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SUMMARY

Efficient cements have always been produced in Germany from the regionally available raw materials to ensure reliable and cost-effective methods of construction with cement-based building materials. One of these methods of construction involves the production of cement-based floor screeds. The constantly rising demands for environmental protection mean that particular importance is now placed on the production and use of Portland composite cements (CEM II) and blastfurnace cements (CEM III). Laboratory investigations and practical experience confirm that Portland cement and cements with two or three main constituents that contain granulated blastfurnace slag, limestone or oil shale are basically suitable for producing cement-based floor screeds. The article provides an overview of the constructionally relevant properties of cement floor screeds made with CEM I, CEM II and CEM III/A cements. The evaluation is based on investigations that were carried out or commissioned by member companies of the VDZ (German Cement Works Association) from 1998 to 2008.

ZUSAMMENFASSUNG

Zu allen Zeiten wurden in Deutschland auf der Basis der regional verfügbaren Rohstoffe leistungsfähige Zemente für sichere und zugleich wirtschaftliche Bauweisen mit zementgebundenen Baustoffen hergestellt. Die Herstellung von zementgebundenen Estrichen ist eine dieser Bauweisen. Aufgrund der stetig steigenden Anforderungen an den Umweltschutz kommt heute der Herstellung und Verwendung von Portlandkompositzementen (CEM II) und Hochofenzementen (CEM III) eine besondere Bedeutung zu. Laboruntersuchungen und praktische Erfahrungen bestätigen die grundsätzliche Eignung von Portlandzement sowie hüttensand-, kalkstein- und ölschieferhaltigen Zementen mit zwei bzw. drei Hauptbestandteilen für zementgebundene Estriche. Der Beitrag gibt einen Überblick über bautechnisch relevante Eigenschaften von Zementestrichen mit CEM I-, CEM II- und CEM III/A-Zementen. Basis der Auswertung sind Untersuchungen, die in den Jahren zwischen 1998 und 2008 von VDZ-Mitgliedsunternehmen durchgeführt bzw. beauftragt wurden.

(Translation by Robin B. C. Baker)

Use of CEM II and CEM III/A cements in cement-based floor screeds

Verwendung von CEM II- und CEM III/A-Zementen in zementgebundenen Estrichen

vdz. Deutsche Zementindustrie

CONCRETE TECHNOLOGY REPORTS

1 Introduction

Cement-based floor screeds have been used successfully in residential, commercial and industrial construction for decades. In comparison with other mineral-based floor screeds, cement-based floor screeds are characterized in particular by their stability in moist conditions, so they are suitable for internal and external use. The production of floor screeds is a complex process that is influenced considerably by the selection of suitable starting materials and by building site conditions such as transport, storage, mixing, conveying and laying on site.

All standard types of cement may be used in the production of cement-based floor screed mortar, provided that their suitability has been verified. In particular applications it may be appropriate to use quick-setting floor screed cements. Cements without any information about the main constituents or without the required certificates of conformity or conformity marks should not be used [1, 2].

Individual problems encountered in floor screed production (for example insufficient surface strength, formation of voids, slow drying) have in some cases been across-the-board linked by the industry that lays the screeds to the change-over from CEM I cement to cements with several main constituents. Although there are no documented cases that would allow any conclusions to be drawn on the influence of the cement there are still some reservations about the use of CEM II or CEM III cements for producing floor screeds. The Research Institute of the Cement Industry has therefore investigated the influence of cement type on the constructionally relevant properties of floor screeds.

2 Objective and scope of the investigative programme

The objective of the evaluation programme carried out by the Research Institute of the Cement Industry was to compile a database for cement-based floor screeds made with Portland composite cement and blastfurnace cement and, in particular, to observe the constructionally relevant properties of cement-based floor screeds. Comparative investigations into cement-based floor screeds made with varying cement compositions but otherwise having the same floor screed composition were carried out under identical production and testing conditions and the results were evaluated. These investigations were carried out between 1998 and 2008 by member companies of the VDZ (German Cement Works Association) in their own laboratories or by independent testing laboratories on behalf of the companies. 26 different cements of varying origin were used as starting materials. 40 floor screed mortars with different compositions were produced for the investigations. The following properties taken from the database of more than 1000 individual results were compiled and analysed: workability and air content, strength development, final strength and surface strength, residual moisture content, shrinkage and dishing.

3 Floor screed mortar composition

3.1 Starting materials

3.1.1 Cement

The cements used met the requirements specified in DIN EN 197-1:2004-08. The compressive strengths of the cements were measured at the age of two days and 28 days in accordance with DIN EN 196-1:2005-05. The initial setting time and water demand were established as per DIN EN 196-3:2005-05. The fineness or Blaine specific surface area was measured as specified in DIN EN 196-6:2008-05. ❯ Table 1 provides an overview of the cements investigated and their main properties.

3.1.2 Aggregate

Coarse Rhine sand was used to produce the cement-based floor screed mortar in all the comparative investigations. A sieve analysis of the aggregate was carried out for all the tests. Based on the "standard grading curves" specified in DIN EN 206-1/DIN 1045-2, the grading curves were in the range of grading curves B8 for nine of the comparative investigations and in the range of grading curves A8 and C8 for one test each.

3.1.3 Other starting materials

Some of the floor screed mortars were produced using admixtures or additions (synthetic resin dispersions). This involved seven different commercial products designed specifically for cement-based floor screeds and produced by three different admixture manufacturers. The manufacturers' product data are summarized in ❯ Table 2.

3.2 Mix composition

The floor screed mortar properties were determined on cement-based floor screed mortars of different compositions, which are summarized in ❯ Table 3. In each case the composition was held constant for the comparative investigations in order to identify the influence of the cement type used. The admixture addition level was modified slightly in test series V8 to obtain the target consistency. The addition levels used lay in the ranges recommended by the manufacturers, with the exception of V10-C. In this case the addition level was raised for research purposes.

4 Production and investigation of the floor screed mortar

4.1 Production of the floor screed mortar

All the floor screed mortars were produced in the same way in a mechanical mixer and the conditions were held constant for each comparative investigation. 50-litre and 30-litre (V1 to V4 and V5 to V11 respectively) mixes were produced. In one case, a floor screed pump suitable for use on a building site was used (V6).

