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Advisory Opinion No. GS 6.1/18-046-3

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Object: Assessment of the load bearing behaviour of MKT wedge anchors BZ3, BZ3 A4 and BZ3 HCR under tension load and shear load and one-sided fire loading according to the standard-time-temperature-curve in combination with concrete members - abbreviated version

Client: **MKT Metall-Kunststoff-Technik GmbH & Co.KG**
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This document covers 11 pages, including 0 appendices.

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I Objective and request

MFPA Leipzig GmbH was ordered by MKT Metall-Kunststoff-Technik GmbH & Co.KG to assess the load bearing behaviour of MKT wedge anchors BZ3, BZ3 A4 and BZ3 HCR under tension load and shear load and one-sided fire loading according to the standard-time-temperature-curve (STTC) according to [N1]. The assessment bases on results of fire tests and includes 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.
The document at hand summarizes the design concept in case of fire and the corresponding characteristic load bearing capacities for a fire duration of 180min. These load bearing capacities explicitly do not correspond to [N3, N4], but are calculated on the basis of the regulations given in [N3, N4].
For the detailed derivation of the values, please see [G1, G2].

II Description of the construction

The advisory opinion at hand covers wedge anchors BZ3, BZ3 A4 and BZ3 HCR for anchorage in concrete structures, consisting of an anchor, expansion sleeve, hexagonal nut and washer.
Anchorage is produced by means of force-controlled expansion of the expansion sleeve within the drilled hole. The manufacturer aims for a European Technical Assessment according to [N3] for the use under static and quasi-static loading in reinforced and unreinforced normal concrete of the strength class of at least C20/25 and at most C50/60 according to [N2]. The geometry of the wedge anchors is specified in Figure 1. In the course of installation of the wedge anchors, the manufacturers' instructions have to be obeyed.

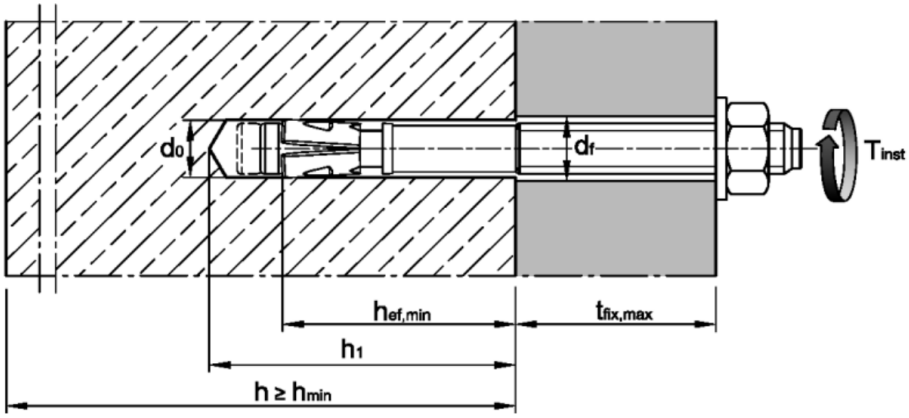

Figure 1: MKT wedge anchors BZ3, BZ3 A4 and BZ3 HCR: On-site geometry, provided by the client

The MKT wedge anchors BZ3, BZ3 A4 and BZ3 HCR are manufactured using the materials

- BZ3: galvanized steel, zinc plated,
- BZ3 A4: stainless steel A4,
- BZ3 HCR: high corrosion resistant steel.

Each type is available in sizes M8, M10, M12 and M16.

