

krampeharex
Strahlmittel abrasives Stahlfasern steel fibres

Time for solutions

KrampeHarex® steel fibres and synthetic fibres

Refractory concrete
Residential buildings
Road construction
Tunnel construction
Precast concrete elements
Flooring

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Steel fibres for Tunnelling

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Steel fibres for Tunnelling

- Kind of fibres
- Mode of action
- Fields of applications
- Integration

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Kind of Fibres

Drawn wire steel fibres, endhooked

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Steel Fibres

	possible	common in tunnels
Length	6-60 mm	25-60 mm
Diameter	0.15-1.2 mm	0.5-1.0 mm

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Approvals

Modes of Action

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Post-crack behaviour

Residual tensile strength after cracking

Working capacity

Material behaviour can be used for design purpose:

- Replacement of shear reinforcement
- Replacement of nominal reinforcement

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Working capacity

Fasertyp	Schlankheit	Anhaltswerte der notwendigen Dosierung für 800 Joule	Unterschied in Prozent
DE 30/0,8 N	38	54	34%
DE 35/0,9 N	39	51	29%
DE 30/0,75 N	40	50	26%
DE 30/0,7 N	43	47	17%
DE 35/0,8 N	44	46	14%
DE 35/0,75 N	47	43	9%
DE 35/0,7 N	50	40	0%
DE 30/0,6 N	50	40	0%
DE 30/0,55 N	55	37	-9%
DE 35/0,6 N	58	34	-14%
DE 30/0,5 N	60	33	-17%
DE 35/0,55 N	64	32	-20%
DE 35/0,5 N	70	29	-29%

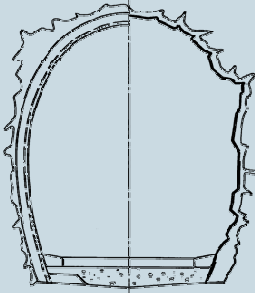
* 6mm length

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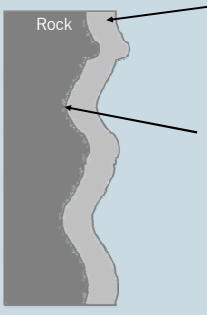
Reasons for steel fibres:

- Following the contour
- Less material (concrete and reinforcement)
- Time savings



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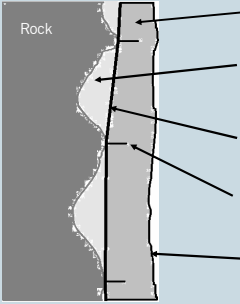
Rock

Steel fibre shotcrete

Contact and bond to the entire surface

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Rock

Shotcrete

Potential for problems: badly compacted concrete, „shadows“


Mesh reinforcement

Fixing of mesh

Concrete cover

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Modes of Action



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Slab tests

Beam tests



Modes of Action



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Tests deliver input data for:

- Evaluation of energy absorption
- Design values

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Energy absorption

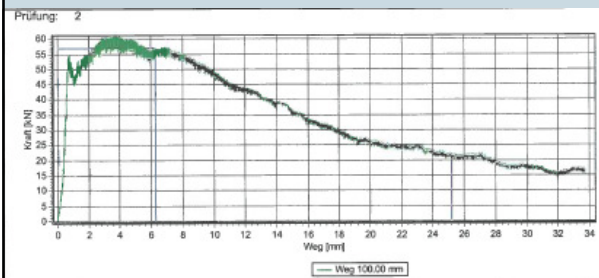
Tests of concrete for shotcrete EN 14488, part 5

