POST-TENSIONING INSTITUTE
OF AUSTRALIA LIMITED

ENSURING EXCELLENCE AND ACCREDITATION FOR THE POST-TENSIONING INDUSTRY
Post-Tensioning Institute of Australia Limited ABN 86 121 218 228 PO Box 861, Five Dock NSW 2046
T: 02 8765 6199 F: 02 9743 4013 E: info@ptia.org.au W: www.ptia.org.au

Mono-strand Post-tensioning of Concrete Buildings

PTIA Guidance Note
GN05/v.2
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Stressing should only be carried out by experienced personnel who have been assessed as competent to operate stressing equipment and have acquired knowledge of all safety requirements necessary during the stressing operation.

FOREWORD

This Guidance Note has been produced by the Post-tensioning Institute of Australia to provide employers, self-employed persons and employees with practical advice on safe Mono-strand Post-tensioning of concrete buildings. It has been produced as a general guide in the correct methods of installing, stressing and grouting of a Mono-Strand Post-tension System.

This Guidance Note is not intended to be a comprehensive specification regarding site safety, handling, installing, stressing, and grouting of the Post-tensioning system. Post-tensioning contractors and employers are obliged to implement and maintain their own Safety Management Plans and Safe Work Procedures and ensure their employees are familiar with these systems.

1. Introduction

The Post-tensioning Institute of Australia recognises the need for assistance in providing the Post-tensioning industry with information in order to improve workplace quality and safety – hence this Guidance Note has been produced to provide employers, self-employed persons, employees, principal contractors, suppliers of components and others involved in using Mono-strand Post-tensioning systems with practical advice on the safe Mono-strand Post-tensioning of concrete buildings.

All Post-tensioning components must be certified to AS/NZS 1314: Prestressing Anchorages.

The Workplace Health & Safety Act, specifies a person conducting a business or undertaking has a primary duty of care to ensure, so far as reasonably practicable, the health and safety of workers at work in the business or undertaking. This duty of care includes providing information, training and instruction to protect persons from risks to health and safety arising from work. To facilitate this obligation, along with producing this guidance material, the PTIA offers training and assessment for the national unit of competency CPCCSF3002A Carry out Mono-strand Post-tensioning.

Contributors to this Guidance Note include:

- Post-tensioning Institute of Australia;
- Australian Prestressing Services Pty Ltd;
- Australian Post-tensioning
- Structural Systems Group.

2. Purpose

This Guidance Note sets out practical guidelines designed to prevent injury to persons engaged in, or in the vicinity of, the process of mono-strand post-tensioning of concrete buildings.

3. Scope

This Guidance Note applies to Mono-strand Post-tensioning and does not apply to:

- multi-strand post-tensioning;
- post-tensioning of civil structures, such as dams, bridges;
- rock anchors; or
- prefabricated pre-tensioned components.

4. Definitions

"Additive" A material that may be added to a cementitious grout to alter its properties.

"Anchorage" The components at the ends of Tendons that combine to transfer the force from the Tendon to the structure.

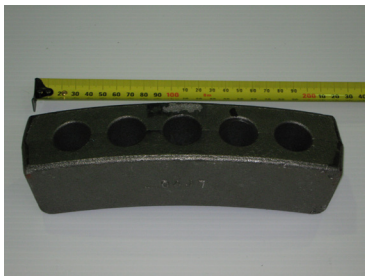
"Antiburst" (or Antibursting Reinforcement)-a non-stressed steel deformed bar (usually turned into a spiral) that is placed over the end of each Tendon.

"Bar" (or Stress Bar)-high tensile Bar used in Post-tensioning Tendons.

"Barrel" A cylindrical steel component fitted over an individual strand that bears against the anchor casting. This component is used in conjunction with wedges.

"Bleed" Water that emerges from newly place grout. This is caused by the settlement of the solid materials within the grout and the filtering action of the strands.

Block a metal component with multiple conical holes that fits over multiple strands.



Bonded Tendon Tendons (strand or bar) that are bonded to the structure by grouting.

Bripac A metal frame that is secured around a coil of strand to allow dispensing of the strand.

Calibration Certificate
A mandatory document that is matched to a particular stressing Jack, which states the stressing pressures and loads.

Cementitious material
Materials having cementing properties.

Competent person
Means a person who an employer ensures has acquired through either, training, qualification, or experience or a combination of those, the knowledge and skill enabling that person to correctly perform the task required. i.e. Cert III in Post-tensioning or CPCCSF3002A Mono-strand Post-tensioning.

Compressive Strength
This is the strength of the concrete under compression and is determined by the "crushing" of test cylinders. Specific Compressive Strengths must be achieved before stressing can commence.

Construction work
As defined in the Workplace Health and Safety Regulations clause 289 - any work carried out in connection with the construction, alteration, conversion, fitting-out, commissioning, renovation, repair, maintenance, refurbishment, demolition, decommissioning or dismantling of a structure..

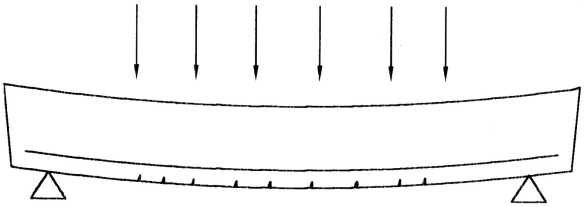
Coupler/Coupling
The means by which one Prestressing Tendon may be attached to another Tendon in an adjoining slab

Four strand Coupler block

Curved Nose A stressing devise used when stressing pans to deflect the strand at an angle.

Dead End The end of a Tendon which is anchored in the concrete beam or slab whilst stressing takes place from the opposite end. Dead Ends may be of a Swaged or Onioned Type. No stressing takes place from a Dead End.