III References

1 Utilized guidelines, rules and standards

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

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

[N2] EN 206:2017-01: Concrete - Specification, performance, production and conformity

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

[N4] TR 020: Evaluation of Anchorages in Concrete concerning Resistance to Fire; 05/2004

[N5] EN 1992-4:2018: Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete

[N6] EN 1992-1-2:2010-12: Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design

2 Reference documents

The analyses are based on the following additional documents:

2.1 Assessment and test reports

[G1] Advisory Opinion No. GS 6.1/18-046-1-r1: Assessment of the load bearing behaviour of MKT wedge anchors BZ3 under tension load and shear load and one-sided fire loading according to the standard-time-temperature-curve in combination with concrete members. – MFPA Leipzig GmbH; 28.02.2020

[G2] Advisory Opinion No. GS 6.1/18-046-2: Assessment of the load bearing behaviour of MKT wedge anchors BZ3 A4 and BZ3 HCR under tension load and shear load and one-sided fire loading according to the standard-time-temperature-curve in combination with concrete members. – MFPA Leipzig GmbH; 05.03.2020

IV Assessment of the performance

1 Design concept

The characteristic load bearing capacity of a wedge anchor in case of fire under tension load 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

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

In case of a shear load, the characteristic load bearing capacity has to be determined as the minimum value of the load bearing capacities for the failure modes steel failure, concrete pry-out failure and concrete edge failure

$$V_{Rk,fi}(t) = min\left[V_{Rk,s,fi}(t), \quad V_{Rk,cp,fi}(t), \quad V_{Rk,c,fi}(t)\right]. \tag{2}$$

2 Steel failure

In Table 1 to Table 6, the characteristic load bearing capacities $N_{Rk,s,fi}(t)$ $[kN]$ according to [N3], Equation (2.26) as well as $V_{Rk,s,fi}(t)$ $[kN]$ according to [N3], Equation (2.27) and $M^0_{Rk,s,fi}(t)$ $[Nm]$ according to [N3], Equation (2.28) for steel failure are specified for a duration of fire-exposure of 180min for all investigated types of wedge anchors. The values are to be limited by the load bearing capacity in ambient climate according to the manufacturers' instructions.

	fire duration 180min
M8	0.44
M10	0.65
M12	0.86
M16	1.45

Table 1: MKT wedge anchors BZ3: Characteristic load bearing capacities $N_{Rk,s,fi}(t)$ $[kN]$ for steel failure under tension load

	fire duration 180min
M8	0.67
M10	1.16
M12	1.86
M16	3.06

Table 2: MKT wedge anchors BZ3 A4 and BZ3 HCR: Characteristic load bearing capacities $N_{Rk,s,fi}(t)$ $[kN]$ for steel failure under tension load

	fire duration 180min
M8	0.15
M10	0.38
M12	0.76
M16	1.27

Table 3: MKT wedge anchors BZ3: Characteristic load bearing capacities $V_{Rk,s,fi}(t)$ $[kN]$ for steel failure under shear load

	fire duration 180min
M8	1.60
M10	2.50
M12	3.65
M16	5.99

Table 4: MKT wedge anchors BZ3 A4 and BZ3 HCR: Characteristic load bearing capacities $V_{Rk,s,fi}(t)$ $[kN]$ for steel failure under shear load

	fire duration 180min
M8	0.15
M10	0.49
M12	1.18
M16	2.70

Table 5: MKT wedge anchors BZ3: Characteristic load bearing capacities $M^0_{Rk,s,fi}(t)$ $[Nm]$ for steel failure under shear load with lever arm

	fire duration 180min
M8	1.63
M10	3.22
M12	5.67
M16	12.71

Table 6: MKT wedge anchors BZ3 A4 and BZ3 HCR: Characteristic load bearing capacities $M^0_{Rk,s,fi}(t)$ $[Nm]$ for steel failure under shear load with lever arm

