TECHNICAL REPORT

# Design of fastenings based on EAD 330232-00-0601, EAD 330499-00-0601 and EAD 330747-00-0601

TR 055

December 2016

Amended February 2018

EUROPEAN ORGANISATION FOR TECHNICAL ASSESSMENT

WWW.EOTA.EU

Essential characteristics of post-installed fasteners for use in concrete according to EAD 33-0232-00-0601 Table 2.1 (mechanical fasteners) and EAD 330499-00-0601 Table 2.1 (Bonded fasteners including bonded expansion fasteners) and EAD 330747-00-0601 (Fasteners for use in concrete for redundant non-structural systems) are related to FprEN 1992-4 which is currently not yet published.

The Essential characteristics given in ETAs which are based on EAD 330232-00-0601 and EAD 330499-00-0601 may be used for design according to CEN/TS 1992-4-4:2009 or ETAG 001 Annex C with EOTA Technical Reports TR 020 (for fastenings under fire exposure) and TR 045 (for fastenings under seismic action) to bridge the time span until publication of EN 1992-4. Some symbols for essential characteristics are different in the different design codes. Therefore the correct symbols for design in CEN/TS 1992-4-4:2009, ETAG 001 Annex C and EOTA Technical Reports TR 020:2004, TR 029:2010 and TR 045:2013 are given in Table 1.

**Table 1 Essential characteristics**

| Designation | Symbols used in | | |
|---|---|---|---|
| | EN 1992-4:2016 | CEN/TS 1992-4-4:2009, TR 020 and TR 045 | ETAG 001 Annex C, TR 020 TR 029 and TR 045 |
| Concrete compressive strength [N/mm²] | Concrete **cylinder** strength $f_{ck}$ | Concrete **cube** strength $f_{ck,cube}$ | Concrete **cube** strength $f_{ck,cube}$ |
| Characteristic value of steel resistance of a fastener under tension load | $N_{Rk,s}$ [kN] | | |
| Modulus of elasticity | $E_s$ [N/mm²] | - | - |
| Increasing factor for pull-out resistance for different concrete strength classes related to C20/25 | $\psi_c$ | | |
| Characteristic resistance in case of pull-out failure under tension load | $N_{Rk,p}$ [kN] | | |
| Factor for determination of the resistance to concrete cone failure in cracked concrete | $k_1 = k_{cr,N}$ [-] for equation (7.2) based on concrete cylinder strength $f_{ck}$ (Indicative value $k_{cr,N} = 7,7$) | $k_{cr} = 7,2$ for equation (2) for applications in cracked concrete based on concrete cube strength $f_{ck,cube}$ | $k_1 = 7,2$ for equation (5.2a) for applications in cracked concrete based on concrete cube strength $f_{ck,cube}$ |
| Factor for determination of the resistance to concrete cone failure in uncracked concrete | $k_1 = k_{ucr,N}$ [-] for equation (7.2) based on concrete cylinder strength $f_{ck}$ (Indicative value $k_{ucr,N} = 11,0$) | $k_{ucr} = 10,1$ for equation (3) for applications in uncracked concrete based on concrete strength $f_{ck,cube}$ | $k_1 = 10,1$ for equation (5.2a) for applications in uncracked concrete based on concrete strength $f_{ck,cube}$ |
| Effective embedment depth | $h_{ef}$ [mm] | | |
| Characteristic edge distance for ensuring the transmission of the characteristic resistance of a single fastener in case of concrete break-out under tension load | $c_{cr,N}$ [mm] | | |
| Factor accounting for the sensitivity to installation of post-installed fastener | $\gamma_{inst}$ [-] for Table 4.1 | $\gamma_{inst}$ [-] for equation (11) | $\gamma_2 = \gamma_{inst}$ [-] for 3.2.2.1 |
| Minimum allowable edge distance | $c_{min}$ [mm] | | |
| Minimum allowable spacing | $s_{min}$ [mm] | | |
| Minimum allowed thickness of concrete member | $h_{min}$ [mm] | | |
| Basic value of characteristic resistance for splitting concrete | $N^0_{Rk,sp}$ [kN] for equation (7.23) | $N^0_{Rk} = N^0_{Rk,sp}$ [kN] for equation (12) | $N^0_{Rk,c} = N^0_{Rk,sp}$ [kN] |
| Basic value of characteristic resistance to combined pull-out and concrete | $\tau_{Rk,ucr}$ [N/mm²] | | |

