PUBLISHED DOCUMENT

PD CR 13933:2000
CR 13933:2000

Masonry cement — Testing for workability (cohesivity)

ICS 91.080.30; 91.100.10

National foreword

This Published Document reproduces verbatim CR 13933:2000.

The UK participation in its preparation was entrusted by Technical Committee B/516, Cement and Lime, to Subcommittee B/516/10, Masonry cement, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, the CR title page, pages 2 to 22, an inside back cover and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

This British Standard, having been prepared under the direction of the Sector Committee for Building and Civil Engineering, was published under the authority of the Standards Committee and comes into effect on 15 July 2001

ISBN 0 580 36747 9

Amendments issued since publication

Amd. No.	Date	Comments

CEN REPORT

RAPPORT CEN

CEN BERICHT

CR 13933

July 2000

ICS

English version

Masonry cement - Testing for workability (cohesivity)

This CEN Report was approved by CEN on 3 June 2000. It has been drawn up by the Technical Committee CEN/TC 51.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

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

Central Secretariat: rue de Stassart, 36 B-1050 Brussels

Ref. No. CR 13933:2000 E

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.

Contents

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	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	BS6463	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	EN459	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	NS3107	3,495	9				German	166	175	184	191	198	
ave													
VDZ	EN459	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 $\log_{10}$ 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.

4 Test Procedure

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 $\pm$ 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 $\pm$ 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 $\pm$ 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

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

4.6.2

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

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	Pene-tration mm	Flow Table Spread mm after jolting								Index CI(A)	Jolts for 210 mm spread	Index CI(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				1,35	16	14,4
		Ave													
	ENCI	1	236	34	147	172	190	204	215				1,37	23	17,7
		Ave													
	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						
	UNI	4/6	245	35:35:35	160	189	205	223	231						
		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						
		2			158	187	206	220	231						
		3			156	185	203	217	228						
		Ave			156	185	204	218	230				1,38	17	14,8

Table 4 - Masonry cement - MC5 (ENV 413-1) from Germany

Sam-ple	Test Lab	Test No	Water g	Pene-tration mm	Flow Table Spread mm. after jolting										Index CI (A)	Jolts for 210 mm spread	Index CI (B)
MC5					5	10	15	20	25	30	35	40	45	50			
(G)	B.C.	1	232	36	156	177	190	201	209	222							
		2	232	37	157	177	190	200	213								
		3	232	35	157	177	191 .	202	216								
		Ave	232	36	157	177	190	201	213						1,27	24	21,6
	BLI	1	245	38	159	180	194	206	218	226	233						
		2	244	38	159	181	195	208	219	227	235						
		3	243	37	157	182	194	210	218	226							
		Ave	244	38	158	181	194	208	218	226					1,31	21	18,9
	Cimpor	1	230	35	165	183	197	205	213								
		2	232	37	166	187	198	208	213								
		3	229	36	164	185	196	207	214								
		Ave	230	36	165	185	197	206	213						1,21	23	38,2
	DBDK	1	235	35	148	171	186	197	206	212					1,21	28	25,1
		Ave															
	ENCI	1	229	36	130	147	160	167	175	181					1,20	55	42,3
		Ave															
	Italicm	1/3	230	36:36:37	138	156	171	180	189	195	200	205	210	214			
		4/6	230	37:37:37	140	159	172	182	190	195	201	206	210	214			
		7/9	230	37:37:34	141	160	173	183	190	199	202	207	211	214			
		Ave	230	36,2	140	158	172	182	189	196	201	206	210	214	1,25	45	33,6
	Italicm	1/3	230	36:36:37	143	162	175	184	191	197	202	206	210	214			
	UNI	4/6	230	37:37:37	142	160	173	182	189	195	200	205	209	213			
		7/9	230	37:37:34	141	159	172	181	189	194	199	204	208	212			
		Ave	230	36,2	142	160	173	182	190	195	200	205	209	213	1,25	46	32,5
	Lafarg	1	234	37	169	192	207	220	231								
		2			170	190	207	218	230								
		3			170	193	208	223	235								
		Ave			170	192	207	220	232						1,39	16	14,4
	Norcm	1	226	35	111	120	149	134	139								
		2	226	34													
		Ave	226	35													
	VDZ	1	235	37	147	165	183	193	202	211							
		2			146	168	182	193	201	210							
		3			147	169	182	193	202	210							
		Ave			147	167	182	193	202	210					1,23	30	26,9

