



Global Standards in Construction & Engineering

Taking E-Solutions in Construction &
Engineering to a New Level

Post Tension Concrete



e-solution
Construction & Engineering

The Company

e-solution Construction & Engineering. e-solution Construction & Engineering with its headquarter in USA- Ohio-Toledo and main branches in Saudi Arabia and Cairo-Egypt Since 2004, we have been providing our clients with reliable solutions to their most complex construction challenges. Our strength lies in traditional construction methods and for our creative, fresh approach to cutting-edge technologies and delivery systems.

We specialize in wide range of construction techniques that includes:

- traditional construction methods
- precast concrete construction
- Tilt up concrete construction
- Insulated concrete forms
- Consultancy

Our success is driven by our innovative solution to complex projects that met the client demands and within project budget. Our clients are turning to us for our ability to implement project management techniques and to serve as a reliable provider of knowledge-driven solutions for construction projects.

The people who make up the team at e-solution Construction & Engineering Company embody our values of strength, performance and passion. Our employees have strong connections to these ideas, which have contributed significantly to the progressive growth, success and leadership of our company. They have helped us develop the solutions, systems and project methods required to bring innovation, quality and value to the projects we deliver for our clients.

Our team of construction professionals offers a single-source solution for all of your construction-related needs. Whether it's restoration, site preparation, a new building or building renovation, we have the experience and personnel to provide the highest quality construction on schedule and within budget. We support our clients from project inception, to the commissioning of the fully operational facility. And our network of local offices enables us to offer our clients the dual advantage of a strong local presence and broad geographic reach.

Memberships

e-solution construction & Engineering pride itself to hold membership in prestige associations and contributes with this associations in their educational activities in the area served by e-solution

- Post tension concrete institute
- Tilt up concrete association
- American concrete institute

Vision

To be the leading organization by providing through innovation the most innovative solutions to the construction field, our pledge is to establish lasting relationships with our customers by exceeding their expectations and gaining their trust through exceptional performance by our construction team.

Mission

To become the preferred supplier for engineering services and integrated solutions to our valued customers in the diversified market segments

Company core values

Our client's satisfaction is a constant measure of achievement, while this satisfaction is due to our commitment to our clients, it is directly related to the values through which e-solution Construction & Engineering, manages its operation. These include:

- **Strength**
We are a solid partner for our customers and all stakeholders based on the integrity and competence of our people, our decades of experience, our track record for delivering results and the backing of a global industry leader.
- **Performance**
We demand excellence, deliver on our promises and continuously search for new and better ways to provide the best solutions for our customers and our stakeholders.
- **Passion**
We care about and are personally committed to everything we do, our people safety and development, our customers and their success.

Community involvement

By providing volunteers to educate individuals on the new construction techniques and contribute with educational seminars that deliver the technology to wide range of audience, e-solution shared American associations in education their international students about the precast concrete.

A Reputation for excellence since 2004

POST-TENSION CONCRETE

Post-tensioned concrete slabs have become a major factor on the construction of floor systems for commercial and residential buildings of all types. In their two most popular forms (one way slabs, two way flat plates) they have been found to be economical for structural applications in parking structures, apartment buildings, office buildings, hospitals and industrial buildings of both the high rise and low rise type.

One of the main reasons that led to the development of this technology is that post-tensioning can solve simultaneously weight, deflection and cracking problems, which arose with conventionally reinforced slabs. Other major factors that contributed to the growth of post-tensioned slab construction included:

- Improvements and simplifications in post-tensioning hardware and field methods, making post-tensioned slab construction easy for the

contractor as conventionally reinforced slabs.

- Improvements in forming systems, which enhanced the overall economics of cast-in place slab construction.

- Testing programs on post-tensioned slabs, which greatly expanded the understanding of their behavior, and led to improved code criteria and more economical, safe designs. While more conventional reinforced is used, both for minimum crack distribution steel and for strength requirements, the combined use of per-stressed and non-per-stressed reinforcement results in considerable savings compared to the previous highly post-tensioned slabs.



WHAT IS THE POSTTENSION CONCRETE

The principle is easily observed when loading together several books by pressing them laterally.

Under such pressure the whole row gains enough stiffness and strength to ensure its integrity.