Table 1: Properties of the cements: water demand (WD), fineness (Blaine), initial setting time (IS), cement standard compressive strength at the age of 2 d and 28 d

Cements for the comparative investigations		WD mass %	Blaine g/cm²	IS min	Compressive strength 2 d MPa	Compressive strength 28 d MPa
V1	CEM I 32.5 R	26.5	2870	150	25.4	46.2
	CEM II/B-S 32.5 R	27.0	2900	180	20.2	45.3
V2	CEM I 32.5 R	26.0	3180	155	28.2	47.2
	CEM II/B-S 32.5 R	27.0	3460	185	19.6	48.2
V3	CEM I 32.5 R	26.5	3200	175	27.2	54.7
	CEM II/A-M (S-LL) 32.5 R	27.5	3900	215	24.9	49.7
V4	CEM II/B-S 32.5 R	28.8	3535	226	16.8	50.6
	CEM III/A 42.5 N	29.5	3940	230	20.2	58.1
V5	CEM I 32.5 R	28.0	3340	195	28.6	48.7
	CEM II/B-S 32.5 R	27.8	3450	253	20.9	49.8
V6	CEM I 32.5 R	27.7	2940	177	24.0	51.0
	CEM II/B-S 32.5 R	28.6	3170	168	25.0	51.0
	CEM II/A-LL 32.5 R	28.4	3690	166	26.0	49.0
V7	CEM I 32.5 R	26.9	2500	187	17.2	49.9
	CEM II/A-LL 32.5 R	27.9	4480	141	25.1	49.4
	CEM II/B-M (S-LL) 32.5 R	27.6	3450	162	23.0	51.1
	CEM II/B-M (V-LL) 32.5 R	29.0	4740	165	24.3	48.3
	CEM III/A 32.5 N	26.7	2900	193	12.0	47.5
V8	CEM I 32.5 R	27.3	3298	171	22.9	49.4
	CEM II/B-S 42.5 N	29.5	4683	183	22.8	59.5
V9	CEM I 32.5 R	25.2	2900	190	21.0	47.0
	CEM II/B-S 42.5 N	29.0	3900	180	23.0	55.0
V10	CEM I 32.5 R	27.6	3150	185	27.7	49.7
	CEM II/B-S 32.5 R	27.5	3290	210	19.9	49.2
V11	CEM I 32.5 R	24.6	2866	228	17.9	21.0
	CEM II/B-S 42.5 N	28.5	4229	204	49.9	56.0

Table 2: Manufacturers' data for the admixtures and additions used for producing the cement-based floor screed mortar

Acronym	Admixtures and additions used (manufactureres' information)
V6-A, V7-A	*Product:* floor screed admixture consisting of synthetic aliphatic alcohol sulfate salts; *Action:* dispersive, plasticizing and stabilizing; *Addition level:* 0.1 to 0.12 mass % wrt to cement content
V6-B	*Product:* floor screed admixture; *Action:* plasticizing; *Addition level:* no information
V8-A	*Product:* floor screed admixture consisting of synthetic aliphatic sulfate salts; *Action:* plasticizing, stabilizing and homogenizing; *Addition level:* 0.03 to 0.05 mass % wrt cement content
V8-B, V11-A	*Product:* synthetic resin dispersion with surface-active additives; *Action:* stabilizing; *Addition level:* 0.5 to 2.0 mass % wrt to cement content
V10-A	*Product:* liquid concentrate for producing floating floor screeds of CT-F4 quality; *Action:* plasticizing; *Addition level:* 0.2 to 0.3 mass % wrt to cement content
V10-B	*Product:* liquid cement-based floor screed admixture for producing cement-based floor screeds of the CT/CA F4 / F5 quality on insulation and parting layer; *Action:* plasticizing and acceleration of the drying; *Addition level:* 3 mass % wrt to cement content
V10-C	*Product:* synthetic dispersion for producing cement-based floor screeds from CT-C35-F5 quality: *Action:* improvement of the workability and quality of the floor screed; *Addition level:* 5 to 7 mass % wrt cement content

Table 3: Mix composition of the cement-based floor screed mortar

Designation	c	w/c	Sand	Gravel	Additives	
	kg/m^2		kg/m^2	kg/m^2	Addition level, mass % wrt cement	Acronym
V1	300	0.58	1008	792	none	
V2	300	0.58	1080	720	none	
V3	300	0.58	1075	725	none	
V4	300	0.57	1080	720	none	
V5	280	0.79	1015	798	none	
V6	289	0.78	936	798	none	
	277	0.55	896	764	0.10	V6-A
	272	0.63	881	751	0.15	V6-B
V7	300	0.52	1005	670	0.05	V7-A
V8	295	0.65	1346	498	0.05 or 0.04	V8-A
					0.70 or 0.65	V8-B
V9	295	0.75	1175	598	none	
V10	310	0.47	711	1159	none	
	310	0.42	694	1132	0.30	V10-A
	320	0.42	718	1172	3	V10-B
	450	0.30	682	1113	10	V10-C
V11	295	0.65	1346	498	0.55	V11-A
					0.47	

The mix was generally pre-mixed after half of the aggregate, with a moisture content set to approximately 3 mass %, and the cement had been added. The rest of the aggregate and water were then added and mixed for two minutes (V1 to V7, V9). In some cases, the solids were introduced into the mixer first and water was added while the mixer was running (V8, V10, V11). The mixing lasted for 2 to 3 minutes until the mix appeared uniform, as specified in DIN EN 13892-1:2003-02. When admixtures were used, the manufacturers' information was followed and the product was either added with the mixing water or to the slightly moist mortar while the mixer was running. The test pieces for the various investigations were produced directly after the mixing process.

4.2 Material properties investigated

4.2.1 Fresh mortar properties

The fresh mortar properties of the floor screed mortar were determined as specified in ❱ Table 4. The tests were carried out directly after mortar production or 10 and 30 minutes after production. The change in consistency over time was established in investigation V6 by taking measurements 5, 10, 20, 30 and 50 minutes after production.

4.2.2 Bulk density, flexural tensile and compressive strengths of standard prisms

The strength tests and bulk density measurements were carried out as shown in Table 4 on standard prisms. In all the investigations, the flexural tensile and compressive strengths were measured at the age of 3 days, 7 days and 28 days. In some of the investigations the values for these properties were also determined at the age of 1 day, 2 days and 56 days.

4.2.3 Further strength tests

Further strength tests were also performed on specially produced test pieces with different dimensions. Slabs were produced as floating floor screed on insulating layers for the suitability and confirmatory tests. The flexural tensile strength or the surface tensile strength as well as the adhesive tensile strength and deflection were measured. In some cases, the scratch strength was also measured. ❱ Table 5 provides an overview of the tests performed.

4.2.4 Deformation behaviour under short-term load

The deformation behaviour under short-term uniaxial pressure loading (elastic modulus) was measured at the age of 28 days (see Table 4).

4.2.5 Deformation behaviour with varying moisture content

Changes in shape caused by variation in the moisture content in floor screed mortar, i.e. drying shrinkage, were investigated using standard prisms at ages of 1 day to 56 days (see Table 4). Shrinkage measurements were also carried out in shrinkage test channels of different dimensions (❱ Table 6). The horizontal and vertical deformation (dishing) at the edges of the horizontal surfaces with dimensions of 6 m x 3 m and a thickness of 50 mm were measured in investigations V1 to V4 and V6 as well as in the shrinkage test channels.