Defection When a beam or slab sags under load



Denso Putty/Tape
A product used to seal the ends of a Tendon to stop concrete slurry entering the duct.

Design Engineer
The person/company engaged by the Principle contractor to prepare the design for the project.

Dogman Designated worker that controls crane movements. He is responsible for securing and directing the movement of loads to be hoisted by the crane.

Dry Pack Generally, a mixture of sand, cement and water. A limited amount of water is added to the dry ingredients so as when the product is packed into a stressing recess the Dry Pack dose not slump. The project specifications should be checked for any special requirements such as the type of product to use and coatings for the components e.g. Cold Gal.

Duct A round or oval shaped metal conduit that encases the strand.

Elongation An addition to the length of strand by way of stressing.

Employee representative
Represents the employees in relation to health and safety matters at their place of work. Includes an employee member of a health and safety committee or a person elected by the employees at a place of work to represent them on health and safety matters.

Grout A mixture of cement, water and Additives.

Grout Vent A metal or plastic fixture attached to a Tendon to allow grout to be pumped within.

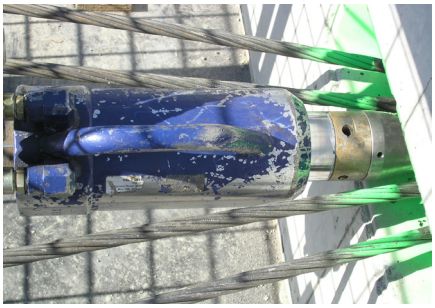
Grouting The pumping of a cement grout into the duct from one end to the other.

Initial stress A relatively low stressing load which is applied to the Tendons soon after the concrete has set. This initial stress is designed to prevent or minimise shrinkage cracking in the concrete.

Jack The Jack is a hydraulically operated piece of equipment that grips the strand and stretches it by bearing on the anchorage.

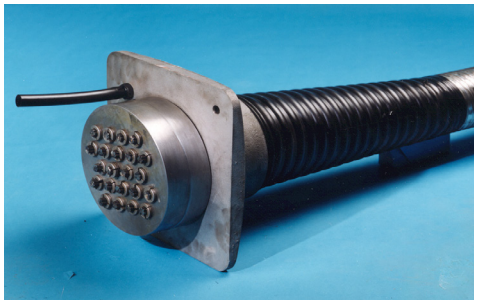
Live End The end of the Tendon from which stressing is done.

Mono-strand stressing
The system of stressing concrete members by means of applying hydraulic force to each strand individually and progressively transferring the load to the concrete. It is often referred to as a “slab system” because it is ideally suited to the floor slabs of buildings. This is the system referred to in this Guidance Note.



Multi-strand stressing

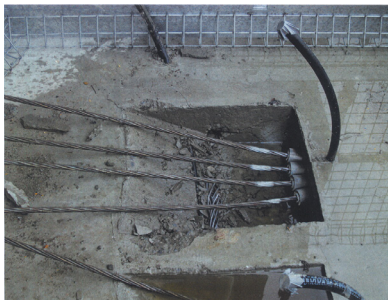
(Not covered in this Code). The system of stressing concrete members by means of applying the load simultaneously to all strands. Multi-strand post-tensioning is mainly used in large structures such as dams and bridges.



Onion/Onion Head

Is produced at the end of a length of strand by deforming it into a bulb.

Pan A removable recess located in the top of a slab to allow stressing access.



Parging The act of using Dry pack to seal recess pockets.

Post Tensioning

A method of stressed reinforcement which the Tendons are tensioned after the concrete has reached a specific strength.

Potable water

Drinking water.

Pre-tensioned

(Not covered in this Code) The process of placing concrete around pre-tensioned steel strands with subsequent transfer of the load to the concrete once it reaches a specified strength. This is usually used in factory production of pre-cast members such as beams, panels and columns.

Principle contractor

The person or Company that has entered into a contractual agreement with the owner to construct the project. They have the responsibility for the overall construction of the project.

Profile

Refers to the drape or the height of the Tendon above the formwork. Chairs are secured to the underside of the Tendon at specified heights to form a Tendon profile.

Slurry

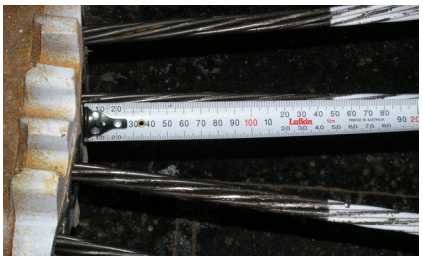
A cementitious liquid.

Strand

Refers to a length of cable within a Tendon.

Strand Extension

A measurement of the strand after stressing. Measuring the Elongation.

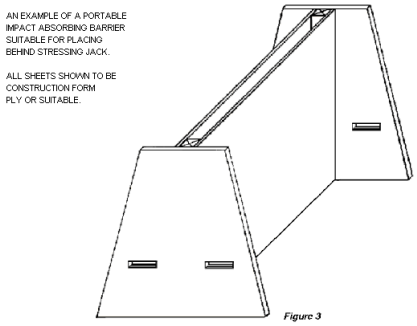


Strand Pusher (Sometimes referred to as a Cable Pusher) An electric machine that pulls cable from a coil and pushes it into a Tendon.

Stressing The process of applying load to the strands. Pre-stressing of concrete includes pre-tensioning and post-tensioning.

Stressing Barricade

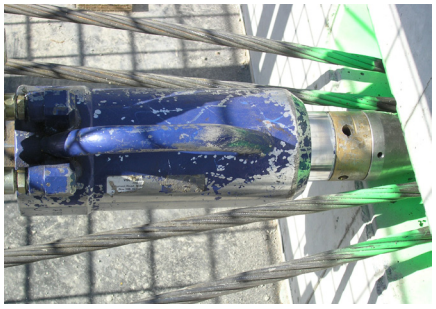
(Or Backing Board) A safety device made of two layers of ply wood placed behind live end Tendons during stressing.



