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TECHNICAL REPORT

Design of wire loop systems for the connection of precast and in-situ concrete elements

TR 074

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EUROPEAN ORGANISATION FOR TECHNICAL ASSESSMENT
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Contents

1 SCOPE OF THE TECHNICAL REPORT

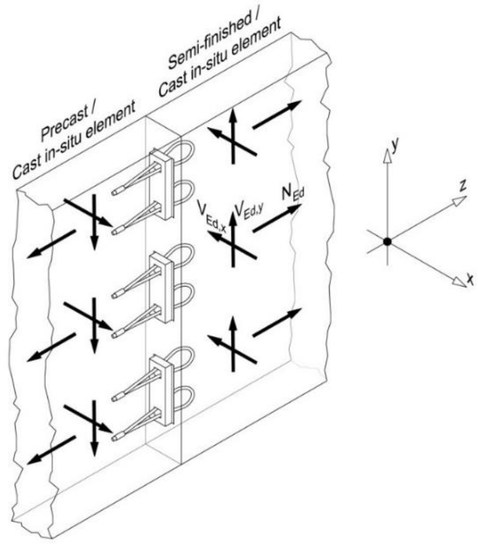
The design rules in this Technical Report (TR) are valid for wire loop systems with a European Technical Assessment (ETA) in accordance with EAD 3302589-00-0601 [1] and EAD 332589-01-00-0601 [2]. This document relies on the resistances stated in the ETA and referred to in this TR.

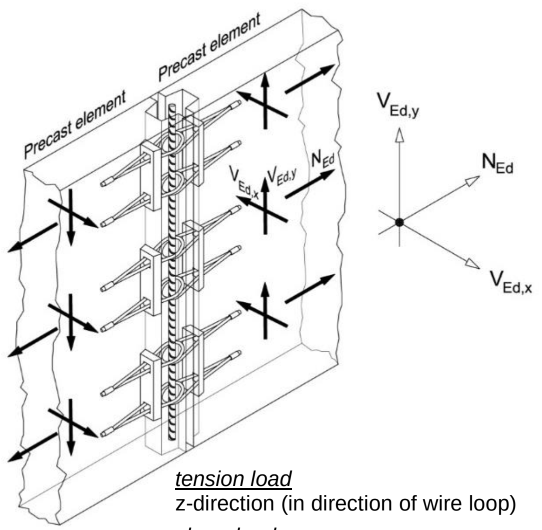
This Technical Report covers the design of wire loop systems for the connection of precast and in-situ concrete components, for the connection of two in-situ concrete components or for the connection of two precast concrete components.

The verification of local transmission of the loads from the first concrete component to the wire loop system and further into the second concrete component is ensured by using the design methods described in this document.

The design and construction of concrete components in which the wire loop systems are to be embedded shall be comparable with the general rules and rules for buildings of concrete structures according to EN 1992-1-1 [3] and the relevant national regulations.

The wire loop system is intended to be used under static or quasi-static loads. The system can be used to transmit tension loads, shear loads perpendicular to the longitudinal axis of the joint, shear loads acting in direction of the longitudinal axis of the joint or any combination of these loads in accordance with Figures 1.1 into the concrete.





tension load
z-direction (in direction of wire loop)
shear load
x-direction (perpendicular to longitudinal axis of box/joint)
shear load
y-direction (in longitudinal axis of box/joint)

Figures 1.1: Load directions: tension load, shear load and any combinations of these

Specific terms used in this TR

E_d	=	design value of action
R_d	=	design value of resistance
N_{Ed}	=	acting tension load
N_{Rd}	=	design resistance under tension load
$N_{Ed,x/y}$	=	acting tension load components of shear action in direction x/y
$V_{Ed,x/y}$	=	acting shear load in direction x/y
$v_{Ed,x}$	=	acting shear load in direction x per meter of joint
$V_{Rd,x/y}$	=	design resistance under shear load in direction x/y
$v_{Rd,x}$	=	design resistance under shear load in direction x per meter of joint
n	=	number of boxes per meter of joint
$k_{x/y}$	=	load combination factor in direction x/y

2 DESIGN AND SAFETY CONCEPT

2.1 Design concept

The design of anchorages shall be in accordance with the general rules given in EN 1990 [4]. It shall be shown that the value of the design actions E_d does not exceed the value of the design resistance R_d.

$$E_d \leq R_d \tag{2.1}$$

with: E_d design value of action

R_d design value of resistance

Actions to be used in design may be obtained from national regulations or in the absence of them from the relevant parts of EN 1991 [5].