4.2.6 Moisture content

The moisture content was measured by kiln drying at 105 °C (Darr method) or by using the calcium carbide method (CM method) in accordance with [4]. In the kiln drying process the samples were dried to constant weight in a drying cham-

Table 4: Fresh mortar properties and hardened mortar properties (standard prisms) of the cement-based floor screed mortar

Properties			Storage	Investigation
Fresh mortar	Consistency	Compaction factor DIN 18555-2:1982	DIN 13892-1:2003 (in some cases* also at 10 °C)	V1, V2*, V3*, V4
		Flow table spread (Hagermann unit) DIN 18555-2-1982 DIN EN 1015-3:1998		V5, V6, V8, V9, V10, V11
		Flow table spread (concrete flow table) DIN EN 12350-5:1999		V7
	Bulk density DIN 18555-2:1982 DIN EN 1015-6:2007			V1, V2*, V3*, V4, V5, V6, V7, V8, V9, V10, V11
	Air void content DIN 18555-2:1982 DIN EN 1015-7:1998			V1, V2*, V3*, V5, V6, V7, V8, V9, V10, V11
Hardened mortar properties Standard prisms (40 mm x 40 mm x 160 mm)	Flexural-tensile and compressive strengths DIN 18555-3:1982 DIN EN 13892-2:2003		DIN 18555-3:1982 DIN EN 13892-1:2003	V1, V2, V3, V4, V5, V6, V7, V8, V9, V10, V11
			Climatic chamber 10 °C (in some cases* after 14 d, climatic chamber at 20 °C)	V2*, V3*, V7
	Elastic modulus DIN 1048-5:1991		DIN 18555-3:1982 DIN EN 13892-1:2003	V5, V9, V10
	Shrinkage DIN 52450:1985 DIN EN 13454-2:2004		1 d or 7 d 20 °C, 95 % r.h. then 20 °C, 65 % r.h.	V5, V6 or V10

ber. The moisture content was calculated from the difference in weight between the wet and dry samples and from the dry weight of the samples. In the CM method, samples are mixed with calcium carbide in a steel cylinder with a manometer, thus forming acetylene gas. The moisture content was measured on the basis of the pressure increase indicated by the manometer and a calibration table.

❱ Table 7 provides an overview of the tests carried out. The moisture contents of the samples were measured at the age of 3 days, 7 days, 14 days, 28 days and 56 days (V6, V8 to V11) or at the age of 28 days (V1 to V4, V7).

5 Discussion of results

5.1 General

The results of the comparative investigations are summarized below. As a rule, within the corresponding test series, i.e. with otherwise comparable ratios in terms of floor screed composition and under identical production, storage and test conditions, there is a direct comparison of the results for cement-based floor screed containing CEM II cements, shown on the ordinate (y-axis), with the results for cement-based floor screed containing CEM I Portland cement, shown on the abscissa (x-axis).

5.2 Workability

The workability properties of a floor screed are determined by its composition, the properties of the starting materials and the temperature. The water demand of a floor screed is primarily influenced by the type, composition and amount of aggregate used. Due to the optimized particle size distributions of CEM II and CEM III/A cements, it should generally be assumed that mortars and concrete produced with these cements will exhibit good workability [5–7].

CEM II and CEM III/A cements are generally ground to a finer particle size than comparable CEM I cements (see Table 1). This greater fineness may lead to an increase in the water demand of cement in the standard test. However, this effect generally does not influence the water demand of the mortar, as the workability properties of a mortar are basically determined by its composition and the properties of all the constituents. This has been confirmed by these investigations.

❱ Fig. 1 shows the results of consistency measurements and air content obtained in the comparative investigations.

❱ Figs. 2 and 3 show that the influence of cement on consistency (flow table spread) and on air content is much lower, for example, than the influence of the water/cement ratio or the use of admixtures.

5.3 Early stiffening, setting, hardening

The early stiffening, setting and hardening of mortars are retarded or accelerated respectively by low or high fresh mortar temperatures. For the same composition, a decrease in workability and strength is to be expected at low temperatures, irrespective of the type of cement used. ❱ Figs. 4 and 5 show that the same familiar correlations also occur with cement-based floor screeds, irrespective of the cement type used.

Table 5: Strength tests on slabs with various dimensions and storage conditions

<table>
<tr><th colspan="2" rowspan="2">Test piece dimensions</th><th rowspan="2">Storage</th><th colspan="3">Strength tests</th></tr>
<tr><th>Flexural tensile strength
DIN 18560-2:2004</th><th>Adhesive tensile strength [3]
DIN 1048-2:1991
DIN EN 13892-8:2003</th><th>Scratch strength
(non-standard scratch test)</th></tr>
<tr><td rowspan="5">Thickness 40 mm to 45 mm</td><td>1 m x 1 m</td><td rowspan="4">Without cover
16 °C to 20 °C,
40 to 60 % r.h.</td><td colspan="3">V5 (Test age 28 d)
Deflection was measured</td></tr>
<tr><td>1 m x 0,5 m</td><td colspan="3">V6 (Test age 28 d)</td></tr>
<tr><td>4 m x 2 m</td><td colspan="3">V9 (Test age 56 d)</td></tr>
<tr><td>0.4 m x 0.4 m</td><td>n.d.</td><td>V8, V11
(Test age 56 d)</td><td>n.d.</td></tr>
<tr><td>0.6 m x 0.5 m</td><td>With cover
(PE film)
DIN EN 13892-1: 2003</td><td colspan="2">V10 (Test age 28 d)
Deflection was measured</td><td>n.d.</td></tr>
<tr><td rowspan="2">Thickness 80 mm</td><td rowspan="2">1 m x 0.7 m</td><td>Without cover
16 °C to 20 °C,
40 to 60 % r.h.</td><td colspan="2">V1, V2, V3, V4 (Test age 28 d)</td><td>n.d.</td></tr>
<tr><td>Without cover,
climatic chamber 10 °C,
after 14 d, climatic
chamber 20 °C</td><td colspan="2">V2, V3 (Test age 28 d)</td><td>n.d.</td></tr>
</table>

n.d.: *not determined*

5.4 Strength

The strength development of concretes made with CEM II and CEM III/A cements is, under conditions encountered in practice in construction, comparable with that of CEM I concrete. ❯ Fig. 6 compares the compressive and flexural tensile strengths in relation to the age of different cement-based floor screeds made with Portland composite cements and Portland cement that have comparable compositions and storage conditions. The results of the strength tests performed as part of the suitability and confirmatory testing on floor screed slabs are shown by way of example in ❯ Fig. 7. With the same floor screed composition and comparable storage conditions, the influence of the type of cement used on the strength results was not consistent.

❯ Fig. 8 shows that the flexural tensile strength of standard prisms or of prisms obtained from the production of test slabs is higher than the flexural tensile strength measured in confirmatory testing. The flexural tensile strengths established for the floor screeds produced from Portland composite cements were in some cases higher than those established for Portland cement during standard testing but during the confirmatory testing it was found that the cement had almost no influence.

5.5 Deformation behaviour

❯ Fig. 9 shows the results of the deformation behaviour test carried out under short-term, uniaxial pressure loading, measured as the modulus of elasticity (see Section 4.2.4).

