SHRINKAGE OF STEEL FIBRE CONCRETE

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Steel fibre concrete is one of the well proved sorts of fibre reinforced concretes. It may be considered as a new building material because its composition, its physical, mechanical and deformation properties differ — partly very much indeed — from the corresponding characteristics of reinforced concrete.

The steel fibre reinforced concrete is a recent building material, looking back to a relatively short time. In its present form it has been used for different structures since about 20 years abroad, and since about a decade in this country.

The advantageous properties of steel fibre concrete are generally known, they are, however, not cleared enough experimentally.

Shrinkage tests

Our investigations aimed at clearing up how and to what extent the different steel fibre dosages influence shrinkage of the steel fibre concrete.

Test concrete was of grade B 400—15/1, made with portland cement S-54.350 dosed at 450 kg/m^3, w/c ratio of 0.31. The aggregate was second class Danube sand and gravel, composed of 35% of 0.1/1 mm, 19% of 3/7 mm, 29% of 7/15 mm, $d_{max} = 15$ mm and $m = 6.2$. Air content in the concrete was max. 1.5%.

The steel fibres were produced by December 4 Drótművek, Miskolc (Hungary). Fibre diameter: 0.4 mm, length: 40 mm. Fibre dosage to the concrete: 0 (reference); 2.3; 4.6; 5.7 percent by mass.

The concrete was mixed in a gravity mixer. The steel fibres were added manually to the concrete during mixing.

Test specimens

Specimens $100 \times 100 \times 515$ mm were cast in steel moulds and compacted by a poker vibrator. (Specimens were prepared in the laboratory of the Civil Engineering Enterprise.)

Into the middle of their end faces brass gauge pins were stuck on their face of 20 mm in diameter with a synthetic resin glue. The pin height was 17 mm.

For the shrinkage tests four series of specimens were prepared with different fibre dosages.

Variants of the specimens:

Series	Fibre dosage (percent by mass)	Number
1	0 (reference)	6
2	2.3	6
3	4.6	6
4	5.7	6

Test method

Measurements were carried out in an *Amsler* SM 551 shrinkage measuring instrument, starting by determining the length of the specimens in relation to the invar reference. Confrontation of the measurement results permitted to calculate the change in length i.e. shrinkage of the specimens as a function of time.

The gauge pins were stuck on the concrete specimens at 3 days of age and the same day the first measurements were carried out.

The specimens were stored and tested in air conditioned environment. For the entire time of the experiments, the ambient temperature was kept at 20 ± 3 °C, $65 \pm 5\%$ r.h.

Evaluation of the measurement results

The shrinkage deformation of the specimens in mm was calculated from consecutive read-off values. Referring these values to the original length of the specimens, the specific shrinkage of the specimens in $^0/_{00}$ was determined. Average values of specific shrinkage were calculated series by series (see Table 1).

Shrinkage curves were plotted from tabulated values (Fig. 1) leading to the following conclusions:

— Shrinkage of the concrete practically is complete at the age of 270 days.

Table 1

Average specific shrinkages of concrete specimens with different steel fibre dosages

Concrete age, days	Shrinkage, ‰			
	Fibre dosage % by mass			
	0% (reference)	2.3%	4.6%	5.7%
3	0	0	0	0
7	0.1398	0.1340	0.0874	0.0622
14	0.2874	0.2477	0.1883	0.1204
28	0.4075	0.3344	0.2524	0.1962
56	0.5157	0.4284	0.3404	0.2723
90	0.6015	0.5145	0.4103	0.3346
120	0.6714	0.5640	0.4519	0.3782
180	0.7473	0.6312	0.5382	0.4305
270	0.7631	0.6408	0.5476	0.4524

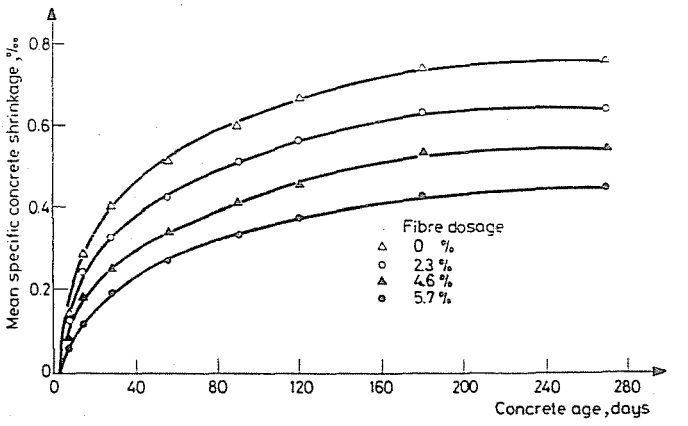

Fig. 1. Average specific shrinkages of concrete specimens with different steel fibre dosages

— Increase of fibre dosage considerably reduces the concrete shrinkage.
— Increase of fibre dosage slows down shrinkage in the initial period.

Figure 2 was plotted to help studying the effect of different fibre dosages and to establish numerical relationships. The 270-day shrinkage values considered as shrinkage measures were investigated under the effect of fibre dosage.

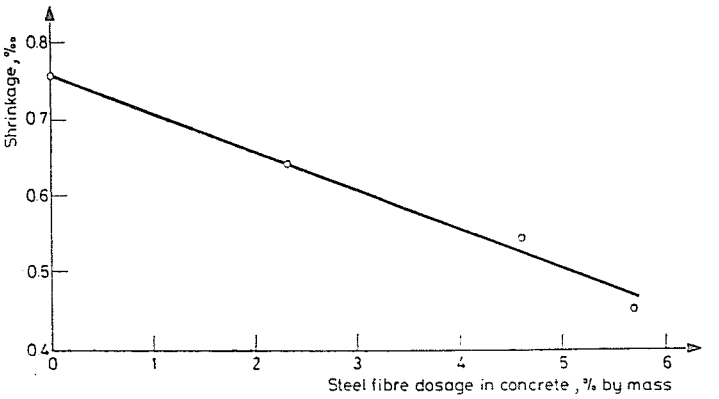

Fig. 2. Shrinkage rate of concrete specimens vs. steel fibre dosage

Numerical values:

Series	Fibre dosage percent	Shrinkage measure permille
1	0	0.7631
2	2.3	0.6408
3	4.5	0.5476
4	5.7	0.4524

Figure 2 has led to the following statements:

— The shrinkage measure decreases linearly with increasing fibre dosage.

— Shrinkage of a given concrete from 0.7631 for 0% by mass decreases to 0.4524 for 5.7% by mass hence by 40.72%.

— In the tested concrete 1% increase of steel fibre dosage reduced the shrinkage measure of the concrete by 7%.

Summary

Test results unambiguously showed concrete shrinkage to be decisively reduced by steel fibre dosage.

Increase of fibre dosage and decrease of the shrinkage rate are about linearly related. Increase by 1% of the steel fibre dosage reduced the shrinkage rate by 7%.

The test results yielded absolute and comparative values for the shrinkage of concrete grade B 400—15/1 with max. 5.7% fibre dosage.

Relying on the above, similar values and relationships can be determined for different grade concretes.

References

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* In Hungarian