



SLOVENSKI STANDARD
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Zidarski cement - Preskušanje obdelavnosti (kohezivnost)

Masonry cement - Testing for workability (cohesivity)

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Masonry cement - Testing for workability (cohesivity)

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

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Foreword

This CEN Report has been prepared by Technical Committee CEN/TC 51 "Cement and building limes", the secretariat of which is held by IBN.

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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. These they defined 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.

It may be interpreted that consistence is a measure of wetness and could be 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 CEN report deals with the development of the test using flow tables.

1 Scope

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

This CEN report incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this CEN report only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

- | | |
|---------------|---|
| EN 196-1:1994 | Methods of testing cement - Part 1: Determination of strength |
| EN 413-2:1994 | Masonry cement - Part 2: Test methods |

3 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 requires no equipment beyond that already required 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 effected 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 programme are given in Table 1.

Table 1 - Calibration Results

Test Lab	Flow Table (drop in mm)			Flow Table mould mm			Sand 196-1	Flow table calibration - spread after jolting mm					
	Type	Top kg	Drop	Top	Btm dia	Ht.		5	10	15	20	25	30
BC (UK)	ASTM	4,08	12,5	70,7	102	51	German	129	140	153	165	171	
								131	139	148	160	172	
								129	139	150	161	172	
ave								129	139	150	161	172	
BLI (UK)	ASTM	4,002	14	70	101	51	France	126	138	146	158	167	177
								127	139	149	156	164	171
								124	137	148	157	170	180
ave								126	138	148	157	167	176
Cimpor (Port'al)	BS6463	6,6	19,1	70	100	60	France	150	158	162	163	163	
								152	158	160	163	164	
								154	159	164	164	163	
ave								152	158	162	163	163	
DBDK	EN459	4,352	10,2	70	100	60	German	119	132	154	160	163	
ave													
ENCI	RMU	3,298	10	70	100	90	German	122	134	139	145	147	
ave													
Italicem (Italy)		3,34	10,1	69,9	100	60	France	114	129	140	145	149	
								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 (France)	ASTM	4,1	12,5	70	100	50	France	132	143	151	153	162	
								129	145	151	154	161	
								127	130	146	151	159	
ave								129	139	149	153	161	
Norcem	NS3107	3,495	9				German	166	175	184	191	198	
ave													
VDZ Germany	EN459	4,35	10	70	100	60	German	125	141	147	153	157	
								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 \log_{10} 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	Jolts required 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	NS3107	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.

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4 Test Procedure

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The test procedure adopted for evaluation in a co-operative test programme followed that given in the papers by Slavin [see (1) in Bibliography] and by Bowler, Jackson & Monk [see (2) in Bibliography] and was as follows:

4.1 Introduction

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 should not be confused with 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.

4.2 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 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.

4.3 Apparatus

4.3.1 Flow tables:

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

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

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.

4.3.2 Calliper with jaws opening to the diameter of the flow table. This may incorporate a measuring device calibrated in units of 1 mm or may be used in conjunction with a ruler also calibrated in units of 1 mm.

4.3.3 Timer indicating seconds or better.

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

4.3.5 Consistence plunger and associated equipment as described in EN 413-2:1994.

4.3.6 Tamper to use with the flow table mould. 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 to be flat and at right angles to the length of the tamper.

4.3.7 Metal straight edge as described in 5.3.2 of EN 413-2:1994.

4.4 Calibration of the Flow Table

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

Place (1350 ± 5) g of CEN standard sand complying with 5.1.3 of EN 196-1:1994 into the bowl of the mixer complying with 4.4 of EN 196-1:1994. Add (203 ± 1) g of water and proceed through the mixing procedure described in 6.3b, 6.3c and 6.3d of EN 196-1:1994.

Place the mould in the centre of the flow table top and fill it in two layers each of approximately the same height. Tamp each layer 10 times using the tamper described in 4.3.6 above. Strike off excess material, avoiding any spillage onto the table surface. There should be no water separation between the base of the mould and the table top. If this occurs, then the tamping has been too vigorous.

Remove the mould and spread the mix by jolting the table top at a rate of one jolt every second. Jolting to commence within 2.0 minutes of the mixing procedure having been completed.

Measure the spread 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 may be necessary with some flow tables to achieve the required spread to calculate Cohesivity Index "B".

Report the average of the two measurements to 1 mm.