❯ Fig. 10 shows the results of measurements performed in the shrinkage investigations (see Section 4.2.5). ❯ Figs. 11 and 12 show the measurements of the deflection of the floor

Table 6: Investigation of the deformation behaviour in shrinkage-test channels

<table>
<tr><th>Dimensions of the shrinkage-test channel</th><th>Storage</th><th>Investigation: Test duration</th></tr>
<tr><td>0.5 m x 40 mm x 40 mm</td><td rowspan="2">20 °C, 65 % r.h.</td><td>V5, V9: Testing up to 10 d
V6: Testing up to 33 d
V10: Testing up to 7 d</td></tr>
<tr><td rowspan="2">1 m x 80 mm x 40 mm</td><td>V1, V3, V4: Testing up to 28 d</td></tr>
<tr><td>Climatic chamber 10 °C, after 14 d,
climatic chamber 20 °C</td><td>V2, V3: Testing up to 28 d</td></tr>
</table>

Table 7: Investigation of the moisture content

Dimensions of the test piece			Storage	Investigation of the moisture content by	
				Kiln drying at 105 °C	CM method
Area of thickness	40 mm to 50 mm	0,15 m x 0,15 m	20 °C, 95 % r.h. (7 d) then 20 °C 65 % r.h.	V10*	
		0,2 m x 0,2 m	28 d at 10 °C, 80 % r.h. then 20 °C, 65 % r.h.	V6	n.d.
		0,3 m x 0,3 m	20 °C, 65 % r.h.	V5, V8, V9, V11	
		0,4 m x 0,4 m	20 °C, 65 % r.h.	V7	
		6 m x 3 m	16 °C to 22 °C 35 % r.h. to 65 % r.h.	V6	n.d.
	80 mm	1 m x 0,7 m	DIN EN 18560-1:2004	V1, V3, V4	V1, V4
			Climatic chamber 10 °C (14 d) then 20 °C	V3	n.d.
Prisms	40 mm x 40 mm x 160 mm		DIN EN 18560-1:2004 Climatic chamber 10 °C (14 d) then 20 °C	V1, V2, V3, V4	n.d.

n.d.: *not determined*
For V10-B only 24 h at 95 % r.h.

screeds and the horizontal and vertical measurements of test slabs. The cement type was not found to have a consistent influence in any of the comparisons.

5.6 Moisture content

Depending on the drying conditions, a moisture content was established that was dependent on the water content, floor screed thickness and environmental conditions. In practice, the moisture content is considered as residual moisture.

When the floor screeds were dried at 105 °C, all the capillary water and also the physically bound water, i.e. water that cannot evaporate under normal environmental conditions, was recorded. ❱ Figs. 13 and 14 show that the influence of

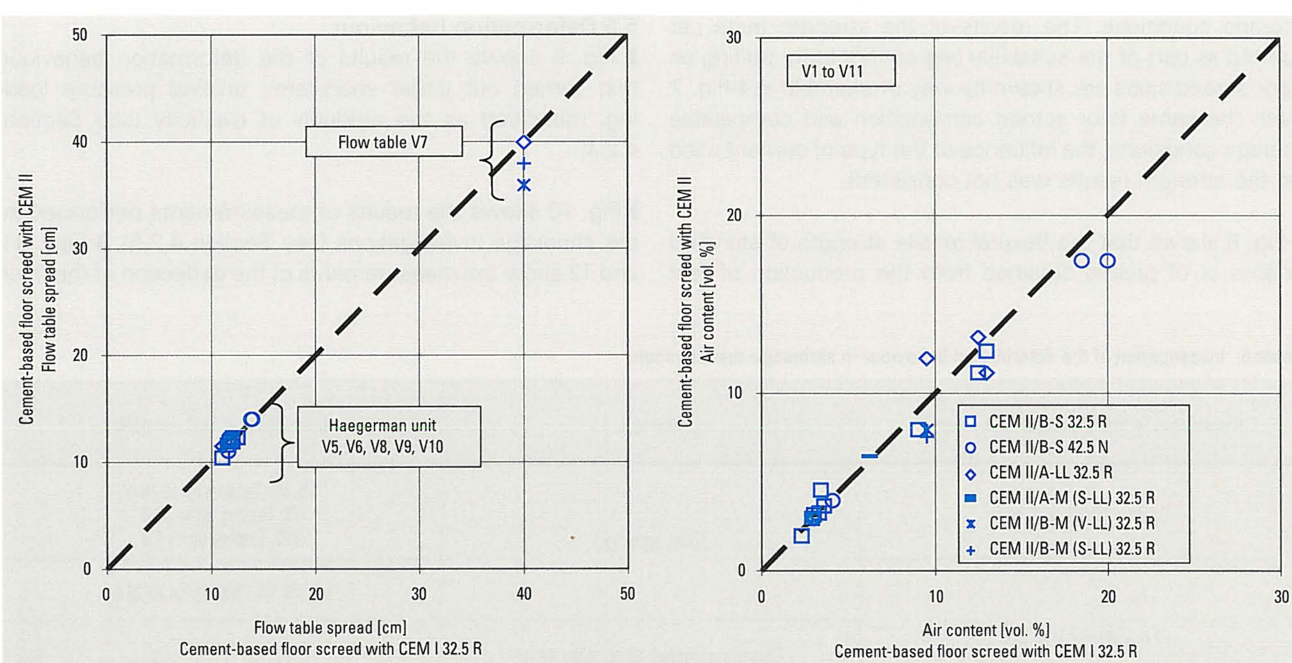


Figure 1: Flow table spread and air content of cement-based floor screeds

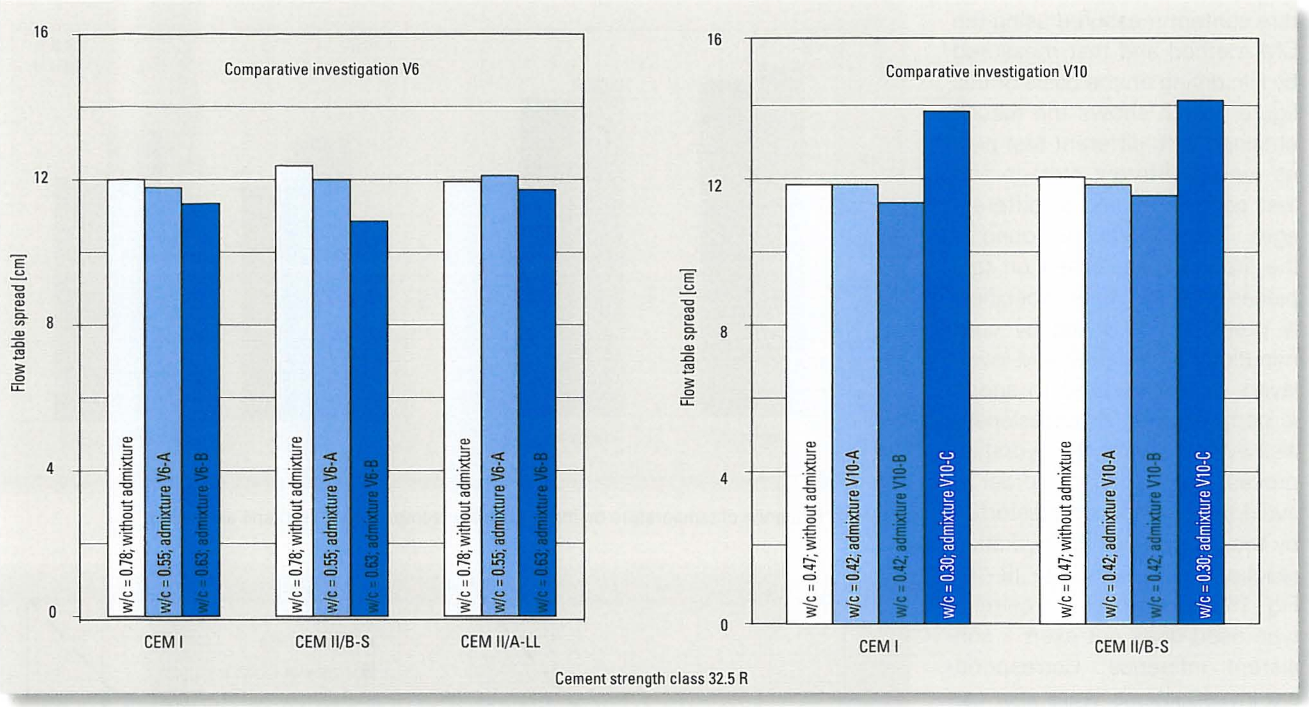


Figure 2: Workability (flow table spread) of cement-based floor screeds

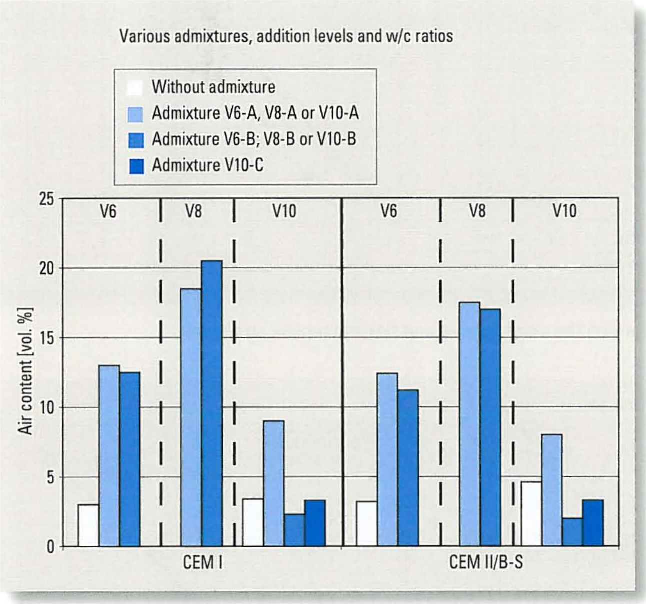


Figure 3: Air content of cement-based floor screeds in relation to the admixture

cement on the residual moisture measured by kiln drying at 105 °C is not significant, irrespective of age, testing geometry and storage conditions.

› Figs. 14 and 15 show that the w/c ratio has a major effect on the drying of floor screeds under constant environmental conditions. At comparable w/c ratios, (0.78 in V5 and 0.79 in V6), the high relative atmospheric humidity for V6 is a crucial factor (see Table 7). No significant influence of the cement could be detected under identical production and test conditions. The moisture content was clearly affected to a greater extent by the admixture. The influence of the different test piece geometries, storage conditions and compositions cannot be identified clearly from the test results.

› Fig. 16 shows that the residual moisture measured using the CM method at the same testing age and under identical test conditions was lower than the residual moisture measured by drying at 105 °C. It is not possible to derive a clearly quantifiable correlation between the mois-

Table 8: Comparison of the results obtained with floor screed mortars using CEM II/B-S and CEM III/A cements

		CEM II/B-S 32.5 R		CEM III/A 42.5 N	
Property	Age [d]	Initial test	Hardening test	Initial test	Hardening test
Compressive strength in N/mm^2	3	13.4	16.7	14.4	15.4
	7	20.5	22.8	25.7	24.7
	28	21.7	24.4	30.6	26.4
Flexural tensile strength in N/mm^2	3	2.9	3.3	2.9	3.4
	7	3.9	4.3	4.4	4.2
	28	4.4	4.3	5.1	4.5
Residual moisture[1)] in mass %	3	4.7	4.2	4.8	4.3
	7	4.5	3.3	4.5	3.2
	28	3.9	1.8	4.1	1.8

V4: c = 300 kg/m^3, w/c = 0.57 — [1)] Kiln drying at 105 °C ture content measured using the CM method and that measured by kiln drying on the basis of this figure, which shows the results obtained with different test pieces, under different storage and test conditions, and at different ages. The correlations found in the literature are based on test pieces that had been specifically prepared for drying by comminution of the upper and lower layers of the samples to specific particle sizes, or occasionally also by interrupting the hydration process before drying in order to avoid the results being distorted by the progress of the hydration reaction at an early age [8–10]. Fig. 16 shows that the cement type used does not exert a consistent influence. Corresponding investigations were also carried out for CEM III/A cements in comparison to CEM II/B-S cements.

Table 8 shows the results for residual moisture, compressive and flexural tensile strength of these floor screed mortars. The floor screed mortar made with CEM III/A cement did not exhibit significantly different behaviour from that made with CEM II/B-S cement.

6 Final remarks

Investigations carried out on cement-based floor screeds were evaluated at the Research Institute of the Cement Industry. The investigations were carried out in the laboratory, sometimes under conditions resembling those on a building site. The evaluation was based on investigations that were carried out or commissioned by member companies of the VDZ (German Cement Works Association) from 1998 to 2008. The fresh mortar properties of bulk density, consistency and air content were evaluated. Moreover, the flexural-tensile and compressive strengths, surface strength, modulus of elasticity, shrinkage and residual moisture content in relation to the age were determined. The results can be summarized as follows:

The structural engineering properties measured in the investigative programme form an important database for cement-based floor screed mortars. The constructionally relevant properties of cement floor screeds made with CEM I, CEM II and CEM III/A cements were evaluated. Comparative investigations on cement-based floor screeds made with varying cement compositions, but otherwise with the same composition of the floor screed and identical production and testing conditions, were analyzed. No significant influence of the type of cement could be detected. The results confirm the basic suitability of Portland cement, Portland composite cements and blastfurnace cements for the production of

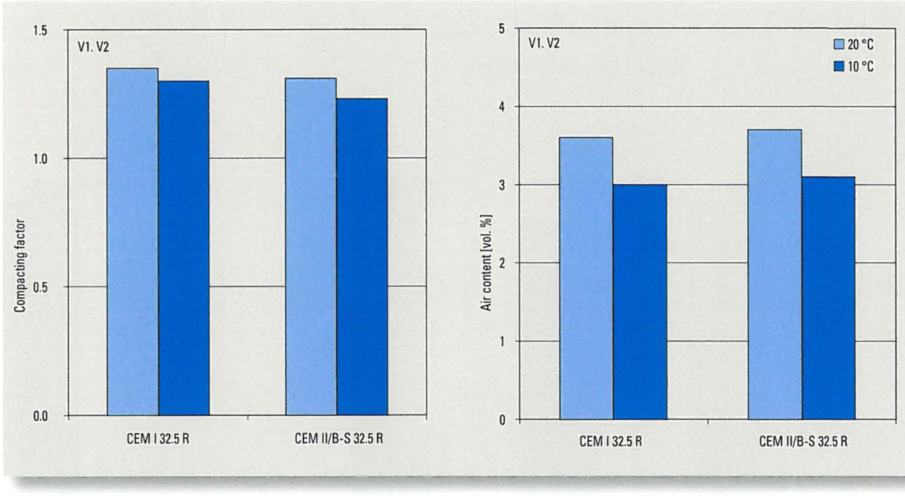


Figure 4: Influence of temperature on the workability (compacting factor) and air content

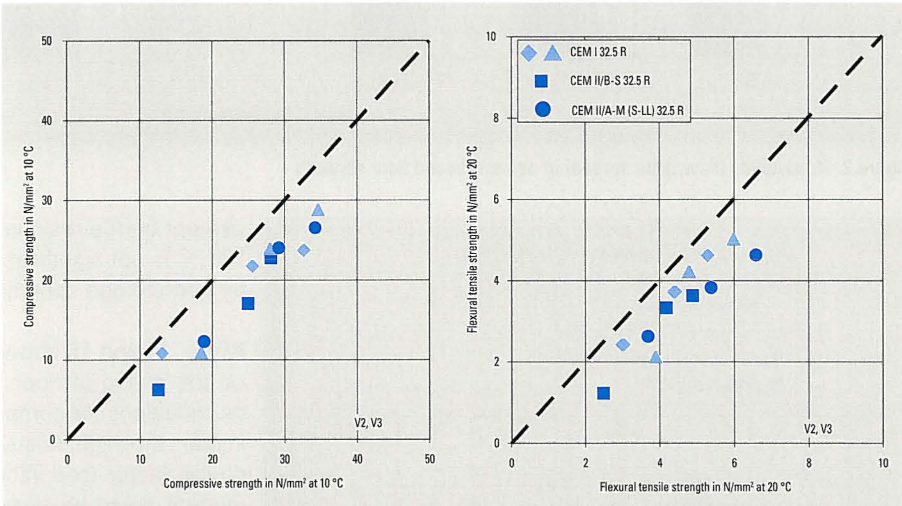


Figure 5: Influence of temperature on the compressive and flexural tensile strengths

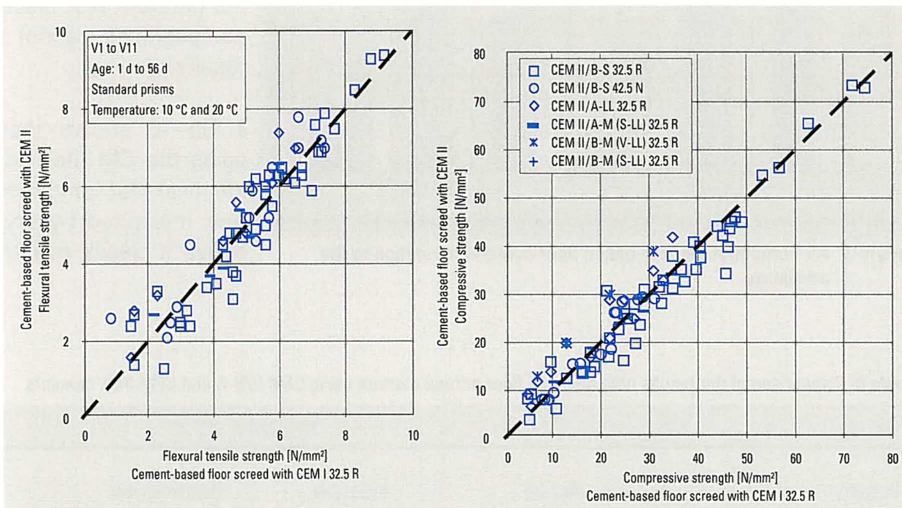
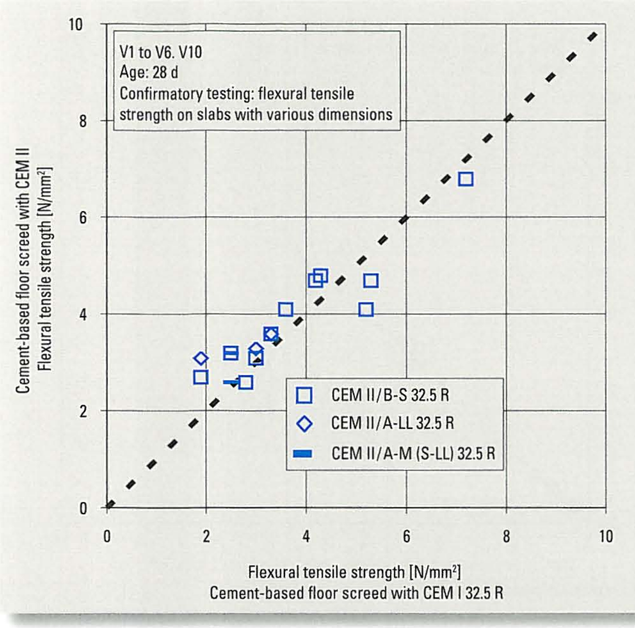


Figure 6: Flexural tensile and compressive strengths of cement-based floor screeds



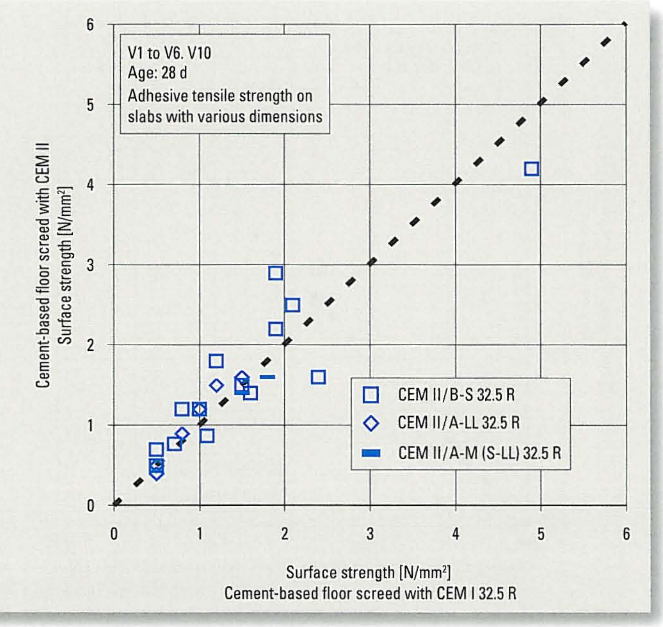


Figure 7: Verification testing as flexural tensile strength, and surface strength as adhesive tensile strength of cement-based floor screeds

