

Procurement of post-tensioned slabs

This guide is intended to enable those involved in the procurement of post-tensioned slabs in buildings to ensure that a quality product is constructed. It provides background information on post-tensioning and explains why it is important to make certain that specialist post-tensioning contractors operate a quality assurance system and be certified by CARES.

What is post-tensioning?

Concrete has a high compressive strength, but has low tensile strength. Traditional reinforcement is often used to give concrete more ductility because the steel resists the tensile forces in the element. In post-tensioned structures high-strength steel is used, which is tensioned against the concrete. This puts the concrete into compression, utilising more of the inherent strength and enabling thinner concrete sections to be used.



A typical post-tensioning installation.

Current post-tensioning market

The use of post-tensioning (PT) has increased dramatically over the last decade (see Figure 1). There are now many companies which offer post-tensioning supply and installation services in the UK; giving a choice for the purchaser and providing healthy competition. Most of these companies are subsidiaries of larger organisations involved in the construction industry, but there are also independents.

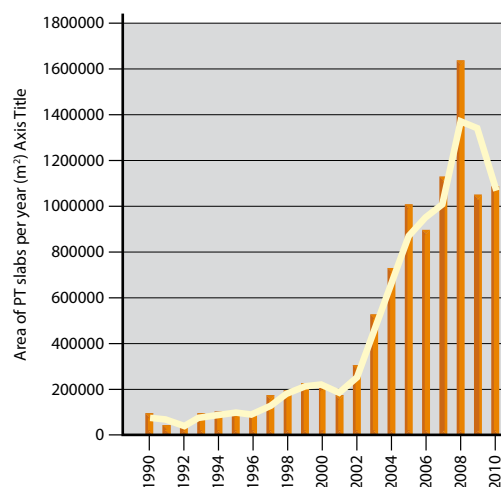


Figure 1: Increased use of post-tensioning in the UK buildings market.

Why use post-tensioning?

Post-tensioning is increasingly recognised as a cost-effective construction technique for many types of buildings. Here are some of the reasons to use post-tensioning on your next project:

- Long-spans – post-tensioned concrete can span further than reinforced concrete and competes economically with steel structures. Long spans reduce the number of columns and foundations and increase flexibility for space-planning.
- Minimum floor thickness – Post-tensioning has the minimum structural thickness of any floor system. This reduces self-weight and the overall height of the building.
- Flat soffits – the most popular post-tensioned solution is a flat slab which gives a clear flat soffit that makes services distribution simple – saving costs on the M&E package.
- Openings – post-tensioned slabs can readily accommodate openings. Smaller holes can be formed between tendons, and larger holes can be designed into the system.
- Programme – post-tensioning has a short lead-in time and can be constructed rapidly. Once complete the slabs provide a safe working platform for other trades allowing follow-on trades to commence earlier in the programme than say, steel-framed buildings.
- Performance – post-tensioning comes with all the benefits of concrete such as good vibration control, fire resistance and sound insulation.
- Sustainable – The thermal mass of the concrete can be utilised to moderate the temperature fluctuations in the building. Post-tensioning also reduces the materials used in the structure. Longer spans offer future flexibility – increasing the potential life-span of the building.

Typical procurement approaches

Post-tensioning is procured in a variety of ways; some are more suitable than others.

The most common approach in the UK is for the structural engineer to prepare an outline design for the post-tensioning that gives the overall layout and member sizes. A performance specification for the post-tensioned floor slabs is then prepared. The concrete frame contractor will then appoint a post-tensioning contractor to carry out the design, supply and installation of the post-tensioning for the floor slab. This would include fixing the system in place and carrying out the stressing and grouting operations as necessary.

Alternatively, the structural engineer can design the post-tensioning in a similar way to a reinforced concrete slab. The concrete frame contractor then appoints a post-tensioning contractor to carry out the supply and installation of the post-tensioning.

A third approach is for the concrete frame contractor to purchase the post-tensioning products from a specialist supplier and to carry out the installation themselves. The specialist supplier may also be asked to carry out the design. This approach is not recommended as it can be difficult to ensure adequately trained personnel install, stress and grout the system. As will be described later the installation of post-tensioning is a skilled job that should be carried out and supervised by experienced personnel.



Strata is the first of three tall buildings planned for the redevelopment of Elephant and Castle in London

Experience and quality

In principle the installation of post-tensioning is a relatively straight forward operation, and no more difficult than reinforced concrete. However, it is important to get the details correct because the system relies on a few critical components. The following are some of the areas where lack of attention to detail is of particular importance.

- Tendon drape – the tendons should be fixed in the position assumed in the design. Where the tendon has been fixed out of position (or accidentally moved during concreting) the slab will not have the intended design strength.
- Anchorages – large stresses are resisted by the anchorages, which should be installed as shown on the drawings and with the correct reinforcement around them.
- Concrete strength – partial stressing is often carried out at an early age to control cracking. The timing of this operation is important to ensure that the concrete has sufficient strength to resist the prestress force, but before too much shrinkage has taken place.
- Final stressing – the stressing operation uses a jack that can exert high forces on the structural elements.
- Checking the prestress – post-tensioning has the advantage that the prestress force in the strands can be checked by measuring the length that the strand has extended during stressing. This check should be taken seriously and corrective action should be taken where discrepancies are identified.
- Grouting – for bonded systems the grouting operation is important because it ensures that the strands are protected against corrosion and that the strands are fully bonded to the concrete slab.

