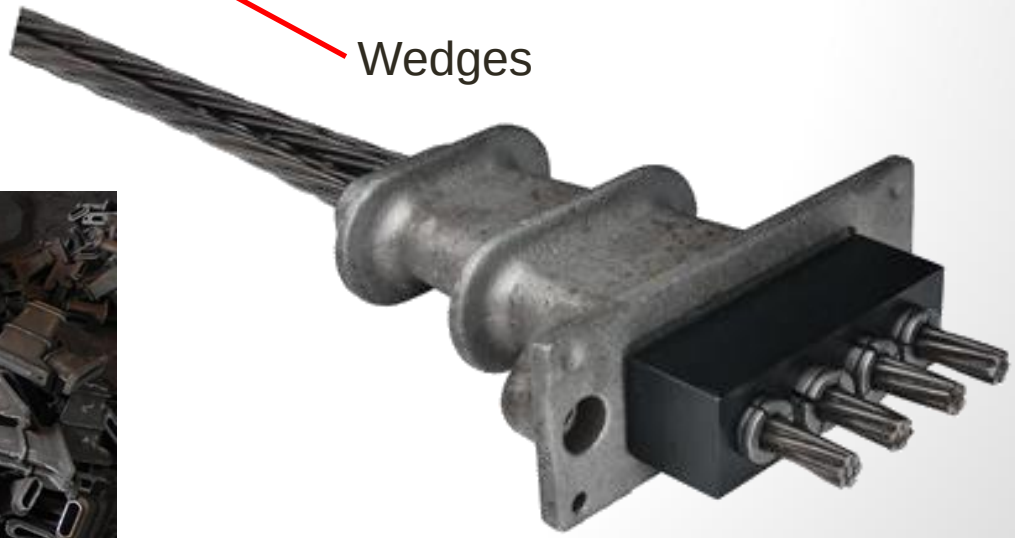


Swages, collars & protective covers/ grouting materials

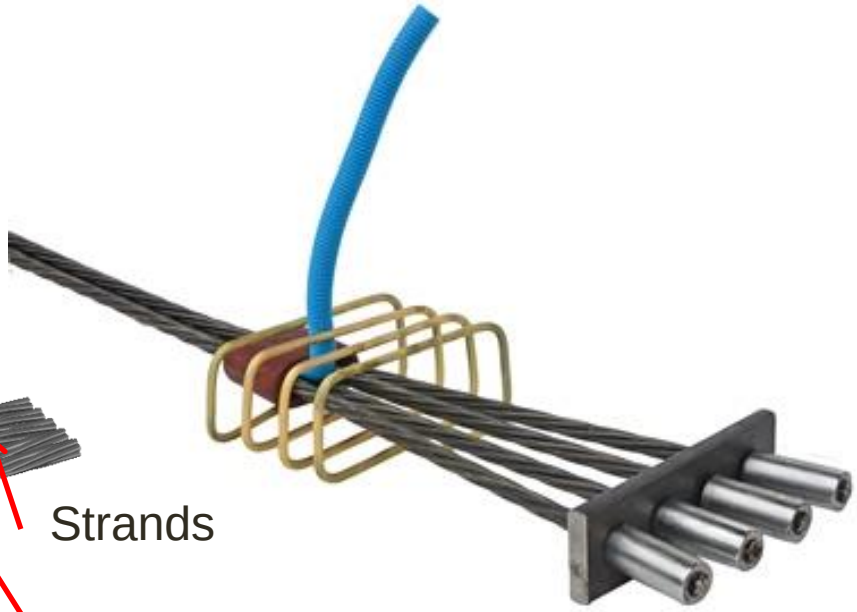
ASTM A29-1045 – EN10083, ASTM A53 - EN10255, ASTM D3841-16 – EN1796

