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SCAFFOLDING FIXINGS + DATA SHEETS (IBN)

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TG4:17

Anchorage Systems for Scaffolding

NASC
National Access & Scaffolding Confederation

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Implementation

This TG includes guidance for everyone involved in scaffolding from managers and designers to scaffolders and supervisors. Its implementation will require companies to set out and make clear to all staff their policy regarding the anchors they use, who is responsible for testing anchors on site, who should be referred to in case of problems with anchor capacity and how information on working loads for each anchor type *in each project* is communicated to scaffolders etc. It will require training of key staff in testing of anchors and of all scaffolders in the correct selection and installation of the anchors to be used. It will require method statements on installation and testing to be established and made available to those who need them.

1. INTRODUCTION

This Guidance Note covers the use of drilled in anchors used to tie scaffolding to a building structure. It takes account of requirements of the NASC document TG20:13 *Guide to Good Practice for Scaffolding with Tubes and Fittings*[3].

The stability of a scaffold structure is dependent, among other things, on the security of the anchors used to tie it back. That security depends on anchors being correctly ***selected*** and ***installed*** and, where necessary, ***tested***. This Guidance Note sets out the factors to be considered to achieve this. Guidance is given primarily for designers of scaffold structures in order that they can specify anchors and testing regimes correctly. Recommendations for correct installation are also made and are included in summary sheets for the use of installers[4].

This guidance is given in good faith but where particular anchor types are discussed the guidance from the manufacturer concerned must take precedence. No liability can be taken by either the NASC or CFA for any adverse consequences arising from this guidance being followed.

1.0 Background

This edition is revised from the version published in 2011 (TG4:11) which is withdrawn. The main changes in this edition are:

- Advice on the use of Nylon PA6 and PA66 plugs and screw in eyebolts – see section 4.3.
- Warnings regarding the use of plastic plugs – see sections 4.3 and 6.1 .
- Explanation of safety factors required for Preliminary Testing of Nylon PA6 and PA66 anchors – see section 6.1.
- The potential for corrosion

1.1 Terminology

In this Guidance Note the terms listed are taken to have the following meanings:

Allowable Load
The load which may be applied to the anchor as determined from “Preliminary” tests on site when there is no manufacturer’s Recommended Load data available for the base material concerned..

Anchor
A component installed in the building structure to transfer the necessary forces between the tie and the building structure, it may be temporarily or permanently fixed into the structure.

Anchorage
The combination of anchor, a fixture e.g. a bracket, and the immediately surrounding base material on which the anchor depends in order to transfer the relevant forces.

Masonry
Brickwork, stonework and concrete blockwork

Masonry unit
Individual brick, block or stone within a masonry wall.

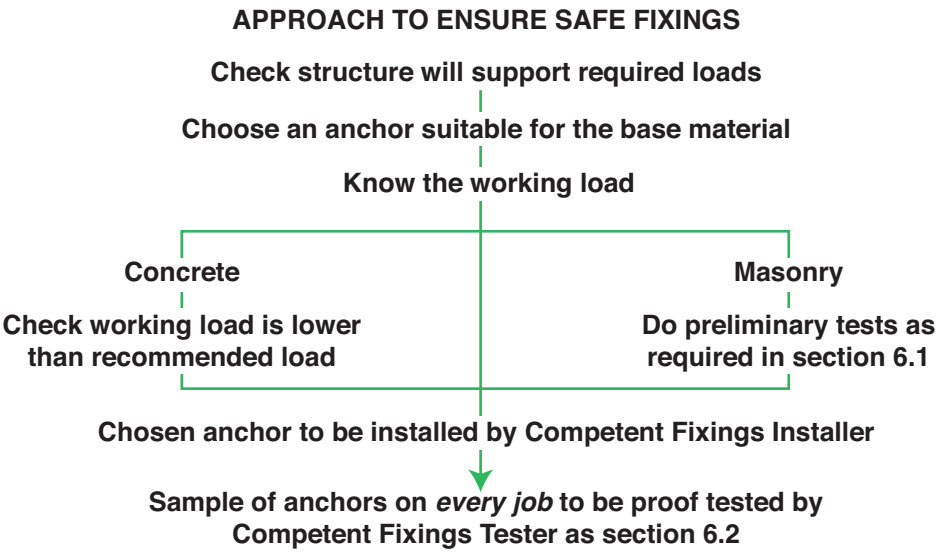
Recommended Load
The actual load which may be safely applied to the anchor as quoted by the manufacturer for a specific base material.

Tie
A component used to connect the scaffold structure with the building structure via an anchor

Tie assembly
The combination of tie and anchor

Working Load
The load to be applied to the anchor according to the design, also known as Applied Load. It may be taken from tables in the NASC document TG20 – *Guide to Good Practice for Scaffolding with Tube and Fittings* or calculated from first principles. In designs to Eurocode 2 the equivalent term is "Characteristic action" [5].

1.2 Approach



2. SELECTING ANCHORS FOR TYING SCAFFOLD STRUCTURES

2.1 General

Aspects which need to be considered in selecting anchors for tieing scaffold structures are:

- The type of linkage to the scaffold structure
- The base material and suitability of the structure
- Working load compared to recommended or allowable load
- The way loads are transferred through the ties and the direction they are applied – tension, shear, bending or a combination.
- The need for testing
- The potential for corrosion

2.2 Linkage to the scaffold

Restrictions on the use of "Drop-in" type expansion anchors in brickwork together with developments in new fixing methods means that the traditional scaffold ringbolt with a large eye and long shank threaded M16, as illustrated below, is used much less than before. A wider range of methods of linking scaffolds to buildings is now available, some are described below others in sections 3.3.2 and 4.

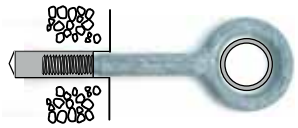
Proprietary ties should be fixed with anchors approved by the tie manufacturer whose loading data should be taken into account.

Most system scaffolding will deploy traditional tie equipment in the same way as tube and fittings; also used are special link tubes with hooks. These will attach to eye type fixings with internal eye diameters typically of 20 – 24mm.

Restraint with wire or band through rings or eyes will transfer only tensile loads so compression loads should be catered for with suitable supports e.g. butting transoms.

Examples of ties

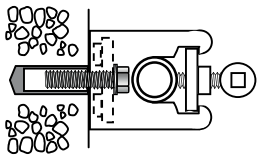
Ringbolt in internally threaded socket anchor



Proprietary tie in socket anchor



Band and plate coupler in socket anchor



Special hook in Nylon plug and screw in eye



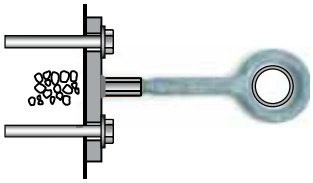
M16 threaded rod set in socket anchor and sheathed by tube under compression to avoid buckling



Threaded coupler on stud projecting anchor



Threaded coupler welded to base plate



2.3 Suitability of base material

Not all anchors are suitable for use in all materials. A guide is given in section 4 but manufacturer's guidance should be checked and will take precedence over the guidance given here.

Base material	Suitable anchor types	See section
Concrete	Drop-in expansion anchor Self-tapping screws Nylon anchors with screw-in eyes Resin anchors	4.1 4.2 4.3 4.4
Brickwork and stonework	Self-tapping screws Self-tapping screws with resin Nylon anchors with screw-in eyes Resin anchors	4.2.1 4.2.2 4.3 4.4
Concrete blockwork	Self-tapping screws Nylon anchors Resin anchors	4.2 4.3 4.4
Lightweight blockwork	Check strength and refer to manufacturer	
Timber	Screw-in eyes Self-tapping screws	4.6 4.6
Steelwork	Self-drilling & tapping screws Bolts for hollow sections	4.5.1 4.5.2

2.4 Suitability of the structure

The suitability of the building structure to sustain the loads transferred from the scaffold must be checked by a competent person. In general, concrete elements which are part of the load bearing structure will be suitable once they have cured sufficiently to sustain the loads. Masonry structures may be suitable if they are load bearing and of solid, rather than cavity, construction and composed of strong masonry units with sound mortar joints. Cavity brickwork constructions and cladding panels may not be capable of transferring the tensile and compressive loads involved. Scaffold structures should not be tied to newly built masonry structures until the mortar joints have cured sufficiently to withstand the loads and structures have adequate stability. Masonry structures in the early stages of construction, e.g. domestic dwellings, without the stability gained from floor joists, internal walls and roof structures need special care. An engineer's advice should be sought before fixing into these structures and others which may not be load bearing e.g. areas under windows, parapet walls, etc.

3. TIE LOADS

3.1 General

The following guidance relates to predictable loads arising from normal use of scaffold structures, e.g. wind loads, as per TG20. Additional, accidental, loads are not covered. Loads arising from fall arrest events should be considered by the scaffold designer for which useful references include SG4[6] and BS EN 795[7] and BS 7883[7].

Points to take into account are:

- Working load compared with Recommended or Allowable load.
  The working load must be less than or equal to the recommended load (or allowable load) of the chosen fixing.
  If not, the number of fixings must be increased pro rata. This may, or may not, mean increasing the number of ties.
- Loading direction
  The way loads are transferred through the tie affects the loading on the anchor.
  Tie and anchor capacities vary depending on the direction of the load and design of the tie or anchor.