Table 5 - Masonry cement MC5 (ENV 413-1) from Italy

Sam-ple	Test Lab	Test No	Water g	Pene-tration mm	Flow Table Spread mm after jolting										Index CI(A)	Jolts for 210mm spread	Index CI(B)
MC5					5	10	15	20	25	30	35	40	45	50			
(I)	BC	1	220	34	171	194	219	237	246								
		2	220	36	169	195	221	237	249								
		3	220	34	172	195	219	236	250								
		Ave	220	35	171	195	220	237	248						1,46	13	11,7
	BLI	1	228	34	170	194	210	225	237								
		2	228	36	171	193	212	224	236								
		3	228	37	168	193	212	224	235								
		Ave	228	36	170	193	211	224	236						1,43	15	13,5
	Cimpor	1	216	34	173	192	212	216	224								
		2	215	33	172	191	208	215	226								
		3	217	32	172	193	210	218	225								
		Ave	216	33	172	192	210	216	225						1,30	15	24,9
	DBDK	1	225	38	159	185	201	215	226						1,31	18	16,2
		Ave															
	ENCI	1	214	34	140	161	172	183	190	198					1,23	40	30,7
		Ave															
	Italicm	1/3	220	34:33:33	141	166	181	193	203	210							
		4/6	220	35:33:33	139	160	176	187	197	205	211						
		7/9	220	33:35:33	141	162	179	193	200	209	215						
		Ave	220	33,5	140	163	179	191	200	208	213				1,29	32	23,8
	Italicm	1/3	220	34:33:33	151	173	187	199	209	216							
	UNI	4/6	220	35:33:33	149	171	186	197	207	215							
		7/9	220	33:35:33	150	171	185	195	205	213							
		Ave	220	33,5	150	172	186	197	207	214					1,35	29	20,5
	Lafarg	1	234	36	187	218	237	250									
		2			190	215	236	250									
		3			182	215	235	250									
		Ave			186	216	236	250							1,58	09	8,1
	Norcm	1	219	36	119	132	142	151	158								
		2	219	37													
		Ave	219	37													
	VDZ	1	215	35	149	172	189	202	213	223							
		2			149	173	188	201	211	221							
		3			152	177	193	203	216	226							
		Ave			150	174	190	202	213	223					1,29	24	21,5

Table 6 - Masonry cement MC12.5 (ENV 413-1) from Netherlands

Sample	Test Lab	Test No	Water g	Pene-tration mm	Flow Table Spread mm. after jolting								Index CI(A)	Jolts for 210 mm spread	Index CI(B)
MC12.5					5	10	15	20	25	30	35	40			
(N)	BC	1	220	36	167	190	211	233	245						
		2	220	36	169	192	214	229	243						
		3	220	38	169	191	212	231	243						
		Ave	220	37	168	191	212	231	244				1,41	14	12,6
	BLI	1	228	36	170	193	211	225	235	244					
		2	225	33	169	191	210	223	233	243					
		3	225	35	168	192	213	223	234	245					
		Ave	226	35	169	192	211	224	234	244			1,43	15	13,5
	Cimpor	1	213	35	170	194	209	219	224						
		2	213	37	172	193	208	217	223						
		3	213	36	171	192	210	218	225						
		Ave	213	36	171	193	204	218	224				1,26	16	26,6
	DBDK	1	220	34	151	176	192	204	215				1,25	23	20,6
		Ave													
	ENCI	1	214	35	141	159	170	179	187	194			1,22	45	34,6
		Ave													
	Italicm	1/3	220	36:36:36	146	167	181	192	201	208	215				
		4/6	220	37:37:34	145	166	180	190	198	206	212				
		7/9	220	36:35:36	143	164	177	189	197	204	211				
		Ave	220	35,8	145	165	179	190	199	206	213		1,30	33	24,6
	Italicm	1/3	220	36:36:36	152	173	185	196	205	211	217				
	UNI	4/6	220	37:37:34	150	171	184	194	203	210	215				
		7/9	220	36:35:36	150	170	184	194	203	210	216				
		Ave	220	35,8	150	171	184	195	203	210	216		1,33	30	21,2
	Lafarg	1	225	36	179	204	223	236	249						
		2			174	200	219	234	245						
		3			175	200	217	232	246						
		Ave			176	201	220	234	245				1,48	12	10,8
	Norcm	1	219	36	118	134	144	149	156						
		2	219	38											
		Ave	219	37											
	VDZ	1	217	34	152	175	191	204	213	222					
		2			154	177	193	205	214	223					
		3			150	174	189	202	210	219					
		Ave			152	175	191	204	212	221			1,27	24	22,2