Recommendations

It is recommended that:

- As a minimum, CARES accredited PT companies are used for post-tensioning and, ideally, the PT contractor should also be a PTA member.
- The specialist post-tensioning contractor should carry out the supply and installation to ensure full compatibility of components and equipment and to be certain that installers are familiar with and trained in that PT system.
- The specification requires a CARES certified post-tensioning contractor is to be appointed.
- The client's designer ensures that a single engineer takes the overall responsibility for the design and ensures that the post-tensioning design is compliant.

Ensuring quality

To ensure that attention to detail and good quality control is carried out it is important to appoint a specialist post-tensioning contractor who operates a quality control system. In the UK, CARES operates a certification scheme for the supply and installation of post-tensioning. This scheme requires that the contractor has a quality system that complies with CARES requirements and BS EN ISO 9001. The contractor must only use components that are CARES certified and must operate a training scheme that meets CARES requirements. Trained personnel will be issued with CARES cards to demonstrate their competence.

Under the CARES certification scheme, the contractor's offices will be audited once a year and a minimum of two sites will be audited every year, this will include a check that the workforce hold CARES cards. The appointment of a CARES accredited post-tensioning contractor will ensure the site works are carried out in accordance with the CARES Model Specification (as a minimum). This can be downloaded from the CARES website, www.ukcares.co.uk

It is therefore strongly recommended that when appointing a specialist post-tensioning contractor that they are CARES certified. CARES recommends that the following wording is used in the specification:

"Only firms that have achieved full certification under the CARES Certification Scheme for the Supply and Installation of Post-tensioning Systems in Concrete Structures shall be permitted to bid for or undertake contracts to supply and install post-tensioning systems"



When appointing a PT contractor, a copy of the CARES certificate should be requested and care should be taken to ensure that the company listed on the certificate is the same as the company which is going to undertake the work, particularly as there are companies in the industry

with similar names. Furthermore, the scope on the certificate needs to match the works on site, for example bonded/unbonded, bridges/buildings. The current status of a company should also be checked on the CARES website (www.ukcares.co.uk/approved_companies). In addition to being CARES accredited, PTA member contractors bring the additional benefits of working to accredited Health and Safety systems, are committed to maintaining high skill levels in the industry and support the development of the industry through best practice.

Design of post-tensioned slabs

Post-tensioning can be designed using either BS 8110 or Eurocode 2. In practice there is relatively little guidance in these British Standards and designers refer to TR 43: *Post-tensioned concrete floors: Design handbook*, published by The Concrete Society for more detailed guidance. See Guidance Note GN02 for more information on the design of PT slabs in terms of stress limits.

The principles of post-tensioning are relatively simple, but in practice require a lot of calculations. Post-tensioning designers therefore use commercial software packages to carry out the calculations. Experienced post-tensioning designers are able quickly to reach an efficient design by varying the concrete strength, quantity of pre-stressing steel and reinforcement.

In the UK the design is often undertaken by the specialist. BS 8110 makes it clear that a single engineer should take responsibility for the overall design, including that undertaken by others. The client's engineer is in the best position to fulfil this requirement and should ensure they understand the design methods used and that the post-tensioning designer, who may be working as a sub-contractor to the post-tensioning contractor, is competent.

Bonded or Unbonded?

Post-tensioned floors may be bonded, unbonded or a combination of both.

With the bonded system the prestressing tendons run through small continuous flattened ducts which are grouted after the tendons are stressed, creating bond between the concrete and tendons. The ducts are formed from spirally-wound or seam-folded galvanised metal strip. The limit on the curvature or profile that can be achieved with the prestressing tendons is dependent on the flexibility of the ducts.

In an unbonded system the tendon is not grouted and remains free to move independently of the concrete between its end anchorages. This has no effect on the serviceability design or performance of a structure under normal working conditions. It does, however, change both the design theory and structural performance at the ultimate limit state.

The greater resistance to accidental damage of bonded construction is often an important consideration in the choice of system.

Post-tensioning association

The PTA is the trade association of the UK post-tensioning industry. Membership of the Association is open to companies directly engaged in the manufacture and/or installation of post tensioning materials and/or the design of post-tensioned structures in the UK.

The objectives of the Association are:

- To promote the use of post-tensioning in buildings, bridges, silos and tanks, ground floor slabs and other structural types throughout the UK construction industry.
- To promote best practice in the design, procurement and execution of post-tensioned structures.
- To support and take part in research and development to improve the efficiency and technical capabilities of post-tensioning.
- To support high quality in PT construction through the CARES certification scheme and other relevant bodies.
- To support safe working practices throughout the UK post-tensioning industry and to maintain high levels of training.
- To find out more about the PTA including a current list of members visit www.post-tensioning.co.uk

The Post-Tensioning Association: Promoting Perfect Post-Tensioning

This Guidance Note has been produced with help from the following members ConForce, MPA The Concrete Centre, CCL, Matthew Consultants and Ramboll

This Guidance Note, as well as a wealth of case studies are available online at:

www.post-tensioning.co.uk

Missed GN01 on hole cutting through PT slabs?

Download a copy from our website
www.post-tensioning.co.uk