In concrete structures, this is achieved by placing high tensile steel tendons (cables) in the element before casting, when the concrete reaches the desired strength; the tendons are pulled by special hydraulic jacks and held in tensioning using specially designed anchorages fixed at each end of the tendon.

This provides compressions at the edges of the structural member that increase the capacity of the concrete resisting tension stresses

If tendons are appropriately curved to certain profile they will exert in addition to the compression at the perimeter a beneficial upwards set of forces that will counteracts applied loads, relieving the structure from a portion of gravity effects

Post tensioning is a process of pre-stressing with reinforced concrete or equivalent material that possesses high strength steel strands or bars commonly referred to as tendons. Concrete is strong in compression but weak in tension so to counter this, compression force is introduced to the concrete after casting, lending it strength to withstand slab weight and heavy loads. This also helps in minimal deflection and cracking under heavy load.

Post-tensioning process could be applied on any building, residential, commercial or office

buildings. It could also be applied to parking structures slabs-on-ground, bridges, sports stadia, rock and soil anchors or water tanks.

Post tensioning even allows construction at sites where it is not feasible to build owing to site and architectural deficiencies.

Post-tensioning as a process requires specialized knowledge and well trained staff. Its usage makes construction easy with knowhow of fabrication, assembling and installation



POST-TENSIONING IN BUILDINGS A TOOL TO ACHIEVE SUBSTANTIAL Benefits

- Post tension slabs generally have much less cracking than conventionally reinforced slabs. Design criteria and technology for post-tensioned slabs have been developed to a level comparable to that available for conventionally reinforced slabs. In detail, the advantages of the use of post-tensioned slab can be summarized as follows:

- Control of Cracks - Post-tensioned slabs control cracks much better than other reinforced slabs, due to the squeezing pressure (tension) of the cables compressing the cracks.

- Time Savings - Post -tensioned can be installed much faster than other reinforced foundation systems. A typical residential foundation takes 3-4 hours to install. Time is also saved by, using fewer joints, narrower footings, less digging and easier to clean up in the event of inclement weather. Slab post-tensioning systems

- Reinforcing Savings - As steel and concrete increase in pricing, the savings with a post-tensioned slab will increase, because the quantity of steel and concrete required for a post-tensioned slab is less than for a

conventionally reinforced foundation.

- Deflection Control - Post-tensioning increases the slab stiffness and by its increased flexural and tensile capacities. For example in the presence of expansive soils, it's obvious that post-tensioned slab is more resistant. In fact, movement of soils can sometimes be significant enough to move the structure (slab on ground support foundation systems are still interactive with the soil).

- Improved Modulus of Rupture - It is a fact that concrete shrinks when it dries and cracks. By utilizing a two part tensioning process, shrinkage cracking can be reduced.

- Improved Flatness and Slab Levelness - With fewer joints and greater joint spacing, slab curling is greatly reduced.

- Reduction in slab thickness – Minimum floor thickness maximizes the ceiling zone available for horizontal services, minimizes the self-weight and foundation loads, and keeps down the overall height of the building



BONDED SYSTEM

Bonded Post-Tensioning Slab System consists of fully encapsulated, bonded multi-strand (two to five strands) tendons contained in flat ducts filled with a high-performance cementitious grout that bonds the strands to the surrounding concrete.

Intermediate anchorages provide continuous encapsulation at construction joints. Tendons are protected by both duct and grout.

These bonded multi-strand post-tensioning systems have been successfully applied to **commercial building, healthcare and parking structure** construction by e-solution.

Benefits include enhanced crack and deflection control and a reduction in reinforcing steel. That allows for thin post-tensioning slab design—reducing overall building height which lowers costs for foundation, frame and facade/cladding components. Because bonded tendons may be cut with only localized loss of capacity, another significant advantage of bonded PT is the ease of future building modifications. Design advantages include increased span lengths and load-carrying capacities.

Additionally, the reduction of mild reinforcing steel minimizes the primary sources of corrosion and significantly reduces life cycle maintenance costs.

Bonded post-tensioned concrete is the descriptive term for a method of applying compression after pouring concrete and the curing process (in situ).

The concrete is cast around plastic, steel or aluminium curved duct, to follow the area where otherwise tension would occur in the concrete element.

