LOAD BEARING BEHAVIOUR OF POST INSTALLED ANCHOR SYSTEMS IN CRACKED CONCRETE UNDER TENSION LOADING

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1. INTRODUCTION

For a safe design of post-installed anchorages the first step is the correct definition of the base material and the acting loads.
2. ANCHOR SYSTEMS AND LEGISLATION

Post Installed Anchor systems transfer applied loads to the base material in various ways;

![Mechanical interlock](image1)
![Friction](image2)
![Bond](image3)

The design is covered by the Guideline for European Technical Approval (ETAG) for the member states of the European Union.

Approved anchors have their intended use shown in the respectively valid European Technical Approval (ETA).

The anchor may be anchored in cracked and non-cracked concrete.

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3. CRACKED CONCRETE

In the design of tension components, a cracked tension zone is assumed because concrete possesses relatively low tensile strength.

![Crack widths result](image4)


Crack widths resulting from primarily quasi permanent loads do not exceed the value of $w_{95\%} \approx 0.3\text{mm}$ to $0.4\text{mm}$.

Wider cracks under maximum permissible service loads are expected to reach $w_{95\%} \approx 0.5\text{mm}$ to $0.6\text{mm}$.


There is a relatively high likelihood that cracks will intersect the anchor location.
4. LOAD TRANSFER MECHANISMS

4.1. MECHANICAL INTERLOCK

Hilti undercut anchor HDA

ETA - 99/0009:
Intended use:
Cracked and Non-Cracked Concrete

Undercut Anchor
Post-Installed

Headed Stud
Cast-in-place anchor

Rotationally symmetric stress pattern around the anchor

Disturbance of the rotational stress field

Reduction of failure load in cracked concrete

~25% reduction compared to non-cracked concrete
4. LOAD TRANSFER MECHANISMS

4.2. EXPANSION

Hilti Torque Controlled expansion anchor HSL-3

ETA - 02/0042:
Intended use:
Cracked and Non-Cracked Concrete

Load resistance is similar to that observed for headed studs but with higher displacements

~30% reduction in cracked concrete

Expansion anchors not suitable for applications in cracked concrete can exhibit uncontrolled slip i.e. develop follow-up expansion only after significant displacement.
4. LOAD TRANSFER MECHANISMS

4.3. BOND

Hilti HY 200 + Threaded Rod
ETA 11/0493
Intended use: Cracked and Non-Cracked Concrete

Bond Strength is primarily a function of:
Type of Mortar
Hole Cleaning
Condition of borehole (Dry, Wet)
Drilling Process
Temperature
4. LOAD TRANSFER MECHANISMS

4.3. BOND

Tests were conducted using various mortar types. Anchors were loaded to failure with cracks open while pullout failure occurred. The anchor capacity in cracked concrete with a crack width of \( w = 0.3\text{mm} \) to \( 0.4\text{mm} \) is on average about 50%. However, there was a scatter of results because it was not distinguished between the individual behavior of the mortars.

The mortar system influences the crack trajectory.

Due to the high tensile strength of the mortar, crack opening after anchor installation results in a redirection of the crack around the anchor along the interface between mortar and concrete, effectively causing bond loss on one side of the anchor. Assuming that the crack trajectory occurs over the full embedment depth, the bond capacity is theoretically 50% of the capacity in non-cracked concrete. Investigations in Appl. J (2008) indicate that this assumption is not generally valid.
4. LOAD TRANSFER MECHANISMS

4.3.1 TORQUE CONTROLLED BONDED ANCHORS

Hilti HY 200 + HIT-Z Helix Rod
ETA 12/0006
Intended use:
Cracked and Non-Cracked Concrete

Compression forces are created along the helix when subjected to tension forces

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4. LOAD TRANSFER MECHANISMS

4.3.1 TORQUE CONTROLLED BONDED ANCHORS

ETA 12/0006 – Annex B. Characteristic values of resistance under tension loads

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For this particular system, accordingly to valid ETA 12/0006, the bond capacity in cracked concrete has a reduction of 10%.

5. CONCLUSIONS

- When designing tensile components in monolithic structures, specially in rehabilitation projects, cracked concrete has to be assumed.
- For undercut anchors installed in cracked concrete (with mechanical interlock), there is a known decrease of the tension resistance of ~25%.
- Expansion anchors can have a considerable displacement but the resistance of approved anchors is reduced ~30%.
- Bonded Anchors have an outstanding performance but their resistance to tension loading depends on various parameters, among them the characteristic bond resistance of the mortar.
- Accordingly to EOTA there are now available anchorage systems approved for cracked concrete that only have a reduction of 10% of the value of characteristic bond resistance in non-cracked concrete, which can increase considerable the overall resistance of the fixture.
Thank you for your attention!