

**FUTURE SLAB
PENETRATIONS and
DEMOLITION of
POST-TENSIONED FLOORS**

Future slab penetrations and demolition of post-tensioned floors

1.0 INTRODUCTION

Post-tensioned floor slabs in Australia and South East Asia are now universally regarded as the most cost effective form of construction for shopping centres, office buildings, and carparks where spans exceed 7.5 metres. The preferred post-tensioning system used is the well proven 'bonded' tendon utilising from 3 to 5 individual prestressing strands housed in oval ducting and anchored in flat fan shaped anchorage castings.

A question often asked of post-tensioned slab systems is what happens if we wish to make a penetration in the slab after construction.

From time to time it has been brought to our attention that certain members of the building profession see this question as a major obstacle and are reluctant to accept the use of prestressing in some types of buildings. This is often due to a perceived lack of flexibility in the structure when it comes to the formation of openings through the slabs some time after construction.

This report will outline the options available to enable the designer to produce a building which is both economic to construct and easy to modify in the future.

2.0 PLANNING FOR OPENINGS

2.1 Possible Future Requirements

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 lettable in the future it must have the flexibility to accommodate openings for stairs, services or lifts, and the possibility for changes in loading patterns.

2.2 Choice of Building System

No building system can be infinitely flexible in terms of future tenant requirements.

Whether a slab is constructed from post-tensioned concrete, pre-cast concrete, structural steel or insitu reinforced concrete there will be certain areas such as main beam strips where holes cannot be accepted without significant difficulty.

2.3 Overall Structural adequacy

Whatever the building system and material, it is important to locate the new opening with due regard to the structural stability of the remaining portion of slab. The Structural Engineer must check the penetration location and advise any remedial work required, such as trimming beams, regardless of the structural system.

A post-tensioned slab will have similar strengths and weaknesses in terms of its flexibility as

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insitu reinforced concrete. For example, if a new stair well were to be located in the centre of a panel such that short cantilever slabs were retained on all sides to counterbalance the adjacent bays, it is quite possible that no additional supporting members would be required.

A precast system or steel framed structure may require the removal of the whole panel, construction of trimmer beams around the new void, and replacement of the slab to the surrounding edges.

3.0 DESIGNING POST-TENSIONED SLABS FOR FUTURE OPENINGS

3.1 Locating post-tensioning tendons

For post-tensioned slabs and beams where tendon positions may not be readily identifiable, soffit marking can be employed. Prior to casting the slab, stainless steel staples are used to secure the ducts to the formwork. When the formwork is struck, the position of the tendons is obvious, especially if the staple lines have been linked by painted lines.

Alternatively, chalk lines can be marked on the slab top surface to aid in the locating of post-tensioning tendons. These procedures will assist in locating openings away from tendons.

3.2 Structural systems in post-tensioned concrete

3.2.1 Band Beam and Slab

For rectangular grids the band beam and slab solution may be appropriate. This is the system typically used for shopping centres and car parks due to the economic benefit and relative insensitivity to floor height restrictions.

Normally band beams span in the long direction and impose the same constraints on hole placement as would a steel or reinforced concrete beam. However, small hydraulic type penetrations (approximately 150 mm diameter) can usually be accommodated without the need for remedial action.

The slabs however, are usually quite lightly prestressed with tendons in one direction only at approximately 1500 mm centres. Reasonable size openings or large slots are therefore easy to accommodate without the need to cut post-tensioning tendons.

3.2.2 Flat Slabs and Flat Plates

For structures requiring minimum floor to floor height and regular grids the two-way post-tensioned flat slab is usually the most cost effective solution.

The normal installation procedure would concentrate the tendons into 'column strips' along the column grids at approximately 600 mm centres with tendons away from the column strip at approximately 1400 mm centres.

Consequently small holes for services could be located without the need to cut tendons.