Load-Deflection test \longrightarrow Energy absorption

Modes of Action



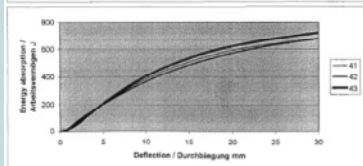
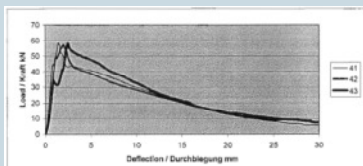
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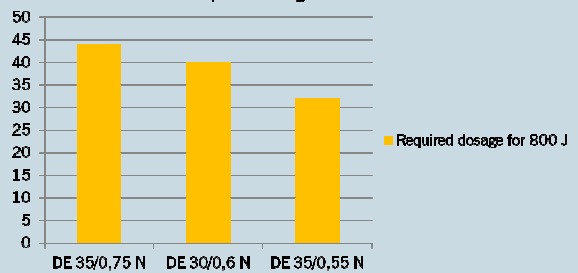
The value which has to be matched is given. 700-1,000 Joule is common

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Required dosage for 800 J

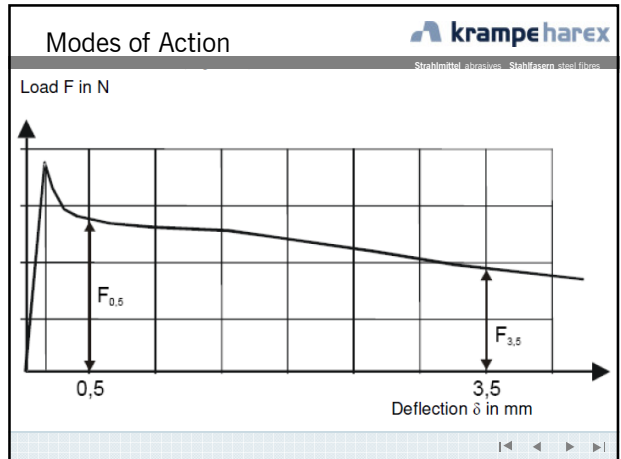


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Residual tensile strength

Guideline „Steel fibre reinforced concrete“, DIN 1045

Load-Deflection test \longrightarrow Design values



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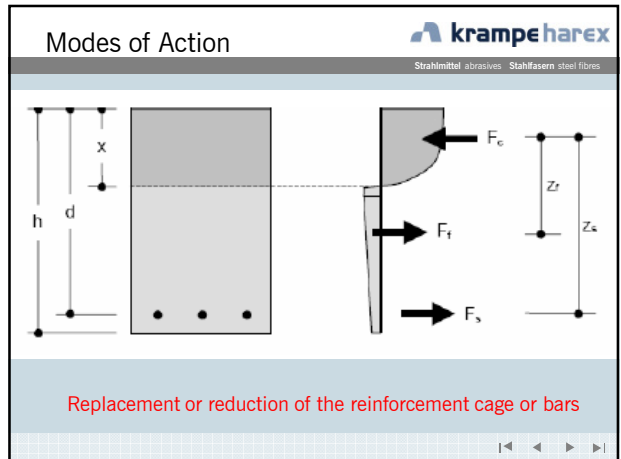
Interpretation of the test results:

The average postcracking bending tensile strengths of the test series based on the $n \geq 6$ beams are as follows:

$$f_{ctm,L1}^I = \frac{1}{n} \sum_{i=1}^n \frac{F_{0,5i} \cdot l}{b_i \cdot h_i^2} \quad \text{in N/mm}^2 \quad (O.1)$$

$$f_{ctm,L2}^I = \frac{1}{n} \sum_{i=1}^n \frac{F_{3,5i} \cdot l}{b_i \cdot h_i^2} \quad \text{in N/mm}^2 \quad (O.2)$$