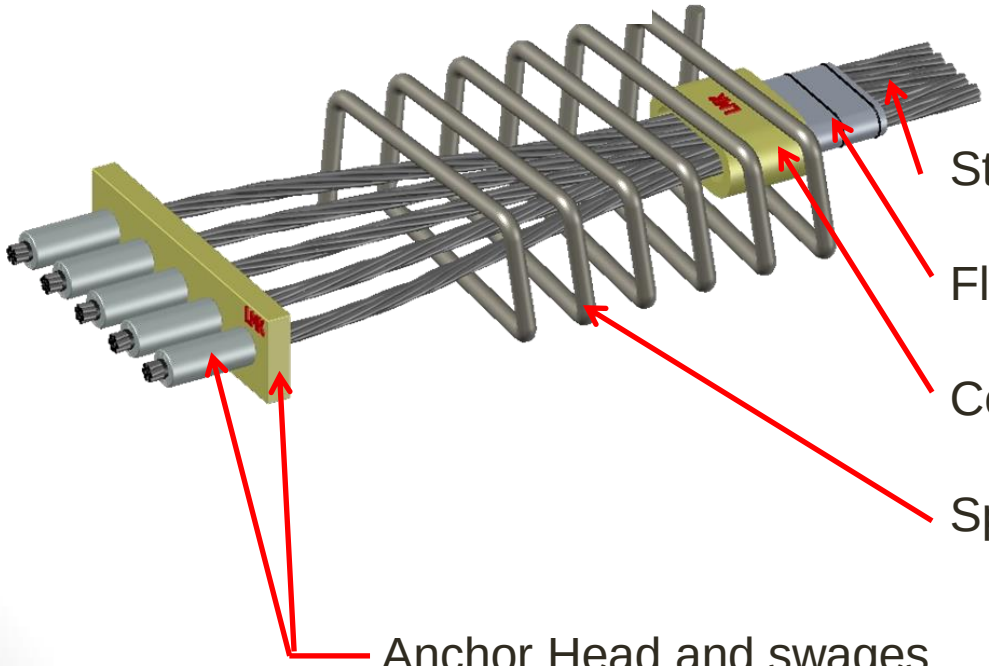
Stressing flat anchorages “SFL” type

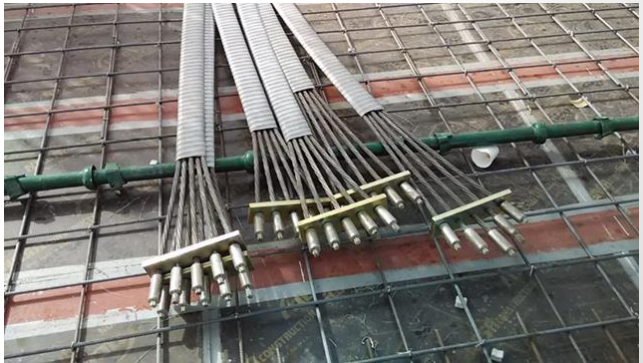




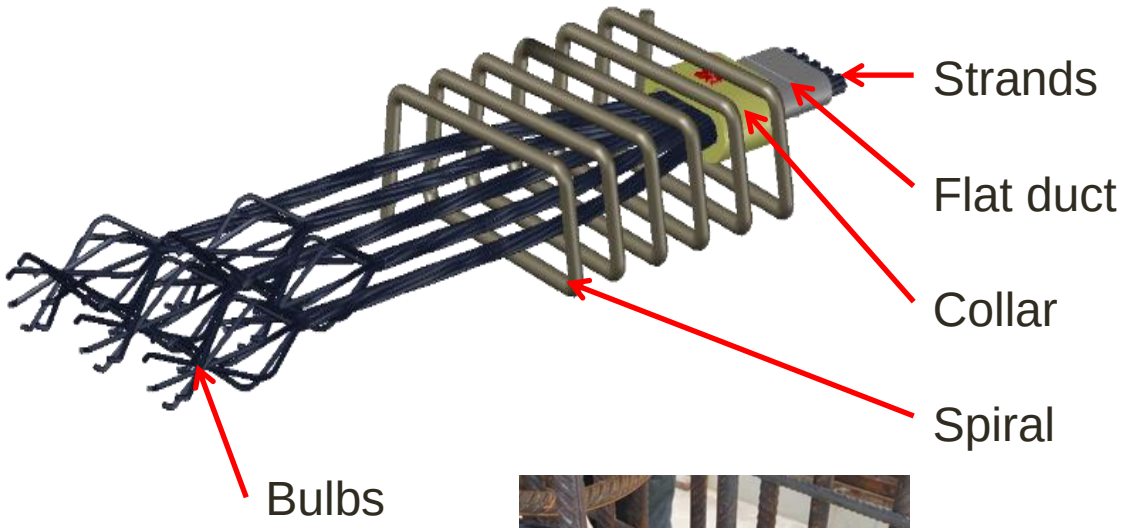
Fixed flat anchorages “FFL” type



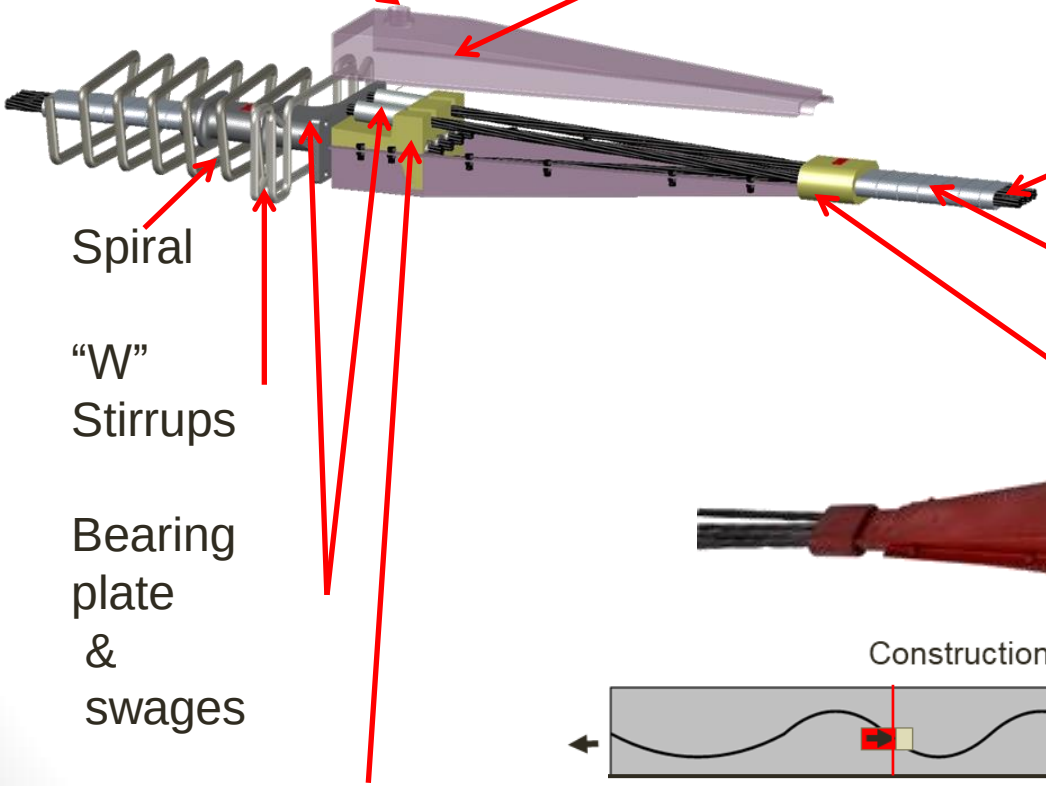


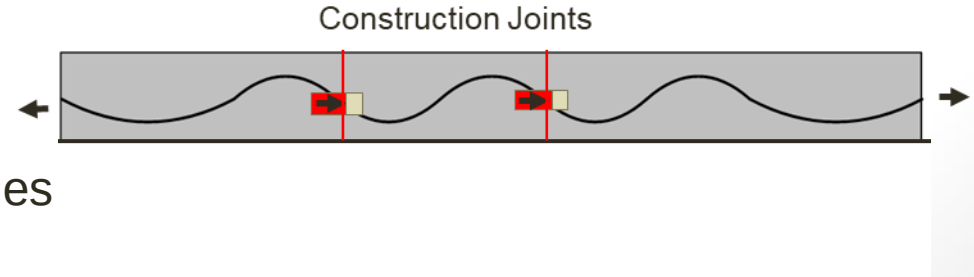