Table 7 - Masonry cement MC12.5 (ENV 413-1) from United Kingdom

Sample	Test Lab	Test No	Water g	Penetration mm	Flow Table Spread mm after jolting										Index CI(A)	Jolts for 210 mm spread	Index CI(B)
MC12.5					5	10	15	20	25	30	35	40	45	50			
(UK)	BC	1	235	33	158	181	197	209	223								
		2	235	33	160	182	197	205	222								
		3	235	34	160	182	196	201	224								
		Ave	235	33	159	182	197	205	223						1,31	22	19,8
	BLI	1	259	38	170	194	210	223	233								
		2	255	38	169	191	206	220	230								
		3	255	38	170	193	209	225	234	241							
		Ave	256	38	170	193	208	223	232						1,41	16	14,4
	Cimpor	1	240	33	167	190	202	210	218								
		2	240	35	169	192	204	208	220								
		3	240	34	165	189	203	212	219								
		Ave	240	34	167	190	203	210	219						1,25	20	33,2
	DBDK	1	240	35	146	159	185	197	206	215					1,20	27	24,2
		Ave															
	ENCI	1	237	36	136	155	168	177	184	192					1,21	49	37,7
		Ave															
	Italicm	1/3	235	33:32:32	139	158	174	184	192	200	206	211	215				
		4/6	235	33:34:33	140	159	173	184	192	198	205	211	216				
		7/9	235	33:32:32	140	160	173	184	193	200	206	211	216				
		Ave	235	32,7	139	159	173	184	192	199	205	211	216		1,25	39	29,1
	Italicm	1/3	235	33:32:32	142	163	176	186	194	201	206	212	216				
	UNI	4/6	235	33:34:33	143	162	177	186	195	201	207	213	216				
		7/9	235	33:32:32	143	162	177	187	194	202	208	213	216				
		Ave	235	32,7	142	162	176	186	194	201	207	213	216		1,28	39	27,6
	Lafarg	1	253	38	174	200	218	232	243								
		2			177	201	220	234	247								
		3			180	204	223	237	248								
		Ave			177	202	220	234	246						1,48	12	10,8
	Norcm	1	241	36	117	130	139	147	153								
		2	241	37													
		Ave	241	36													
	VDZ	1	240	36	146	168	183	193	203	212							
		2			145	166	183	194	202	211							
		3			147	169	183	194	203	211							
		Ave			146	168	183	194	203	211					1,22	29	26,9

Table 8 - Masonry cement MC22.5X (ENV 413-1) from France

Sample	Test Lab	Test No	Water g.	Pene-tration mm.	Flow Table Spread mm. after jolting								Index CI(A)	Jolts for 210 mm spread	Index CI(B)
MC22.5X					5	10	15	20	25	30	35	40			
(F)	BC	1	245	36	186	212	229	243	255						
		2	245	35	181	210	229	242	256						
		3	245	37	179	209	230	238	254						
		Ave	245	37	182	210	229	241	255				1,53	10	9,0
	BLI	1	263	33	169	196	216	231	241						
		2	265	35	168	201	217	234	244						
		3	265	35	171	199	218	231	242						
		Ave	264	34	169	199	217	232	242				1,47	13	11,7
	Cimpor	1	256	33	180	208	224	232	239						
		2	254	37	184	212	226	235	241						
		3	255	35	182	210	228	236	240						
		Ave	255	35	182	210	226	234	240				1,40	10	16,6
	DBDK	1	235	32	143	171	199	207	217				1,29	21	18,9
		Ave													
	ENCI	1	-	-	-	-	-	-	-	-	-	-	-	-	-
		Ave													
	Italicm	1/3	255	33:34:34	147	173	191	206	217	226					
		4/6	255	32:33:34	145	169	187	200	211	221					
		7/9	255	35:34:33	146	170	189	202	213	222					
		Ave	255	33,6	146	171	189	203	214	223			1,37	23	17,1
	Italicm	1/3	255	33:34:34	157	180	197	209	219	227					
	UNI	4/6	255	32:33:34	154	178	194	207	217	226					
		7/9	255	35:34:33	154	176	193	206	216	225					
		Ave	255	33,6	155	178	195	207	217	226			1,41	22	15,7
	Lafarg	1	252	33	180	209	226	242	250						
		2			183	211	229	243	250						
		3			183	217	230	246	250						
		Ave			182	212	228	244	250				1,53	10	9,0
	Norcm	1	242	34	118	133	145	155	163						
		2	242	34											
		Ave	242	34											
	VDZ	1	245	35	153	179	196	212	221						
		2			155	182	199	213	224						
		3			156	184	203	214	227						
		Ave			155	182	199	213	224				1,36	19	16,6

The assessment of the results obtained was made on the basis of the two proposed cohesivity indices CI(A) and CI(B). Table 9 provides a summary of the CI(A) indices and Table 10 the cohesivity (workability) ranking obtained from these results. Each of the figures quoted for the laboratories designated BC, BLI, Cimpor, Italicementi, Lafarge and VDZ are the averages of three tests, whilst those from DBDK, ENCI and Norcem are from single tests.