Development to achieve design values



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Table R.3 – Performance classes L1 and L2 for steel fibre concrete with the appurtenant basic values of the axial postcracking tensile strengths

column	1		2		3		4		5		6	
	Basic values of axial postcracking tensile strength						f_{ctd} in [N/mm ²]					
	deformation 1			deformation 2			deformation 1			deformation 2		
lines	L1	$f_{ctm,L1}^I$	L2	$f_{ctm,L2}^I$	f_{ctm}	f_{ctd}	L1	$f_{ctm,L1}^I$	L2	$f_{ctm,L2}^I$	f_{ctm}	f_{ctd}
1	0	< 0.16	0	-	-	-	1	0	0	0	0	0
2	0.4 ^a	0.16	0.4 ^a	0.10	0.15	0.15	2	0.4 ^a	0.16	0.10	0.15	0.15
3	0.6	0.24	0.6	0.15	0.22	0.22	3	0.6	0.24	0.15	0.22	0.22
4	0.9	0.36	0.9	0.23	0.33	0.33	4	0.9	0.36	0.23	0.33	0.33
5	1.2	0.48	1.2	0.30	0.44	0.44	5	1.2	0.48	0.30	0.44	0.44
6	1.5	0.60	1.5	0.38	0.56	0.56	6	1.5	0.60	0.38	0.56	0.56
7	1.8	0.72	1.8	0.45	0.67	0.67	7	1.8	0.72	0.45	0.67	0.67
8	2.1	0.84	2.1	0.53	0.78	0.78	8	2.1	0.84	0.53	0.78	0.78
9	2.4	0.96	2.4	0.60	0.89	0.89	9	2.4	0.96	0.60	0.89	0.89
10	2.7 ^b	1.08	2.7 ^b	0.68	1.00	1.00	10	2.7 ^b	1.08	0.68	1.00	1.00
11	3.0 ^b	1.20	3.0 ^b	0.75	1.11	1.11	11	3.0 ^b	1.20	0.75	1.11	1.11

^a For planar components, only ($\beta > 5$)
^b For steel fibre concrete of these performance classes, a national technical approval or permission is required in the individual case.

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- Advantages for tunnel constructions:
- Effectiveness of fibres at the edge (no concrete cover)
 - Less or no reinforcement cage
 - Bearing of multiaxial tensions
 - Bearing of partial area loadings
 - Improved absorption of dynamic loads (installation works)
 - Increased deformation abilities
 - No spallings due to corrosion
 - Higher speed of progress
 - Shorter construction time

Integration of steel fibres



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Dosing by hand



Integration of steel fibres



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Conveyor belt KH 500

- flexible
- mobile
- versatile usable
- pouring by hand
- no weighing protocol
- hardly no batching into the mixer
- difficult in case of $l/d > 50$



Integration of steel fibres



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Blower KH 300

- mobile
- proper batching
- all types of fibres
- person required
- no weighing protocol
- hardly no batching into the mixer



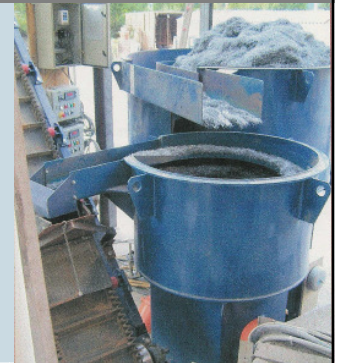
Integration of steel fibres



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Automatic dosing equipment

- batching by silo
- system control
- protocol
- individual solutions



Fresh Concrete



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Influences caused by fibres:

- Flowability



- 4-8 cm PP fibres
- 3-5 cm steel fibres

Fresh Concrete



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- Pumpability:



- Fibre amount
- Fibre geometry
- Flowability
- Air content

Application



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Cast-in-place concrete

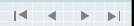


Application



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Shotcrete



Application



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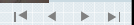
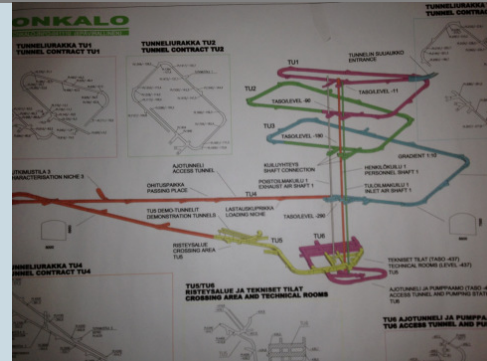
Shotcrete



Application



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Application



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Shotcrete



Application



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Tubbings