Complete the full number of jolts within 5.0 minutes of the first jolt.

Prepare two further fresh batches of the sand/water mix and repeat the test described above in order to provide an average of three results.

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

Use the number of jolts 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".

4.5 Procedure for the assessment of the Cohesivity of Test Mortars.

4.5.1 Prepare the test mortar in accordance with 4.2.2 of EN 413-2:1994. Add sufficient water 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.

4.5.2 Place the flow table mould on to the flow table top (prepared as in 4.4 above). Gently turn over the mortar remaining in the mixing bowl by hand using a suitable implement. Place the mortar into the mould (as described in 4.4 above).

Remove the mould and spread the mortar by jolting the flow table top at one jolt each second. Jolting to commence within 4.0 minutes of the mixing procedure having been completed. Measure the spread 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 may be necessary with some flow tables to achieve the required spread to calculate Cohesivity Index "B".

Report the average of two measurements to 1 mm.
Complete the full number of jolts within 5.0 minutes of the first jolt.

Prepare two further fresh mortar batches and repeat the test described above to provide an average of three results.

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

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

Calculate Cohesivity Index "B" {CI(B)} 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).

4.6 Calculation of Results

4.6.1

Cohesivity Index "A" =
$$\frac{\text{Flow table spread (in mm) after 15 jolts using the calibration mix}}{\text{Flow table spread (in mm) after 15 jolts using the test mortar}}$$

4.6.2

Cohesivity Index "B" =
$$\frac{\text{Number of jolts to give a spread of 210 mm using the test mortar}}{\text{Log}_{10} \text{ number of jolts to give a spread of 145 mm using the calibration mix}}$$

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5 Results from the Co-operative Test Programme

Nine laboratories in seven European countries participated in the co-operative test programme. One EN 197-1 CEM I cement and five ENV 413-1 masonry cements were tested in each laboratory using the procedures given in 4 above. The ENV 413 masonry cements comprised one MC5 from Germany, one MC5 from Italy, one MC12.5 from the Netherlands, one MC12.5 from the UK and one MC22.5X from France. The EN 196-1:1994 sand as used was that in normal use in the laboratory in question and was as used in the calibration work (Table 1).

The results obtained are given in tables 3,4,5,6,7 and 8.

Table 3 - CEM I Common Cement (EN 197-1) from UK

Sample	Test Lab	Test No	Water g	Penetration mm	Flow Table Spread mm after jolting								Index Cl(A)	Jolts for 210 mm spread	Index Cl(B)	
					5	10	15	20	25	30	35	40				
CEM I	BC	1	235	34	178	211	231	240	251							
		2	235	35	180	212	233	244	250							
		3	235	34	176	210	229	245	253							
		Ave	235	34	178	211	231	243	251					1,54	10	9,0
BLI		1	245	35	176	211	232	240								
		2	244	33	172	205	225	239								
		3	248	34	175	217	229	241								
		Ave	247	36	174	211	229	240						1,55	10	9,0
Cimpor		1	255	36	179	208	229	240	251							
		2	255	34	179	208	228	241	250							
		3	255	35	180	208	228	242	253							
		Ave	255	35	174	208	228	241	251					1,41	11	18,3
DBDK		1	236	34	156	186	208	224	235							
		Ave												1,35	16	14,4
ENCI		1	236	34	147	172	190	204	215							
		Ave												1,37	23	17,7
Italicm		1/3	245	35:34:35	154	183	202	217	225							
		4/6	245	35:35:35	152	179	197	211	223							
		7/9	245	34:35:35	152	180	199	213	224							
		Ave	245	34,9	152	181	200	214	224					1,45	19	14,2
Italicm		1/3	245	35:34:35	159	187	206	220	231							
		4/6	245	35:35:35	160	189	205	223	231							
UNI		7/9	245	34:35:35	160	186	205	219	229							
		Ave	245	34,9	160	187	205	221	230					1,49	17	12,0
Lafarg		1	243	33	189	222	244	250								
		2			186	219	238	250								
		3			190	224	244	250								
		Ave			188	222	242	250						1,62	8	7,2
Not CEM I	Norcm	1	238	37	130	156	175	189	201							
		2														
		Ave														
		VDZ	1	235	34	153	183	203	218	230						
VDZ		2			158	187	206	220	231							
		3			156	185	203	217	228							
		Ave			156	185	204	218	230					1,38	17	14,8

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