Table 11 gives the CI(A) indices related to the ASTM or the EN 459-2 flow tables, although it should be noted that for the EN 459-2 flow table the DBDK result was based upon only one test.

Table 9 - Comparison of Indices CI(A)

Testing Laboratory	CEM I	MC 5 G	MC 5 I	MC 12.5 N	MC 12.5 UK	MC22.5XF
BC	1,54	1,27	1,46	1,41	1,31	1,53
BLI	1,55	1,31	1,43	1,43	1,41	1,47
Cimpor	1,41	1,21	1,30	1,26	1,25	1,40
DBDK	1,35	1,21	1,31	1,25	1,20	1,29
ENCI	1,37	1,20	1,23	1,22	1,21	
Italicementi	1,45	1,25	1,29	1,30	1,25	1,37
(UNI)	1,49	1,25	1,35	1,33	1,28	1,41
Lafarge	1,62	1,39	1,58	1,48	1,48	1,53
Norcem						
VDZ	1,38	1,23	1,29	1,27	1,22	1,36
Average	1,46	1,26	1,36	1,33	1,29	(1,42)
Stn Dev	0,094	0,060	0,110	0,091	0,096	(0,085)

Table 10 - Ranking on the basis of the CI(A) Indices (Masonry cements giving mortars having the highest level of cohesivity designated as 1)

Testing Laboratory	CEM I	MC 5 G	MC 5 I	MC 12.5 N	MC 12.5 UK	MC22.5XF
BC	6	1	4	3	2	5
BLI	6	1	3=	3=	2	5
Cimpor	6	1	4	3	2	5
DBDK	6	2	5	3	1	4
ENCI	(5/6)	1	4	3	2	(5/6)
Italicementi	6	1=	3	4	1=	5
(UNI)	6	1	4	3	2	5
Lafarge	6	1	5	2=	2=	4
Norcem						
VDZ	6	2	4	3	1	5
Average	6	1	4	3	2	5

Table 11 - CI(A) Index assessed in terms of the ASTM and the EN 459-2 Flow Tables

ASTM FLOW TABLES							
Testing Laboratory	CEM I	MC 5 G	MC 5 I	MC 12.5 N	MC 12.5 UK	MC 22.5X F	Average
BC	1,54	1,27	1,46	1,41	1,31	1,53	
BLI	1,55	1,31	1,43	1,43	1,41	1,47	
LAF	1,62	1,39	1,58	1,48	1,48	1,53	
Average	1,57	1,32	1,49	1,44	1,40	1,51	1,46
Stn Dev	0,044	0,061	0,079	0,036	0,085	0,035	0,059*
%CV							4*
EN 459-2 FLOW TABLES							
DBDK	1,35	1,21	1,31	1,25	1,20	1,29	
VDZ	1,38	1,23	1,29	1,27	1,22	1,36	
Average	1,37	1,22	1,30	1,26	1,21	1,33	1,28

* Pooled

Tables 12,13,14 and 15 provide similar test data for the CI(B) index

Table 12 - Comparison of Indices CI(B)

Testing Laboratory	CEM I	MC 5 G	MC 5 I	MC 12.5 N	MC 12.5 UK	MC22.5XF
BC	9,0	21,6	11,7	12,6	19,8	9,0
BLI	9,0	18,9	13,5	13,5	14,4	11,7
Cimpor	18,3	38,2	24,9	26,6	33,3	16,6
DBDK	14,4	25,1	16,2	20,6	24,2	18,9
ENCI	17,7	42,3	30,7	34,6	37,7	-
Italicementi	14,2	33,6	23,8	24,6	29,1	17,1
(UNI)	12,0	32,5	20,5	21,2	27,6	15,7
Lafarge	7,2	14,4	8,1	10,8	10,8	9,0
Norcem						
VDZ	14,8	26,9	21,5	22,2	26,9	16,6
Average	13,0	28,2	19,0	20,7	24,9	(14,3)
Stn Dev	3,9	9,2	7,2	7,6	8,7	(3,9)