Stressing operator

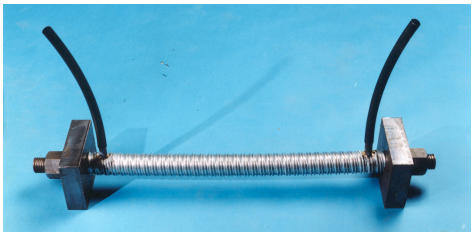
Person suitably trained and nominated by their employer to operate the stressing equipment.

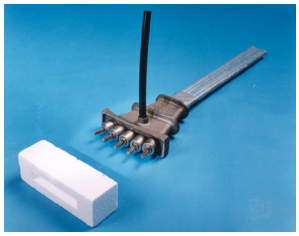
Stressing Jack A hydraulic ram that is fitted to and stresses cables and Bars.



Sub contractor A person or Company that is engaged by the Principle contractor to provide selected or specialised construction activities.

Tendon A single or group of prestressing elements (E.G. strands) and their anchorage assemblies, which include duct, attachments and grout.





Transfer Strength

The minimum compressive strength that the concrete must have reached before Final Stressing as defined by the Engineer.

Wedge

A conically shaped device, usually used in sets of two to three, that fit around the strand and into a block or barrel.

5. Planning and preparation

The first essential step in ensuring work is done safely is to plan and prepare for it. Planning and preparation should be done in consultation with those engaged in all aspects of the work, including, suppliers, design engineers, principle contractors, safety officers, project engineers and employee representatives.

Consideration should be given to other trades working in the immediate area.

If post-tensioning is to be done, consideration should be given to the following:

a. When planning for the provision of scaffolding and perimeter safety screens ensure that they are suitable and safe to use for the intended purpose. In particular ensure that:

- stressing operators do not have to work between the Jack and the Stressing Barricade during stressing;
- scaffold working platforms are at the appropriate level for stressing;
- enough space has been left for the Jack extension during stressing; and
- scaffolding can accommodate or incorporate Stressing Barricades as described in *Appendix: Stressing Barricade construction*. (Usually a minimum of 800mm between the slabs edge and the outside scaffold rail).

b. Provision of safe and appropriate access to all working areas for workers, materials and equipment. Taking into account that the workers may need to carry materials and equipment.

c. Design and erection of formwork to ensure that it provides adequate support for the placement and movement of coils of strand (approximately 3 tonnes in weight and 1500mm diameter) as well as all other construction loads.

d. All site personnel are aware that Post-tensioning works are being carried out on the project and have been made aware of the risks. The Principle Contractor should incorporate Post-Tensioning Hazards into their site specific inductions.

e. Only change the design layout or installation method with approval from the design engineer.

6. Communication

Communication is a vital tool to ensure others working in the immediate area aren't put at risk by post-tensioning procedures and that the works by others don't adversely affect the post-tensioning operatives.

Verify with the Formwork Supervisor where to safely load the formwork with Post-tensioning components - Anchors, Tool Box, Duct, Coil of Strand (approximately 3 tonnes).

Verify with the Formwork Supervisor that the formwork deck is clear and ready for installation and that all penetrations, lift shafts, service ducts and stair wells are guarded and have adequate fall protection in place.

Verify with the Steel Fixing Supervisor that the first layers of non-stressed reinforcement are in place and that the installation of Tendons can commence.

7. Safe Work Practices

7.1 Scaffolding

Operators involved in the installation, stressing and grouting of post-tensioning systems perform a lot of their work on the perimeter of the slab and building. It is vital that a safe working platform and fall protection is in place, not only for the safety of the people carrying out the work but for the safety of those below.

Operators who intend to use a scaffold should first check that it is safe to use. Scaffolds should be tagged by a competent person to confirm 'safe to use' and constructed in accordance with design or method requirements. Specifically, scaffolds must be fully boarded and with guard rails (top and mid) and toe boards in place, be correctly braced and tied-back. They must also have a safe access fitted. There should be sufficient space for a Stressing Barricade to be erected at each live end Tendon and enough clearance for the Jack to extend during stressing. The scaffold should be kept clear of unnecessary tools and debris, and should not have any unplanned forces put on it.

7.2 Material Protection

During the Stressing procedure high loads are stressed into the Post-tensioning Tendons. It is important that the materials used are protected from damage at all stages of the process.

To prevent corrosion, kinks and notches, coils of strand should be adequately stored at all times during transport and storage periods.

Do not drag coils of strand this will damage the outer layer of the coil.

Coils of strand should be stored vertical and undercover or suitably covered to reduce the likelihood of corrosion.

Coils of strand should be chocked to prevent rolling.

Under no circumstances should any prestressing materials be subjected to electrical currents, welding splashes or excessive heat as this may damage the strand.

Anchorage components must be protected from dirt, corrosion and mechanical damage.

Ducting should be stored to prevent dents and kinks.

7.3 Setting up the Coil of Strand

Check that the coil of strand to be used, complies with the specifications. If the coil of strand is in anyway damaged (e.g. broken straps or lopsided) notify the supervisor before attempting to handle as there is a risk of collapse.

The hooking and lifting of the coil must be controlled by a suitably qualified person.

If the coil is to be placed on a suspended slab, verification must be obtained from the Principle Contractor or Formwork Supervisor, where the coil is to be placed is suitable and capable of carrying the weight of the coil.

When the designated area has been checked and declared structurally sound, the coil of strand can be placed, by the Dogman, in the designated area. This should be as close to the anchorage locations as possible, taking into account the bend radius that the strand can follow.