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|---|---|---|---|
| | EN 1992-4:2016 | CEN/TS 1992-4-4:2009, TR 020 and TR 045 | ETAG 001 Annex C, TR 020 TR 029 and TR 045 |
| cone failure in uncracked concrete | | | |
| Basic value of characteristic resistance to combined pull-out and concrete cone failure in cracked concrete | $\tau_{Rk,cr}$ [N/mm²] | | |
| Basic value of design resistance valid for all load directions and modes of failure for simplified design method B | $F^0_{Rd}$ [kN] | | |
| Design resistance valid for all load directions and modes of failure for simplified design method C | $F_{Rd}$ [kN] | | |
| Characteristic edge distance to prevent splitting of concrete under load | $c_{cr,sp}$ [mm] | | |
| Basic value of characteristic resistance to steel failure under shear load | $V^0_{Rk,s}$ [kN] | $V_{Rk,s} = V^0_{Rk,s}$ [kN] | $V_{Rk,s} = V^0_{Rk,s}$ [kN] |
| Basic value of characteristic resistance to steel failure with lever arm | $M^0_{Rk,s}$ [Nm] | | |
| Factor taking into account the ductility of the fasteners | $k_7$ [-] for equation (7.35) | 6.2.2.2 a): $k_2 = k_7$ | 5.2.3.2. a): fixed values 0,8 for non-ductile steel |
| Thickness of the fixture | $t_{fix}$ [mm] | | |
| Factor for determination of resistance to pry-out failure | $k_8$ [-] for equation (7.39a) | $k_3 = k_8$ for equation (16) | $k = k_8$ for equation (5.6) |
| Outside diameter of a fastener | $d_{nom}$ [mm] | | |
| Effective length of the fastener for transfer of shear load | $l_f$ [mm] | | |
| Displacement of the fastener under short term tension load | $\delta_{N0}$ [mm] | | |
| Displacement of the fastener under short term shear load | $\delta_{V0}$ [mm] | | |
| Displacement of the fastener under long term tension load | $\delta_{N\infty}$ [mm] | | |
| Displacement of the fastener under long term shear load | $\delta_{V\infty}$ [mm] | | |
| Characteristic resistance to steel failure under tension load for seismic applications | $N_{Rk,s,eq}$ [kN] | $N_{Rk,s,seis} = N_{Rk,s,eq}$ [kN] | |
| Characteristic resistance to steel failure under shear load for seismic applications | $V_{Rk,s,eq}$ [kN] | $V_{Rk,s,seis} = V_{Rk,s,eq}$ [kN] | |
| Characteristic resistance to pull-out failure under tension load for seismic applications | $N_{Rk,p,eq}$ [kN] | $N_{Rk,p,seis} = N_{Rk,p,eq}$ [kN] | |
| Basic value of characteristic resistance to combined pull-out and concrete cone failure for seismic performance categories C1 and/or C2 | $\tau_{Rk,eq}$ [N/mm²] | $\tau_{Rk,seis}$ [N/mm²] | |
| Fracture elongation | $A_5$ [%] | | |
| Reduction factor taking into account | $\alpha_{gap}$ [-] | | |

| Designation | Symbols used in | | |
|---|---|---|---|
| | EN 1992-4:2016 | CEN/TS 1992-4-4:2009, TR 020 and TR 045 | ETAG 001 Annex C, TR 020 TR 029 and TR 045 |
| inertia effects due to an annular gap between fastener and fixture | | | |
| Displacement under seismic action | $\delta_{N,eq}$, $\delta_{V,eq}$ [mm] | $\delta_{N,seis} = \delta_{N,eq}$, $\delta_{V,seis} = \delta_{V,eq}$ [mm] | |
| Characteristic resistance to steel failure under fire exposure for tension load | $N_{Rk,s,fi}$ [kN] | | |
| Characteristic tension resistance to pull-out failure under fire exposure | $N_{Rk,p,fi}$ [kN] | | |
| Characteristic resistance to steel failure under fire exposure for shear load | $V_{Rk,s,fi}$ [kN] | | |
| Basic value for the characteristic bending moment under fire exposure | $M^0_{Rk,s,fi}$ [Nm] | | |