Fixed Flat anchorages “FFB” type



Fixed Flat coupler “FFC” type





Technical features of Post-tensioning System

Unbonded Monostrand “U” type

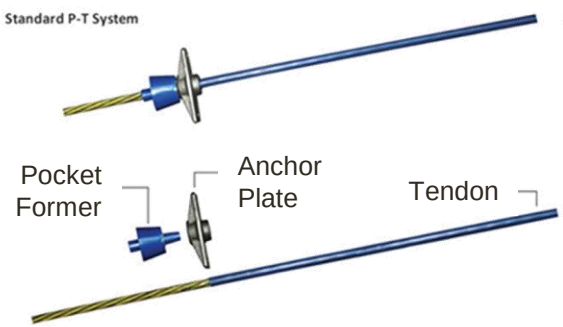
Components

Greased & Coated strand

Anchor Plate

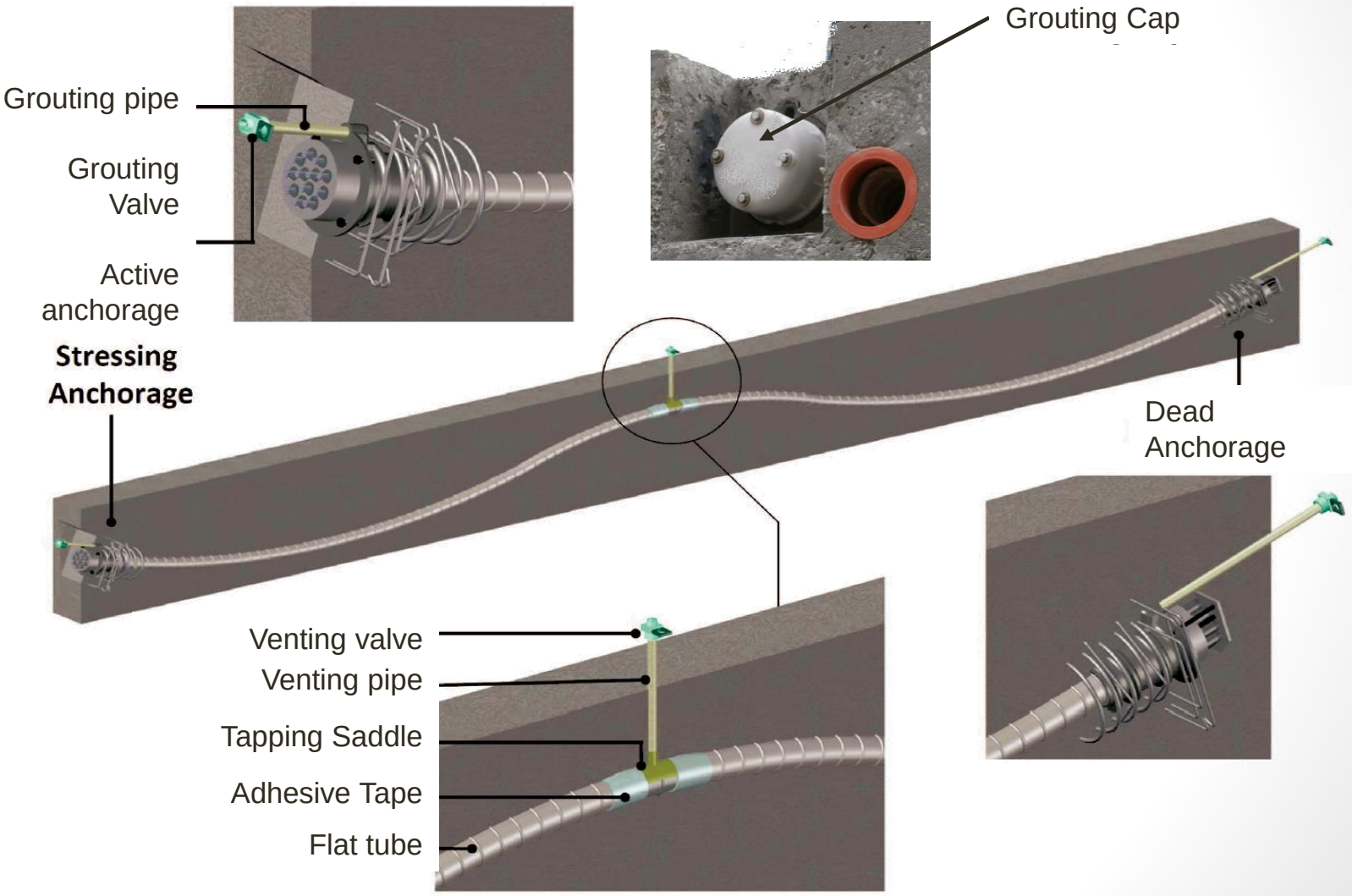
Wedges

Pocket Former



Post-tensioning duct

Manufactured by standard galvanized strap or plastic HDPE or PP ASTM A653 - EN-10130/10346



Post-tensioning sheaths

ASTM D-3350-PE/4101-PP-FIB Bulletin 7 & EN-1872

PLASTIC

Plastic polyethylene (HDPE) or polypropylene (PP).

