SLOVENSKI STANDARD
kSIST-TP FprCEN/TR 13933:2023

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Zidarski cement - Preskušanje obdelavnosti (kohezivnost)

Masonry cement - Testing for workability (cohesivity)

Putz- und Mauerbinder - Bestimmung der Verarbeitbarkeit (Kohäsion)

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FINAL DRAFT
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English Version

Masonry cement - Testing for workability (cohesivity)

Putz- und Mauerbinder - Bestimmung der Verarbeitbarkeit (Kohäsion)

This draft Technical Report is submitted to CEN members for Vote. It has been drawn up by the Technical Committee CEN/TC 51.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (FprCEN/TR 13933:2023) has been prepared by Technical Committee CEN/TC 51 “Cement and building limes”, the secretariat of which is held by NBN.

This document is currently submitted to the Vote on TR.

This document will supersede CR 13933:2000.

This document includes the following significant technical changes with respect to CR 13933:2000:

— The titles have been added in French and in German,

— Normative references have been added,

— Text has been rewritten to exclude permissions, recommendations and requirements.

Introduction

Mortars incorporating masonry cements are used for bedding masonry units and also for rendering and plastering. In 1988 the CEN Technical Committee responsible for Cements and Building Limes (TC 51) charged its Working Group 10 to produce a Standard for Masonry cements and for the test methods to support that Standard.

Test methods for setting time, soundness and strength are common requirements in most cement standards. However, where the cement is specifically designed to adhere to and subsequently provide a good bond with masonry units, it is important that an adequate level of workability is achieved. In contrast to the concept of workability as applied to concrete, workability in mortars is not just a question of adjusting the "wetness" of the mortar by adding more or less water. In masonry work, the craftsman requires rather more of his materials in that he expects them to flow easily from the trowel and to spread on to the masonry unit evenly and without segregation. It is only when these properties are present that he can expect to achieve the consistent degree of bonding necessary to produce durable watertight joints and renderings.

The appropriate RILEM Committee considered that workability comprised two main components, notably: consistence and plasticity. They defined these components as follows:

Consistence: That property of a mortar by virtue of which it tends to resist deformation.

Plasticity: That property of a mortar by virtue of which it tends to retain its deformation after reduction of the deforming stress to its yield point.

Consistence is a measure of wetness and is measured using a penetration device, but that plasticity required a more dynamic assessment such as could be achieved by using apparatus which caused the mortar to move. However, in order to obtain any meaningful numerical measure of plasticity, it was adjudged important to ensure that the testing for this characteristic was carried out on mortars where the consistence had been controlled to a narrow band.

Since the testing procedure adopted in the CEN Standard EN 413-2:1994, *Masonry cement - Part 2: Test methods* involved the preparation of a mortar using standard sand and with sufficient water to achieve a narrow band of consistence as assessed using a plunger (penetration) test, this was considered as the starting point for the work to assess workability, or as was deemed more appropriate "cohesivity".

Early work involved measuring the time taken for a mortar of standard consistence to flow between two points in the AFNOR workability meter. This method was incorporated into EN 413-2:1994 as a test method, but on account of the limited amount of experience available no limits were set in the Masonry cement Prestandard ENV 413-1. Subsequently, further testing revealed significant calibration problems between laboratories and consideration was given to the use of a flow table as an alternative means of providing the dynamic component of the test. This document deals with the development of the test using flow tables.

1 Scope

This document deals with the adaption of existing test methods and equipment to provide a repeatable and reproducible means of assessing the workability ("cohesivity") imparted to mortar by masonry cements.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— IEC Electropedia: available at https://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp/

4 Equipment

As has been discussed in the introduction, there is considerable merit in using the standard consistence mortar produced in EN 413-2:1994 as the starting point for the cohesivity test. Such a practice uses no equipment beyond that already in use for masonry cement testing. The mortar is prepared in the mixer defined in EN 196-1:1994 and the sand used and the plunger device for measuring consistence are those specified in EN 413-2:1994.

Since flow tables are not uncommon in cement testing laboratories it was decided to evaluate these in order to provide a measure of cohesivity. However, previous experience suggests that even where these pieces of equipment are covered by strict specification requirements, their performance can be expected to vary from table to table. A review of the flow tables in use in various European testing laboratories revealed considerable differences as is shown in Table 1. Calibration of the tables was therefore considered to be an essential step in the test procedure.

In order to keep this calibration procedure as simple as possible, the first attempts at calibration were carried out using the EN 196-1:1994 sand damped with a fixed amount of water. The results from this calibration as carried out in the nine laboratories participating in the co-operative test program are given in Table 1.

