Anchor watch – New dimensions for resin anchor spacing and edge distance.

Anyone who has ever been involved in the selection of post fixed anchor systems for connecting steel to concrete will be very aware that limits for characteristic and minimum anchor spacing and edge distances must be observed.

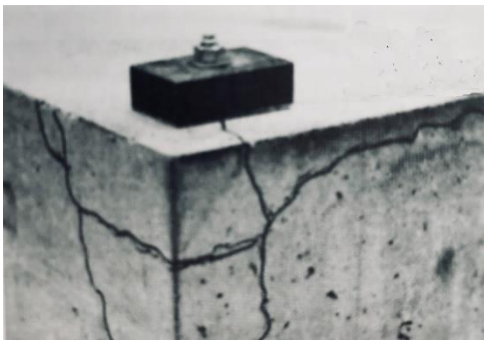
Few people however are aware of the reason for these limits and the origin of their dimensions.

In this article I want to give a detailed explanation to help you understand why such limits exist and where the required values come from. To simplify matters I am going to only focus on tension actions.

If I start with **edge distance**, there are three reasons why edge distances exist;

1. To ensure concrete splitting does not occur during anchor installation.
2. To ensure concrete splitting does not occur during anchor loading.
3. To ensure sufficient concrete cover for corrosion protection (not dealt with here)

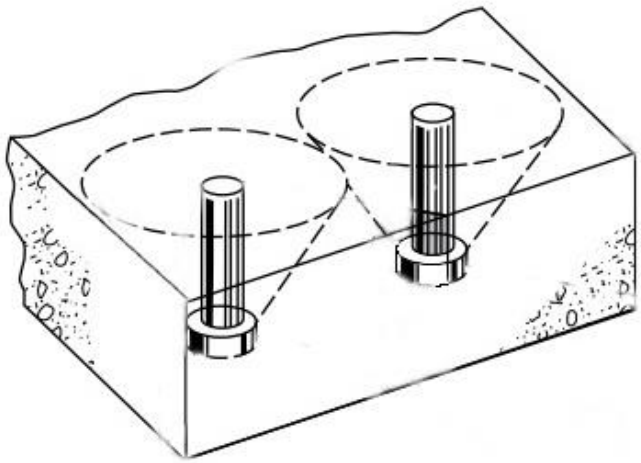
1) Splitting failure during installation:
   Most expansion anchors generate radial expansion pressure in the concrete during the installation process. The magnitude of this pressure depends on the amount of expansion and the deformation resistance of the concrete. For undercut and bonded anchors, the magnitude of this pressure depends on the level of prestressing generated while torqueing the anchor to create the required clamping force.



2) Splitting failure during loading:
   Even if an edge dimension is determined to ensure splitting failure does not occur during installation, it must be ensured that splitting failure does not then occur when the intended loading is applied to the anchor.

The minimum edge distance is determined experimentally, and the value is then provided in the products European Technical Assessment (ETA).

If I move on to **anchor spacing**, the reason for anchor spacing is totally different. When an anchor is loaded in tension it will attempt to pull a concrete cone out of the concrete, the size of this cone is a function of the anchors embedment depth (See article 15th Sept 2014). When a pair of anchors are spaced at $\geq 3 \times h_{ef}$ the failure load of the pair corresponds to 2 x the failure of a single anchor. At a theoretical spacing = 0 the concrete cone, corresponding to one anchor, is developed and the failure of the pair corresponds to that of a single anchor. The relationship between $s = 3 \times h_{ef}$ and $s = 0$ is linear.



With regard to resin anchors, the anchor spacing and edge distance dimensions used until now were derived using the k (kappa) method, developed back in the 1980's. At that time resin anchors were only available in the capsule form and injection systems were not yet developed.

The capsule systems had pre-set embedment depts to match the standard capsule length. Concrete cone failure according to the κ method developed at a 45º angle to the horizontal so the characteristic anchor spacing in tension $s_{cr,N}$ was 2 x h_{ef} and the characteristic edge distance in tension $c_{rr,N}$ was 1 x h_{ef}.

The below table shows typical anchorage depths for standard capsule diameters.

"κ" Method

	M8	M10	M12	M16	M20	M24	M30
Standard Setting Depth [mm]	80	90	110	125	170	210	280
Anchor spacing s_{cr} [2 x h_{ef}] mm	160	180	220	250	340	420	560
Edge distance c_{cr} [1 x h_{ef}] mm	80	90	110	125	170	210	280
Min anchor spacing mm [0.5 x $c_{cr,n}$]	40	45	55	65	85	105	140
Min edge distance mm [0.5 x $c_{cr,n}$]	40	45	55	65	85	105	140