- Suitable solution for electrically insulated tendons.
- The continuity between the tendons is achieved by welding or through special couplers.

STEEL

Ducts made of galvanized strip in a special press.

- Steel strip certified according to international standards.
- Minimum thickness between 0.30 to 0.60 mm, depending on its diameter and class (flat or slotted).

Grouting Procedure

- Restoration of the cross-section to achieve bonding.
- Protection of the post-tensioning system from corrosion.
- Proper selection and fitting of parts is necessary.
- Composition of grout and grouting process based on specifications.

Standard Tests and Certification of Post-tensioning System

The LMK post-tensioning system has been tested by internationally acclaimed laboratories and has successfully passed International standard tests:

- AASHTO (American Association for Highway & Transportation),
- PTI (Post Tensioning Institute – USA)
- EN 13391 (European Norm)
- ETAG 013 (European Technical Approval Guideline)

LEHIGH UNIVERSITY

ATLSS Advanced Technology for Large Structural Systems National Engineering Research Center

MFPA

EOTA European Organisation for Technical Assessment

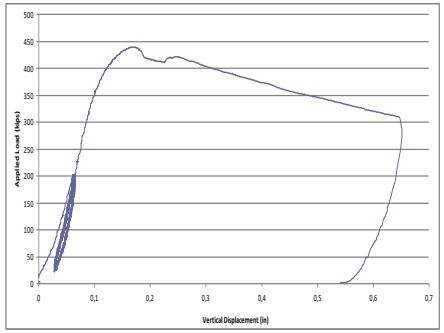
TU WIEN TECHNISCHE UNIVERSITÄT WIEN

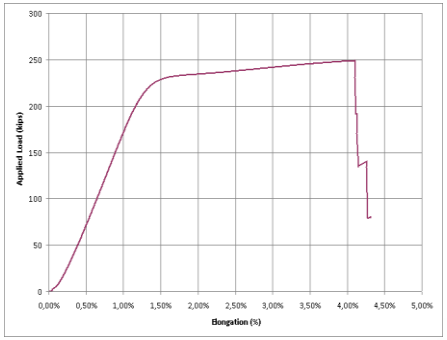
OiB AUSTRIAN INSTITUTE OF CONSTRUCTION ENGINEERING

AASHTO LRFD & PTI Tests

LEHIGH UNIVERSITY OF PENNSYLVANIA / FRITZ ENGINEERING LABORATORY - USA

- Anchorage Efficiency Test - ***section 10.3.2 AASHTO***
- Strand Wedge Connection Tests - Static & Dynamic, Lubricated & non-Lubricated - ***sections 4.1.2 & 6.1.6 / PTI Acceptance Standards for Post-Tensioning Systems***
- Load Transfer Test - ***section 10.3.2.3 AASHTO***

