From DAwf

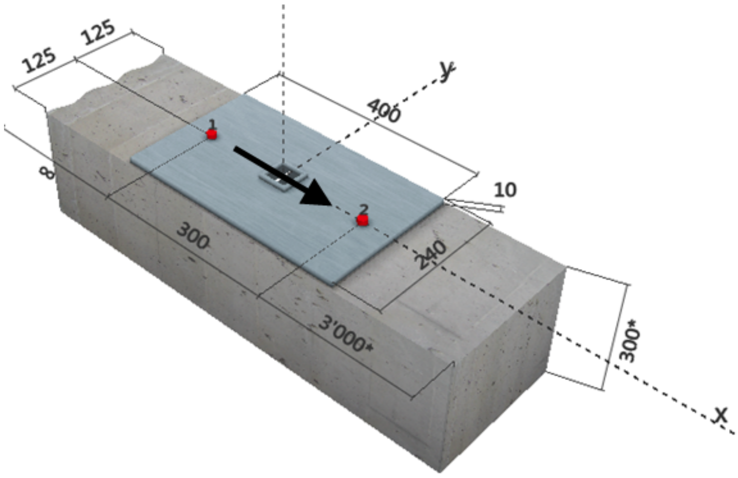
T +423-234 2914
E Fritz.wall@hilti.com

Concrete edge failure for large edge distances

Question:

Why calculate concrete edge failure for edge distances $c > 10\ h_{ef}$ (and $c > 60d$) for an example such as given below?

Example:
concrete: C20/25 (non-cracked)
concrete thickness: h = 300mm
anchor: HSA M16
load: shear load V_x



Answer:

As mentioned in the ETAG 001, Annex C (2nd Amendment November 2006), section 5.2.3.4 the check of the characteristic concrete edge failure resistance may be omitted for anchorages with an edge distance of $c \geq 10\ h_{ef}$ in all directions.

> 5.2.3.4 Concrete edge failure
>
> For anchorages shown in Figure 1.1 with an edge distance in all directions $c \geq 10\ h_{ef}$, a check of the characteristic concrete edge failure resistance may be omitted.

In the ETAG 001, Annex C (3rd Amendment February 2009) the criteria $c > 60\ d$ has been added:

> **5.2.3.4 Concrete edge failure**
>
> Concrete edge failure need not to be verified for groups with not more than 4 anchors when the edge distance in all directions is $c > 10\ h_{ef}$ and $c > 60\ d$.

In the example, in which context the question was raised, the edge distance c is larger than $10\ h_{ef}$ in one direction but not in all directions. Hence, an automatic omission of the proof is not supported by the ETAG 001, Annex C.

In such a situation the following considerations may be useful:

Typical failure pattern resulting from shear loads acting on anchorages close to an edge in the direction perpendicular to the edge are given in e.g. CEB Bulletin No. 216 “Fastenings to concrete and masonry structures, 1994 (see Fig. 1 below) or Eligehausen/Mallée/Silva: “Anchorage in Concrete Construction”, Ernst & Sohn, 2006).

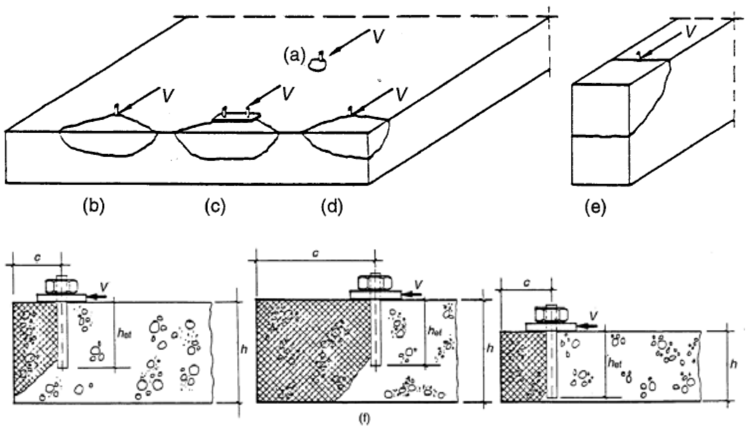


Fig. 1: failure mode edge breakout

The result of an actual shear load test with a shear load applied perpendicular to the edge on a single anchor is shown in Fig. 2.