Using this structural system it is possible to leave the central panel as traditionally reinforced

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and designed as a 'soft zone' to easily accommodate large openings. The cost penalty for the extra reinforcement required would need to be offset against the perceived benefits.

3.2.3 Ribbed and Waffle Slab

Larger grids or heavier loads may dictate the introduction of ribs spanning either one-way or two-way (waffle) depending upon the aspect ratio of the grid.

Rib spacings for post-tensioned slabs are generally larger than for reinforced concrete, being typically 1.2 to 1.5 metres. Consequently small to moderate holes can easily be cut through the topping slab without disturbing the ribs. Indeed with tendons confined to the ribs their location is readily identifiable, assisting in the siting of the openings.

4.0 CUTTING OF TENDONS

4.1 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 600 to 800 mm.

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

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). A typical detail successfully used in Australia on many Projects is shown in Appendix A. A drawing showing how a to create an internal stair linking two floors is also in Appendix A.

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.

4.2 Unbonded 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.

Note that this form of post-tensioning is not allowed in suspended slabs in Australia and therefore problems associated with cutting unbonded tendons are not applicable.

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When contemplating the cutting of an unbonded tendon it is therefore necessary to consider the aspects as noted below.

4.2.1 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.

4.2.2 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.

4.2.3 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 restressed, thus restoring full structural integrity. The above operations are not difficult but will require the expertise of a post-tensioning sub-contractor.

5.0 DEMOLITION OF POST-TENSIONED STRUCTURES

In the case of post-tensioned structures using bonded tendons, demolition can be carried out using techniques similar to those used to demolish reinforced concrete structures. Due to its induced compression the concrete is significantly harder and whilst tendons are made from high tensile strand there is considerably less steel to cut and generally concrete sections will be thinner than comparable reinforced concrete structures.

Only in the case of transfer slabs or beams, which have been progressively stressed, must extra precautions be taken to avoid upward bursting of concrete as the self weight of the structure above is progressively removed.

The cutting of unbonded tendons may result in dramatic collapse of a structure, but properly considered, can be used to advantage, enabling rapid demolition of large areas as the force in the supporting tendons is released.

6.0 CONCLUSION

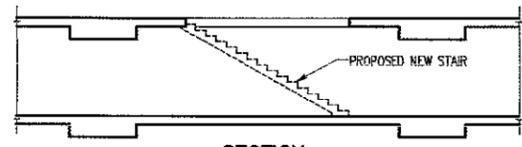
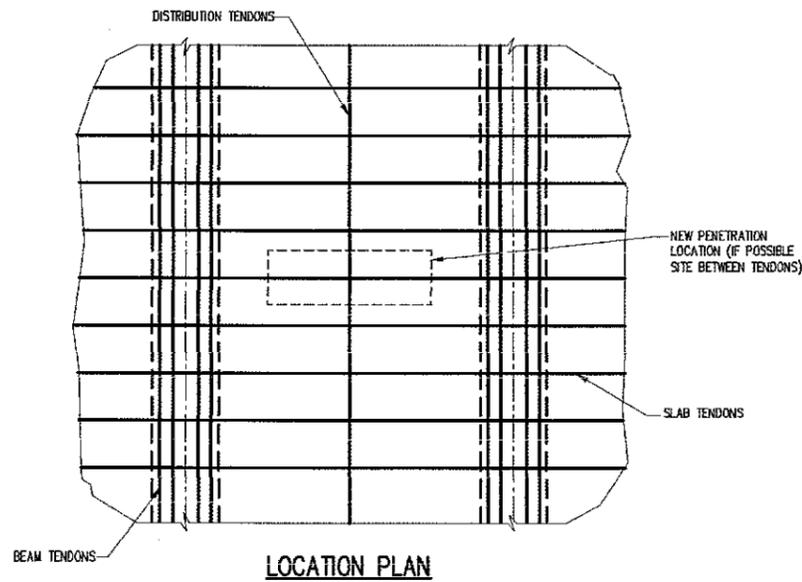
It is not uncommon for post-tensioning to be rejected in certain types of building project due to a perceived lack of flexibility. This, in the majority of cases, is based more on a fear of the unknown than on sound technical knowledge.