A set of tendons are fished through the duct and the concrete is poured. Once the concrete has hardened, the tendons are tensioned by hydraulic jacks.

When the tendons have stretched sufficiently, according to the design specifications they are wedged in position and maintain tension after the jacks are removed, transferring pressure to the concrete.

The duct is then grouted to protect the tendons from corrosion.



UN-BONDED SYSTEM

Adaptable to a variety of structures, un-bonded mono-strand post-tensioning can be easily, rapidly and economically installed. Concrete construction applications for mono-strand systems include elevated slabs, slab-on-grade, beams and transfer girders, joists, shear walls and mat foundations.

e-solution's mono-strand post-tensioning systems use 0.5" and 0.6" diameter strands coated with a layer of specially formulated grease with an outer layer of seamless plastic extruded in one continuous operation to provide protection against corrosion. Each tendon is precisely coiled, cut, labeled, color-coded and delivered to the construction site. A wide variety of anchorage systems are available to meet design specifications.

Encapsulated un-bonded mono-strand post-tensioning systems are used in areas that are subject to corrosive conditions. Strands are protected at the anchorages using greased plastic sleeves and grease-filled end caps. Additionally, anchorage components are fully encapsulated in a high density polyethylene plastic covering and an optional encapsulated intermediate coupler anchorage system can be used to protect the strand at construction joints.

Un-bonded post-tensioned concrete differs from bonded post-tensioning by providing each individual cable permanent freedom of movement relative to the concrete, to achieve this; each individual tendon is coated with grease (generally lithium based) and covered by a plastic sheathing formed in an extrusion process.

The transfer of tension to the concrete is achieved by the steel cable acting against steel anchors in the perimeter of the slab.

The main disadvantage over bonded post-tensioning is the fact that a cable can de-stress itself and burst out of the slab if damaged (such as during repair on the slab).



BONDED VS UNBONDED SYSTEMS

The un-bonded mono-strand system offers the following advantages:

- Thin, light and flexible tendons that allow maximum tendon eccentricity in relatively thin members and are easy to handle and place
- Only small friction losses during stressing
- Factory provision of corrosion protection for the pre-stressing steel
- No grouting necessary

The advantages of the bonded systems include:

- Full exploitation of the yield strength of the pre-stressing steel
- Improved cracking behavior by activation of bond forces, reducing the amount of additional non-pre-stressed steel required for crack control compared with an un-bonded system
- For the flat duct system: thin tendons allow maximum tendon eccentricity in relatively thin members
- For the multi-strand system: the ability to transfer large forces using large tendons.



MAIN COMPONENTS

- **Strand - the tensile member of the tendon.**



- **A stressing anchorage or 'live-end' to allow both the dead end and the live end to transfer the post-tensioning forces from the tendon to the concrete**



- **Ducts**



- **A passive 'dead-end' anchorage**



STRUCTURAL SYSTEMS

The three most common floor systems used for building structures such as offices, shopping centers and car parks are the flat plate, flat slab and banded slab. For high rise construction a fourth system is widely used which consists of band beams at relatively close spacing spanning from the building perimeter to the service core. Although economy of each of these depend primarily on the span and applied load, it is generally true to say that a band beam scheme is cheaper than a flat slab which in turn is cheaper than a flat plate.

Post-tensioning is not limited to simple flat slabs and the range of structural types which can be economically stressed is almost limitless. Some of the most common floor systems are presented below along with recommended concrete sizes and span to depth ratios.

FLAT SLAB

This system is commonly used for high rise residential construction where the span is usually 7 to 8 meters. The most attractive feature of this floor system is its flush soffit which requires simple formwork and greatly simplifies construction. The depth of a flat plate is often dictated by shear requirements.

FLAT PLATE

A widely used system today for many reasons flat soffit, simple formwork and ease of Construction, as well as flexibility for locating services. The economical span range over a flat plate is increased by the addition of drop panels. The drop panels increase the flexural stiffness of the floor as well as improving its punching shear strength.

This system provides the thinnest floors and can lead to height reductions and substantial savings in facade costs.

What is the difference between a flat-plate and a flat-slab?

The flat plate is a two-way reinforced concrete framing system utilizing a slab of uniform thickness, the simplest of structural shapes. The flat slab is a two-way reinforced structural system that includes either drop panels or column capitals at columns to resist heavier loads and thus permit longer spans.



