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Construction Products and Construction Types

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Object: Assessment of the load bearing behaviour of anchor screws "Wall-Dog" under tensile loading and one-sided fire loading according to the standard-time-temperature-curve

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Gesamtinhaltsverzeichnis

I Objective and request

MFPA Leipzig GmbH was ordered by Stanley Black & Decker Deutschland GmbH to assess the load bearing behaviour of anchor screws "Wall-Dog" under centrical tensile loading and one-sided fire loading according to the standard-time-temperature-curve (STTC) (see [N1]). The assessment and with that the determination of the characteristic tensile load bearing capacities under fire-exposure base on results of fire tests and include the failure mode "steel failure". Considering the failure modes "pull-out failure" and "concrete cone failure", reference to the acknowledged rules of technology is given.

1 Description of the construction

The advisory opinion at hand covers anchor screws "Wall-Dog" with the screw heads "pan head" and "countersunk" for anchorage in concrete structures, each produced in the variant "cross-recessed" and "torx". For each variant, screws with the length $l = 32mm$, $l = 50mm$ and $l = 70mm$ are available. The nominal diameter amounts to $d = 5mm$ for each variant, the embedment depth amounts to $h_{nom} = 29mm$, independent from the screw length.
As bulk material, carbon steel AISI C1018-1022 is utilized in all cases. Since the surface treatment (chrome plating, coat of paint) does not influence the load bearing capacity of the screws in case of fire, no distinction is made with respect to the feature. For a detailed product description and further information with respect to the scope of application, please see the manufacturers' instructions.

II References

1 Utilized guidelines, rules and standards

The analyses are based on the following guidelines, rules and standards:

Literatur

[N1] DIN EN 1363-1:2012-10: Fire resistance tests - Part 1: General Requirements; German version EN 1363-1:2012

[N2] DIN EN 206:2017-01: Concrete - Specification, performance, production and conformity; German version EN 206:2013+A1:2016

[N3] EAD 330232-00-0601: Mechanical fasteners for use in concrete; 10/2016

[N4] TR 048:2016-08: Details of tests for post-installed fasteners in concrete; 08/2016

[N5] TR 020: Evaluation of Anchorages in Concrete concerning Resistance to Fire; 05/2004

[N6] FprEN 1992-4:2017: Eurocode 2: Design of concrete structures - Part 4: Design of fastenings for use in concrete

[N7] DIN EN 1992-1-2:2010-12: Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design; German version EN 1992-1-2:2004 + AC:2008

2 Reference documents

The analyses are based on the following additional documents:

2.1 Assessment and test reports

Literatur

[G1] Test Report No. PB 3. 2/18-121-1: Screw Anchor “Wall Dog“: Tests according to TR 020 “Evaluation ofAnchorages in Concrete concerning Resistance to Fire“ (May 2004) to determine the characteristic bond strength under tensile load. – MFPA Leipzig GmbH; 09.01.2019

III Assessment of the performance

1 Design concept

The characteristic load bearing capacity of a screw in case of fire has to be determined as the minimum value of the load bearing capacities for the failure modes steel failure, pull-out failure and concrete cone failure

$$N_{Rk,fi}(t) = min\left[N_{Rk,p,fi}(t), \quad N_{Rk,s,fi}(t), \quad N_{Rk,c,fi}(t)\right]. \tag{1}$$

2 Steel failure

The temperature-dependent load bearing capacity of anchor screws "Wall-Dog" is limited to the load bearing capacity of the screw cross section. Hence, steel failure under fire-exposure always occurs in the shape of tearing of the screw.
The analysis of the temperature-dependent load bearing capacity is carried out in dependence on [N3] and [N5], respectively. According to [N3], the load bearing capacity in conjunction with steel failure has to be determined by means of fire tests considering fire loading according to STTC (see [N1]). The procedure is described in [N4] and coincides with the instructions given in [N5]. The respective test are documented in [G1], the evaluation of the test results is carried out in the framework of the document at hand in dependence on [N3, N5].

2.1 Influence of screw head

The fire tests documented in [G1] were mainly carried out considering the screw variant "pan head", being on the safe side. The load bearing capacities specified in Section III.2.4 may also be used for the screw variant "countersunk".

2.2 Influence of length

All fire tests described in [G1] were carried out using screws of the length $l = 70mm$. The load bearing capacities specified in Section III.2.4 may also be used for screws of the length $l = 32mm$ and $l = 50mm$.