3.2 Working loads, recommended loads and design approach

The NASC TG20 *Guide to Good Practice for Scaffolding with Tube and Fittings* proposes tie patterns for three classes of tie based on working loads in pure tension as a) light duty ties (3.5kN), b) standard duty ties (6.1kN) or c) heavy duty ties (12.2kN). Where heavy duty ties are not adequate additional ties will be needed. Anchors should be selected with a recommended or allowable load for the base material concerned which is at least equal to the working load. It is important to ensure that there exists an adequate margin of safety with respect to the working tie load. The approaches outlined below and in section 6.1 are intended to achieve this.

Most anchor manufacturers quote Recommended (Safe Working) Loads for concrete and some for other base materials; these loads may be used for the selection of anchors against the working load as long as the base material of the structure concerned is known to be at least as strong as that quoted.

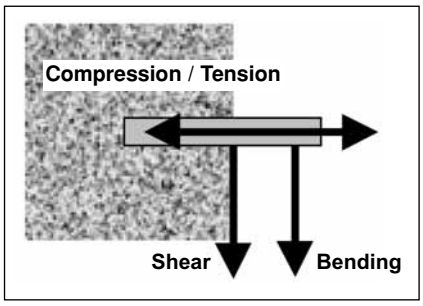
Manufacturers' recommended loads quoted for concrete should not be used for masonry. If no load data exists or the strength of the base material is in doubt, e.g. masonry or old concrete, then preliminary tests should be carried out to check suitability and determine the allowable load for the particular structure, see section 6.1.

Many anchors are available with European Technical Approvals[8] (ETAs) and CE marking. This means anchors have been thoroughly proven against the most rigorous testing regime. Load capacities quoted in ETAs are based on ultimate limit state approach with partial safety factors quoted in the ETA; this involves a partial safety factor being applied to the working load. Care must be taken in using quoted load values or entering data into software to make sure that the values used are compatible with the working loads of the scaffold design. For instance where, in the traditional anchor design approach, the "Working, or applied (unfactored) load" must be less than the "Recommended Load"; in the new approach the "Design Action" must be less than the "Design Resistance". Bearing in mind that the design action is larger than the working load by a partial safety factor of around 1.4 and the design resistance is larger than the recommended load, usually by a similar factor, see [5]. If in doubt refer to the anchor manufacturer.

3.3 Loading direction

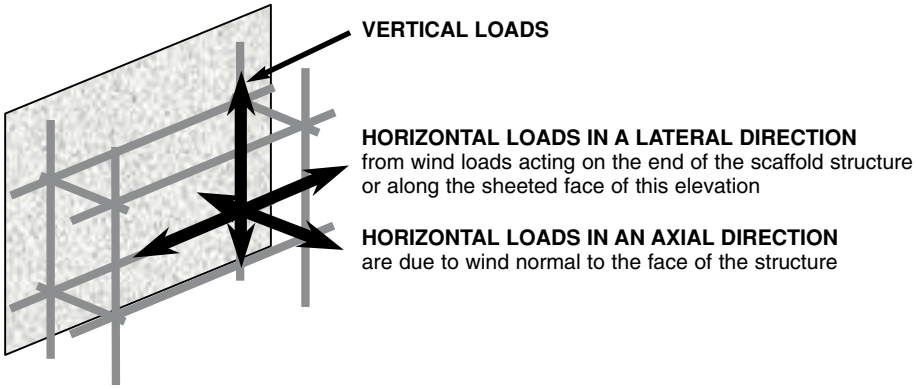
Loads may be applied to anchors in a variety of ways – tension, compression, shear, bending or a combination. Their capacity in these directions vary significantly.

It is therefore important to understand where these loads come from and the limitations of anchors and ties in coping with them.



3.3.1 Loads through the structure

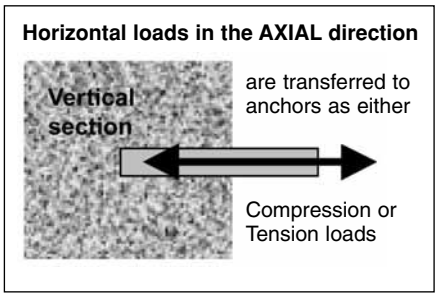
Loads may be directed from the scaffold structure through the ties either horizontally or vertically.



3.3.1.1 Horizontal loads

Horizontal loads in the axial direction

This is the major loading the tie assembly must cope with. It derives from wind loads normal to the structure so the load experienced by the anchor may be either tension or compression. Compressive loads are frequently taken into the structure by separate props such as extended transoms and the assumption sometimes made that the anchor will therefore see no compressive load. If compressive loads must be taken through the ties into the anchors, e.g. when props are removed for access of other trades, the manufacturer should be asked to confirm if the proposed anchor will support compressive loads and, if so, what thickness of structure is needed behind the anchor to support them. If structural fittings are used the capacity may be limited to the safe working load of the fitting.



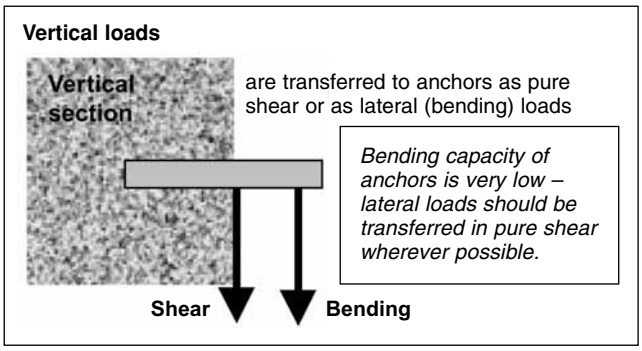
Horizontal loads in the lateral direction

NASC TG20:13 *Guide to Good Practice for Scaffolding with Tube and Fittings* recommends that account is taken of the need for certain tie assemblies to transmit horizontal forces, see TG20:13 section 2.1.9. Normally these loads are catered for by bracing arrangements against structural features of the building; e.g. extended transoms to each side of a window reveal, butting tubes into returns or recessed areas or plan bracing against columns. However, if such lateral loads do need to be taken into the structure via ties then it should be arranged such that loads are transferred through the fixings as shear loads rather than bending loads as most anchors have poor capacity in bending.

3.3.1.2 Vertical loads

On conventional, independent, scaffolds the weight of the scaffold itself and any materials carried on it are taken through the standards directly to the ground so no vertical load should be transferred through the ties to the anchors.

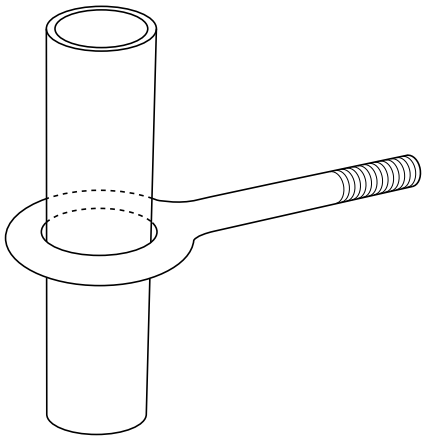
However, in the case of a scaffold supported by the building structure e.g. on a chimney, or where the scaffold structure is used to support a temporary roof and must sustain loads from wind uplift, vertical loads may arise. These loads should be transferred to the anchors as shear loads, see 3.3.2.



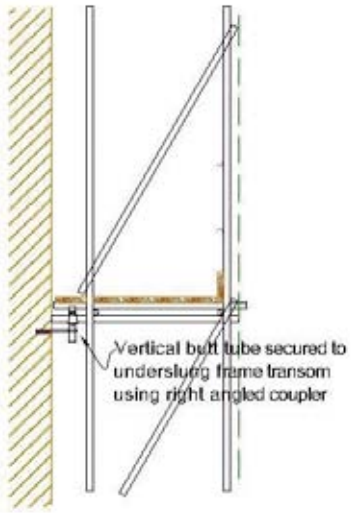
3.3.2 Loads through tie assemblies

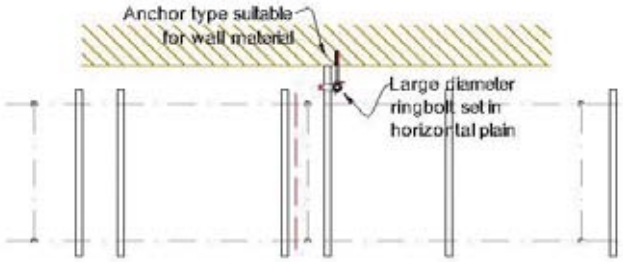
This section discusses the effect different ties have on load transfer to the anchor.
In this section only, loads applied from the scaffold structure are shown as ➔
while resulting loads experienced by the anchor are shown as ⇢.