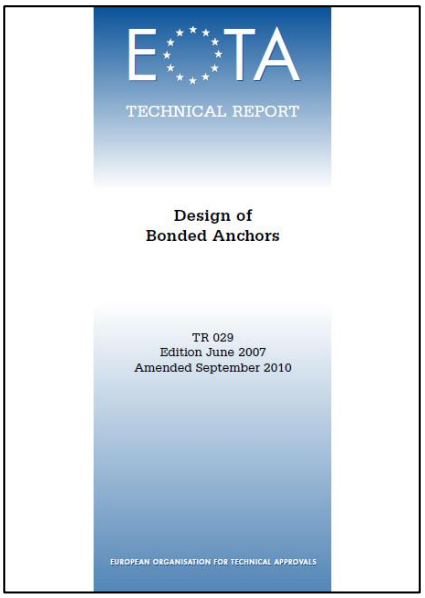
If we take an M16 for example, the characteristic anchor spacing $s_{cr,N}$ was 250 mm (2 x h_{ef}), the critical edge distance $c_{cr,N}$ was 125 mm (1 x h_{ef}). It was decided that the minimum edge distance could be 0.5 x $c_{cr,N}$ = 62.5 mm (rounded up to 65 mm) and the minimum anchor spacing could equal the min edge distance as reduced anchor spacing is not critical to concrete edge splitting.

Generally, the computed reduced capacity of an M16 resin anchor at the min edge and spacing was such that an M12 would resist the same actions and so it was never necessary to consider an M16 at lesser dimensions.

These dimensional restrictions, while derived from cones in tension were, for reasons of simplification, applied to anchors in shear also.

These values, being conservative, were successfully used for many years.

In 2007 EOTA TR029 was introduced to reflect the development of, and increased use of chemical injection systems. One fundamental difference introduced in TR 029 was that resin anchors could now be installed with depths in a range of 4 times to 20 times the bar diameter. So, for an M16 the setting depth can be between 64 mm and 320 mm.



TR 029 ensured that the concrete capacity in tension reflected this by ensuring that the characteristic anchor spacing in tension $s_{cr,N}$ and the characteristic edge distance in tension $c_{cr,N}$ are, in accordance with the CC method, **3** times h_{ef} ($s_{cr,N}$) and **1.5** times hef ($c_{cr,N}$). These values increase or reduce as the setting depth is increased or reduced.

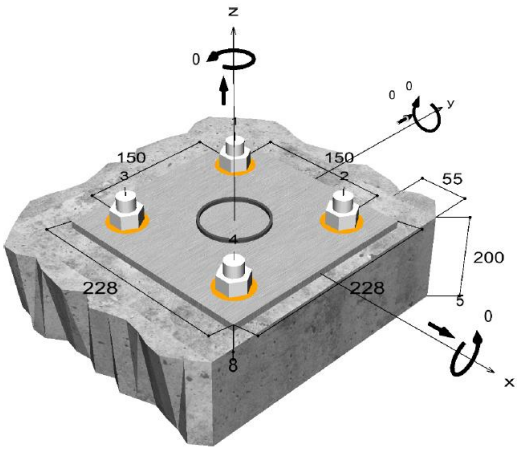
For concrete capacity in shear TR 029 uses a formula that considers, among other things, the actual edge distance c_1 and the concrete compressive strength $f_{ck,cube}$.

The computed capacity for concrete resistance in shear, according to TR 029, will be similar irrespective of anchor diameter and there is therefore no reason why for example we cannot calculate the concrete edge capacity for a 20 mm resin anchor with a 55 mm edge distance. This places a question over why we need to observe an outdated requirement to limit the M20 anchor to a min edge c_{min} of 85 mm.

The CC method and other developing methods such as that of EN 1992-2 are referred to as being “state of the art” meaning that they reflect current knowledge. As research is continuous the models within the standards are fluid and frequently changing to reflect new developments.

While TR 029 brought many new possibilities with the introduction of varying setting depths, the anchor producers and approval bodies continued to use the standard values developed by the k method in the 1980’s for min anchor spacing s_{min} and min edge distance c_{min}.

Developments in recent times have removed the restrictions that the κ method placed on resin anchors for s_{min} and c_{min}.
Less conservative values are now allowed to be included in any European Technical Assessment update.



For this reason, you will, over the coming months, start to see published data for resin anchors with smaller values for s_{min} and c_{min}. This is not because of changes in the product itself but is simply because the regulations have advanced.

The concrete capacity in tension and in shear will still be calculated according to the models of TR 029 and EN 1992-4.

There are other changes in the pipeline and they will be introduced into anchor manufacturers manuals and software as and when they are validated by the regulators. We at Masonry Fixings pride ourselves with being close to the current and incoming regulations and we offer excellence in technical support. We have had a 40-year presence on the Irish construction market in the post fixed anchor sector and we have worked with practically all major design engineers and contractors during that time. It is also our intention to highlight these types of changes for you in future articles similar to this one.

In the meantime, should you have any doubt or questions on any aspect of the codes please pick up the phone and call us on 00353 1 6426700, or email us on technical@masonryfixings.ie.

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