The partial factors for actions may be taken from national regulations or in the absence of them according to EN 1990 [4].

2.2 Required verifications

2.2.1 Resistance to tension loads

Resistance to steel failure:

$$N_{Ed} \leq N_{Rk,s} / \gamma_R \tag{2.2}$$

with $\gamma_R = 1,0$ according to EN 1993-1-11 [6]

$N_{Rk,s}$ Resistance of the wire loop system, given in the relevant ETA

Resistance to concrete failure:

$$N_{Ed} \leq N_{Rd} = min\ ((N_{Rk,c,u,5\%} / \gamma_{M,c})\ ;\ (N_{Rk,c,u,min} / \gamma_{M,c,uls})\ ;\ (N_{Rk,c,crack} / \gamma_{M,c,sls})) \tag{2.3}$$

with $\gamma_{M,c} = 1,5$ according to EN 1992-4 [7]

$\gamma_{M,c,uls} = 2,0$

$\gamma_{M,c,sls} = 1,0$

$N_{Rk,c,u,5\%}$, $N_{Rk,c,u,min}$, $N_{Rk,c,crack}$ Resistances of the wire loop system, given in the relevant ETA

2.2.2 Resistance to shear loads perpendicular to the longitudinal axis of box/joint

Calculation for connections with in-situ concrete elements

One of the equations (2.4) and (2.5) shall be fulfilled:

$$V_{Ed,x} \leq V_{Rd,x} = V_{Rk,x} / \gamma_{M,c} \tag{2.4}$$

with $\gamma_{M,c} = 1,5$ according to EN 1992-4 [7]

$V_{Rk,x}$ Resistance of the wire loop system, given in the relevant ETA

$$V_{Ed,x} \leq V_{Rd,x} = min\ ((V_{Rk,c,u,x,5\%} / \gamma_{M,c})\ ;\ (V_{Rk,c,u,x,min} / \gamma_{M,c,uls})\ ;\ (V_{R,c,x,crack} / \gamma_{M,c,sls})) \tag{2.5}$$

with $\gamma_{M,c} = 1,5$ according to EN 1992-4 [7]

$\gamma_{M,c,uls} = 2,0$

$\gamma_{M,c,sls} = 1,0$

$V_{Rk,c,u,x,5\%}$; $V_{Rk,c,u,x,min}$; $V_{Rk,c,x,crack}$ Resistances of the wire loop system, given in the relevant ETA

Calculation for connections of two precast concrete elements

One of the equations (2.6) and (2.7) shall be fulfilled:

$$v_{Ed,x} \leq v_{Rd,x} = v_{Rk,x} / \gamma_C \tag{2.6}$$

with $\gamma_{M,c} = 1{,}5$ according to EN 1992-1-1 [3]

$v_{Rk,x}$ Resistance per meter of joint, given in the relevant ETA

$$v_{Ed,x} \leq v_{Rd,x} = min\,((v_{Rk,c,u,x,5\%} / \gamma_{M,c}) ; (v_{Rk,c,u,x,min} / \gamma_{M,c,uls}) ; (v_{R,c,x,crack} / \gamma_{M,c,sls})) \tag{2.7}$$

with $\gamma_{M,c} = 1{,}5$ according to EN 1992-1-1 [3]

$\gamma_{M,c,uls} = 2{,}0$

$\gamma_{M,c,sls} = 1{,}0$

$v_{Rk,c,u,x,5\%}$; $v_{Rk,c,u,x,min}$; $v_{Rk,c,x,crack}$ Resistances per meter of joint, given in the relevant ETA

2.2.3 Resistance to shear loads in the longitudinal axis of box/joint

$$V_{Ed,y} \leq V_{Rd,y} = min\,((V_{Rk,c,u,y,5\%} / \gamma_{M,c}) ; (V_{Rk,c,u,y,min} / \gamma_{M,c,uls}) ; (V_{Rk,c,y,crack} / \gamma_{M,c,sls})) \tag{2.8}$$

with $\gamma_{M,c} = 1{,}5$ according to EN 1992-4 [7]