Table 13 - Ranking on the basis of the CI(B) Indices
(Masonry cements giving mortars having the highest level of cohesivity designated as 1)

Testing Laboratory	CEM I	MC 5 G	MC 5 I	MC 12.5 N	MC 12.5 UK	MC22.5XF
BC	5=	1	4	3	2	5=
BLI	6	1	3=	3=	2	5
Cimpor	5	1	4	3	2	6
DBDK	5	2	3	1	4	6
ENCI	(5/6)	1	4	3	2	(5/6)
Italicementi	6	1	4	3	2	5
(UNI)	6	1	4	3	2	5
Lafarge	6	1	5	2=	2=	4
Norcem						
VDZ	6	1=	4	3	1=	5
Average	6	1	4	3	2	5

Table 14 - CI(B) Index assessed in terms of the ASTM and the EN 459-2 Flow Tables

ASTM FLOW TABLES (BC, BLI, LAF)							
Testing Laboratory	CEM I	MC 5 G	MC 5 I	MC 12.5N	MC 12.5UK	MC 22.5XF	Average
BC	9,0	21,6	11,7	12,6	19,8	9,0	
BLI	9,0	18,9	13,5	13,5	14,4	11,7	
LAF	7,2	14,4	8,1	22,2	10,8	9,0	
Average	8,4	18,3	11,1	12,2	15,0	9,9	12,5
Stn Dev	1,04	3,6	2,7	1,5	4,5	1,6	2,8*
%CV							22,4*
EN 459-2 FLOW TABLES (DBDK, VDZ)							
DBDK	14,4	25,1	16,2	20,6	24,2	18,9	
VDZ	14,8	26,9	21,5	22,2	26,9	16,6	
Average	14,6	26,0	18,9	21,4	25,6	17,8	20,7
* Pooled							

6 Re-appraisal of calibration

In view of the comparatively large numerical differences between the indices obtained with the ASTM and the EN 459-2 flow tables, the calibration characteristics were examined. This was achieved by calculating the increase in spread obtained from the original mould diameter upon the application of 15 jolts of the flow tables. The results are shown in Table 15 and suggest that the increase obtained is of a similar order for the two tables. That being so was taken to indicate that the physical nature of the calibration material (the EN 196-1:1994 sand/water mixture) was not perhaps suitable for the purpose.

Table 15 - Flow table calibration - relationship between spread and jolts

	Increase in spread (mm) from original moulded diameter after 15 jolts	
Testing Laboratory	ASTM	EN459-2
BC	50	
BLI	48	
Lafarge	49	
Average	49	
Stn Dev	1,0	
DBDK		54
VDZ		48
Average		51

The values for the two indices were recalculated using the CEM I Common cement as the calibration material and these are given in Table 16.

Table 16 - Cohesivity Indices CI(C) calculated using the Test laboratory results on the CEM I cement as the calibration material

$$CI(C) = \frac{\text{Spread (mm) obtained after 15 jolts using the CEM I cement}}{\text{Spread (mm) obtained after 15 jolts using the masonry cement}}$$

$$CI(D) = \frac{\text{Spread (mm) obtained after 20 jolts using the CEM I cement}}{\text{Spread (mm) obtained after 20 jolts using the masonry cement}}$$

	Cohesivity Index CI(C)					Cohesivity Index CI(D)				
Test Laboratory	MC5(G)	MC5(I)	MC12.5 (N)	MC12.5 (UK)	MC22.5X (F)	MC5(G)	MC5(I)	MC12.5 (N)	MC12.5 (UK)	MC22.5X (F)
BC	1,22	1,05	1,09	1,17	1,01	1,21	1,03	1,05	1,19	1,01
BLI	1,18	1,09	1,09	1,10	1,06	1,15	1,07	1,07	1,08	1,03
Cimpor	1,16	1,09	1,12	1,12	1,01	1,17	1,12	1,11	1,15	1,03
DBDK	1,12	1,03	1,08	1,12	1,05	1,14	1,04	1,10	1,14	1,08
ENCI	1,19	1,10	1,12	1,13		1,22	1,11	1,14	1,15	
Itali	1,16	1,12	1,12	1,16	1,06	1,18	1,12	1,13	1,16	1,05
Itali(UNI)	1,19	1,10	1,11	1,16	1,05	1,21	1,12	1,13	1,19	1,07
Lafarge	1,17	1,03	1,10	1,10	1,06	1,14	1,00	1,07	1,07	1,02
Norcem	(1,17)	(1,23)	(1,22)	(1,26)	(1,21)	(1,41)	(1,25)	(1,27)	(1,29)	(1,22)
VDZ	1,12	1,07	1,07	1,11	1,03	1,13	1,08	1,07	1,12	1,02
Ave	1,17	1,08	1,10	1,13	1,04	1,17	1,08	1,10	1,14	1,04
Stn dev	0,033	0,032	0,019	0,027	0,022	0,035	0,045	0,033	0,043	0,025