Before removing the straps, from the coil, place a Bripac around the coil of strand with the front being placed on the same side of the coil from which the strand will be fed. In the case of a solid Bripac, the pack is to be placed in the designated area with the Dogman then lifting the coil into the Bripac.

Ensure the coil of strand is securely maintained within the Bripac. Ensure the stabiliser bars have been placed in the Bripac, all of the securing nuts have been tightened and the tail of strand is located and restrained prior to cutting and removing the straps, using tin snips. DO NOT USE AN ANGLE GRINDER TO CUT THE STRAPS. Be aware that the straps may kick out when cut, and that the ends are very sharp.

Wear gloves when handling strand, and straps. Clear cut straps and scrap strand into a skip as soon as possible after cutting.

7.4 Installation

Before commencing any installation check that the drawings are the latest issued and approved for construction.

A. Anchorages

Only anchorages which have been tested and certified to the Australian Standard AS1314 are to be used. Check there are no penetrations in the concrete near the anchorages that may lead to concrete failure during stressing.

Set out the anchorage/dead end locations, drill the fixing bolt holes and cut the slots for strands to protrude through the edge formwork at the appropriate positions as detailed on the Post-tensioning drawings. Attach the anchor to the edge form. These locations should be checked for accuracy and never relocated from their designated positions without specific written approval from the design engineer.

Make sure Anti-burst reinforcement is in place, check that it is in accordance with the drawings.

Pans may need to be installed for internal stressing access to the slab. In this case, fix an Anchor to the Pan and secure the Anchor/Pan assembly at the appropriate positions as detailed on the drawings.

B. Laying Duct

Insert ducting up to 50mm inside the anchorage, to ensure that grout holes are not obstructed, and cables can be spread easily when blocking up for initial stressing, use duct tape to secure in position.

The ducting is joined by inserting its normal end into a flared end (bell end). Ensure that the bell end is facing the direction from which the strand will be pushed (to prevent cable catching on the joints).

Trim the ducting to allow for bond length on dead end (this ensures an adequate bond between the strand and the concrete). This dimension will be detailed in the Post-tensioning details of the drawing.

During the duct installation check for dents, splits and kinks, and replace any damaged sections if necessary. Adequately tape all joints on completion of the installation.

C. Pushing Strand into the Duct

Place exclusion zones and caution signs where the strand will be travelling, from the coil to the Strand Pusher.

Place the Strand Pusher on a sound base in front of the anchorage/ducting.

Pull the strand from the Bripac and manually feed it through the Strand Pusher until the leading end of the strand is inserted into the mouth of the anchorage or Dead end/duct.

Check the far end of the Tendon to ensure that the second man of the pushing team is in position ready to give the signal when the strand exits from the Tendon at his end, and that nobody is standing in direct line with the strand exit point.

When the strand emerges from the far end of the ducting the second team member should give a pre-arranged signal that the strand has emerged from the far end (normally 'hand up' means run, 'hand down' means stop). Stop the pushing machine and release the strand.

Using the second team member as a guide manually manoeuvre the strand into the correct previously determined position, and using an angle grinder cut the strand between the Strand Pusher and the anchorage at the pre-designated cutting mark. If using an angle grinder, cut from right to left away from the body, make sure you have a stable position and wear goggles and gloves. Be aware that occasionally the strand end may unwrap suddenly after cutting.

Repeat the above procedure until the correct amount of strands, as designated on the drawings for that deck/slab and Tendon, are installed.

D. Forming Dead Ends

There are two forms of anchoring a Dead End within a Tendon;

1. Onion Dead Ends are formed by deforming or compressing the strand into an "onion" bulb using a hydraulic ram.

   NOTE: anti-burst is required prior to "onioning" dead ends.

The strand to be onioned, should be placed into the onion forming machine (known as an Onion Jack) so it is centrally located between the gripping jaws and firmly fitted into the dolly at the end of the ram.

Push the gripping jaws lever, on the Onion Jack, forward so the strand is held securely. Place the hydraulic pump's control valve into the pressure position. Turn on the hydraulic pump and switch it off again when the dolly in the onion heading machine has moved the required distance to form a correctly shaped and dimensioned onion head. Usually between 60mm and 90mm diameter.

When using an Onion Jack keep fingers clear of the hydraulic ram and always wear safety glasses in the event that a wire within the strand breaks and propels away from the ram.

2. Swaged Dead Ends are formed by compressing a barrel & wedge onto the end of the s strand using a hydraulic ram.

   NOTE: anti-burst is required prior to Swaging dead ends.

The strand to be swaged, should have a barrel & wedge placed around the end of the strand (the wedges within the barrel taper should be facing the end of the strand, i.e. the non-stressing end). Place the strand/barrel/wedge assembly into the Swaging Jack so that it is centrally located.

Assemble the hydraulic equipment. Check to see that the Jack and gauge have identification markings and that those markings correspond to the calibration sheet. Check the Swaging pressure required by referring to the calibration sheet.

Place the hydraulic pump's control valve into the pressure position. Extend the ram on the Swaging Jack until the stated pressure has been achieved. Return the ram on the Swage Jack.

When using a Swaging Jack keep fingers clear of the hydraulic ram and always wear safety glasses.

E. Profiling Tendons

Tendons are given a profile to provide uplift between supports.

The Tendons are generally profiled by, placing metal or plastic chairs of varying heights under the duct as shown on the Post-tensioning drawing.

From the Post-tensioning drawings locate the positions and heights of the profile points. Never relocate or change the profile points of a Tendon from the details as shown on the drawings without specific written instructions from the design engineer. Changing profile points will introduce different forces into the concrete.

Place the appropriate size duct support chair/profile bar in the designated position under the ducting and Dead End locations.

