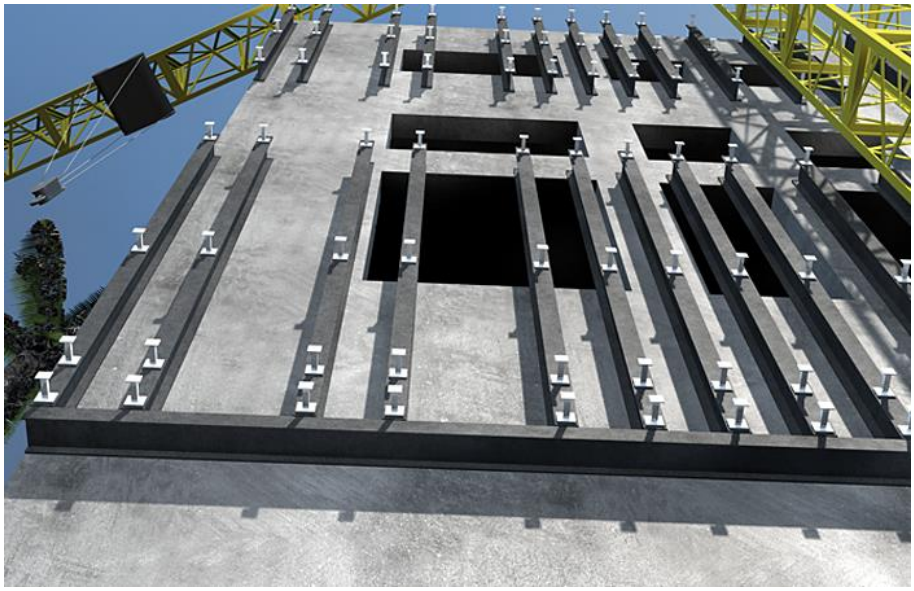
Anchor watch – Selecting and specifying the most effective anchor type.

In order that the major producers of anchoring systems respond to the increasing requirement for their products to satisfy the high demands of the Eurocodes and the design models of CEN EN 1992-4, they must constantly develop and improve their products and design aids. This has led to the development of sophisticated products and design software the use of which can be most effective if the user understands the principles behind them.



As with many aspects of design the move from national standards to Eurocodes has resulted in familiar simplistic designs becoming comprehensive and technologically advanced standards. The design and use of anchors is no exception to this.

As a designer it is important to understand the different anchor types so that you can “value engineer” the connection. You must however not lose sight of the fact that fixings are a very small part of the overall value in any project. While the value can vary depending on the nature of the project recent research suggests that all fixings on a project equate to about 0.5% of the overall cost of the project. For this very reason fixings are often treated in accordance with their monetary value and their value with regard to safety and structural integrity is often overlooked. If spending an extra few thousand Euro is going to save a life or prevent extensive remedial works at a later date then this needs to be considered.

Some of the main changes that have come about with anchors are that anchors must now function in either cracked or non-cracked concrete, chemical injection

resin can now be installed to a depth of 20 times the bar diameter, fire and seismic design has been developed and chemically anchored post installed rebar can be designed to EC2.

Before I explain the different anchor types and how they function I would like to mention the concept of cracked and non-cracked concrete. Many people I speak to in my working day are confused by the term “Cracked concrete”, they think somehow it refers to broken or damaged concrete when in fact it refers to cracking in the tensile zone of concrete due to loading. These cracks open and close as the building member is loaded and unloaded. Anchors located in these cracks have to be able to cope with this opening and closing by exhibiting a function commonly known as “follow-up expansion” in the case of expansion anchors, or by having higher bond strengths in the case of bonded anchors.

When cracked concrete is considered the design calculation for concrete capacity will return a lower resistance capacity if compared to a design resistance for anchors in non-cracked concrete. The typical difference is 1.4.

