

EOTA<sup>®</sup>

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

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/mm <sup>2</sup> ]	Concrete <b>cylinder</b> strength $f_{ck}$	Concrete <b>cube</b> strength $f_{ck,cube}$	Concrete <b>cube</b> 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/mm <sup>2</sup> ]	-	-
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	$N_{Rk,sp}^0$ [kN] for equation (7.23)	$N_{Rk}^0 = N_{Rk,sp}^0$ [kN] for equation (12)	$N_{Rk,c}^0 = N_{Rk,sp}^0$ [kN]
Basic value of characteristic resistance to combined pull-out and concrete	$\tau_{Rk,ucr}$ [N/mm <sup>2</sup> ]		

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
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/mm <sup>2</sup> ]		
Basic value of design resistance valid for all load directions and modes of failure for simplified design method B	$F_{Rd}^0$ [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	$V_{Rk,s}^0$ [kN]	$V_{Rk,s} = V_{Rk,s}^0$ [kN]	$V_{Rk,s} = V_{Rk,s}^0$ [kN]
Basic value of characteristic resistance to steel failure with lever arm	$M_{Rk,s}^0$ [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/mm <sup>2</sup> ]	$\tau_{Rk,seis}$ [N/mm <sup>2</sup> ]	
Fracture elongation	$A_5$ [%]		
Reduction factor taking into account	$\alpha_{gap}$ [-]		

Designation	Symbols used in		
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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	$M_{Rk,s,fi}^0$ [Nm]		