3 Pull-out failure

If the tensile loading of a wedge anchor exceeds the load bearing capacity of the interface between concrete and anchor, pull-out failure occurs. The characteristic tensile load bearing capacity $N_{Rk,p,fi}(t)$ for pull-out failure is calculated according to [N4], Chapter 2.2.1.2 (Simplified design method for the determination of the duration of the fire resistance of anchorages) and according to [N5], Appendix D.4.2.3, respectively. For durations of fire-exposure up to 90 minutes holds

$$N_{Rk,p,fi(90)} = 0.25 \cdot N_{Rk,p} \tag{3}$$

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

$$N_{Rk,p,fi(120)} = 0.2 \cdot N_{Rk,p} \tag{4}$$

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 tension loaded wedge anchors 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 [N4], Chapter 2.2.1.3 (Simplified design method for the determination of the duration of the fire resistance of anchorages) and according to [N5], Appendix D.4.2.2, respectively. For durations of fire-exposure up to 90 minutes holds

$$N^0_{Rk,c,fi(90)} = \frac{h_{ef}}{200} \cdot N^0_{Rk,c} \leq N^0_{Rk,c} \tag{5}$$

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

$$N^0_{Rk,c,fi(120)} = 0.8 \cdot \frac{h_{ef}}{200} \cdot N^0_{Rk,c} \leq N^0_{Rk,c} \tag{6}$$

with $N^0_{Rk,c}$: characteristic load bearing capacity of a single wedge anchor 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 anchors and the edge distance. In this context, reference is given to [N5], Chapter 7.2.1.4 and Appendix D.4.2.2.

5 Concrete pry-out failure

Concrete pry-out failure in conjunction with shear loaded wedge anchors occurs, when the load bearing capacity of the concrete is locally exceeded at the non-loaded side of the member. The characteristic load bearing capacity $V_{Rk,cp,fi}(t)$ for concrete pry-out failure is calculated according to [N4], Chapter 2.2.2.2 and according to [N5], Appendix D.4.3.2, respectively. For durations of fire-exposure up to 90 minutes holds

$$V_{Rk,cp,fi(90)} = k_8 \cdot N_{Rk,c,fi(90)} \tag{7}$$

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

$$V_{Rk,cp,fi(120)} = k_8 \cdot N_{Rk,c,fi(120)} \tag{8}$$

with $N_{Rk,c,fi}$: characteristic load bearing capacity for concrete cone failure, k_8: factor to be taken from the relevant ETA under normal temperature.

6 Concrete edge failure

Concrete pry-out failure in conjunction with shear loaded wedge anchors occurs, when the load bearing capacity of the concrete is locally exceeded at the edge below the anchor. The characteristic load bearing capacity $V^0_{Rk,c,fi}(t)$ for concrete edge failure is calculated according to [N4], Chapter 2.2.2.3 and according to [N5], Appendix D.4.3.3, respectively. For durations of fire-exposure up to 90 minutes holds

$$V^0_{Rk,c,fi(90)} = 0.25 \cdot V^0_{Rk,c} \tag{9}$$

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

$$V^0_{Rk,c,fi(120)} = 0.2 \cdot V^0_{Rk,c} \tag{10}$$

with $V^0_{Rk,c}$: characteristic load bearing capacity of a single wedge anchor at room temperature in cracked concrete C20/25. The characteristic load bearing capacity $V_{Rk,c,fi}$ to be considered in the framework of the design has to be determined for each specific construction e.g. capturing the influences of neighbouring anchors and the edge distance. In this context, reference is given to [N5], Chapter 7.2.2.5.

V Special notes

The assessment at hand is valid for MKT wedge anchors BZ3, BZ3 A4 and BZ3 HCR according to the specifications in [G1, G2] for anchorage in concrete structures, which are installed according to the manufacturers' instructions. The mechanical loading must not exceed the load bearing capacity in ambient climate. The size of the fixed member must not exceed $t_{fix,max}$.

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 [N4], Chapter 2.1 and [N5], Appendix D.1(5) the values may also be used for multilateral fire loading when the edge distance of the wedge anchor 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 wedge anchor's longitudinal direction and shear loading.

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 wedge anchors. The design of the concrete construction has to be carried out according to [N6].

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 [N6], Chapter 4.5.

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

Leipzig, 10.03.2020

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