Anchor Types:

There are principally 4 different categories into which all anchors fall

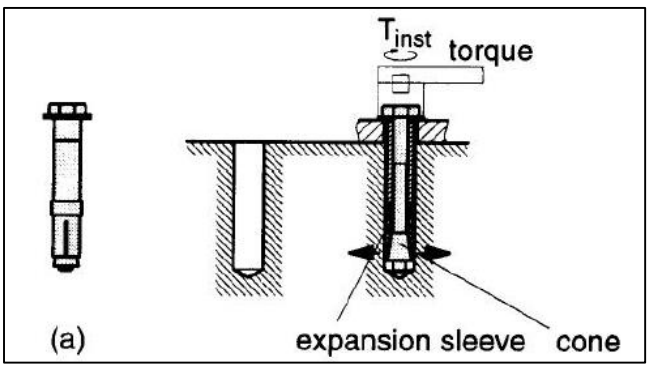
- Torque controlled expansion anchors
- Undercut anchors
- Deformation controlled anchors
- Bonded anchors

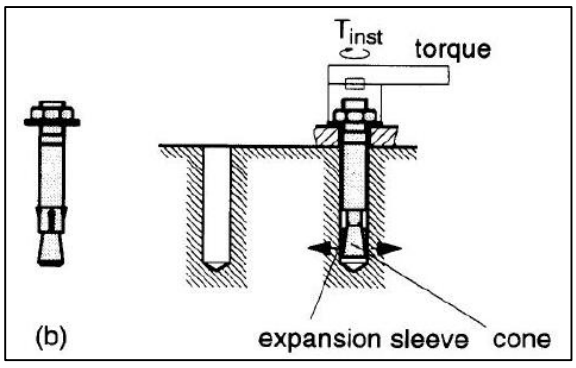
These are covered in ETAG 001 1997 parts 2-5 and in CEN 1992-4-4 and CEN 1992-4-5.

ETAG 001 1997 Parts 1-5 can be downloaded free from the EOTA web site and the CEN standards can be purchased from BSI.

Torque controlled expansion anchors
These are the most commonly used steel anchors, and are anchored by the principle of expansion. The anchors covered are:

a) Shell type expansion anchors with one cone (Fig. a) or more than one cone.
b) Bolt type expansion anchors with one cone (Fig. b) or more than one cone.
c) A combination of a) and b).



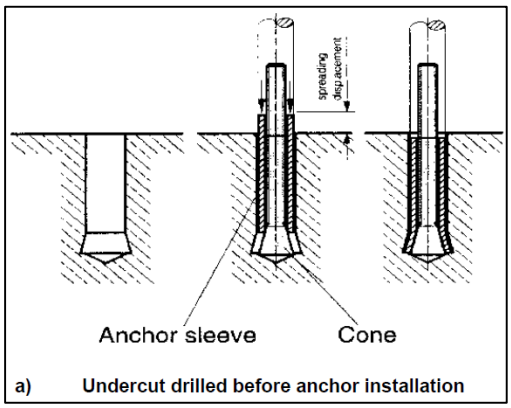


These types of torque controlled anchors can be fixed through the fixture (through fixed) which means the anchors can be installed with the fixture in place, this can be an important factor for the installer.
As the name suggests these are “torque controlled” and the intensity of the anchorage is controlled by this torque, therefore they should be installed using a calibrated torque wrench and tightened to a pre-determined torque.
They can be suitable for use in cracked and non-cracked concrete depending on the anchor type. Anchors that are suitable for cracked concrete will exhibit “follow-up expansion”. This is achieved in several ways but essentially the anchor body has to be able to move independent of the expansion clip. This is achieved by using special lubricants between the anchor body and the expansion clip to reduce friction. The downside of this is that many of these anchor types cannot be produced in Hot Dipped Galvanised as the galvanising re-introduces friction.

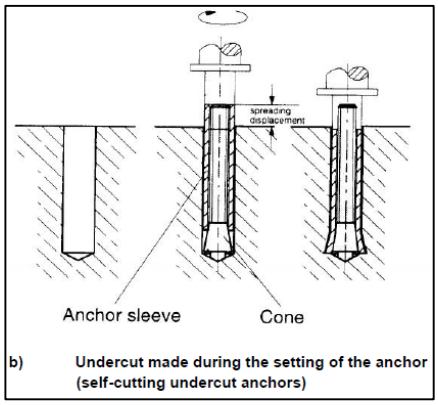
Undercut anchors

Undercut anchors are anchored mainly by mechanical interlock provided by an undercut in the concrete. The concept is to achieve a similar resistance to a cast in system with a post installed system. The anchors covered are:

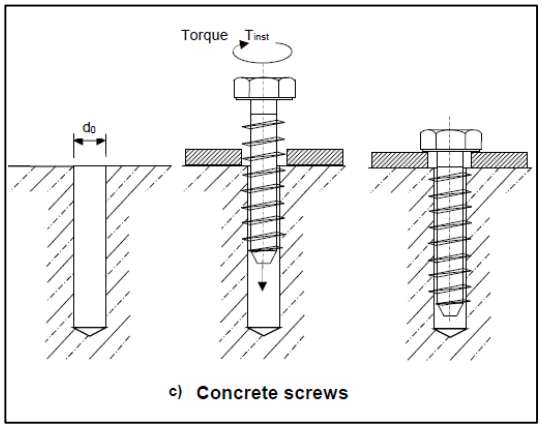
a) Anchors installed into drill holes where the undercut is pre-formed using special drilling tools, *undercut drilled before anchor installation (Fig a).*
b) Anchors installed into cylindrical drill holes and rotated or hammered to form the undercut, *self-cutting undercut anchors (Fig b).*
c) Concrete screws installed into a pre-drilled cylindrical drill hole. *The special thread of the anchor cuts an internal thread into the concrete member while setting (Fig c).*



a) Undercut drilled before anchor installation



b) Undercut made during the setting of the anchor (self-cutting undercut anchors)



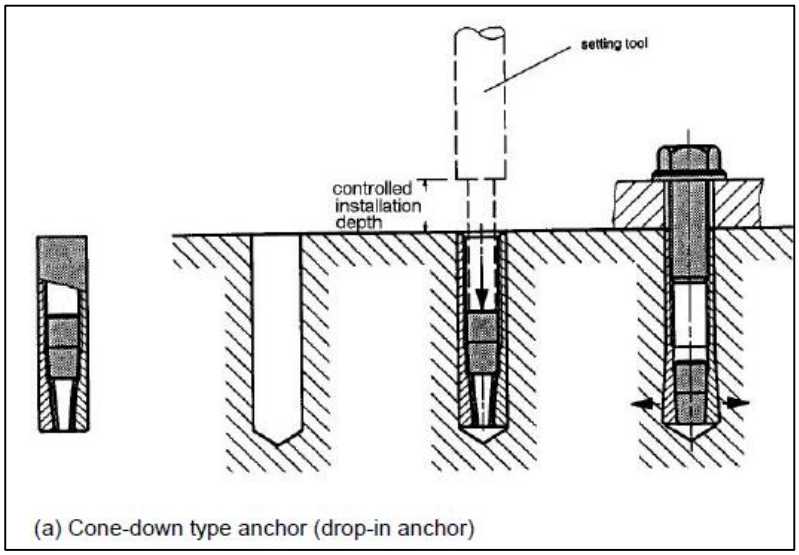
c) Concrete screws

These anchors are available in “through fix” and “prefix” form. They offer very good design resistance and function well in cracked concrete. Type a) and b) require either special drilling equipment or special setting tools along with specialist knowledge with regard to the installation process. If you are going to select this type of anchor you need to ensure the cost of all tools are considered and that the installers are familiar with the installation process.

Concrete screws are becoming more popular in recent years, they offer good design resistance and can be aesthetically pleasing. Care should be taken not to exceed the stated installation depth as trying to set them too deep will generate excessive installation torsion and can damage the screw. These are also easily removable which can be an advantage for temporary fixings. The guideline currently states the anchors may be used only once, this is because the threads can wear out with reuse. Some products are now being provided with wear indicator “go/no-go” gauges to identify the suitability of the screw for reuse.

Deformation controlled anchors

With deformation-controlled anchors, the expansion is generally achieved by impacts acting on a sleeve or cone the most common of these is the so called “drop-in anchor”. With this anchor the sleeve is expanded by driving in a cone, the anchorage being controlled by the length of travel of the cone (fig a).