With a little forethought it can be seen that post-tensioning need not mean a dense mat of tendons in all directions. Tendons are usually spaced sufficiently far apart to allow penetrations of reasonable size to be made later, without cutting through the tendons.

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Where there is a reasonable possibility that a penetration may be required in the future, slabs can be built with `soft zones' to allow later perforation by voids without cutting tendons.

Should it be necessary to cut tendons this can easily be achieved using well established methods and in short, whilst the modification of a post-tensioned slab may require more planning than other forms of construction, its use will present the client with a building which is both economical to construct and flexible for its life.



SECTION
DIAGRAM FOR STEP 2

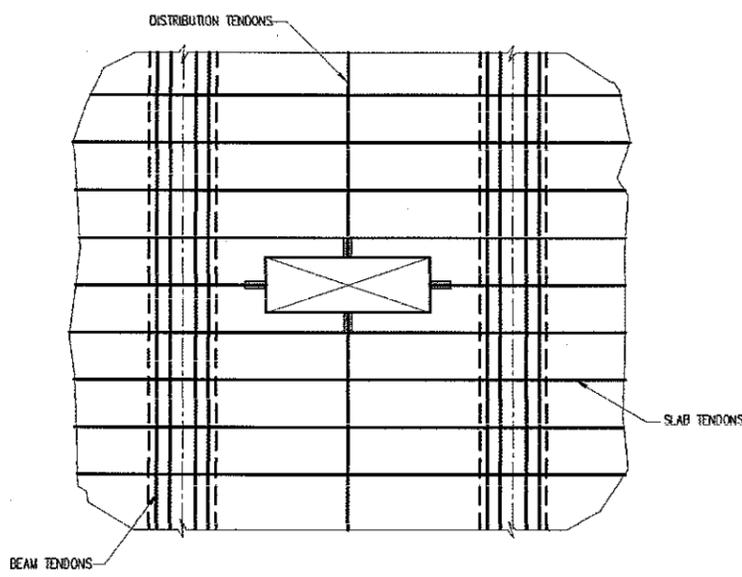


DIAGRAM FOR STEP 5
TERMINATED TENDON
(REFER TO DETAILED PROCEDURE)

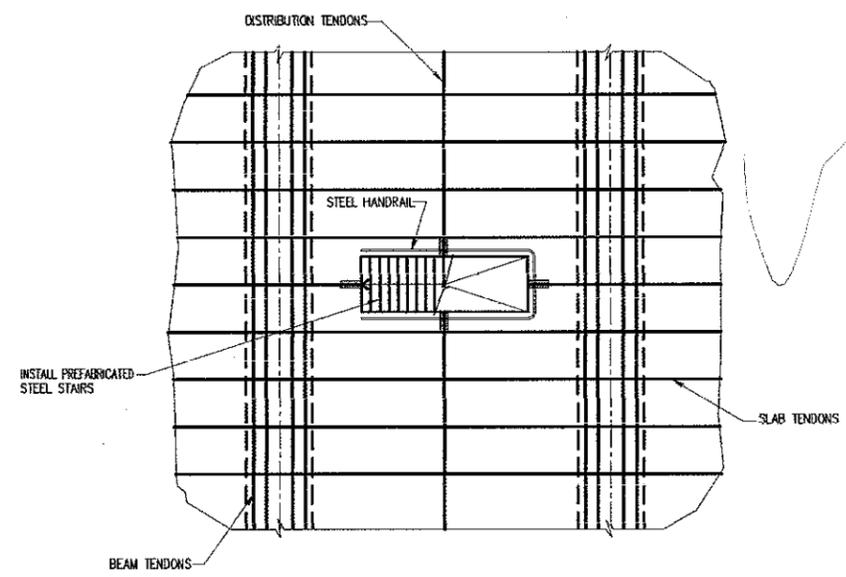


DIAGRAM FOR STEP 6

1. INSTALL ANY BACKPROPPING AS REQUIRED BY THE STRUCTURAL ENGINEER.
2. MARK OUT THE CABLE POSITIONS ON THE TOP SURFACE OF THE SLAB.
3. BREAK OUT CONCRETE TO FORM A POCKET AS SHOWN BELOW:-