Large diameter ringbolts intended to receive scaffold tubes have only a limited capacity to resist shear force parallel to the façade because of the distance between the tube and the effective anchorage in the structure causing bending of the bolt. Ring bolts should preferably be aligned in the horizontal plane to ensure that any settlement does not apply a vertical bending load into the ringbolt. Significant lateral loads should be taken through brackets designed to transfer the forces to the anchors as tension or shear loads (see TG20.13)

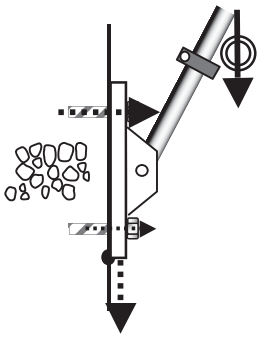


Ringbolts set horizontally with short vertical butt tube fixed to underslung frame transom with a right angled coupler. Ringbolts set horizontally to ensure any settlement does not apply a bending load to the ringbolt.

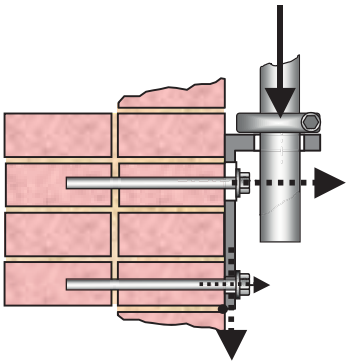




Pin-jointed bracket



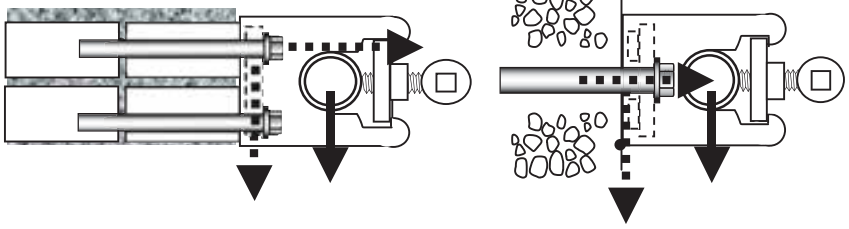
Conventional bracket



In both these examples the vertical load causes rotation about the bottom edge of the bracket so the top anchor sees a tensile load and the bottom anchor a shear load and a very small tensile load.

When used in brickwork hole centre spacings should ensure fixings locate on brick centrelines with at least one clear brick course between.

Band and plate coupler



These couplers are capable of taking tensile loads or shear loads (as shown below) and may be fixed with one or two fixings, depending on type, the latter will share the shear load between the two fixings but centre spacings will not allow a full brick course between anchors, which is recommended.

They should be fixed using a suitable anchor through a chair or saddle which spreads the load and allows the bolt head of the anchor(s) to bear properly against the saddle without bending. If these accessories are not used damage to the bolt head is possible.

3.3.3 Loads on anchors

Tension

The tensile capacity of the anchor is checked by reference to the manufacturer's quoted performance or by tests, see sections 3.2 and 6.1.

Shear

In calculating the applied shear load the possibility of shear loads from two sources must be considered i.e. horizontal loads in the lateral direction and vertical loads. Where this is the case they should be combined to give one resultant shear load and this used in the selection process.

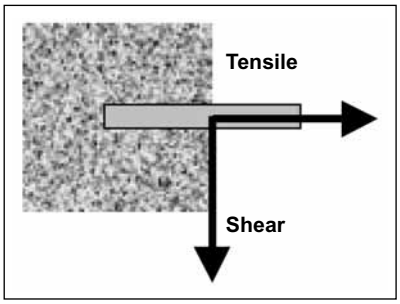
Recommended shear loads are published by the manufacturers for most anchors in concrete but few quote values in other materials. Shear testing on site is possible but generally impractical. For significant shear loads into materials other than concrete refer to the manufacturer.

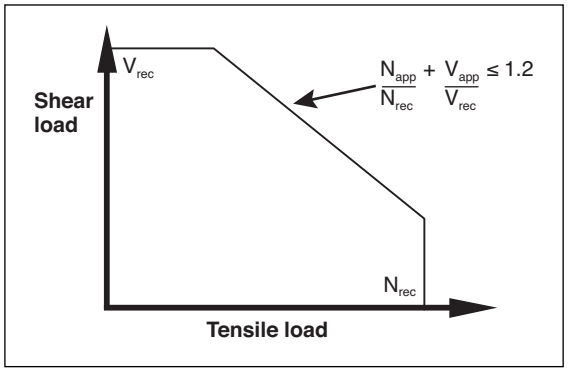
Bending

Most anchors have very poor bending capacity so vertical loads should always be transferred to anchors as pure shear. If small bending loads are unavoidable some manufacturers can quote allowable bending moments for anchors and proprietary ties.

Combined tensile and shear loads

When anchors are subjected to a combination of tensile and shear loads it is not enough simply to compare working and recommended tensile and shear loads independently (as in equations 1 and 2 below). A special check of the overall capacity must be carried out to ensure the fixing will not be overloaded, one approach is shown below (Equation 3); refer to the specific manufacturer for theirs.





Check that the following conditions are met:

$N_{app} \leq N_{rec}$ Equation 1

$V_{app} \leq V_{rec}$ Equation 2

$\frac{N_{app}}{N_{rec}} + \frac{V_{app}}{V_{rec}} < 1.2$ Equation 3

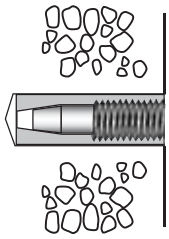
Where N_{app} (V_{app}) = Working tensile (shear) load
and N_{rec} (V_{rec}) = Recommended tensile (shear) load

4. ANCHOR TYPES

The anchors discussed here are those currently used within the industry and considered suitable with the qualifications outlined. Other types may be equally suitable.

When choosing anchors preference should be given, where possible, to anchors which have been awarded an ETA[8] as these will have been exhaustively tested to prove their functioning in a wide range of site conditions and will have reliable and comparable load data.

4.1 "Drop-in" expanding socket anchors



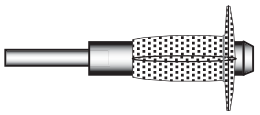
"Drop-in" internally threaded, hammer set expansion socket anchor – fully set.
For concrete only.
May not be used in brickwork or other forms of masonry.

The traditional drilled in scaffold tie anchor. The M16 size is used with M16 scaffold ringbolts. Drop-in anchors are designed for use in concrete. Recommended loads of M16 drop-in anchors vary from 9.0 kN to 12.6 kN – check with the manufacturer, especially if being considered for anchoring a heavy duty tie. They must not be set too close to an edge or the shock loads induced by the hammering action during setting may induce cracks. Typical minimum edge distances recommended by manufacturers for M16 drop-in anchors in concrete are 220 – 230mm. Care should be taken when installing into columns or the edges of floor slabs to ensure fixings are installed according to the designed edge distances.

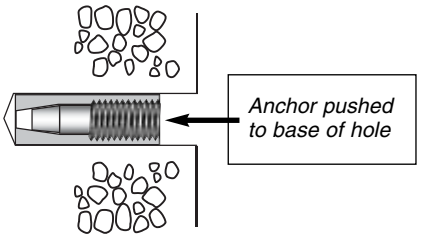
Drop-in anchors may not be used in brickwork as correct expansion will lead to cracking of bricks and anything less than correct expansion will result in reduced load capacity and safety margins.

Drop-in anchors cannot be removed so, if not specified in stainless steel, they should be capped to prevent rusting.

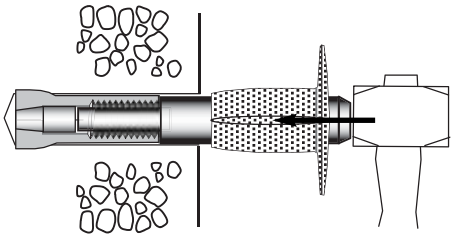
Installation points to watch:



- These are expanded by hammering a pre-assembled expander plug to the base of the anchor using a special setting punch. Some types show a witness mark on the shell when fully expanded.
- Only when the shoulder of the punch meets the shell of the anchor is it fully expanded. Drop-in anchors must not be set by screwing in a ringbolt or other bolt, the anchor is not threaded far enough for this method to expand the anchor. If a bolt or ringbolt is tightened against the thread run-out the shell may be weakened and shear off. Once ringbolts are fully inserted they should be turned back to align them with the tube.



Anchor pushed to base of hole

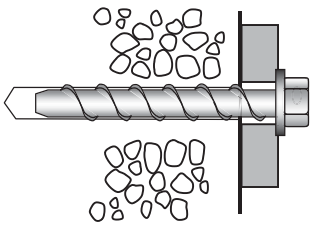


Expander plug hammered fully home using special punch

4.2 Self-tapping screws

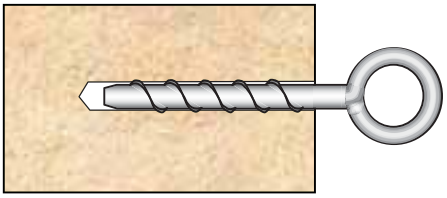
Frequently called "Concrete screws" but capable of working well in hard masonry such as brickwork, stonework and concrete blockwork but not light weight, thermal or hollow blockwork. They may also be used in timber if that usage is approved by the manufacturer.