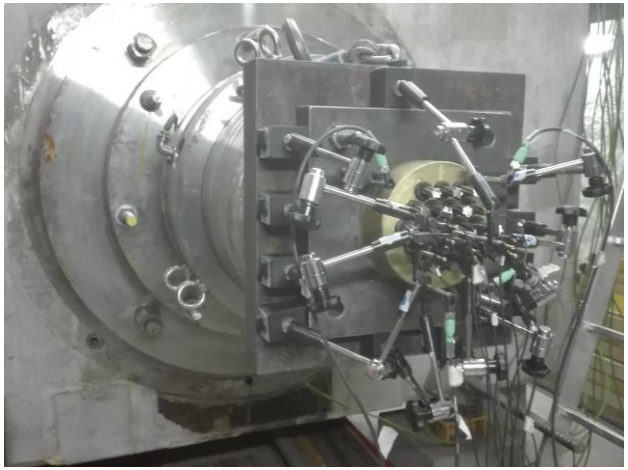


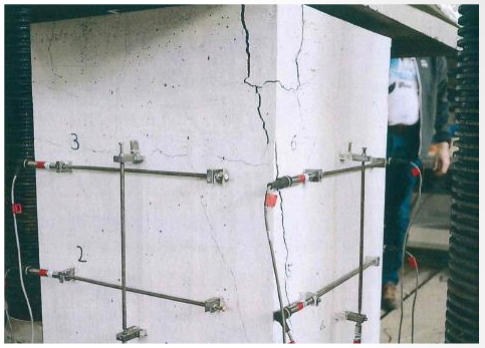


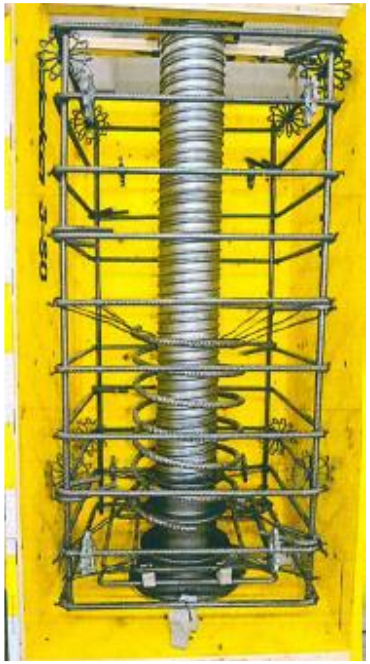
EN 13391-EAD 160004 (former ETAG 013) Tests

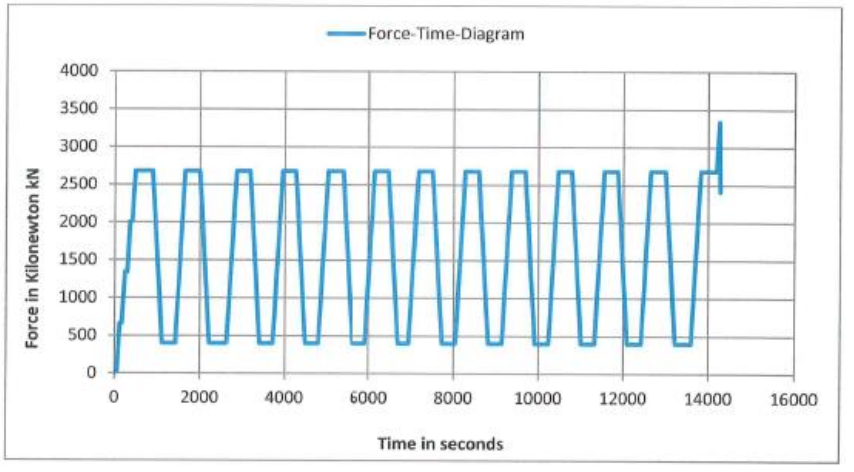
LEIPZIG INSTITUTE FOR MATERIALS, RESEARCH & TESTING – GERMANY
TECHNISCHE UNIVERSITAT WIEN - AUSTRIA