4. REMOVE THE DUCT ALONG THE 600 mm LENGTH.
5. CHIP AWAY ALL GROUT AROUND THE INDIVIDUAL STRANDS WHILST ENSURING THAT THE STRANDS ARE NOT DAMAGED.
6. INFILL THE POCKET WITH AN EPOXY MORTAR AND ALLOWED TO CURE.
7. CUT THE TENDON AT THE 'LINE OF CUT' AND REMOVE THE CONCRETE.

TENDON TERMINATION DETAIL

STEP 1.
THE STRUCTURAL ENGINEER CHECKS THE PROPOSED PENETRATION LOCATION AND ADVISES ANY ADDITIONAL WORK REQUIRED, SUCH AS TRIMMER BEAMS, AS IS THE CASE FOR REINFORCED CONCRETE.
WHERE POSSIBLE THE PENETRATION SHOULD BE LOCATED TO MINIMISE THE EFFECT ON THE SURROUNDING STRUCTURE.
WITH GOOD PLANNING IT MAY WELL BE POSSIBLE TO LOCATE THE PENETRATION TO MISS ANY POST-TENSIONING TENDONS.

STEP 2.
IN THIS INSTANCE WE WILL LOCATE A PROPOSED STAIR OPENING OF APPROXIMATELY 4.5m LONG BY 1.5m WIDE IN THE MIDDLE THIRD OF THE SLAB SPAN.

STEP 3.
THE PROPOSED PENETRATION LOCATION IS MARKED ON THE TOP SURFACE OF THE SLAB.
THE TENDONS IN THE VICINITY OF THE PENETRATION ARE LOCATED. THIS IS DONE BY LOOKING AT THE SOFFIT OF THE SLAB FOR THE STAPLES USED TO SECURE THE DUCTS TO THE FORMWORK.
AT TIMES, THE SOFFITS CAN BE MARKED WITH TENDON LOCATIONS IMMEDIATELY AFTER FORMWORK STRIPPING TO SIMPLIFY THIS TASK.

STEP 4.
TENDONS CROSSING THE PROPOSED PENETRATION NEED TO BE TERMINATED IN ORDER TO PROVIDE FULL CORROSION PROTECTION, AS DO ANY REINFORCING BARS CROSSING THE PENETRATION.
A TYPICAL TERMINATION DETAIL USED SUCCESSFULLY MANY TIMES IS SHOWN ADJACENT.

STEP 5.
THE CONCRETE WITHIN THE ZONE BORDERED BY THE PROPOSED PENETRATION CAN NOW BE REMOVED IN THE NORMAL MANNER.
THIS PROCEDURE IS OFTEN EASIER THAN FOR REINFORCED CONCRETE DUE TO THE LACK OF CONVENTIONAL REINFORCEMENT THAT IS REQUIRED TO BE CUT.

STEP 6.
INSTALL PREFABRICATED STEEL STAIRS. IF INSITU CONCRETE STAIRS ARE REQUIRED IT WILL BE NECESSARY TO EPOXY STARTER REINFORCEMENT INTO THE EXISTING SLAB, AS IS THE CASE FOR REINFORCED CONCRETE.
INSTALL HANDRAILS AROUND STAIR OPENING.

Appendix 'A'

Rev	Date	Drawn	Checked	Description

Project: **POST-TENSIONING STANDARD DETAILS FOR CONSTRUCTION**

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Title: **ADDITION OF A STAIR LINKING TWO POST-TENSIONED FLOORS**

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