$\gamma_{M,c,uls} = 2{,}0$

$\gamma_{M,c,sls} = 1{,}0$

$V_{Rk,c,u,y,5\%}$; $V_{Rk,c,u,y,min}$; $V_{Rk,c,y,crack}$ Resistances of the wire loop system, given in the relevant ETA

2.2.4 Resistance to combined shear loads perpendicular to the longitudinal axis of box/joint and shear loads in the longitudinal axis of box/joint

Calculation for connections with in-situ concrete elements

For combined shear loads the following equations shall be satisfied:

$$V_{Ed,x} / V_{Rd,x} + V_{Ed,y} / V_{Rd,y} \leq 1{,}33 \tag{2.9}$$

Calculation for connections of two precast concrete elements

For combined shear loads the following equations shall be satisfied:

$$v_{Ed,x} / v_{Rd,x} + V_{Ed,y} / V_{Rd,y} \leq 1{,}33 \tag{2.10}$$

2.2.5 Resistance to combined tension loads, shear loads perpendicular to the longitudinal axis of box/joint and shear loads in the longitudinal axis of box/joint

For combined tension and shear loads the following equations shall be satisfied:

$$N_{Ed} + N_{Ed,x} + N_{Ed,y} \leq N_{Rd} \tag{2.11}$$

The tension loads $N_{Ed,x}$ *and* $N_{Ed,y}$ are load components resulted from shear actions:

$N_{Ed,x} = k_x \cdot V_{Ed,x}$ (for calculating the connection of in-situ concreteelements) (2.12)

$N_{Ed,x} = k_x \cdot v_{Ed,x} / n$ (for calculating the connection of two precast concrete elements) (2.13)

$N_{Ed,y} = k_y \cdot V_{Ed,y}$ (2.14)

with n number of boxes per meter of joint

The load combination factors k_x and k_y result from the ratio of resistances N_{Rd}, $V_{Rd,x}$ / $v_{Rd,x}$ and $V_{Rd,y}$ as follows:

$k_{x,calc} = N_{Rd} / V_{Rd,x}$ (for calculating the connection of in-situ concrete elements) (2.15)

$k_{x,calc} = (N_{Rd} \cdot n) / v_{Rd,x}$ (for calculating the connection of two precast concrete elements) (2.16)

$k_{y,calc} = N_{Rd} / V_{Rd,y}$ (2.17)

with N_{Rd} according to Equation (2.3)

$V_{Rd,x}$ according to Equation (2.4) or (2.5)

$v_{Rd,x}$ according to Equation (2.6) or (2.7)

$V_{Rd,y}$ according to Equation (2.8)

Definition of load combination factors k_x and k_y for wire loop systems for the connection of precast and in-situ concrete components or for the connection of two in-situ concrete components:

For $k_{y,calc} \geq 0{,}5$: $k_y = k_{y,calc}$

For $k_{y,calc} < 0{,}5$: $k_y = 0{,}5$

Definition of load combination factors k_x and k_y for wire loop systems for the connection of two precast concrete components:

For $k_{x,calc} \leq 0{,}25$: $k_x = k_{x,calc}$

For $k_{x,calc} > 0{,}25$: $k_x = 0{,}25$

3 REFERENCE DOCUMENTS

[1] EAD 332589-00-0601:2020-09: Wire loop systems for the connection of precast and in-situ concrete elements

[2] EAD 332589-01-0601: Wire loop system for the connection of precast and in-situ concrete elements (amendment to 332589-00-0601 adopted as EAD 334183-00-0601:2022-02)

[3] EN 1992-1-1:2004 + AC:2010: Design of concrete structures. Part 1-1: General rules and rules for buildings

[4] EN 1990:2002 + A1:2005 / AC:2010: Eurocode: Basis of structural design

[5] EN 1991:2002 + AC:2009: Eurocode 1: Actions on structures

[6] EN 1993-1-11:2006 + AC:2009, Eurocode 3: Design of concrete structures
Part 1-11: Design of structures with tension components

[7] EN 1992-4:2018, Eurocode 2: Design of concrete structures
Part 4: Design of fastenings for use in concrete