Table 1 — Calibration Results

Test Lab	Flow Table (drop in mm)			Flow Table mould mm			Sand	Flow table calibration - spread after jolting mm					
	Type	Top kg	Drop	Top	Btm dia	Ht.	196-1	5	10	15	20	25	30
BC	ASTM	4,08	12,5	70,7	102	51	German	129	140	153	165	171	
(UK)								131	139	148	160	172	
								129	139	150	161	172	
ave								129	139	150	161	172	
BLI	ASTM	4,002	14	70	101	51	France	126	138	146	158	167	177
(UK)								127	139	149	156	164	171
								124	137	148	157	170	180
ave								126	138	148	157	167	176
Cimpor	BS 6463	6,6	19,1	70	100	60	France	150	158	162	163	163	
(Port'al)								152	158	160	163	164	
								154	159	164	164	163	
ave								152	158	162	163	163	
DBDK	EN 459	4,352	10,2	70	110	60	German	119	132	154	160	163	
ave													
ENCI	RMU	3,298	10	70	100	90	German	122	134	139	145	147	
ave													
Italicem		3,34	10,1	69,9	100	60	France	114	129	140	145	149	
(Italy)								114	127	136	143	144	148
								116	128	139	144	148	
ave								115	128	138	144	147	
	UNI	3,22	10,0	70,2	100	60	France	113	131	139	144	146	147
								119	136	137	140	144	148
								116	134	138	138	143	147
ave								116	134	138	141	144	147
Lafarge	ASTM	4,1	12,5	70	100	50	France	132	143	151	153	162	
(France)								129	145	151	154	161	
								127	130	146	151	159	
ave								129	139	149	153	161	
Norcem	NS 3107	3,495	9				German	166	175	184	191	198	
ave													
VDZ	EN 459	4,35	10	70	100	60	German	125	141	147	153	157	
Germany								124	141	148	153	156	
								124	142	150	155	159	
								123	143	150	155	158	
								122	141	146	151	154	
								122	139	147	150	155	
ave								123	141	148	153	157	

DBDK was the German Lime Association, ENCI was the Netherlands cement manufacturer and Norcem was the Norwegian cement manufacturer.

The number of jolts and the log10 of the number of jolts for a spread of 145 mm is shown in Table 2. The log of the number of jolts is given since the relationship between the log of the number of jolts and the spreads approaches linearity.

Table 2 — Number of jolts and the $\log_{10}$ of the number of jolts for a spread of 145 mm

Test Laboratory	Flow Table	Number of jolts requested for a spread of 145 mm	
		Number	log of number
BC	ASTM	13	1.114
BLI	ASTM	13	1.114
Cimpor	BS 6463	4	0.602
DBDK	EN 459	13	1.114
ENCI	RMU	20	1.301
Italicementi	DIN ?	22	1.342
	UNI	26	1.415
Lafarge	ASTM	13	1.114
Norcem	NS 3107	3	0.544
VDZ	EN 459	12	1.079

The results obtained revealed large differences between the design of the flow tables in common use in the different laboratories and also in the spread of mortar obtained from a given number of jolts. However, despite these differences, there was good agreement between the ASTM tables in three of the laboratories in achieving a spread of 145 mm and a tolerable level of agreement between the ASTM tables and the EN 459 tables. The Italian table and those in use in Norway and Portugal however, gave very different results. At this stage of the evaluation there was promise that an effective means of calibration was possible and it was encouraging to proceed further with this type of test procedure.

An attempt was also made to calibrate the flow tables using mixtures of EN 196-1:1994 sand and aqueous solutions of cellulose ethers and standard viscosity oils. The rheological properties of these materials proved to be markedly different from those of the mortars to be tested and they were not proceeded with.

5 Test procedure

5.1 Introduction

The test procedure below was adopted for evaluation in a co-operative test program and follows that given in the papers of Slavin (see [1] in Bibliography) and of Bowler, Jackson & Monk (see [2] in Bibliography).

Recently published work [1] and [2] provide details of a method for the determination of the cohesivity (at a given level of consistence) provided by binders when used to prepare mortars for use in masonry applications (brick and block laying and rendering). This property is different from consistence, which for building mortars implies "wetness", whereas cohesivity describes the ability of the mortar to flow in the desired manner from the craftsman's trowel and to form a coherent mass when placed upon masonry units. This document describes its application to masonry cement.

5.2 Principle

The mortar is prepared in accordance with the method given in EN 413-2:1994.

This mortar is placed in a mould on a calibrated flow table and the spread is measured after the appropriate number of jolts.

Cohesive materials give either a significantly lower spread or an increased number of jolts than the less cohesive materials.

Cohesivity is expressed as indices which incorporate the calibration of the flow table.

5.3 Apparatus

5.3.1 Flow tables

For reference purposes, see the flow table described in EN 459-2:1994.