- Load Transfer Test
- Static tensile test









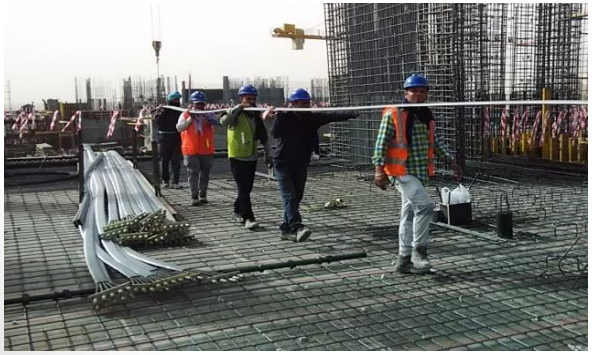
Technical Support -Services

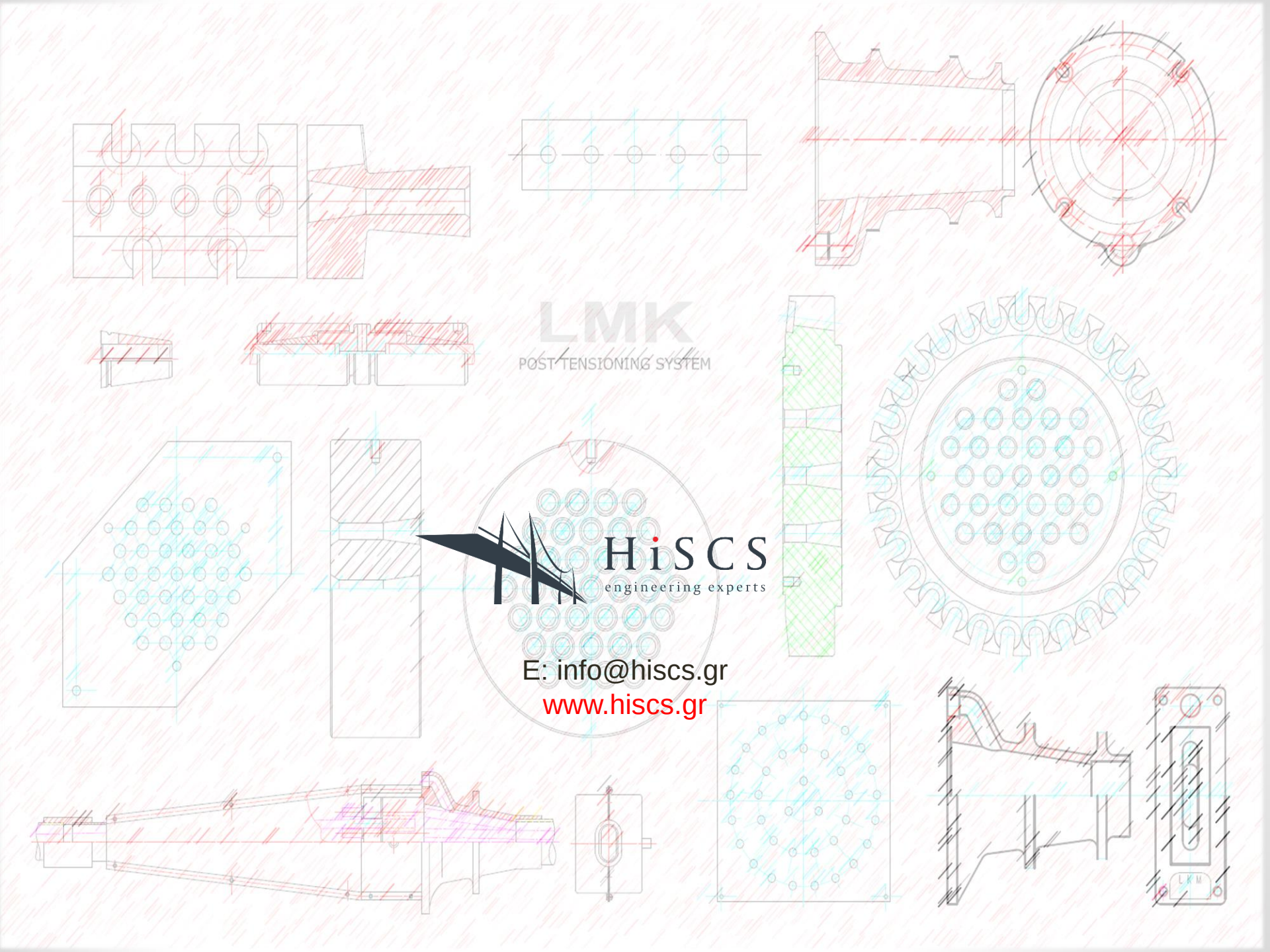
HiSCS has specialized engineers and foremen with expertise and long experience in the field of post-tensioning application in all kinds of technical projects.

Provides a complete set of services including:

- Pre-study & study of post-tensioning applications
- Control of spalling reinforcement, application of tendon's geometry & calculation of elongation
- Supply / equipment lease (jacks, stress and grouting pumps, wire rope machines, winders, pressure gauges and complete wiring)
- Placement - Management - Supervision – Training
- Stressing
- Grouting / Quality control tests (fluidity – grout exudation)
- Other support on any matter relating to post-tensioning technology and generally post-tensioning constructions

On-site support





HiSCS
engineering experts

E: info@hiscs.gr
www.hiscs.gr