Post-formed holes in post-tensioned slabs

As post-tensioning (PT) within buildings becomes increasingly popular in the UK market, understanding of the principles and the attributes of this method of construction is becoming more widespread. Post-tensioning specialist CCL works closely with consultants, contractors and clients to promote this knowledge, but finds there are still a number of areas where misunderstandings persist. One such area includes alterations to existing structures. Matthew Gilliver of CCL reports.

A common misconception exists, which leads some to believe that the creation of openings in existing PT slabs is either extremely complex or impossible. Consideration of the correct procedures demonstrates this not to be the case.

Post-formed holes in PT slabs will vary in size ranging from the smallest penetrations, which may be required to incorporate suspended services, to much larger openings to allow the addition of lifts or similar installations.

In all post-tensioned slabs, the most common tendon layouts use a banded design which provides large, regular spaces between tendons that will easily accommodate smaller openings (see Figure 1). In such instances, alterations can often be more straightforward than in other types of construction, as the creation of holes within these areas can be achieved without affecting structural performance.

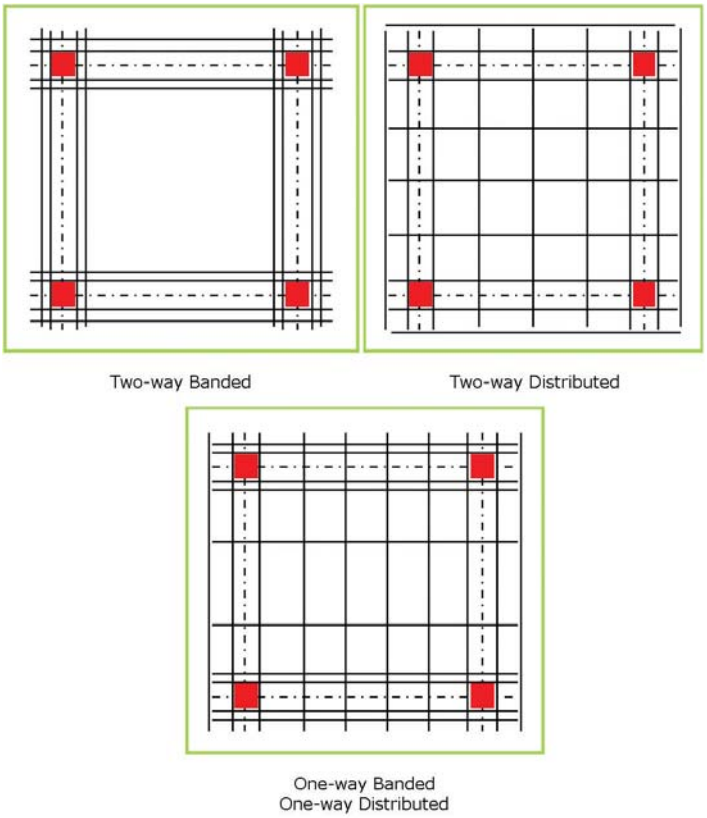

Figure 1: Common tendon layouts.

The Post-Tensioning Association, in its *Guidance Note GN01*[1], identifies four types of post-formed penetration that are categorised according to the effect the operation will have on structural integrity (Figure 2). The first of these relates to the smallest holes, no more than 20mm in diameter, involving no tendon cutting and which offers minimal risk to the structural integrity of the slab. The second group is classed as a low risk to structural integrity and includes somewhat larger openings, up to 200mm in diameter in beams or close to columns, but larger in areas that are less stressed. The voids are still located between tendons to avoid the need to cut these (Figure 3). In the third and fourth categories of penetrations, where it becomes necessary to sever the tendons, the effect on the integrity of the structure is likely to be more significant and calls for strengthening and temporary propping of the slab. As the quantity of cut traditional reinforcement is significantly less, so is the requirement for corrosion protection to exposed cut steel.

Bonded PT slabs

The most common form of post-tensioning in the UK market is bonded PT (Figure 4). Ducts carrying high-tensile steel strands are filled with grout after the tendons have been stressed and locked off by means of split wedges within the anchors, thereby bonding the tendons to the concrete. If larger openings are required in bonded post-tensioned slabs, they can often be treated in the same way as traditional reinforced concrete slabs as the effects of cutting through a bonded tendon remain localised and the tendon redevelops its bond either side of the cut, typically within 1m. In instances where it is necessary to cut multiple tendons, mechanical or epoxy anchorages can be placed on the ends of the severed tendons to provide even greater security.