Other flow tables and their moulds, the performance of which is related to the reference table, are used. It is important that the EN 196-1:1994 sand/water calibration material remains cohesive up to the relevant spread. If a flow table does not permit this, then it is not suitable for this test.

It is important that the flow table is tightly secured to a horizontal, firm and non-plastic base. A monolithic cast concrete base weighing at least 50 kg is suitable.

NOTE The ASTM C-230 flow table and the BS 4551 flow table and their moulds have been shown to be satisfactory. The BS 890:1972 flow table and its mould is not satisfactory.

5.3.2 Calliper with jaws opening to at least the diameter of the flow table is used in conjunction with a measuring device or ruler calibrated in units of 1 mm.

5.3.3 Timer indicating seconds or better.

5.3.4 Mortar mixer and associated equipment, described in EN 196-1:1994.

5.3.5 Consistence plunger and associated equipment, described in EN 413-2:1994.

5.3.6 Tamper to use with the flow table mould. This is made of non-absorptive, non-abrasive, non-brittle material and having a cross section of 13 mm by 25 mm and a length of 127 mm to 152 mm. The tamping face is flat and at right angles to the length of the tamper.

5.3.7 Metal straight edge, described in 5.3.2 of EN 413-2:1994.

5.4 Calibration of the flow table

If the flow table has not been used during the previous hour, the empty table is jolted several times before use. It is ensured that the tabletop and also the inner surface of the mould are dry and free from any dullness due to the presence of moisture.

(1 350 ± 5) g of CEN standard sand, complying with 5.1.3 of EN 196-1:1994, is placed into the bowl of the mixer, complying with 4.4 of EN 196-1:1994. (203 ± 1) g of water is added and the mixing procedure described in 6.3 b), 6.3 c) and 6.3 d) of EN 196-1:1994 is followed.

The mould is placed in the centre of the flow tabletop and filled in two layers, each of approximately the same height. Each layer is tamped 10 times using the tamper described in 5.3.6 above. Excess material is removed, avoiding any spillage onto the table surface. If water separation is seen between the base of the mould and the tabletop, then tamping has been too vigorous.

The mould is removed and the mix is spread by jolting the tabletop at a rate of one jolt every second. Jolting is commenced within 2,0 minutes of the mixing procedure having been completed.

The spread is measured in two directions at right angles to each other after 5,10,15, 20 and 25 or more jolts of the table (sufficient to give a minimum spread of 145 mm).

NOTE More than 25 jolts are needed with some flow tables to achieve the relevant spread to calculate Cohesivity Index "B".

The average of the two measurements is reported to 1 mm.

The full number of jolts is completed within 5,0 min of the first jolt.

Two further fresh batches of the sand/water mix are prepared and the test described above is repeated in order to provide an average of three results.

The average spread on the flow table after 15 jolts in the calculation of Cohesivity Index "A" is used.

The number of jolts is used to give a spread of 145 mm established by interpolation from the spread obtained at 5, 10, 15, 20 and 25 jolts in the calculation of Cohesivity Index "B".

5.5 Procedure for the assessment of the cohesivity of test mortars

5.5.1 The test mortar is prepared in accordance with 4.2.2 of EN 413-2:1994. Sufficient water is added at the start of mixing in the EN 196-1:1994 mixer to give a plunger penetration using the method for consistence described in EN 413-2:1994 of (35 ± 3) mm.

5.5.2 The flow table mould is placed on to the flow tabletop (prepared as in 5.4 above). The mortar remaining in the mixing bowl is gently turned over by hand, using a suitable implement. The mortar is placed into the mould (as described in 5.4 above).

The mould is removed and the mortar is spread by jolting the flow tabletop at one jolt each second. Jolting is commenced within 4,0 minutes of the mixing procedure having been completed. The spread is measured in two directions at right angles to each other after 5, 10, 15, 20 and 25 or more jolts of the table (sufficient to give a minimum spread of 210 mm).

NOTE 1 More than 25 jolts are needed with some flow tables to achieve the relevant spread to calculate Cohesivity Index "B".

The average of two measurements is reported to 1 mm.

The full number of jolts is completed within 5,0 minutes of the first jolt.

Two further fresh mortar batches are prepared and the test described above is repeated to provide an average of three results.

Cohesivity Index "A" {CI(A)} is calculated using the spread in mm on the flow table after 15 jolts.

NOTE 2 More cohesive mortars give LOWER values of CI(A).

Cohesivity Index "B" {CI(B)} is calculated using the number of jolts to give a spread of 210 mm established by interpolation from the spread obtained at 5, 10, 15, 20 and 25 or more jolts.

NOTE 3 More cohesive mortars give HIGHER values of CI(B).