BANDED SLAB

This system is used for structures where spans in one direction are predominant. It is also a very common system due to minimum material costs as well as relatively simple formwork. In most circumstances the width of the band beam is chosen to suit the standard sizes of the formwork. The sides of the band can be either square, or tapered for a more attractive result. The band beam has a relatively wide, shallow cross section which reduces the overall depth of the floor while permitting longer spans. This concrete section simplifies the formwork and permits services to easily pass under the beams. The post-tensioned tendons are not interwoven leading to fast installation and decreased cycle time.

The band beam system has another advantage which is not widely appreciated. In most circumstances depending on the actual geometry of the cross section the beam can be considered as a two way slab for fire rating and shear design. This enables considerable economies to be achieved in both post tensioning and reinforcement quantities.

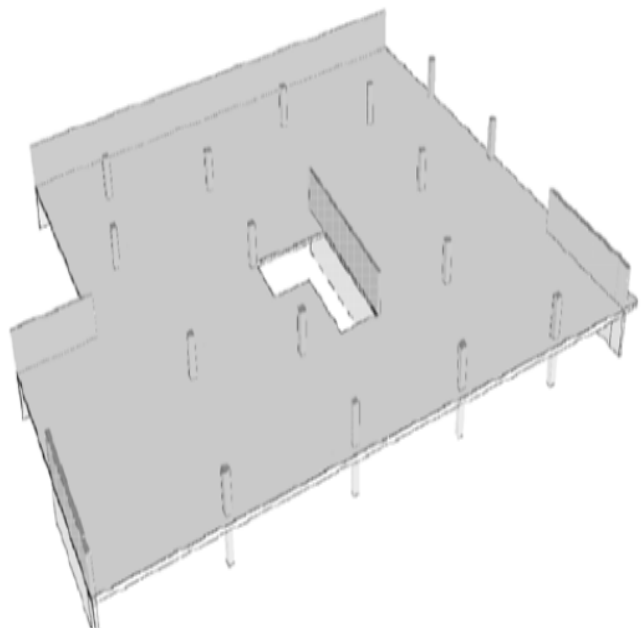
RIBBED SLAB

For longer spans the weight of a solid slab adds to both the frame and foundation costs. By using a ribbed slab, which reduces the self-weight, large spans can be economically constructed. The one-way spanning ribbed slab provides a very adaptable structure able to accommodate openings. As with beam and slab floors, the ribs can either span between band beams formed within the depth of the slab or between more traditional down stand beams. For long two-way spans, waffle slabs give a very material-efficient option capable of supporting high loads.



Design Development

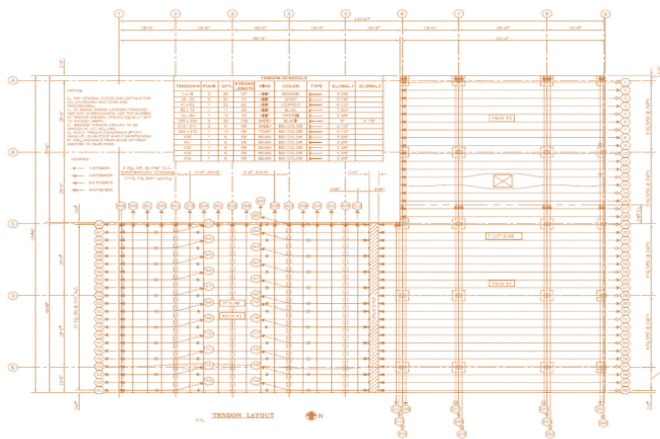
- Determine loading
- Determine floor system
- Calculate cross-sectional properties
- Determine material properties
- Select un-bonded or bonded tendon systems
- Determine cover requirements for reinforcement
- Determine fire rating and wearing surface requirements
- Determine maximum tendon drape profile
- Set target load balancing
- Set average compression limits
- Select allowable stresses
- Determine load combinations



e-solution uses the latest software tool to design the slabs , building information modeling (BIM) typically used to coordinate between disciplines and into analysis of the concrete slabs

FINAL DESIGN

- Determine loading
- Calculate post-tensioning force using load balancing and verify minimum pre-compression level
- Calculate member moments due to gravity loads
- Compute secondary moments
- Calculate moment redistribution
- Check service stresses
- Calculate minimum non-pre-stressed reinforcement (Un-bonded system) & Calculate temperature and shrinkage reinforcement
- Check ultimate strength and supplement with Non-pre-stressed reinforcement, if required
- Check punching shear if required
- Check deflection
- Construction documents
- Prepare framing plans showing post-tensioning layout, final effective forces, and profiles
- Show non-pre-stressed reinforcement layout on the framing plans
- Provide details at openings, reentrant corners.



