STEEL FIBRE REINFORCED CONCRETE MIXDESIGNS FOR INDUSTRIAL FLOORS IN GERMANY

In Germany, around 10,000,000 m² of industrial floors are made from steel fibre reinforced concrete or reinforced concrete (RC) with steel fibres (combination reinforcement) every year. The DBV leaflet "Industrial floors made of concrete"[1] contains reference values/specifications for many parameters that should be fully observed.

This leaflet provides an excerpt of the reference values/ specifications of the DBV leaflet "Industrial floors made of concrete"[1] and compares these in tabular form (see page 2) with concrete mix designs that have been tested in several hundred performance class tests in accordance with the DAfStb guideline "Steel fibre reinforced concrete"[2] and can be found in practice. It should be noted that the raw materials and ranges shown cover the majority of the concrete mixdesigns examined. Based on experience, it is possible **to further tighten the reference values or specifications of the DBV data sheet.**

For industrial floors made of steel fiber reinforced concrete, it is important that there is a **sufficiently high cement paste content**, so that a comparatively **high proportion of fine components** must be included in the concrete mixes. The increased proportion of fine components contrasts with the desire to **design a concrete with a slow shrinking behavior as possible**.

In **practice** a concrete of compressive strength class C30/37 with a maximum grain size of 16 mm is usually used and the cement content is 340 to 360 kg/m³, in the upper range of the recommendation in the DBV leaflet. The cements CEM III/A 42.5 N, CEM II/B-S 42.5 N and CEM II/A-LL 42.5 N are usually used, resulting in a medium strength development. At 345 to 375 kg/m³, the powder grain contents found are slightly below, preferably at the lower end of the range specified in the DBV leaflet. The water-cement ratio is 0.50 to 0.54, in the upper half of the recommendation. The grading curves are largely comparable and are usually in the A/B range. The range up to 2 mm is more in the direction of B and above that tends to be closer to A. The installation consistency generally corresponds to consistency class F4.

There are **regional differences** in the mixtures and, particularly in the case of cements, other CEM II cements and, in exceptional cases, CEM I cement are also used.

From many years of experience, **no systematic problems** are known in practice with the information provided in the mixdesigns. Conversely, this does not necessarily mean that mixes that deviate from the values/information provided must lead to problems in practice.

To limit excessive shrinkage potential and the resulting increase in the risk of cracking, the water-cement ratio should not exceed 0.54 if possible. Similarly, the maximum cement content of 360 kg/m³ and maximum fine aggregate content of 375 kg/m³ should not be exceeded in order to obtain a concrete with the lowest possible shrinkage. In practice, the upper values recommended in the DBV leaflet for the fines/fine sand content are often adhered to. Depending on the region, however, higher values are also found in practice. The limiting value of the DBV leaflet should be adhered to, as an increase in the fines content generally increases the water demand and therefore the shrinkage of the concrete, which can have a negative effect, particularly in the case of jointless industrial floors. The use of aggregates with a high modulus of elasticity has a positive effect on shrinkage behaviour.

For further requirements regarding aggregates, concrete additives, and materials, please refer to the DBV leaflet "Industrial floors made of concrete" [1].

However, based on experience, no significant increases in the residual flexural strength are to be expected when using crushed aggregate. Limiting the maximum grain size to 16 mm – as it is generally found in practice – makes sense, as this ensures that the concrete is well bonded to the fibres and a high residual flexural strength is achieved. An increase in the maximum grain size can result in a reduction in the residual flexural strength. In general, the use of larger aggregates should be avoided, as this can have a comparatively strong negative influence on the residual flexural tensile strength.

References:

[1] DBV-Leaflet - Industrial Concrete Floors, Beton: 2017-02
[2] DAfStb Stahlfaserbeton-2021-06: Guideline "Steel Fibre Reinforced Concrete" - Additions and changes to DIN EN 1992-1-1 in conjunction with DIN EN 1992-1-1/NA, DIN EN 206-1 in conjunction with DIN 1045-2 and DIN EN 13670 in conjunction with DIN 1045-3 – Part 1: Design and construction – Part 2: Specification, performance, production and conformity – Part 3: Execution of structures

STEEL FIBRE REINFORCED CONCRETE MIXDESIGN FOR INDUSTRIAL FLOORS IN GERMANY

Parameter		Unit	DBV - Leaflet Industrial flooring made of concrete[1)]	Practice
Exposure classes		–	Depending on the requirements	XC4, XF1 [XD1, XA1, XM1 or XM2, XS1]
Moisture class			–	WA
Concrete compressive strength class			Depending on the load	C30/37 [C25/30]
Strength development			–	medium
Cement			CEM II, CEM III/A – strength classes 32.5 R, 42.5 N, with higher early strength 42.5 R	CEM III/A 42.5 N CEM II/B-S 42.5 N CEM II/A-LL 42.5 N
Cement content		kg/m³	320 to 360	350 ± 10
Fine aggregates			360 to 400	360 ± 15
Fine aggregates and fine sand content			≤ 430 kg/m³	–*
Total water content			Max. ca. 180	178 ± 5
w/c-ratio		–	0.45 to 0.55	0.52 ± 0.02
Aggregates	Max. grain size	mm	–	16
	0/2 mm	% by mass		40 ± 5
	2/8 mm			22 ± 7
	8/16 mm			36 ± 7
Concrete admixtures		–	s. section 8.2.4	Manufacturer's instructions must be observed – special attention when using PCE superplasticizers
Consistency			F2 to F4	F4

Fine aggregates: Aggregates or concrete components up to 0.125 mm
Fine sand: Aggregates or concrete components up to 0.25 mm
* It is recommended to comply with the limiting value specified in the DBV leaflet. However, depending on the region, higher values may be found in practice.

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