2.3 Influence of recess

The fire tests documented in [G1] were carried out considering the screw variant "torx". The load bearing capacities specified in Section III.2.4 may also be used for the screw variant "cross-recessed".

2.4 Load bearing capacity under fire-exposure

The test results documented in [G1] were evaluated according to [N3, N5]. In Table 1, the characteristic tensile load bearing capacities $N_{Rk,s,fi}(t)$ $[kN]$ for steel failure are specified depending on the duration of fire exposure.

	fire duration $[min]$			
	30	60	90	120
$N_{Rk,s,fi}(t)$ $[kN]$	0,34	0,26	0,18	0,14

Tabelle 1: Anchor screws "Wall-Dog": Characteristic tensile load bearing capacities $N_{Rk,s,fi}(t)$ $[kN]$ for steel failure

3 Pull-out failure

If the tensile loading of a screw exceeds the bond strength, pull-out failure occurs. The characteristic tensile load bearing capacity $N_{Rk,p,fi}(t)$ for pull-out failure is calculated according to [N5], Chapter 2.2.1.2 (Simplified design method for the determination of the duration of the fire resistance of anchorages) and according to [N6], Appendix D.4.2.3, respectively. For durations of fire-exposure up to 90 minutes holds

$$N_{Rk,p,fi(90)} = 0{,}25 \cdot N_{Rk,p} \tag{2}$$

and for durations of fire-exposure between 90 and 120 minutes

$$N_{Rk,p,fi(120)} = 0{,}2 \cdot N_{Rk,p} \tag{3}$$

with $N_{Rk,p}$: characteristic load bearing capacity for pull-out failure at room temperature in cracked concrete C20/25.

4 Concrete cone failure

Concrete cone failure in conjunction with centrically loaded screws occurs, when the tensile strength of the concrete is locally exceeded. The characteristic tensile load bearing capacity $N^0_{Rk,c,fi}(t)$ for concrete cone failure is calculated according to [N5], Chapter 2.2.1.3 (Simplified design method for the determination of the duration of the fire resistance of anchorages) and according to [N6], Appendix D.4.2.2, respectively. For durations of fire-exposure up to 90 minutes holds

$$N^0_{Rk,c,fi(90)} = \frac{h_{nom}}{200} \cdot N^0_{Rk,c} \leq N^0_{Rk,c} \tag{4}$$

and for durations of fire-exposure between 90 and 120 minutes

$$N^0_{Rk,c,fi(120)} = 0{,}8 \cdot \frac{h_{nom}}{200} \cdot N^0_{Rk,c} \leq N^0_{Rk,c} \qquad (5)$$

with $N^0_{Rk,c}$: characteristic load bearing capacity of a single screw at room temperature in cracked concrete C20/25. The characteristic load bearing capacity $N_{Rk,c,fi}$ to be considered in the framework of the design has to be determined for each specific construction capturing the influences of neighbouring screws and the edge distance. In this context, reference is given to [N6], Chapter 7.2.1.4 and Appendix D.4.2.2

IV Special notes

The assessment at hand is valid for anchor screws "Wall-Dog" with the screw heads "pan head" and "countersunk" for anchorage in concrete structures, each as "cross-recessed" and "torx" variant in length $l = 32mm$, $l = 50mm$ and $l = 70mm$ which are installed according to the manufacturers' instructions. The mechanical loading may not exceed the load bearing capacity in ambient climate.

The load bearing capacities specified in the framework of the document at hand are determined for one-sided fire loading according to the standard-time-temperature-curve. According to [N5], the values may also be used for multilateral fire loading when the edge distance of the screw is $c \geq 300mm$ and $c \geq 2 \cdot h_{ef}$.

The load bearing capacities specified in the framework of the document at hand are determined for centrical tensile loading in the screws longitudinal direction. According to [N3], the values may be transferred to tensile loading perpendicular and diagonal to the axis of the screw on the safe side.

The assessment at hand is valid for constructions of reinforced or unreinforced normal concrete of the strength class $\geq$ C20/25 and $\leq$ C50/60 according to [N2], which exhibit at least the same fire resistance class as the utilized screws. The design of the concrete construction has to be carried out according to [N7].

The load bearing capacities specified in the framework of the document at hand are determined assuming that no explosive concrete spalling occurs and are only valid under this condition. Evidence on the prevention of explosive concrete spalling is given in [N7], chapter 4.5.

This document does not replace a certificate of conformity or suitability according to national and European building codes.

Leipzig, den 24.01.2019

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