Align the cable to the correct position as detailed on the construction drawings and secure it in place, by stapling the duct chairs to the formwork or fixing the duct to profile reinforcing bars. This ensures the Tendon isn't displaced during concrete placement. Note: Staples can be Galvanised or Stainless Steel type. Stainless Steel Staples should be used for all exposed concrete soffits.

Insert grouting points at the live and dead end of a Tendon and seal the Tendon for any ingress of concrete slurry.

Check that ducts are not damaged or moved during subsequent reinforcement fixing, or from site personnel traversing the site.

7.6 Concrete Placement

During concreting it is important to have a representative of the stressing contractor and a representative of the Principal Contractor present to ensure that the post-tensioning system is not damaged or displaced. The representative from the post-tensioning contractor is responsible for repairing any damage to the Tendons during the concrete pour.

It is essential that any damage to the post-tensioning system be reported directly to the Principle Contractor and the appropriate remedial action taken.

Responsibilities During Concreting:

Concreting Contractor

- use chairs or other means to support concrete pump lines above the reinforcement and Tendons;
- if a kibble is used to place concrete, care should be taken to ensure the Tendons are not displaced by dropping the concrete in one place only. Concrete should be allowed to flow from the kibble in a controlled manner;
- ensure the Post-tensioning Tendons are treated with care and not damaged;
- check that the concrete is placed in a manner to prevent the ducts from moving;
- Ensure the concrete is placed, well compacted and vibrated around the anchorages;

Post-tensioning Contractor

- check the grout vents are not displaced;
- check the ducts are treated with care and not damaged;
- check that the concrete is placed in a manner to prevent the ducts from moving. Stop the pour if required for rectification;
- check the concrete is placed properly and well compacted and vibrated, especially around the anchorages;
- check inside the anchorages, and clear any concrete slurry that may have entered; and
- ensure that the grout vents/tubes do not get buried and that they are clear.

7.6 Stressing

Inspections

Clean any deleterious material that may be on the anchorages and strands, E.G. concrete slurry. Check the concrete is of good quality near the anchorages. In particular, check there are no voids or honeycombing around the anchorage/dead end locations.

Slide the stressing components, barrels/blocks/wedges, over the strands. Check each component to ensure they are clean and free from grit and they show no signs of flaws and the wedges are free to move inside the taper of the barrels and blocks.

Before commencing any stressing operation check the drawings are the latest issue and approved for construction.

Check the Stressing Notes on the Post-tensioning drawing. These notes will detail a stressing sequence if required (which will include Initial Stressing and Final Stressing), stage stressing if required, the transfer strength of the concrete required before stressing, and the designated loads for which the Tendons are to be stressed.

Check that the concrete has attained the specified compressive strength. Never commence stressing if the concrete has not reached the required compressive strength without specific written approval from the design engineer. **Early age Concrete test cylinders used to verify concrete transfer strength for stressing should be "match cured" to the concrete slab i.e. they should be subject to the exact atmospheric conditions as the slab and NOT put into a water curing bath.**

Check to see that the Stressing Jack and Gauge have identification markings and that those markings correspond to the calibration sheet. A copy of the calibration sheet should be kept with the Jack and Gauge at all times. The calibration sheet should carry the following information:

- final stressing pressure;
- the diameter and grade of strand for which the Jack is being used;
- jack number;
- gauge number; and
- The date calibration expires.

Check to see that the Stressing equipment is in good working order by ensuring:

- all hydraulic fittings are correctly tightened;
- hydraulic lines are not damaged or kinked;
- jack jaws are of the correct size, are clean, lubricated and don't show signs of excessive wear.
- extension noses and curve noses show no signs of excessive wear and the rebates aren't distorted and are a minimum 7mm deep and have a clear path for the strand to travel through.

Ensure a Curved Nose is used on all pans being stressed. This will minimize the amount of friction during the stressing operation and prevent the strand from excessive damage at the stressing end.

Before stressing ensure the block is fully seated against the face of the anchorage and the strand is marked with paint, to measure strand extensions after stressing.

Initial Stressing

During initial stressing it is essential that:

- the stressing is carried out according to the method and schedule determined by the design engineer;
- the stressing is carried out to the load requirements on the Post-tensioning drawings;

- the operator ensures a person (directed by the operator) is always present at the non-Jacking end of double live end Tendons to check that the anchorage blocks and wedges are correctly seated and to advise the operator and warn other site personnel to keep clear; and
- the operator should then check the seating of the anchorage components and adjust if necessary.

Initial stress must be carried out to the load requirements on the Post-tensioning drawings. This is usually 25% of the final stress load on any single strand.

Never exceed the specified Initial Stressing load on any single strand. Never over stress a single strand to compensate for not stressing another.

Initial stress to less than 30% of Final stress load does not require flagging or a Stressing Barricade.

Final Stressing

Do not commence final stressing until:

- Barricades which meet the specifications given in Appendix: Stressing Barricade construction, are erected at all live ends of Tendons being stressed. In the case of double live end Tendons, ensure that Stressing Barricades are erected at both ends even if only stressing from one end;
- the stressing area (including both ends for double live Tendons) must be appropriately flagged and warning signs displayed;
- the operator has checked the area, to be stressed, has been cleared and the person ttaching the Jack (swinging the Jack) onto the strand is not standing between the Jack and the Stressing Barricade and is working in a sequence that allows him to work away from the strands previously loaded;
- the operator has checked the area is clear and there is no person standing between the Jack and the Stressing Barricade or no unauthorised persons standing within 5 meters of any live end anchorage being stressed;
- the operator has checked that no one is standing between the Jack and the hydraulic pump, or on the hydraulic hose;
- the operator has ensured that there are adequate clearances available for the Jack, to prevent possible skewing or lifting during stressing;
- the operator has informed other workers in the immediate area that stressing is to commence; and
- that concrete compression tests indicate the transfer strength has been achieved. This advice should be confirmed in writing.