Results in brackets omitted from the average and from the standard deviation

These results (apart from those from Norcem) were more encouraging in that a CI(C) index of >1.00 showed promise of being capable of distinguishing between the common cement used and masonry cements of the type MC5 and MC 12.5 evaluated. It was also capable of ranking the masonry cements in a similar order to that adjudged by experienced craftsmen.

The "pooled" standard deviation for CI(C) (0,027) was lower than that for CI(D) (0,037).

However, it was considered that it would not be realistic to assume that all EN 197-1 CEM I common cements would be suitable for this purpose and that a ground granulated blastfurnace slag might be more suitable. Two such slags were circulated to the participating laboratories and were used to calibrate their flow tables and then to re-calculate the Cohesivity Indices.

The test results obtained on these two slags when used for flow table calibration are given in tables 17 and 18.

Table 17 - Calibration of Flow Tables with Castle ground granulated blastfurnace slag

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	170	202	222	232	245	
								167	202	223	235	246	
								168	201	221	235	246	
ave								168	202	222	234	246	
BLI	ASTM	4,002	14	70	101	51	France	151	182	204	223	236	
								154	187	210	228	236	
								154	185	210	226	238	
ave								153	185	208	226	237	
Cimpor	BS6463	6,6	19,1	70	100	60	France	125	153	170	182	193	
								124	151	169	183	191	
								129	155	173	185	193	
ave								126	153	171	183	192	
DBDK	EN459	4,352	10,2	70	110	60	German						
ave													
ENCI	RMU	3,298	10	70	100	90	German	144	168	185	200	213	
								143	166	185	200	211	
								144	168	184	199	209	
ave								144	167	185	200	211	
Hanson	ASTM	4,10	10	70	100	51	France	152	190	214	231	245	
								169	202	224	237		
								160	196	218	234	246	
ave								160	196	219	234	246	
Italicem		3,34	10,1	69,9	100	60	France	132	152	169	183	197	206
								129	149	162	182	189	199
ave								130	150	166	182	193	202
	UNI	3,22	10,0	70,2	100	60	France						
ave													
Lafarge	ASTM	4,1	12,5	70	100	50	France	160	192	212	226	236	
								160	191	212	224	240	
								158	189	208	225	235	
ave								159	191	211	225	237	
Norcem	NS3107	3,495	9				German	119	139	154	168	178	
								119	137	152	166	178	
								118	136	149	167	177	
ave								119	137	152	167	178	
VDZ	EN459	4,35	10	70	100	60	German	143	168	187	204	216	
								141	170	190	206	219	
								141	174	194	209	223	
								140	173	196	210	223	
								145	173	193	208	221	
								144	172	192	209	220	
ave								142	172	192	208	220	

Table 18 - Calibration of flow tables using Lafarge ground granulated blastfurnace slag

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	160	196	220	235	245	
								161	197	221	237	246	
								160	195	218	235	243	
ave								160	196	220	236	245	
BLI	ASTM	4,002	14	70	101	51	France	147	182	208	226	241	
								145	180	206	224	240	
								145	183	208	227	241	
ave								146	182	207	226	241	
Cimpor	BS6463	6,6	19,1	70	100	60	France	113	140	162	180	192	
								115	142	164	179	190	
								110	138	162	179	192	
ave								113	140	163	179	191	
DBDK	EN459	4,352	10,2	70	110	60	German						
ave													
ENCI	RMU	3,298	10	70	100	90	German	138	165	184	200	216	
								137	163	182	199	212	
								138	166	186	202	216	
ave								138	165	184	200	215	
Hanson	ASTM	4,10	10	70	100	51	France	149	188	212	236	246	
ave													
Italicem		3,34	10,1	69,9	100	60	France	117	132	145	160	174	187
								119	137	151	171	180	191
								120	136	152	167	179	191
ave								119	135	149	166	178	190
	UNI	3,22	10,0	70,2	100,	60	France						
ave													
Lafarge	ASTM	4,1	12,5	70	100	50	France	150	178	195	215	229	
								152	181	203	220	232	
								151	180	203	214	229	
ave								151	180	200	216	230	
Norcem	NS3107	3,495	9				German	112	129	143	156	170	
								114	135	148	164	174	
								114	134	152	166	177	
ave								113	133	148	162	174	
VDZ	EN459	4,35	10	70	100	60	German	134	167	186	210	225	
								134	162	184	209	221	
								137	166	188	208	221	
								139	165	186	204	219	
								136	165	184	210	219	
								134	161	190	206	221	
ave								136	164	186	208	221	