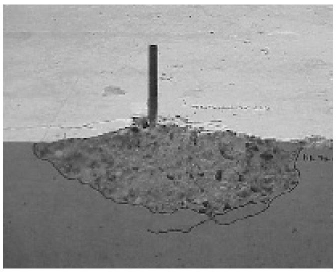


Fig. 2: concrete edge failure

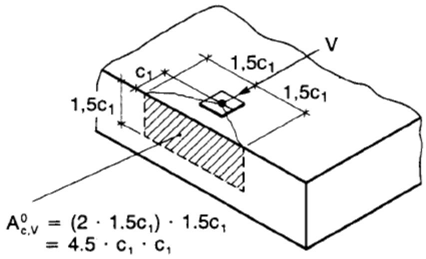


Fig. 3: idealized concrete cone

For the design method as given in the ETAG 001, Annex C an idealized concrete cone with an area of concrete cone $A^0_{c,V}$ for a single anchor is assumed (see Fig. 3). The ETAG 001, Annex C also provides examples for the calculation of the actual areas $A_{c,V}$ for single anchors accounting for edges/corners and thin members, and for anchor groups.

For the current issue consider the following scenario:

- Place an anchor close to the edge c_1(a). The resulting idealized cone is shown Fig. 4a.
- Then increase the edge distance c_1(b) until the area $A_{c,V}$ takes up the whole cross section (Fig. 4b). This is associated with an increase in the characteristic resistance in case of concrete edge failure as well.
- Upon further increasing the edge distance c_1(c) the failure surface moves back but the failure area remains constant (Fig. 4c). Hence, the characteristic resistance regarding concrete edge failure remains constant as well. Please note that this consideration is also the basis for the special case of “anchorages in a narrow, thin member with $c_{2,max} \leq 1.5\ c_1$ and $h \leq 1.5\ c_1$“ given in the ETAG 001, Annex C in the section for concrete edge failure.

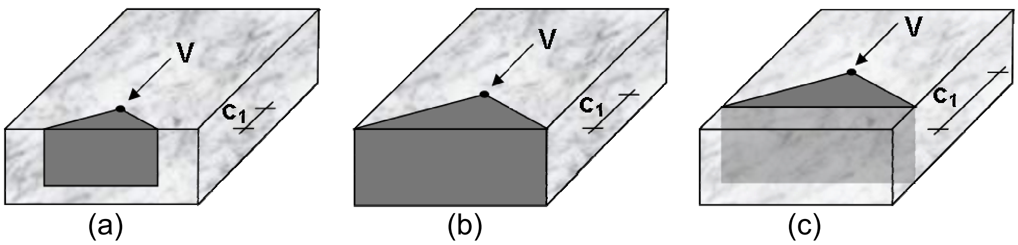


Fig. 4: concrete edge failure in a thin, narrow member

Please note that within these considerations

- the influence of the longitudinal reinforcement along the “beam” is neglected; and
- the failure occurs if the tensile capacity of the concrete is exceeded in the load introduction zone and the failure surface is formed.

An engineer facing e.g. a cantilever beam application, i.e. a narrow thin element, with a fastening that has a large edge distance in one direction (as given in the example in which context the question was raised), needs to assess whether the edge at the end of the beam is relevant for his/her specific situation.
If the engineer comes to the conclusion that this edge is not relevant (e.g. due to the amount of longitudinal reinforcement, and/or other considerations) then PROFIS Anchor 2.0 allows to deactivate the corresponding edge in the "Base material" tab and the application is handled as given in Fig. 5.

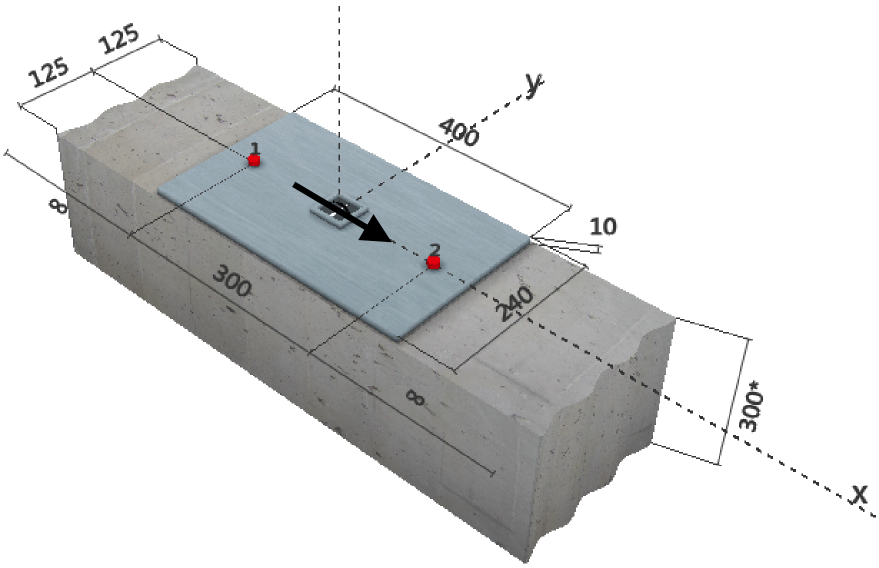


Fig. 5: narrow thin member