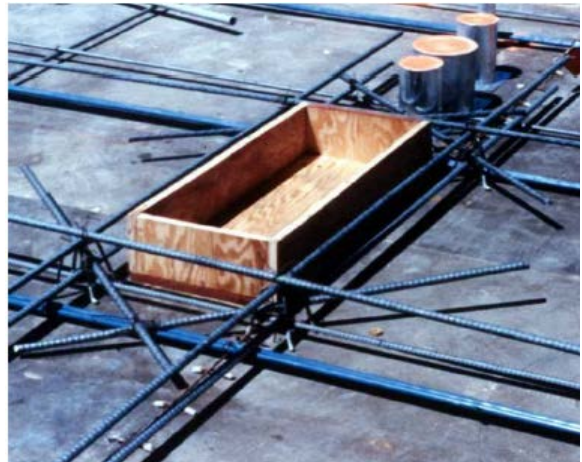
PLANNING FOR OPENING

There is no doubt that during the lifetime of a structure the requirements of a tenant may alter with time or the tenant may change several times. Each new tenant will have his own requirements for mechanical, hydraulic and electrical services, as well as loading arrangements and general layout.

Therefore, for a building to remain readily, it must have the flexibility to accommodate openings for stairs, services or lifts, and the possibility for changes in loading patterns.

Holes through pre-stressed slabs can be accommodated easily if they are identified at the design stage. Small holes (less than 300 mm x 300 mm) can generally be positioned anywhere on the slab, between tendons, without any special requirements. Larger holes are accommodated by locally displacing the continuous tendons around the hole. It is good detailing practice to overlap any stopped off (or 'dead-ended') tendons towards the corners of the holes in order to eliminate any cracking at the corners.

In ribbed slabs, holes can be readily incorporated between ribs or, for larger holes, by amending rib spacing or by stopping-off ribs and transferring forces to the adjoining ribs.



CUTTING OF TENDONS

Bonded Tendons

Bonded tendons are located within oval shaped galvanised ducts which are injected with cement grout following the post-tensioning procedure. Consequently when such a tendon is severed, the free end will become de-tensioned but after a short transmission length the full tendon force will be effective. This distance is in the order of 800 to 1000 mm.

Present quality assurance methods and supervision ensure that the tendons have been adequately grouted after the application of pre-stress.

If a penetration is required that will need the termination of a bonded tendon, then the procedure follows that for a fully reinforced structure.

Cutting a bonded post-tensioned tendon is, structurally, the same as cutting through conventional reinforcement. The tendon, however, needs to be 'terminated' in order to give full corrosion protection (as does conventional reinforcement).

Tendons are easy to cut using a disc cutter. In fact, cutting tendons requires less effort than for a fully reinforced slab due to the relative amount of reinforcing material to be cut.

Un-bonded Tendons

These tendons come individually greased and plastic coated and are therefore permanently de-bonded from the slab. When unbonded tendons are severed, the prestressing force will be lost for the full length of the tendon. When contemplating the cutting of an unbonded tendon it is therefore necessary to consider the aspects as noted below.

Cutting the tendons

The strand is packed with grease which prevents an explosive release of energy when the tendon is severed. Even so a gradual release of force is recommended. This can be achieved by using two open throat jacks back to back. After cutting the strand the force can be gently released by closing the jacks.

Propping the slab

Adjacent spans may require temporary propping depending upon the number of tendons severed at one time. It is rare for a slab to carry its full design load. A design check based on actual loading at the time of the modification may show props to be unnecessary.

Forming the hole

When the edge of the slab is re-concreted new anchors are cast in to enable the remaining lengths of tendon to be Pre-stressed, thus restoring full structural integrity. The above operations are not difficult but will require the expertise of a post-tensioning sub-contractor.



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