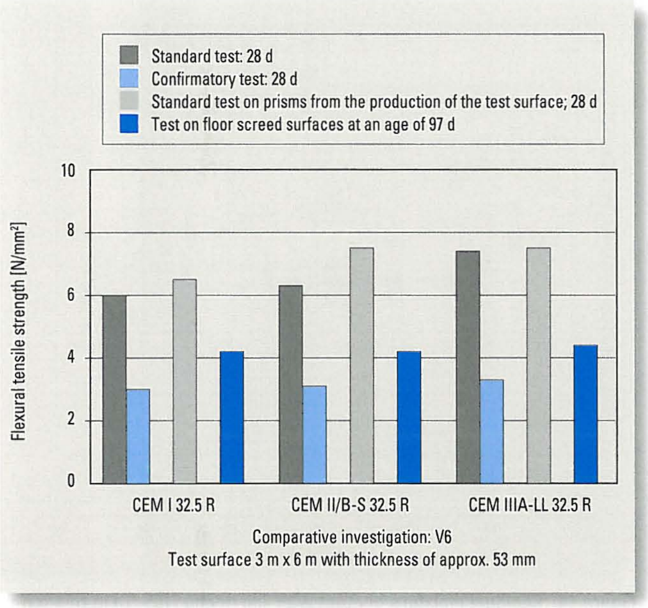


Figure 8: Properties of floor screed surfaces: flexural tensile strength

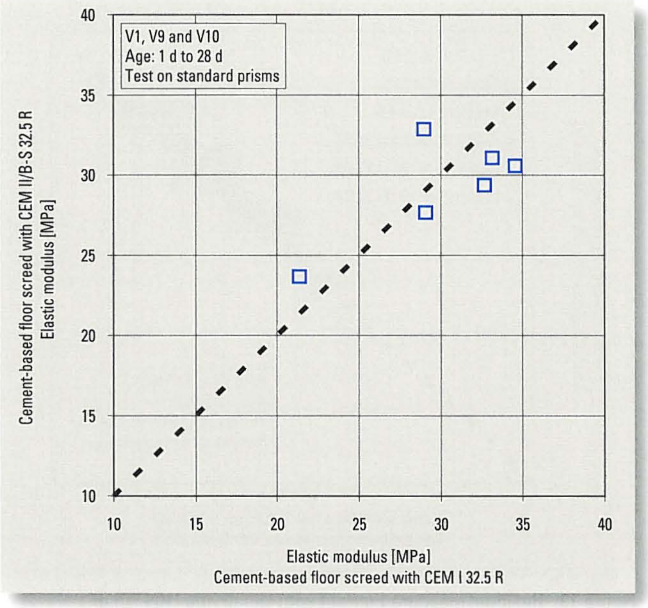


Figure 9: Elastic modulus of cement-based floor screeds

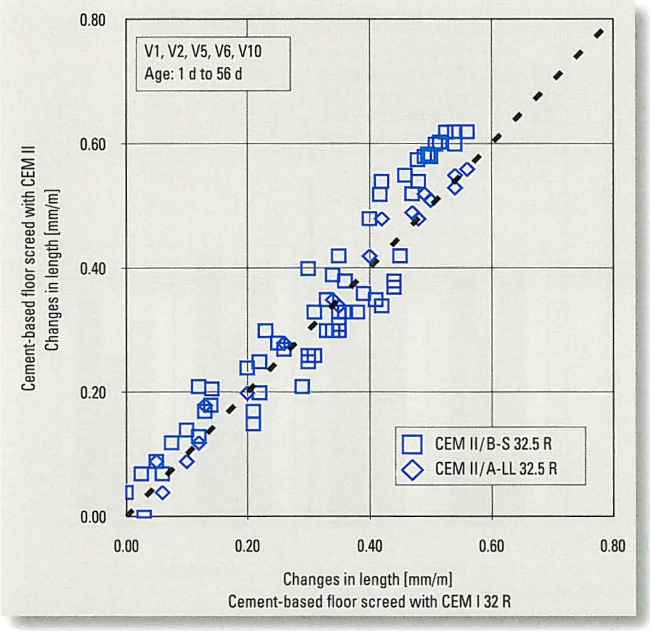


Figure 10: Changes in length (shrinkage) of cement-based floor screeds

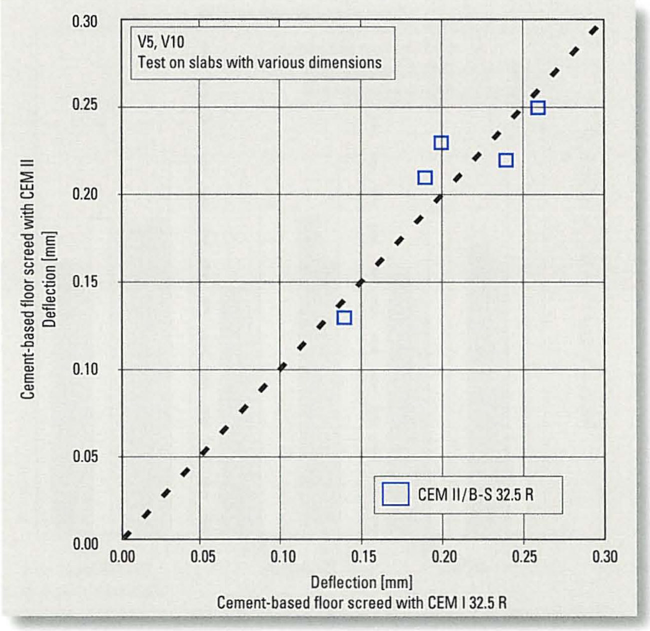


Figure 11: Deflection of cement-based floor screeds

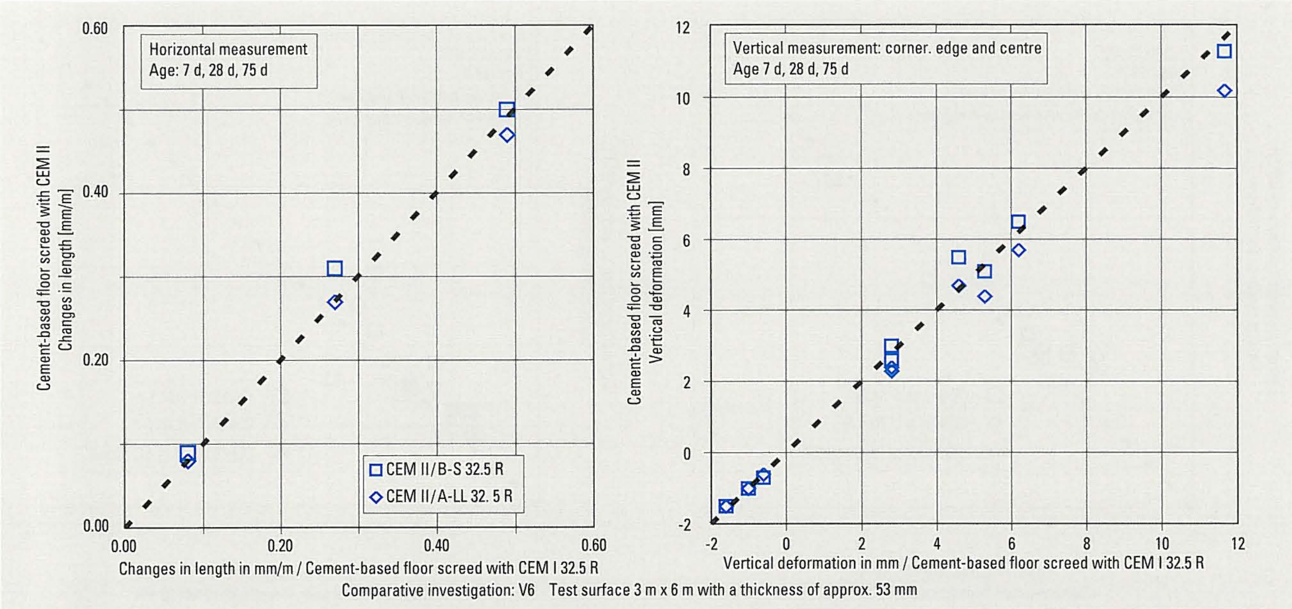


Figure 12: Horizontal and vertical deformation of cement-based floor screeds

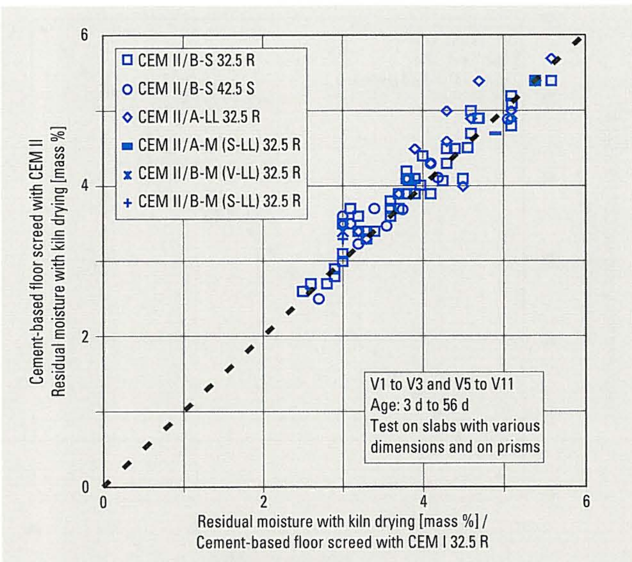


Figure 13: Residual moisture content with kiln drying (105 °C) of cement-based floor screeds

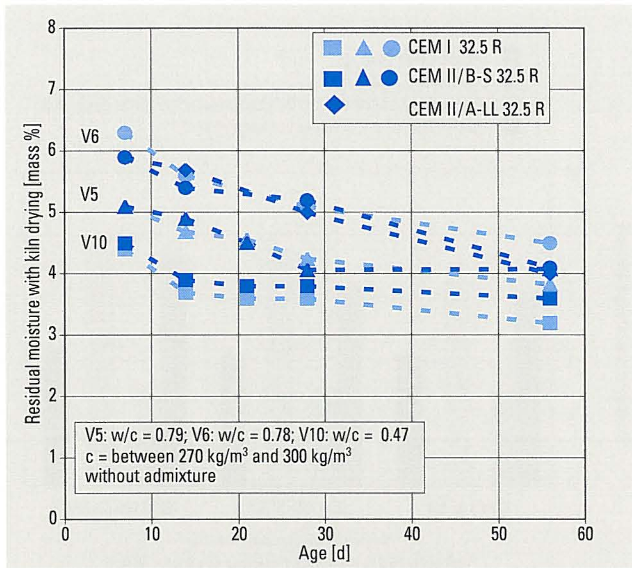


Figure 14: Residual moisture content with kiln drying (105 °C) in relation to the age (mixed without admixtures)

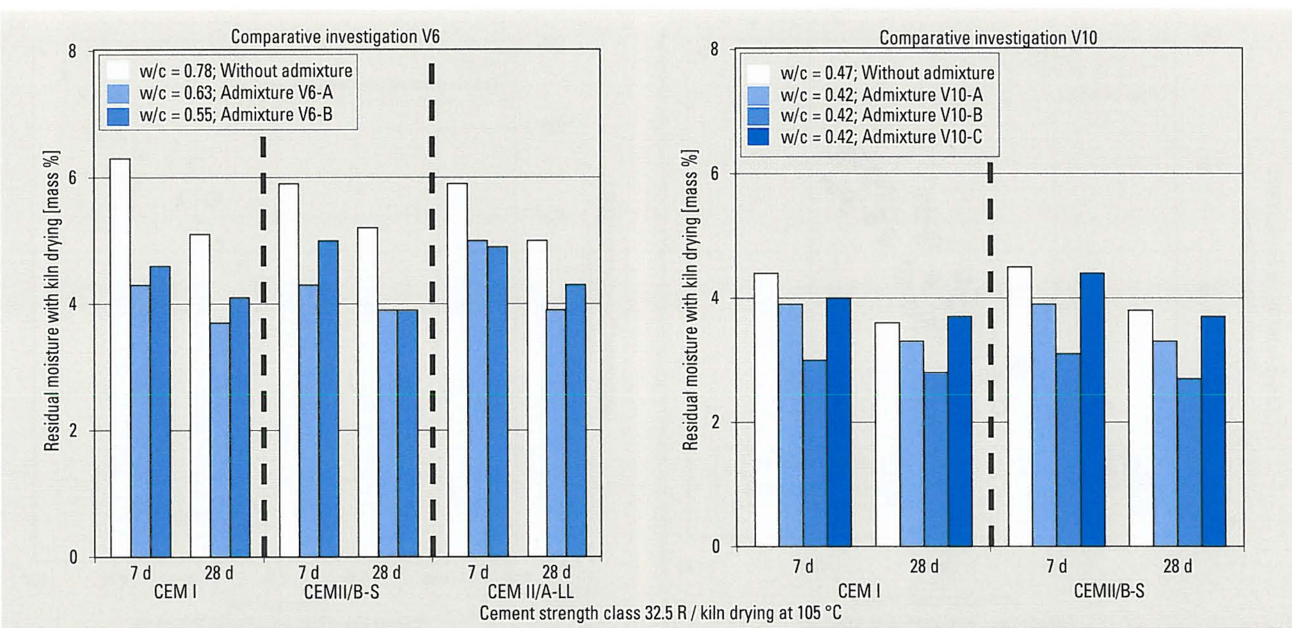


Figure 15: Residual moisture content with kiln drying in the investigations with and without admixtures

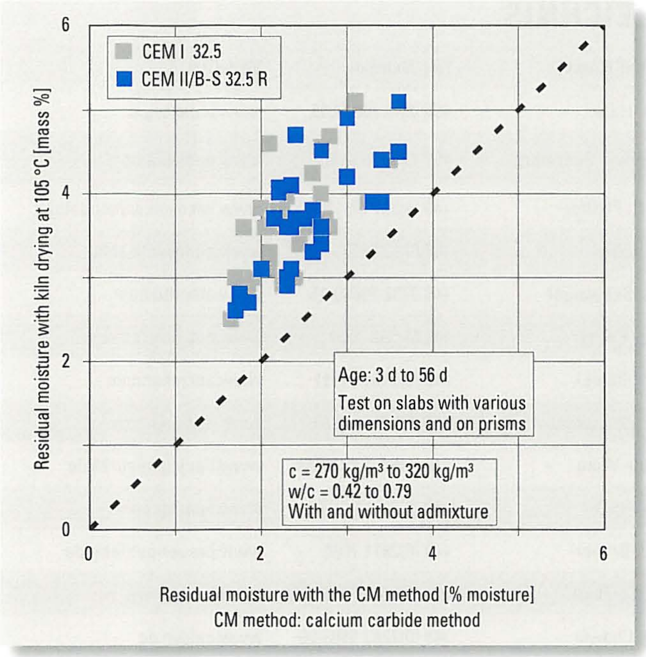


Figure 16: Residual moisture content in relation to the test method used

floor screed mortar as well as for other areas of concrete construction [5].

The suitability of a floor screed mortar should be confirmed in an initial test [2]. General conditions that have an important influence, such as placement conditions and building site conditions, should also be taken into consideration.

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