CCL recently undertook an application that required the creation of voids within bonded slabs, in order to house a number of hoists and an escalator within an existing building. After non-destructively locating the tendons that spanned through the proposed void within the slab, by means of the 'as built' drawings from the operations and maintenance manual, the post-tensioning duct was opened (Figure 5) and epoxy grout anchors were then installed around the exposed strand prior to cutting, thereby giving enhanced surety of anchoring (Figure 6).

Unbonded PT slabs

The tendons within unbonded PT systems are fixed to the structure at the end anchorages but are otherwise free to move independently of the concrete, being greased and encased in plastic sheathing (Figure 7). If penetration of an unbonded slab requires that tendons are cut, they will become de-tensioned along their entire length. This will normally require propping or restricted loading in adjacent spans during the operation.

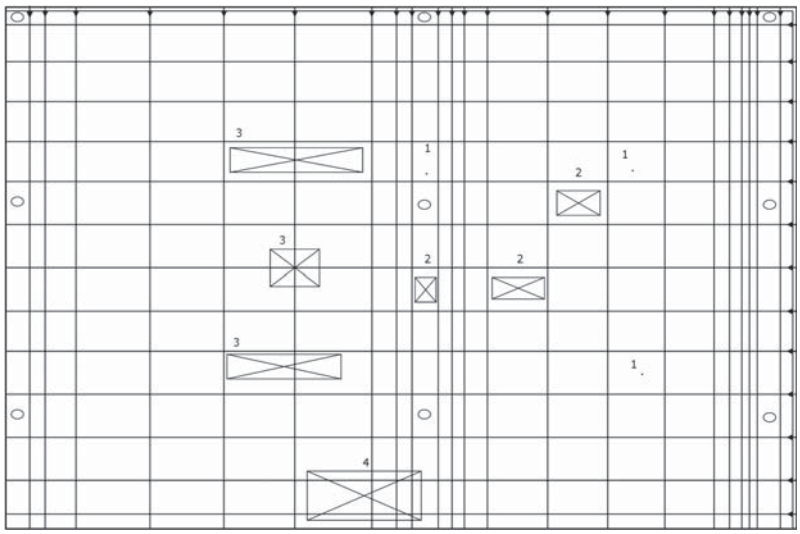

Figure 2 far left: Penetration classes.

Figure 6 left: Epoxy grout anchor.

Figure 3: Bonded post-tensioning layout.

Figure 4: Bonded post-tensioning assembly.

Figure 5: Exposed strand awaiting epoxy grout anchor.

In a recent example of post-forming holes in unbonded slabs in which CCL was involved, the client specified the requirement for a new lift within the existing structure. Normally the grease inside the sheaths of the unbonded system slows the release of energy when strands are cut and the wedges do not become disengaged from the anchorage. However, as this cannot be guaranteed, precautionary measures should be taken if there could be any significant consequence of impact with the façade.

As a measure of added security, CCL carried out the de-tensioning of the tendons. The unbonded system within the slab was first exposed and the live strands were de-tensioned, enabling the main contractor to create the void without any detrimental effect to the slab. In order to maintain structural integrity, the area around the new penetration was propped until completion of the lift shaft, which offered local support in lieu of the tendons, after which the props were removed.

In instances where tendons require restressing after the opening has been created, new PT anchors are positioned over the existing strand ends located around the newly formed void. After casting the concrete around the hole, the tendons are then restressed from the face of the opening.

While post-tensioned slabs can be designed in such a way that will accommodate future penetrations, such alterations cannot always be foreseen. As with traditionally reinforced concrete, the post-forming of holes or voids in PT slabs can be carried out safely and easily provided any alterations that may affect the existing structure are designed by a competent engineer and are carried out by a qualified post-tensioning specialist. ●

As with traditionally reinforced concrete, the post-forming of holes or voids in PT slabs can be carried out safely and easily.

Figure 7: Unbonded post-tensioning assembly.

Reference

1. POST-TENSIONING ASSOCIATION. *Post-Formed Holes Through Post-Tensioned Slabs*. PTA Guidance Note GN01, Available via: *www.concretecentre.com.*