During final stressing it is essential that the operator:

- does not stand or allow any other person to stand between the Jack and the Stressing Barricade;
- does not allow any person to stand on top of an Anchor being stressed or directly behind an Anchor being stressed;
- never strikes the Jack with a hammer or other implement when the Jack is under load;
- ensures the gauge pressure does not exceed the Final stressing pressure noted on the Jack Calibration Sheet; and
- ensures a person (directed by the operator) is always present at the non-Jacking end of double live end Tendons to check that anchorage blocks and wedges are correctly seated, advise the operator and to warn other site personnel to keep clear. This person should not stand directly in line with the Tendon being stressed, while observing.

- note any observation of concrete distress near an anchorage, stressing is to stop immediately and be reported to the design engineer.

The stressing equipment must not be left unattended by the operator unless the Jack has been disengaged from the strand and the power supply disconnected from the hydraulic pump. It is recommended that flagging and warning signage be left in place for 30 minutes after stressing to ensure no one stands between the stressed Tendons and the Stressing Barricades.

If no initial stressing has taken place, the strands should be tensioned first to a low load and the following checked before further stress is applied:

- the seating of the anchorage components; and
- location of Jack and Jack clearances.

The extension of each strand must be accurately measured, recorded and reported to the engineer.

7.7 Cutting and Sealing

Do not cut strands until approval has been given by the engineer. Verbal approval should be confirmed in writing as soon as possible.

Check that when the strand ends are cut off they cannot fall to a lower level and take the necessary precautions to prevent this from occurring.

Check the project specifications for cover requirements and sealing products prior to cutting the strands. If not specified, then a minimum cover of 25mm is to be achieved between the cut strand and the outer face of the filled pocket.

Check the block-outs to be dry-packed/parged to ensure they are clean and free from any material that may prevent the dry-packing mixture from adhering to the inside of the anchorage recess.

Using a shovel, mix the sand and cement thoroughly whilst adding sufficient water to the mix, until a very dry mix is obtained. (Too much water will cause the mixture to slump in the block-outs).

Push in small amounts of the dry-packing mix into the block-out and pack it in tightly using a rammer until the block-out is full.

Finish the face of the block-out per contract requirements.

7.8 Grouting

Grouting of the Post- tensioning Tendons is an important phase of the Post-tensioning operations. It prevents corrosion and provides bond between the pre-stressing steel and the concrete. If not properly grouted the pre-stressing steel could corrode, leading to failure of the Tendon and possibly the structure, furthermore, ungrouted Tendons will not achieve the nominated design strength of the structure. It is therefore important that the grouting operations are carried out under the direct supervision of trained, experienced personnel.

Before Grouting:

- check the project specification for the water/cement ratio by weight of the grout;
- check the project specification requirements for grout additives and grout sample testing, and ensure the correct additive and equipment is available;
- check there are enough water supplies to carry out the grouting operations and it is suitable for grouting. Generally if the water is not suitable for drinking it is not suitable for grouting;
- check that the Parging of the block outs has been carried out in such a manner that the grout cannot leak from the anchorages;
- check that the grout vents are clear and undamaged. If they are blocked clear them before commencing the grouting operations;

- if required by the project specifications flush out the Tendons with compressed air. Do not point a compressed air hose at any person. Wear ear and eye protection when using compressed air;
- check the grout bowl, of the Grout Pump, is clean and free from debris before use;
- check that guarding is fitted to all moving parts and rotating shafts on the mixer, and covering the grout bowls on the Pump;
- check the grout hoses are capable of withstanding the required grouting pressure; and,
- check that the necessary PPE is available for the grouting pump operator, the grout Pumping operator and the grout bucket operator: goggles, gloves, long sleeve shirt and trousers. Grout can cause skins burns and is particularly damaging if it enters eyes.

During Grouting:

Carry out any required quality control tests (e.g. bleed or flow tests) or sampling (e.g. cube or cylinder tests).

With horizontal Tendons the grout can be injected from any one end, whilst in vertical or slightly inclined Tendons the grout should be injected from the lowest end.

The grout injection should be a continuous one-way flow of grout for any one Tendon with successive grout vents in the direction of the grout flow being closed when the grout expelling from that grout vent is the same consistency as that being injected. The Tendon should be grouted in one continuous operation.

When the grout expels the same consistency of grout from the furthest grout vent away, as injected from the injection point the Tendon is full.

Close off the last grout vent from which the grout expelled.

Clean up any grout spillages immediately before it starts to set.

DO NOT return expelled grout from the Tendons back into the Grout Pump. Tendons sometimes contain rain water, this would then unbalance the measured grout mixture.

When a blockage in a Tendon occurs during Grouting, the Tendon should be flushed out with clean water. If the blockage remains, then a series of inspection points must be drilled into the Tendon to locate the blockage. Once the blockage has been located, a new grout injection point should be installed immediately adjacent to the blockage and the remainder of the Tendon grouted.

NOTE: DO NOT use a diamond tip drill bit or core into the Tendon. When drilling inspection points an impact drill and bit should be used and when the Tendon is located drilling should cease immediately.

7.9 De-tensioning

Extreme caution is required throughout all steps of the De-tensioning operation, and as such, should only ever be attempted by trained, experienced stressing personnel. De-tensioning should only ever be undertaken with the express, written approval of the design engineer.

It is essential that during De-tensioning the operator follows the same safety precautions as during Final stressing operations (see Section 7.6.).

Before De-tensioning commences the area should be checked, cleared, flagged and Stressing Barricaded in the same way as for final stressing (see Sections 7.6).

Each strand should be De-tensioned in a manner that eliminates the need to work behind the strands that have been stressed. Ideally the person ‘swinging’ the Jack will work in a sequence that lets them work away from themselves and not over a loaded strand.

A special De–tensioning chair must be placed over the strand to be De–tensioned (the use of the correct equipment is a priority, as a full stressing load will be applied to the chair, and an inadequate strength may lead to a failure under high loads).

When De-tensioning it may be necessary to exceed the Final stressing load, which is usually 85% U.T.S. (Ultimate Tensile Strength), applied to the strand. Do not exceed 90% U.T.S. without referring to the Post-tensioning engineer for advice.

When De-tensioning in multiple strokes of the Stressing Jack (required for longer Tendons) it is critical that on the release stroke, some stroke (minimum 40mm) is left in the Jack prior to re-wedging. i.e. never stroke the Jack back to the completely retracted position while the strand remains under some load.

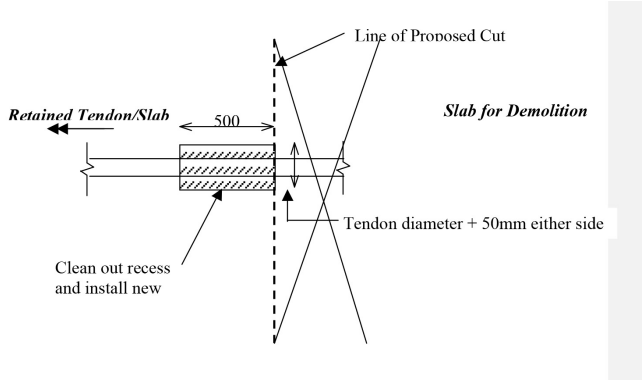
8. Truncating Existing Tendons

The Truncation of Tendons within an existing slab may be necessary if the Tendon has been inadvertently cut or a section of the slab requires demolition. Truncation is required to anchor the cut Tendon and to prevent corrosion.

The following procedure is to be used to terminate existing Tendons after approval has been granted by the engineer. The Truncation (or epoxy plug) shall be installed to all Tendons that intersect the termination point.

Procedure:

1. The engineer is to carry out an analysis of the slab to identify and design any strengthening necessary.
2. Install strengthening system to engineers detail (if any)
3. Locate Tendons. This can be done using the “As Built Post-Tensioning” structural drawings and verified by using a Cover Meter locating device.
4. Install propping below the slab according to the engineers instructions.
5. Excavate a 500mm long by 170mm wide recess (170mm wide recess is determined by the width of the duct + 50mm each side of the duct. Therefore if the duct size is larger the excavation width will be larger E.G. 90mm Duct + 50mm each side = 190mm excavation width), along the Tendon, immediately adjacent to line of proposed cut. Extreme care must be taken not to damage the post-tensioning Tendons.
6. Clean out the excavated recess and strip the ducting from the Tendon. Inspect the grout in the duct. If the quality of the grout isn’t sound or if there are voids, stop work and contact the engineer for further directions.
7. If the quality of grout surrounding the strands within the Tendon is sound, remove the grout from around the strands within the excavated recess. Remove any concrete and concrete dust to the full width of the recess and at least 25mm below Tendon.
8. The excavated void can now be filled, using an Epoxy Grout approved by the engineer.
9. Once the Epoxy Grout has cured (see product data sheet) the slab/Tendon can be cut.
10. Once the section of slab has been removed, paint an epoxy protective coating over the ends of the strands exposed on the cut edge to prevent corrosion.
11. The temporary propping must not be removed until instructed by the engineer.



9. Flagging and warning signs

For projects involving Post-tensioning, erect appropriate warning signs on the site. The signs should display the local telephone contact number for the post-tensioning system in use.

Before Final stressing begins, display prominently "Stressing-in-Progress" warning signs in the immediate area of the stressing operation and at entrance-ways to the area or slab/floor. Display similar warning signs when De-tensioning is in progress. The signs should be removed when stressing in the area has been completed.

During final stressing operations, flag and sign Post-tensioning areas to warn other workers that stressing is in progress and entry is prohibited to the area (within 5 metres of any live end anchorage and between the live end and the Stressing Barricade). Maintain this set-up in place for 30 minutes after stressing. Display similar warning signs when De-tensioning is in progress.

Flagging may be in the form of barricade webbing, pennant type flagging or equivalent.

10. Equipment maintenance

To ensure that all equipment is kept clean and in good working order, it should be stored in a clean and secure area where it is protected from mechanical damage. The following maintenance checks should be made regularly:

- clean all equipment after use, particularly grout pumps and hoses;
- inspect Jack wedges to ensure they are kept clean and free of dirt, grit oil and grease and do not exhibit excessive wear;
- inspect hydraulic hoses and the oil level in the sump reservoir of the pumps; and
- inspect extension noses, curve noses and De-tensioning bridges for wear and cracks. If faults are identified, these devices should be taken out of use immediately.
- Ensure cutting discs, for the Angle Grinder, are kept dry and free from oil and other contaminants.

It is preferable to use self-sealing couplings for hydraulic pressure hoses and the hydraulic system supplied with a by-pass valve which is set to no more than 95% of the minimum specified ultimate breaking strength of the strand.

Ensure that each pressure gauge and Jack combination is calibrated as a unit by a NATA registered or other approved testing body at least once in every 6 months and details provided to the site engineer.

Always keep a copy of the current Jack and gauge calibration certificate with the Jack and gauge on site at all times. If the Jack or gauge suffer any damage or appear to be unstable they should be recalibrated.

11. Personal protective equipment (PPE)

Before starting Post-tensioning work, the employer must assess conditions and Material Safety Data Sheets for products likely to affect the health and safety of employees. If the conditions necessitate the use of personal protective equipment it is the responsibility of the employer to ensure the provision and use of appropriate personal protective equipment. The personal protective equipment provided must be used by all employees at the appropriate times. Typically PPE needs include:-

- Basic (use at all times on site): Safety Helmet, Safety Boots, Gloves, Work uniform, Sunscreen, Safety glasses;
- General (may be required due to site conditions): Safety goggles, hearing protection, hi-visability clothing, rain gear;
- Strand Handling: Gloves and Safety glasses;

- Operating Strand Pushing Machine: Hearing protection, gloves, Safety glasses;
- Cutting strand or straps: Gloves, safety goggles;
- Use of an Angle Grinder: Double eye protection (safety glasses & full face shield), gloves, long sleeves & pants.
- Stressing Pump Operation: Safety Glasses;
- Stressing Jack Operation: Gloves and Safety Goggles;
- Onioning or Swaging: Gloves, Hearing Protection and Safety Goggles;
- Duct Cleaning (compressed air): Safety Goggles and Hearing Protection
- Grouting Pump Operation: Safety Goggles, Hearing Protection; Dust Mask (cement dust rated), rubber gloves, long sleeves;
- Grout Spotting: Safety Goggles and Gloves; and,
- Work at Height (where suitable platform and edge protection cannot be provided): full safety harness and lanyard attached to an approved anchorage, which must be above head height or inside the building.

The employer must ensure that all personal protective equipment provided for employees' use is regularly inspected and cleaned and make sure it suits the particular application, fits correctly and be compatible with other forms of PPE they're wearing. PPE should be repaired or replaced as necessary.

12. Training and supervision

The Workplace Health & Safety Act, specifies a person conducting a business or undertaking has a primary duty of care to ensure, so far as reasonably practicable, the health and safety of workers at work in the business or undertaking. This duty of care includes providing information, training and instruction to protect persons from risks to health and safety arising from work. To facilitate this obligation, along with producing this guidance material, the PTIA offers training and assessment for the national unit of competency CPCCSF3002A Carry out Mono-strand Post-tensioning.

- the training and instruction given should cover at least:
- general site safety, and issues specific to the actual site;
- the work methods to be used, specific to the site;
- the correct use, care and storage of personal protective equipment;
- the correct use, care and storage of tools and equipment to be used, including electrical safety;
- procedures to be adopted in the event of accident, injury or other emergency;
- installation methods for Post-tensioning Tendons;
- stressing methods for Post-tensioning Tendons;
- grouting methods for Post-tensioning Tendons.

It is the role of the supervisor to:

- ensure that only those employees who have received appropriate training and instruction are authorised to carry out the work; and
- provide sufficient monitoring of the work to ensure that the agreed safe work practices are being adhered to, including the use of all protection systems and personal protective equipment.

All operatives should undertake the Post-Tensioning Institute of Australia's Course in Mono-strand Post-tensioning CPCCSF3002A or similar training.

13. Legal Requirements

Employers' responsibilities

Employers must comply with Acts and Regulations relating to occupational health and safety. Compliance applies to work practices, equipment and training and qualifications of workers. If any uncertainty exists, enquiries should be made at the planning stage to the local WorkCover Authority.

Standards and Codes of Practice which give practical guidance on health and safety in post-tensioning work and the relevant Acts and Regulations are listed below.

Because these are subject to change, checks about their current status should be verified.

Employee's responsibilities

The Workplace Health and Safety Act determines while at work an employee must;

(a) take reasonable care for his or her own health and safety, and

(b) take reasonable care that his or her acts or omissions do not adversely affect the health and safety of other persons, and

(c) comply, so far as the worker is reasonably able, with any reasonable instruction that is given by the person conducting the business or undertaking to allow the person to comply with this Act, and

(d) co-operate with any reasonable policy or procedure of the person conducting the business or undertaking relating to health or safety at the workplace that has been notified to workers.

Acts, Regulations, Standards and Codes

The following Acts, Regulations, Standards and Codes of Practice apply to work on Mono-Strand Post-Tensioning of concrete buildings.

"Acts and Regulations"

- Commonwealth Work Health & Safety Act 2011
- Commonwealth Work Health & Safety Regulations 2011
- Victoria – Occupational Health & Safety Act 2004
- Victoria – Occupational Health & Safety Regulations 2007
- Western Australia – Occupational Safety and Health Act 1984
- Western Australia – Occupational Safety and Health Regulations 1996

"Industry Standards and Guidance Material"

- Guidance Note: Electrical safety for construction work "Standards"
- AS/NZS 1314:2003 Prestressing Anchorages
- AS/NZS 3600-2009 CONCRETE STRUCTURES (incorporating Amendment No. 1 and Amendment No. 2)
- AS/NZS 3600 SUPPLEMENT 1 - 1994 CONCRETE STRUCTURES - COMMENTARY
- AS/NZS 1481-1974 SAA PRESTRESSED CONCRETE CODE (This Standard was withdrawn in March 1991 but may still be referenced by local government authorities where the legislation has not been updated to reference the new Standard, AS 3600)
- AS/NZS 1576.1 - 2010 SCAFFOLDING

Appendix: Stressing Barricade construction

Stressing Barricades are provided to stop or reduce the momentum of a Jack, wedge or strand which is dislodged or fails during stressing.

The location of the stressing operation determines the type of Stressing Barricade.

Stressing may occur in any of 2 locations:

1. Wherever walls or external scaffold are more than 2m from the Jack, a portable Stressing Barricade similar to Type 1, Stressing Barricades below must be placed within 2m of the Jack when stressing.
2. Stressing where there is an external scaffold. In this case, a Stressing Barricade similar to Type 2 Stressing Barricade below must be placed on any scaffold within 2m of the Jack. Stressing Barricades Type 1 and 2 incorporate two sheets of form ply or equivalent, at least 75 mm apart in order to restrain a strand which may pierce the sheets of ply. The Stressing Barricades are intended to be portable, easily relocated to the next stressing area and readily built on site.

Type 1 & 2 Stressing Barricade