The slags in both cases were tested at the same water/cement ratio as used in EN 196-1:1994 i.e. 0,50. There were only small differences in the spread obtained using the two different slags.

Various indices were tried in order to improve the selectivity of the method and the results from this work is shown in Table 19.

Table 19 - Cohesivity indicies based on Flow Table calibration using ground granulated blastfurnace slag

INDEX	Cement	Slag	Ratios of spread with calibration slag divided by spread using cement sample Test Laboratory							
			BC	BLI	Cimpor	ENCI	Hanson	Itali	Lafarge	VDZ
Ratio of spread of slag after 15 jolts divided by spread of cement after 15 jolts	Cem I	Lafarge	0,95	0,90	0,71	0,97		0,75	0,83	0,91
	Cem I	Castle	0,95	0,91	0,75	0,97		0,83	0,87	0,94
	MC5(G)	Lafarge	1,16	1,07	0,93	1,15	1,01	0,87	0,97	1,02
	MC5(G)	Castle	1,17	1,07	0,87	1,16	1,04	0,97	1,02	1,05
	MC5(I)	Lafarge	1,00	0,98	0,78	1,07		0,83	0,85	0,98
	MC5(I)	Castle	1,01	0,99	0,81	1,08		0,93	0,87	1,01
	MC12.5(N)	Lafarge	1,04	0,98	0,80	1,05		0,83	0,91	0,97
	MC12.5(N)	Castle	1,05	0,99	0,84	1,05		0,93	0,96	1.01
	MC12.5(U)	Lafarge	1,12	1,00	0,80	1,10	0,99	0,86	0,91	1,02
	MC12.5(U)	Castle	1,13	1,00	0,84	1,10	1,02	0,96	0,96	1,05
	MC22.5XF	Lafarge	0,96	0,95	0,72	-		0,79	0,88	0,93
	MC22.5XF	Castle	0,97	0,96	0,76	-		0,88	0,93	0,96
Ratio of spread of slag after 20 jolts divided by spread of cement after 20 jolts	Cem I	Lafarge	0,97	0,94	0,74	0,98		0,78	0,86	0,95
	Cem I	Castle	0,96	0,94	0,76	0,98		0,85	0,90	0,95
	MC5(G)	Lafarge	1,17	1,09	0,87	1,20	1,10	0,91	0,98	1,08
	MC5(G)	Castle	1,16	1,09	0,89	1,20	1,09	1,00	1,02	1,08
	MC5(I)	Lafarge	1,00	1,01	0,83	1,09		0,87	0,86	1,03
	MC5(I)	Castle	0,99	1,01	0,85	1,09		0,95	0,90	1,03
	MC12.5(N)	Lafarge	1,02	1,01	0,82	1,12		0,87	0,92	1,02
	MC12.5(N)	Castle	1,01	1,01	0,84	1,12		0,96	0,96	1,02
	MC12.5(U)	Lafarge	1,15	1,01	0,85	1,13	1,02	0,90	0,92	1,07
	MC12.5(U)	Castle	1,14	1,01	0,87	1,13	1,01	0,99	0,96	1,07
	MC22.5XF	Lafarge	0,98	0,97	0,76	-		0,82	0,89	0,98
	MC22.5XF	Castle	0,97	0,97	0,78	-		0,90	0,92	0,98
Log of No of jolts to 200mm cement spread divided by log No of jolts to 200mm slag spread	Cem I	Lafarge	0,88	0,81	0,62	1,00		0,72	0,66	0,91
	Cem I	Castle	0,92	0,82	0,62	0,98		0,76	0,72	0,93
	MC5(G)	Lafarge	1,27	1,12	0,80	1,33	1,00	1,00	0,92	1,10
	MC5(G)	Castle	1,33	1,12	0,80	1,31	1,04	1,06	1,00	1,12
	MC5(I)	Lafarge	1,02	1,03	0,77	1,18		0,91	0,72	1,02
	MC5(I)	Castle	1,06	1,04	0,77	1,16		0,96	0,78	1,04
	MC12.5(N)	Lafarge	1,06	0,97	0,75	1,22		0,91	0,85	1,01
	MC12.5(N)	Castle	1,10	0,98	0,75	1,20		0,96	0,93	1,03
	MC12.5(U)	Lafarge	1,20	0,97	0,76	1,22	0,93	0,96	0,85	1,10
	MC12.5(U)	Castle	1,26	0,98	0,76	1,20	0,96	1,01	0,93	1,12
	MC22.5XF	Lafarge	0,88	0,93	0,61	-		0,83	0,77	0,94
	MC22.5XF	Castle	0,92	0,94	0,61	-		0,88	0,84	0,96
Log of No of jolts to 210mm cement spread divided by log No of jolts to 210mm slag spread	Cem I	Lafarge	0,90	0,85	0,70	0,99		0,76	0,72	0,93
	Cem I	Castle	0,93	0,84	0,70	0,97		0,80	0,77	0,93
	MC5(G)	Lafarge	1,25	1,12	0,86	1,26	1,03	1,02	0,96	1,12
	MC5(G)	Castle	1,28	1,11	0,86	1,24	1,06	1,07	1,02	1,12
	MC5(I)	Lafarge	1,00	1,00	0,75	1,16		0,93	0,76	1,05
	MC5(I)	Castle	1,03	0,99	0,74	1,14		0,97	0,81	1,05
	MC12.5(N)	Lafarge	1,04	1,00	0,76	1,20		0,93	0,86	1,05
	MC12.5(N)	Castle	1,07	0,99	0,75	1,18		0,97	0,92	1,05
	MC12.5(U)	Lafarge	1,21	1,02	0,82	1,22	0,97	0,99	0,86	1,11
	MC12.5(U)	Castle	1,24	1,01	0,82	1,20	1,00	1,04	0,92	1,11
	MC22.5XF	Lafarge	0,90	0,94	0,63	-		0,84	0,80	0,97
	MC22.5XF	Castle	0,93	0,93	0,63	-		0,88	0,85	0,97