Bolt type, for use with brackets



Self-tapping screws are easy to install as they cut their own thread in a pre-drilled hole. They may be removed. Hex bolt versions as shown are available up to 20mm diameter and are suitable for use with scaffold brackets, e.g. band and plate. Eye type versions are available with a shank diameter up to 12mm and internal eye diameter of 22mm and may be used with special hooks to link to the scaffold. 12mm diameter screws may have recommended loads in concrete in excess of 6.1kN but may not do so in brickwork. Using a larger diameter – up to 16mm – or a deeper embedment, i.e. a longer screw, may increase capacity sufficiently.

Eye type, for use with hooks



Some self-tapping screws have been known to shear below the head especially if re-used and inserted in particularly strong concrete using worn drill bits. Anchors carrying European Technical Approvals (ETA[8]) will have been comprehensively tested to ensure that this sort of failure cannot happen but drill bits should in any case be discarded if worn significantly ,e.g. when drilling becomes noticeably slower or the bit binds in the hole.

4.2.1 Anchoring ring bolts to masonry using self-tapping screws:

The following techniques may be considered for anchoring ring bolts to masonry (and where necessary to concrete) but, in view of the risk of bending, be it the bending of anchors themselves, couplers or brackets or the effect on welds, care should be taken to avoid anything other than axial loading.

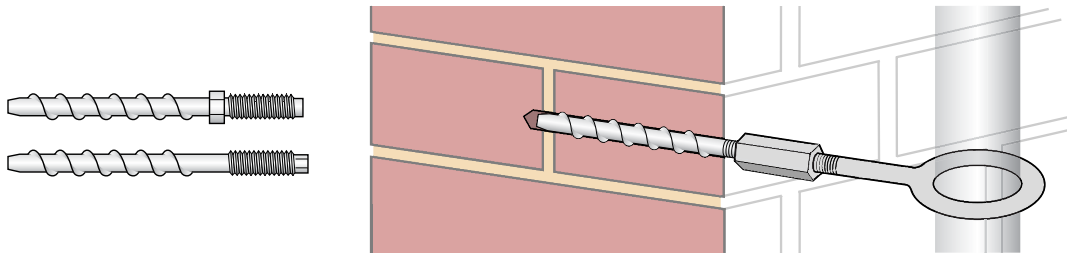
A threaded stud version may be used with an internally threaded connector as shown below.

Care must be taken to ensure there is adequate thread engagement of each component within the connector.

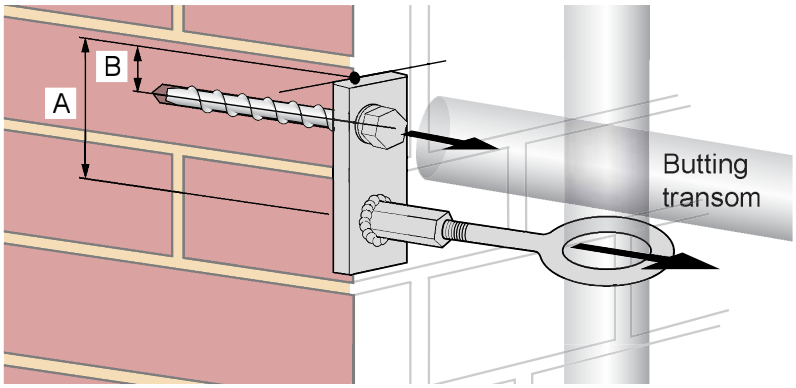
Although M16 threaded self-tapping screws are available they are not yet common, M10 and M12 being more readily available.

To use these a connector with two internal thread diameters as appropriate will be needed, these items should be acquired as parts of a matched system intended for this use.

The load capacity of the thread, as recommended by the manufacturer, may be the limiting factor and must be checked even before Preliminary Load Tests are carried out.



Connectors welded to plates

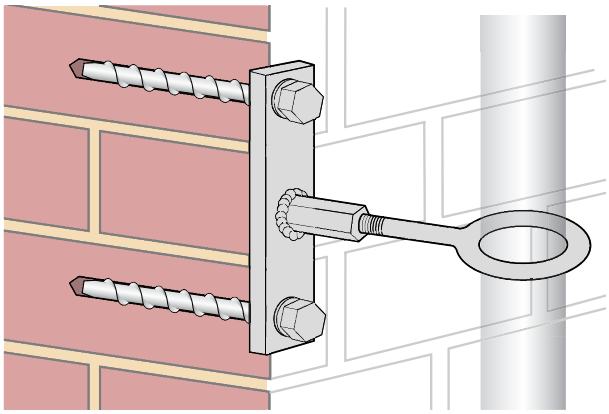


Brackets with welded connectors should be manufactured under a recognised factory production control system (e.g. ISO 9001) in which 100% checks on the quality of the welding of the connector to the plate are carried out.

A bracket using a single fixing, as shown above, may be considered but may be prone to bending of the base plate or fracturing of the weld due to the offset nature of the loading. This risk can be minimised by a) positioning a butting transom level with the fixing, as this will reduce rotation and hence bending and b) using a thick plate, c) increasing dimension 'B'.

In calculating the working load on the fixing note that this will be larger than the working load through the tie by the ratio A/B. This could mean that a standard duty working load of 6.1kN could impose a load in the order of 15 – 20kN on the fixing, which it is unlikely to hold.

Where Preliminary load tests suggest that a single fixing does not have the required capacity then a plate fixed using two hex headed screws may be a suitable answer without increasing the number of actual ties. When used in brickwork hole centre spacings should ensure fixings locate on brick centrelines with at least one clear brick course between, i.e. 150mm vertical spacing.



Axial or "Push-pull" loading only

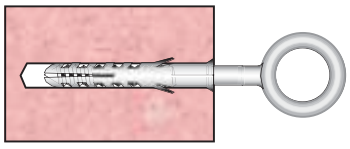
Installation points to watch

- The steep self-tapping thread may easily strip the thread cut in weak or soft base materials if over tightened. Once the head of the bolt type anchor is flush with the fixture it should not be tightened by more than a fraction of a turn to avoid stripping the thread. (Not an issue with eye type and some stud projecting versions.)
- Tightening torques – if quoted by the manufacturer – are a guide to the torque setting of impact wrenches for installation into concrete. They are not a torque which should be achieved but a torque which should not be exceeded. When installing self-tapping screws manually the screw should be turned just until seated against the fixture and then no more than ¼ turn applied. (One full turn from finger tight will strip the thread completely.) If impact wrenches are used the torque setting of the wrench must be checked not to exceed that recommended by the manufacturer of the self-tapping screw. Impact wrenches should not be used when installing in brickwork or stonework.
- Self-tapping screws, when used in concrete, occasionally appear to bind during insertion, this may be due to the cutting surface meeting a hard aggregate. Simply unscrewing by 2 turns and re-tightening usually overcomes this.

4.2.2 Self-tapping screws installed with resin

When masonry is weak or soft the performance of self tapping screws is reduced, as is the performance of any anchor suitable for use in masonry. There is also the increased risk of stripping the thread cut in the base material if over tightened. One solution, currently being proposed by some suppliers of self-tapping screws, is the additional use of an injection resin which stabilises and strengthens the interface between the screw and the masonry. While this can be shown to yield significantly increased performance and may overcome problems of thread stripping on tightening.

4.3 Nylon plug anchors with screw-in eyes



These anchors are suitable for tying scaffold systems via links with hooks. They work in concrete, brickwork and stonework. (If allowed by the manufacturer the screws may also be used in timber.) The plastic plug, usually Nylon, exerts a lower stress on masonry than a metal expansion anchor and so is less likely to crack weak bricks. The eye can be unscrewed after dismantling of the scaffold leaving no components to corrode. Eye diameter is typically 22- 24mm which will accept hooks.

Although the term “Nylon” is being used here this is simply one form of “Plastic” but research and experience over several decades have shown that Nylon, and in particular the type of Nylon known as “PA6” or “PA66”, is proven to be the best material for fixings in this category because the European climate affords sufficient moisture content for the efficient use of Nylon. It is therefore the recommended material to use.

It is very important that before other types of plastic plug are used their characteristics should be checked. Because plastic plugs suffer to a greater extent from a phenomenon known as “Creep” there may be a need to use a higher safety factor applied to the ultimate loads to determine the Recommended Loads. Reputable manufacturers should have taken this into account in their published load data, and many manufacturers of PA6 or PA66 Nylon plugs have stated that creep is not sufficiently significant (i.e. less than 0.35mm over 12 months or not greater than 0.8mm in 10 years, when considering the European climate). This amount of creep is considerably less movement than is likely to be experienced by a scaffold over a twenty four hour period on hot, sunny days without any adverse effect.

It should be noted that some anchors are unlikely to be capable of providing the load capacity for standard duty ties (6.1kN). When determining “Allowable Loads” in base materials for which there is no manufacturer’s recommended load data, higher factors need to be used in the Preliminary Load testing process, see 6.1.1.

Nylon plugs can only be removed with difficulty and are likely to be damaged in the process and are not considered re-usable in that way. If left in the structure they may be capped, but the recommendation remains that the plug should not be reused as it is difficult to determine the amount of damage that may have occurred during the first insertion of the eyebolt.

Installation points to watch

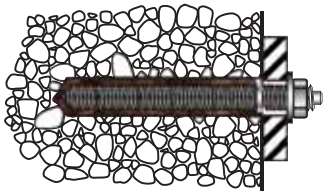
- Take care not to over tighten the eye into the anchor as this may strip the thread formed in the plug.

4.4 Resin anchors

Resin socket for ringbolts or hex headed bolts.



Resin stud anchor for bracket attachment.



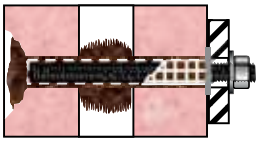
Resin anchors are suitable for use in concrete and hard masonry including brickwork, stonework and concrete blockwork. They are worth considering when expansion anchors are unsuitable e.g. close to edges in concrete or in solid brickwork or stonework, as they do not stress the base material but are traditionally rarely used because of the extra care need for installation and the need to allow the resin to cure before being tightened or loaded. New formulations with shorter curing times are becoming available and may change this. Curing times for all resin systems are set by the manufacturer to give a strength suitable for loading and tightening but they do not imply full curing. Tightening or loading before the full curing time has elapsed may damage the resin bond and reduce safety margins, so the full curing time – relative to the temperature of the substrate – must be allowed.

Internally threaded M16 socket anchors are available for the attachment of traditional M16 scaffold ringbolts, 125mm long versions are suitable for concrete while 170mm long versions will reach into the remote leaf of solid brickwork for greatest strength but care is needed in drilling to avoid spalling out the back of the brick (they are not suitable for use in cavity constructions).

Stud type resin anchors are suitable for direct attachment of brackets.

Anchors set in concrete should ideally be set using spin-in resin capsules and while injection systems can be used in concrete they require more care.

Resin injection systems are ideal for use in masonry. Special mesh sleeve systems are available for use in perforated* or frogged bricks. See comments in section 4.2.2 regarding the use of resins with self-tapping concrete screws. The manufacturer's advice should be followed at all stages.



Resin stud anchors set in perforated brick using mesh sleeve to control the resin.

*The use of perforated bricks implies cavity construction. The suitability of such structures to support the working load should be determined beforehand by a competent person.

Resin materials should always be stored in temperatures within those recommended by the manufacturer for storage. If allowed to become too hot they will cure prematurely – if too cold they will take longer to cure. Resins should not be heated artificially to speed up curing.

Installation points to watch

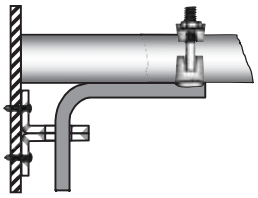
- Hole cleaning is vital for all resin anchors especially injection systems. BRUSH the hole using a round brush, as well as blowing.
- With injection systems pump some resin to waste to ensure proper mixing before injecting into the hole.
- With all resin anchors allow the full curing time before loading or tightening, this varies with base material temperature and is usually longer for injection systems.
- Do not over tighten! Always use a calibrated torque wrench set to the manufacturer's recommended installation torque which should be reached in approximately half a turn from finger tight. Torque values for concrete should be reduced in weaker materials such as brick or stone – refer to the manufacturer.

4.5 Fixings to steel structures

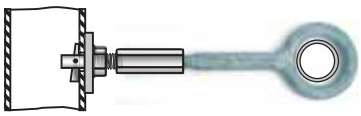
Refer to the manufacturer for selection criteria, loading data and installation instructions. Other systems may be suitable.

4.5.1 Self-tapping screws and Self-drilling & tapping screws

One technique for linking the scaffold to a steel structure is to use a T shaped bracket as shown fixed with 2 self-tapping or self-drilling & tapping screws. A tube hook adaptor will transfer loads from the scaffold. Self-drilling & tapping screws typically work in steel thicknesses up to 12.5mm while self-tapping screws will work in structures over 12mm thick.



4.5.2 Bolts for hollow steel structures.

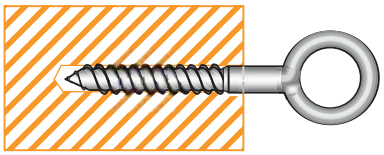


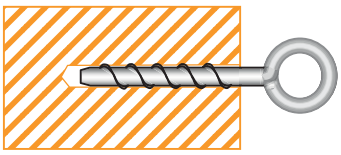
For hollow sections special fittings with toggling action can be used to link to ringbolts via threaded couplers.

4.6 Fixings to timber structures

4.6.1 Screw-in eyes and Self-tapping concrete screws

The fixing types discussed below are regularly used by NASC Member Companies. Refer to the manufacturer for selection criteria, loading data and installation instructions. Other systems may be suitable e.g. through bolting.





Some manufacturers allow the use of these products in timber structures e.g. timber framed buildings.

They should only be used if allowed by the manufacturer and all recommendations made by the manufacturer are followed.

Preliminary tests should be carried out to determine allowable loads.

Installation into timber sections should be carried out to manufacturer's installation instructions with special care needed regarding the distance to the edge of the timber. The possible influence on performance of deterioration in the timber should be taken into account.

5. INSTALLING ANCHORS

5.1 General

It is necessary for the contractor to be able to demonstrate that all anchors have been correctly installed. This means that anchors should be installed only by competent installers – using the correct tools and strictly in accordance with the anchor manufacturer's instructions. Anchors should not be installed into concrete or masonry structures before they have cured sufficiently to withstand the applied loads. See also 2.4.

Proof tests, as described in section 6.2, should be carried out on every project.

Key aspects are:

- Drill holes to correct diameter and depth
- Clean holes thoroughly – important for most anchors but particularly for resin anchors – for which holes should be cleaned by *both brushing*, with a round stiff brush the diameter of the hole, *and blowing*, using a large volume pump.
- Set in accordance with the manufacturer's setting instructions using the correct tools
- Allow resin anchors to cure for the curing time recommended for the temperature of the base material.
- Tighten to the recommended installation torque using a calibrated torque wrench.

Hole dimensions can be critical

Hole diameter must be right to ensure the anchor works and gives the expected performance.

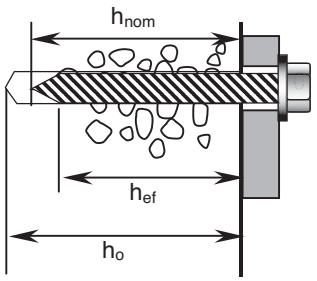
Hole depths in particular must be specified carefully on drawings or in method statements as this affects not only the capacity of the anchor but the ability of ties using bolts to engage properly. For many anchor types hole depth is important. With drop-in anchors for instance the anchor must be set at the right depth. Too shallow and the tie will not seat against the structure, too deep and the bolt will not engage sufficiently. Follow the manufacturer's instructions. For many anchors the hole depth is governed by the required embedment depth, see below – 5.2.

Inserting bolts or ringbolts into sockets

Full anchor strength will only be transferred if the bolt is engaged sufficiently. At least six full turns should be engaged without excessive force. Once the ringbolt is fully engaged turn back to align with the tube otherwise if the ringbolt is tightened hard against the thread of the socket the shell may shear off.

5.2 Embedment depths

The diagram on the right illustrates the difference between embedment depth, h_{nom}, the deepest point the anchor reaches; effective embedment depth, h_{ef} , the depth of the deepest point engaging with the substrate, and hole depth, h_o. (This nomenclature is common to most manufacturers.) Specifiers and users should ensure they are familiar with the meanings of terms they use and those used by others. Anchor performance is usually dependent on effective embedment depth h_{ef}.

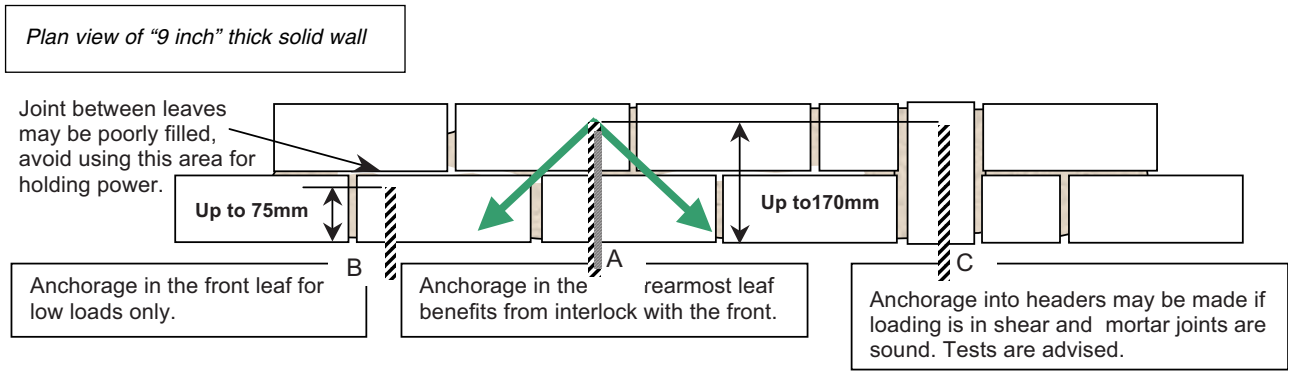


Embedment depths for anchors in concrete

Embedment depths in concrete are straightforward and should follow the manufacturer's recommendations.

Embedment depths for anchors in solid brickwork

To gain maximum strength from anchors set into 9" solid brickwork it is important to achieve optimum embedment into the rearmost leaf which then benefits from load transfer via the front leaf, see (A) below. Maximum hole depth for anchoring into the rear brick of 9" structures is 170mm. Any deeper risks breaking the back of the brick out under the drilling action. Only where loads are small should anchors be set into the front leaf (B) and when this is done the embedment depth should be chosen to optimise the strength in the brick, maximum depth to avoid spalling the back of the front brick is 75mm. Hole depths vary with anchor type. Avoid setting the anchor with its effective embedment in the joint between leaves – particularly resin anchors.



Fixings may be made into header bricks (C) especially if the remote leaf of stretcher courses appears weak during drilling, when brick structures are thicker than 9" and have weak infill material between the leaves or when loads are predominantly shear.

Care must be taken to check that no damage is done to the brick or surrounding mortar joint by drilling or anchor setting. Look for cracks across bricks and around mortar joints. The rate of proof testing anchors set in header bricks (which may be loosened during drilling) should be doubled to make sure that the whole installation (including the brick and surrounding mortar joints) can take any tensile loads involved. If structures are rendered ensure the required embedment depth exists below the render.

5.3 Anchor positioning

The recommendations of the anchor manufacturer should be followed regarding close edge distances and spacings between anchors used in pairs or groups. All reputable manufacturers make detailed recommendations for edge and spacing criteria for anchors used in concrete.

Anchor positioning in brickwork

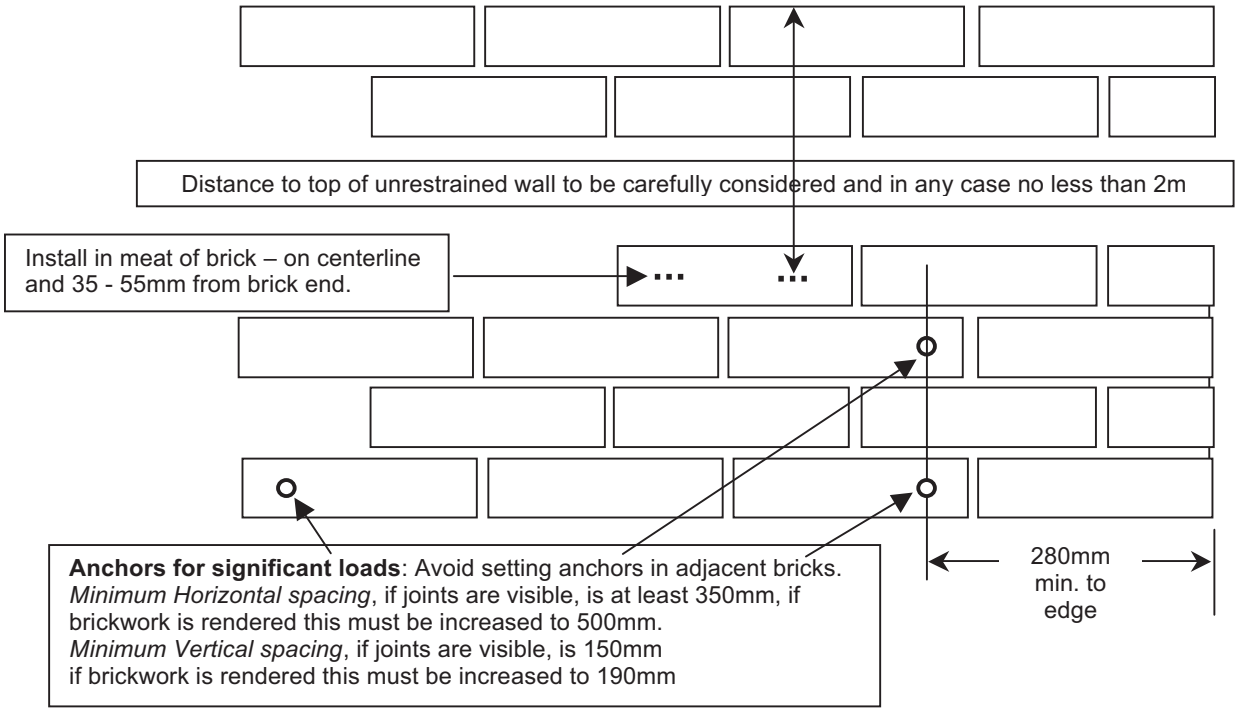
Some manufacturers fail to make recommendations for these criteria in masonry. In the absence of such guidance the following should be observed:

- Fixings which are used to support tensile loads should be located at least one full masonry unit from a vertical edge, in brickwork this means at least 280mm.

- This distance may need to be increase substantially for lateral or shear loads the distance may depend on the magnitude of the load and condition of the masonry.
- A minimum edge distance of at least 2m should be allowed from a horizontal edge in brickwork for loads in any direction.

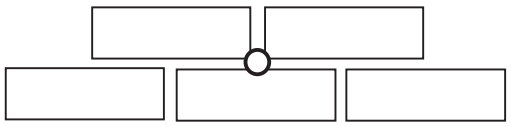
Centre spacings between anchors should be chosen to avoid setting two anchors in the same, *or even adjacent*, bricks.

Anchor positioning guidelines for brickwork



When drilling into brickwork the anchor should ideally be located in the solid portion of the brick rather than into the mortar joint. If the brickwork has been rendered the location of the centres of the courses of bricks should be identified by removing the render or by test drillings. If however anchors may not be fixed into the bricks themselves e.g. as a result of a conservation order, then the following approach may be sanctioned by the responsible engineer if approved by the manufacturer: (resin anchors may provide a good solution for fixings into joints)

- Choose an anchor with a diameter significantly larger than the width of the mortar joints, e.g. 14mm in a 10mm joint.
- Fix into the base of the junction between bed and perpendicular joints



- PRELIMINARY tests must be carried out as in section 6.1 and PROOF tests as in sections 6.2 but with an increased rate of 1 in 10 of the whole job.

6. TESTING ANCHORS

Site tests are needed for two purposes:

"Preliminary" tests are used to check suitability of a particular fixing in the base material and to determine allowable loads.

"Proof" tests are needed to check the quality of installation of the chosen anchors.

Tests should be carried out by competent testers i.e. ideally staff with knowledge of how fixings work and trained in the use of test equipment and in these procedures.

Note – all tests described here are tensile tests relating to tensile anchor loads. Shear tests may be required if significant shear loads are involved and recommended shear loads are unavailable in the base material concerned. The approach described here may be applied. Refer to the manufacturer of the anchor for advice regarding shear test procedures.

6.1 Preliminary tests

These are to be carried out wherever there is any doubt about the suitability or recommended load capacity of proposed anchors for a particular base material, e.g. if there is no manufacturer's recommended load data for the base material which is often the case with brickwork, stonework and timber. The approach is to test a series of 5 sample anchors to a load which demonstrates a satisfactory safety margin and thereby, if possible, avoid testing fixings to failure. If any of these anchors fails to support the test load then, the results should be referred to the responsible designer who should consider the options outlined below.

Procedure

5 tests should be carried out in each different base material of the project. They should be carried out on sample anchors in the same base material but away from areas which will be used and must not be used in the job.

Test load:

All anchor types shall be loaded in tension to a load of 2 x the working load as applied to the anchor. This tensile test load may also be applied to those Nylon anchors PA6 and PA66 (where the manufacturer has stated that creep is not sufficiently significant.) Refer to 4.3.

All other plastic plugs and screw in eyebolt anchors should be tested to 3 x working load.

If all test anchors take the test load without slip then the anchor may be used in that base material for the proposed working load.

Should any anchor fail to meet the required test load then that fact should be referred back to the person responsible for the anchorage design of the project.

Possible courses of action to consider:

(a) use an anchor of the same type but with a deeper embedment depth*

(b) use an anchor of the same type but with a larger diameter*

(c) use a different type of anchor*

(d) redesign the scaffold to reduce the loadings while remaining within the criteria of TG20.

(e) use the original anchor specification but with an allowable load derived from further tests as below:

*For any solution (a) – (c) a new series of preliminary tests must be carried out.

Procedure for option (e) using the same anchor with reduced loads:

- For each anchor in the original series of tests which held the test load take each carefully to failure.
- Determine the allowable load from the lowest of the following values:

For all anchors including Nylon PA 6 and PA 66 plug and screw in eyebolts where the manufacturer has stated that creep is not sufficiently significant. Refer to 4.3

- the average failure load** ÷ 3

or

- the lowest failure load** ÷ 2

For all other plastic and nylon plugs with screw in eyebolts

- the average failure load** ÷ 5

or

- the lowest failure load** ÷ 3

All Factors quoted here, including those used to determine the test loads, are specific to short term or temporary uses including scaffolding and should not be used for other long term applications for which higher factors are needed.

** Calculations are based on all 5 failure loads. The resulting allowable load may not be higher than the manufacturer's recommended load in similar or stronger base materials.

The failure load is taken as the maximum load reached during the test or the load at approximately 1mm movement in the case where an anchor pulls out of the base material.

Note: Allowable loads determined from tests on one job should never be considered suitable for the design of another job unless the base material is known to be identical.

The new "Allowable load" must then be made known to the designer who should decide on the best course of action.

Depending on the proposed anchor type it may be possible to retain the same number of ties while doubling the fixings per tie by, e.g. changing from a tie using one fixing to a tie that uses two – in this case the manufacturer's recommendations regarding anchor centre spacings should be followed. Or the scaffold may be redesigned for a reduced working load (no greater than the Allowable Load just determined) being transferred through the same number of ties while remaining within the criteria of TG20.

When brickwork or stonework is weak then a secondary means of restraint should be considered.

6.2 Proof tests

These are needed to check that anchors to be used in the job have been installed correctly.

They should be carried out on all projects.

This guidance applies to all new jobs and to structures with previously installed anchors.

A sample of anchors to be used shall be tested to a load of 1.25 times the working load; in the case of ties with a working tensile load of 6.1 kN this means a test load of 7.6kN and where a tie load of 12.2 kN is required the proof load is 15.3kN. The pass criterion is that no significant movement of the anchor is apparent; a visual check only is sufficient.

A minimum of 3 anchors shall be tested and at least 5% (1 in 20) chosen at random and spread evenly throughout the whole job.

The minimum number (3) applies to every discreet area where:

(a) different fixings may have been used,

(b) the base material is different

(c) the condition of the base material has been affected by different weather conditions on a different elevation or

(d) a different team of installers have worked.

All anchors that have been proof loaded should be clearly identified with a tag showing the date of test and the test load, any anchors failing the test should be tagged as such.

The failure of an anchor in proof testing is a serious issue and requires the investigation of the cause(s) of failure and an increase in testing rate as follows:

One failure – double the test rate to 1 in 10 and at least 6.

Two failures – double again to 1 in 5 and at least 12

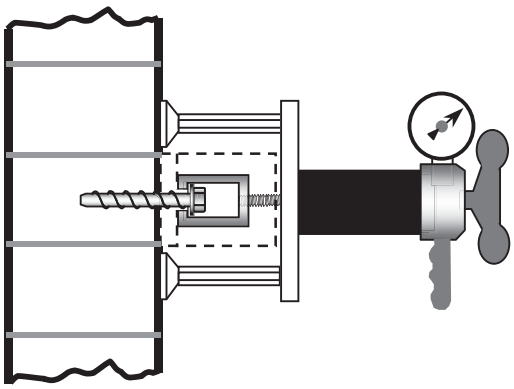
More than 2 failures – test 100% of the job, review the fixing specification and installation method.

6.3 Regular examination

In view of the variations in loading which normally affect scaffold structures the anchors used to tie them to buildings should be re examined at periods not exceeding two years for most fixings but one year for self-tapping concrete screws or immediately following severe weather conditions or any undermining of the scaffold structure. The examination should include a visual inspection of the anchor and surrounding structure for any deformation, damage, rust seeping from the junction between fixture and substrate, cracks in substrate or mortar joints and a tensile test as per section 6.2. The anchors tested in each of these examinations should be on anchors not previously tested. Anchors subject to re-test should be clearly identified with a tag showing the date of test and the test load, any anchors failing the test should be tagged as such.

6.4 Test Procedures

Site tests should be carried out by suitably competent personnel (other than the actual installer of the fixings tested) using a test meter with a gauge calibrated within the last twelve months to an accuracy of ≤ 5%. Test equipment should apply the load to the anchor and not through the tie through suitable couplers and be arranged such that the reaction loads are taken sufficiently far from the anchor so as not to influence the result, typically this means ensuring the feet of the bridge do not rest on the masonry unit being tested.



Typical test rig arrangement.

Self tapping screw tested in situ. Adaptors are available to enable any anchor for scaffold ties to be tested.

When testing in brickwork the feet of the bridge should be spaced far enough apart to span bricks. The bridge may need to be oriented vertically to do this.

Table of proof test sample

Total ties on the job	Number of proof tests
0 – 60	3
61 – 100	5
101 – 120	6
121 – 140	7
141 – 160	8
161 – 180	9
181 – 200	10
200 – 220	11
221 – 240	12

The Construction Fixings Association Guidance Note[1] – "Procedure for site testing construction fixings" contains guidelines for site testing of anchors. Test anchors should be installed strictly in accordance with the manufacturer's recommendations. Test results should be formally recorded and retained with documentation relating to the project.

7. REMOVABLE AND RE-USABLE FIXINGS

Some anchor types are removable which avoids problems with long term corrosion.

Being removable does not make anchors re-usable. The re-usability of particular anchors is referred to in the relevant part of section 4 Anchor types. Anchors should only ever be re-used if the manufacturer specifically allows this and if a control system is in place to ensure they are not re-used more times than the manufacturer allows. They should be subject to 100% inspection and if there is any rust, damage (especially bending) or any doubt about their suitability for re-use then anchors should be discarded. If anchors or ties are found to be bent then the reasons for this should be investigated to ensure it cannot happen again.

References:

[1] One of a series of Guidance Notes downloadable from the CFA website at **www.fixingscfa.co.uk**

Construction Fixings Association
Tel & Fax: 01664 823687
E-mail info@fixingscfa.co.uk

[2] NASC (National Access and Scaffolding Confederation Ltd.)

Email: enquiries@nasc.org.uk
Website: **www.nasc.org.uk**

[3] TG20:13 *Guide to Good Practice for Scaffolding with Tube and Fittings*. NASC.

[4] Installation guide for scaffold anchors. From CFA website www.fixingscfa.co.uk Section: “Safer installations” – click on Sample Method Statements.

[5 Article “Loads, actions and safety factors explained.” CFA website www.fixingscfa.co.uk Section: “Articles”

[6] Guidance Note SG4:15 *Preventing falls in scaffolding*. NASC

[7] BS EN 795:2012 *Personal fall protection equipment. Anchor devices*.

BS 7883: 2005, *Amended 2007, Code of practice for the design, selection, installation, use and maintenance of anchor devices conforming to BS EN 795*. BSI

[8] ETAs are issued in accordance with the appropriate ETAG (European Technical Approval Guideline). ETAG 001 *Metal anchors for use in Concrete*. Downloadable from www.eota.de.

[9] BS EN 12811 – 1 Temporary works equipment – Part 1: Scaffolds – Performance requirements and general design. BSI.

Whilst every effort has been made to provide reliable and accurate information, we would welcome any corrections to information provided by the Writer which may not be entirely accurate, therefore and for this reason, the NASC or indeed the Writer, cannot accept responsibility for any misinformation posted.

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ASS, Apollo scaffold screws

Designer, purchaser and installer benefits

Far stronger than they look. In practise stronger than the M16 insert: providing the installer with tensile loads equal or greater than traditional methods and often far greater than required.

Can be used with tube and fittings as well as lightweight systems such as layer, cuploc and kwikstage.

Small hole sizes that are rapidly drilled using battery drills.

Ideal for fixing blind across a cavity or fixed across a cavity that is being constructed.

Correctly installed fixings can be achieved and visually recognised with every fix. Visual setting guide to enhance the quality and consistency of the installation.

Suitable for contracts that require the smallest possible area of tubing to be in contact with the structure. This can be achieved by using the Apollo internal Scaffold hook.

Can accept small short term shear loads that will return the screw to its original shape.

In applications were the screw will protrude over 100 mm from the wall we suggest the use of the Apollo external hook. In these conditions the internal hook can be used however we suggest the application is discussed with our technical services team.



All screws are measured by their shank length. The amount of protrusion will be the shank length less the length of the selected plug.
All screws have a 23 mm diameter eye that allows the use of an Apollo scaffold hook or other proprietary connections. To install only a 14 mm drill bit is required, unless you are fixing blind across a cavity: for advise on this application contact technical services at Apollo.

Type	Drill bit Diameter mm	Shaft Protrusion using the stated plug lengths mm 70	100	Quantity Per Box
ASS 12 X 90	14	15	na	25
ASS 12 X 120	14	45	15	25
ASS 12 X 160	14	85	55	20
ASS 12 X 190	14	115	85	20
ASS 12 X 230	14	155	125	20
ASS 12 X 300	14	225	195	20
ASS 12 X 350	14	275	245	20
ASS 12 x 450	14	375	345	10

Longer lengths are available on a made to order basis

Average tensile values when using the ASS, Apollo scaffold screw system

Substrate	kN
Concrete C15	15
Concrete C25	15
Solid Brick	15
Granite	15

10 kN = 1 tonne

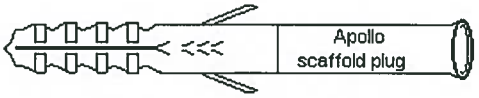
Details of performances into the following materials are available from our technical services team;

Mortar joints
Sandstone
Concrete block
Softwood
Slotted brick
Perforated brick
Engineering brick
Timberstrand

Shear and compressive performances and installation method statements are available on request

NSP, Apollo nylon scaffold plugs

Nylon scaffold plugs are significantly different to standard wall plugs. The scaffold plug is nylon and not plastic and therefore tensile loads are higher: it has a collar at the top of the plug that offers several benefits including the quality check on a safe and secure installation. All performances are based on a collared nylon plug that is referred to as a nylon scaffold plug. Why settle for inferior substitutes?



Nylon scaffold plug data

Size: Diameter and length mm	Apollo code	Plug diameter mm	Plug length mm	Drill bit diameter mm	Min drill Hole depth mm	Safe edge distance mm*	Quantity Per Box
14 x 70	NSP141	14	70	14	85	70	50
14 x 100	NSP142	14	100	14	115	70	50
14 x 135	NSP143	14	135	14	150	70	50

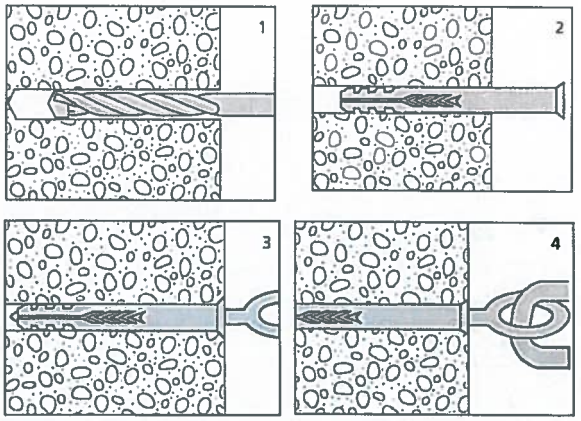
* can be reduced to 50 mm: technical services can offer further advise

Installation advise

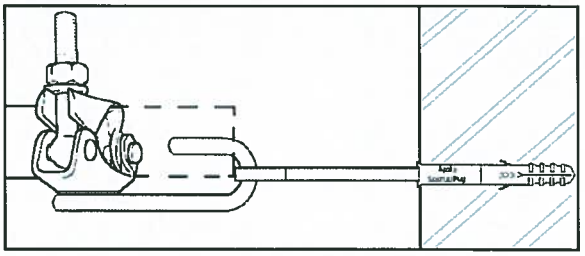
- Selection of the correct plug length:
  70 mm into the face of a base material without render or roughcast.
  100 mm or 135 mm on rendered or roughcast substrates
- Installation possible in concrete, granite or solid base materials: following on site tests, mortar joints
- Before using in holed or slotted bricks, please contact our technical services team
- Holes to be drilled a minimum of 15 mm longer than the plug length
- The minimum anchorage depth and edge distance in structural material is 70 mm.
- Screw the in screw until the appropriate markings on the screw shank are flush with the plug collar. Screwing any further will not enhance performance.
- Connect the tube using a suitable hook. Apollo offer two different designs. When using the internal style ensure that the tubes and screws are close to being perpendicular to the wall.

Cover caps

Available with low profile domed head in a clear colour. See page 51 for additional information.

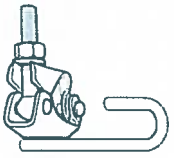


When used with tube and fittings the tie pattern remains the same as that used with traditional metal expansion anchors.



Installation of the scaffold screw system showing the internal scaffold hook: system completely 'locked' in position for zero movement.

Connect onto a scaffold screw using a scaffold hook



Internal style

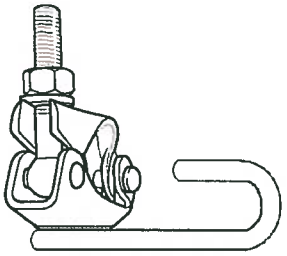


External style

Apollo Scaffold Hooks

For connecting onto scaffold screws or for use with safety netting systems

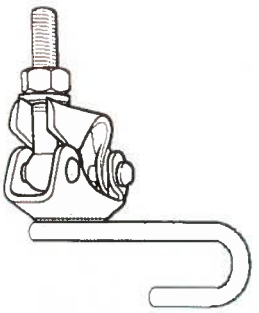
Three styles: Internal and external hook and 90 degree bend
Two types: Pressed metal or drop forged



Internal scaffold hook

Internal scaffold hook

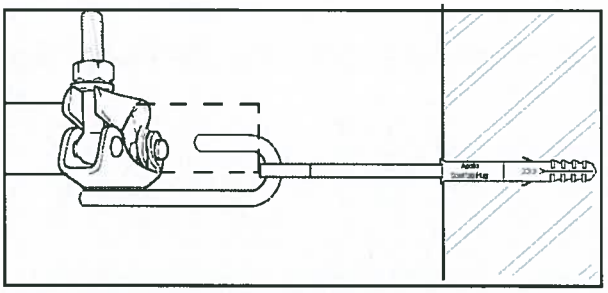
This design achieves almost zero movement between the Apollo scaffold screw and the hook on this fitting by butting the tube up to the back of the screw.
This style of fitting is ideal whenever you require the smallest possible tie connection protruding off the wall of the structure. With the tube not having contact with the wall it means that rendering works or the fixing of panelling and insulation boards can be carried out. In applications were the screw will protrude over 100 mm from the wall the internal hook can be used however we suggest the application is discussed with our technical services team. Screws need to be fixed close too perpendicular to the wall and the abutting tube needs to be line with the screw.



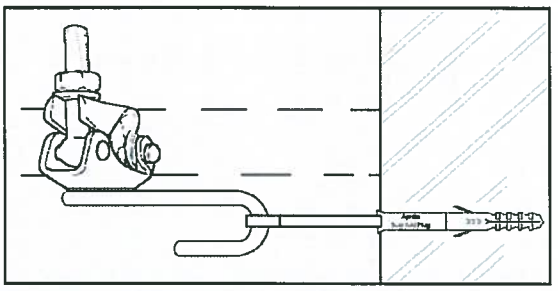
External scaffold hook

External scaffold hook

This design allows the tube to butt up to the wall. This is the recommended fitting for sheeted scaffolds, at a height and in exposed areas.



Internal scaffold hook installed



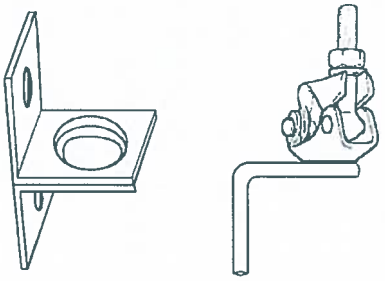
External scaffold hook installed

90 degree scaffold hook for across cavity applications

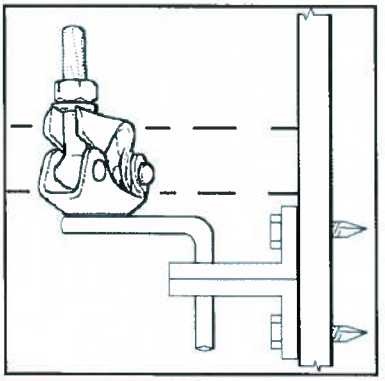
Designed for use with either the cladding bracket system, the two hole timber netting brackets or scaffold screws in 'across the cavity' applications.

This design means that the hook can be disconnected from the connecting hole far easier than with the traditional hook fitting. The hook is easily disconnected from the bracket by moving the tube approximately 80 mm to the side. (recommended position of the connecting hole will usually be horizontal).

To accommodate lateral movement it is recommended that the hooks are fitted into the connecting hole from alternative sides, from the right on one fitting and from the left on the adjacent fittings.



90 degree hook installed



Twin fix steel cladding bracket

Further information on the cladding bracket can be found on pages 10 and 11.

ibn scaffold access limited

Drilled Masonary / Brickwork Tie

Guidance on the usage & installation of ties to permanent structures is given in NASC Technical Guidance note TG4 (latest date) but generally our preference is to use nylon inserts, screw rings and hook fittings as shown below in the following series of photos.

Installation of these ties is relatively simple and is normally carried out on a maximum 16 sq.m grid pattern (although design scaffolds will have a specific designed tie pattern / type), which on a refurbishment scaffold would mean every other lift and every other standard – ie a 4.0m x 4.0m (max) pattern.

Installation requires a series of 14mm holes to be drilled in the structure (normally in mortar joints) to a depth of 85mm (ie 15mm deeper than the insert length). The nylon insert is then pushed into the drilled hole, ensuring that the whole insert is in the façade and the captive ring screwed into the insert up to the scored ring around the screw shaft. Finally, a hook fitting (either external or internal) is attached to the tie tube from the scaffold and hooked onto the protruding ring. External fittings allow the scaffold tie tube to abut the structure for greater stability against inward forces.

Scaffold tie tubes secure the tie to the scaffold and must be within 300mm of a node point (ie the connection between standard, transom and ledger tubes. If this cannot be achieved then raker bracing between standards may be required. On a 2.0m lift refurbishment scaffold the ties are normally placed just below the working platform(s) at the 4.0m height interval and thus no raker braces are normally required.



Picture 1 – Component Parts



Picture 2 – Assembled Tie



Picture 3 – External Hook Fitting (attaches to ring)



Picture 4 – Tie on actual scaffold