(a) Cone-down type anchor (drop-in anchor)

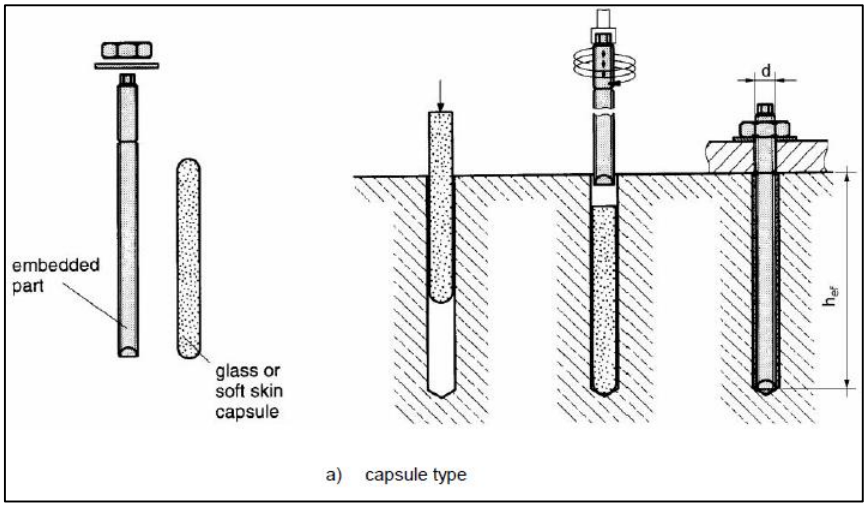
These anchors are most commonly used overhead for the suspension of threaded rods to support mechanical and electrical systems. They are called deformation controlled anchors and it is very important that the deformation is controlled by using the proprietary setting tool. The use of other means to set the cone will not guarantee the correct setting of the anchor and will compromise the resistance capacity in tension.

Most of these are installed overhead and the drill dust falls from the drill hole. If these anchors are being installed horizontally or vertically downwards care should be taken to ensure the drill dust is removed from the hole, otherwise the dust can prevent full travel of the cone.

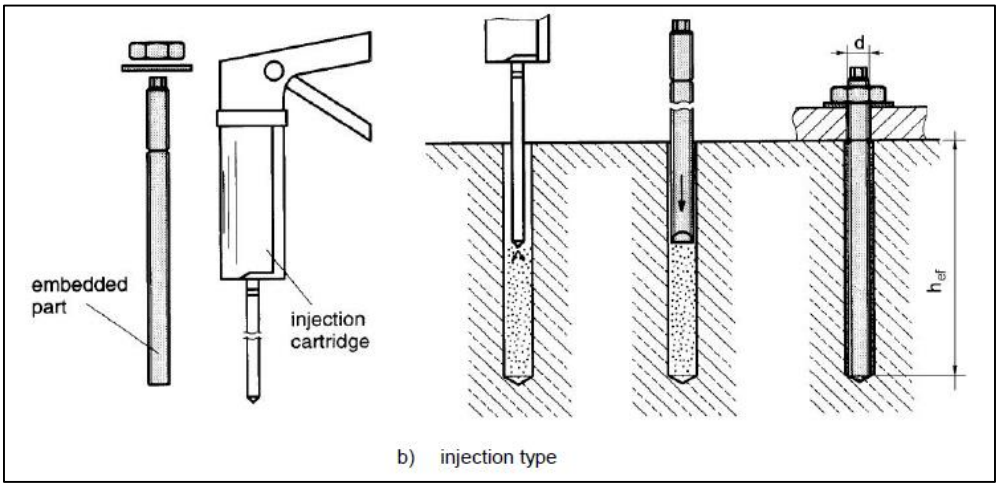
Bonded anchors

Bonded anchors employ the use of resins and mortars to bond steel elements into drilled holes in hardened concrete and masonry. The anchors covered are:

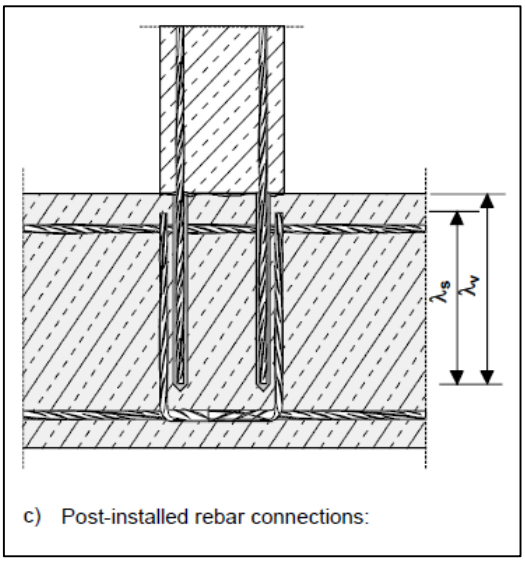
a) Glass capsule or soft-skin capsule,
b) Pre-packed injection (coaxial or side by side) cartridges,
c) Post installed rebar connections to EC2



a) capsule type



b) injection type



c) Post-installed rebar connections:

The glass capsule or soft skin capsules contain a predetermined quantity of resin for predetermined drill hole depths, multiple capsules can sometimes be used. The anchor stud must be driven into the capsule using a drill on rotary and hammer action. It is important that the anchor stud has a chisel point on the end that is inserted into the capsule to enable correct mixing of the two components that are in the capsule. These capsules mostly contain Vinylester based resin and fillers such as quartz aggregate.

Pre packed injection resin systems contain a two part mortar that is mixed in the nozzle (static mixer) as the separate components are extruded from the cartridge. The typical cartridges available are shuttle (side by side cartridges) or co-axial (cartridge inside cartridge) cartridges. These resins can be installed at setting depths from 4 time bar diameter to 20 times bar diameter. The installer just extrudes as much resin as is required for holes of different depths.

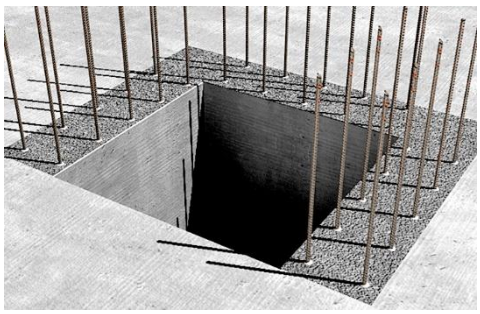
The base resins used in Injection systems are typically Polyester resin, Vinylester resin or pure epoxies. Some of the factors that influence the choice of resin are conditions such as Dry internal conditions, damp external conditions, installation in wet or dry holes, installation under water, temperature, fire behaviour, load behaviour and drill hole conditions like hammer drilling or diamond drilling.

It is important that the selected resin can cope with the anticipated conditions both during installation and during the life of the connection.

Some of the newer resins have very high bond strengths to enable them to cope with the requirements for cracked concrete. This makes them very suitable to resist high loads even in cracked concrete. One topic that is currently under discussion is the long term behaviour of such resins. The test for creep that these resins undergo is an old process that was developed for resins of lower bond strength and with fillers. Under discussion at the moment is the issue of high strength resins when they are used to support fixtures that are overhead and in permanent tension. Until such time that a new test regime for creep is developed it is advised to apply an additional factor of circa 0.5 to the resistance capacity of bonded anchors in overhead applications load in tension.

A few producers have recently developed bonded anchors that don’t require any hole cleaning. While this is a welcome development I would suggest that designers are cautious when specifying such conditions. Drill dust or dirt can cause a problem when bonding any materials together, the anchor industry has spent many years emphasising the importance of hole cleaning. The importance of drill hole cleaning is now well known to anchor installers and supervisors. My personal view is that if an installer is prepared to clean the drill holes then let him do it. Not all resins are suitable for non-cleaned drill holes and if the installer is told hole cleaning is no longer required he could apply his new knowledge to resins that still require hole cleaning, leading to failure. If a system is not sensitive to hole cleaning then this should be seen as a nice feature that will bring a positive influence when the installer is careless and the engineer should just consider it as an additional safenet while still instructing the installer to clean the hole.

Post installed Rebar connections:



Injection resin is very often used for the post fixing of reinforcement bars in concrete. When doing this the designer has the option to design according to EOTA TR 029 for chemical anchors or to EOTA TR 023 for post installed rebar. The first design method employs the same rules as for bonded anchors and considers the bond strength of the resin, the tensile strength of cones in the concrete and the reduction factors for edge distance and bar spacing. The second method employs the same rules as cast in bars and works on the principle of load transfer into other steel. The edge distance and bar spacing are treated in the very same way as cover and bar spacing in EC2 and the bond strength is limited to that for cast in bars. When using the second method the setting depth of the bar is typically in the region of 40 times bar diameter. When cleaning drill holes and injecting resin to such depths the installer must use additional tools to achieve this.

If you have any questions on any of the above please contact us at Masonry Fixing Services Ltd on 01 6426700.