7 Assessment

After the promising results obtained using the CEM I common cement to calibrate the flow tables, the results obtained using the slag as the calibration agency were disappointing. This may have been due to the length of time which had elapsed between the original testing of the cements and the recalibration of the flow tables with the slag i.e. the performance of the flow tables may have changed during that time.
However, by the time the tables had been recalibrated with the slags the project had over-run its scheduled time for completion by something like a year and resources were no longer available to take it further.

The work carried out indicated that in a given laboratory it was possible using the method leading to the CI(A) index to distinguish on grounds of cohesivity between a CEM I common cement and MC5 and MC 12.5 masonry cements (and possibly MC22.5X as well). It was also possible in a given laboratory to rank masonry cements according to their cohesivity.

The reason why it was not considered appropriate to put the test forward as a CEN method was the lack of an adequate proven level of reproducibility (between laboratories). The original concept was to be able to use a range of different types of flow tables. Some - notably the Norwegian table and that in British Standard 890 were not found to be suitable, but the widely used ASTM table and the very similar BS 4551 table gave a good performance. Whether or not the EN 459-2 table, which had originally been designated as the "reference table" had advantages could not be shown in the test work as only two laboratories had such tables and one of those was able only to carry out single (rather than the required triplicate) tests.

8 Future Work

The procedure suggested has been shown to have promise, but further work needs to be carried out to improve flow table calibration. The method using a ground granulated blastfurnace slag would be worth further evaluation - possibly using a slag/water mix taken to a standard plunger penetration rather than being used at a fixed water/slag ratio.

The problem of flow table calibration is one that needs general attention - particularly as in the CEN mortar prestandards it is used as the reference method to be used to establish the water content of the mortars.

This report has been prepared in order to record in some detail the work carried out by members of CEN/TC 51/WG 10 and in the hope that others will take up the challenge and develop a method of producing numerical values for this elusive property.

Bibliography

EN 197-1 Cement - Part 1: Composition, specifications and conformity criteria for common cements

ENV 413-1 Masonry cement - Part 1: Specification

EN 459-2 Building lime - Part 2: Test methods

(1) SLAVIN, C.J. The role of testing in the further development of masonry cements. In *Masonry International*, 1995, vol. 8, no. 3, p. 65-70

(2) BOWLER, G.K., JACKSON, P.J and MONK, M.G. The measurement of mortar workability. In *Masonry International*, 1996, vol. 10, no. 1, p. 17-23

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL