CONCLUSIONS

1. - The chemical test gives a rapid and reliable assessment of the potential reactivity of an aggregate.

2. - The potential reactivity of aggregate can be confirmed by petrographic examinations, various qualitative tests and by quantitative expansion measurements of mortar or concrete specimens.

3. - All the essential symptoms must be clearly present at significant levels in mortar or concrete specimens to confirm aggregate reactivity as the cause of expansion and disruption.

4. - Correct assessment of test results is essential and should be made only by an experienced assessor.

REFERENCES

/1/ Stanton T.E., Proc. Amer. Soc. Civil Engrs., 66: 1781, (1940)

/2/ Mielenz R.C., Greene K.T., and Benton E.J., Proc. Amer. Concr. Inst., 44: 193, (1947).

THE INFLUENCE OF TEST SPECIMEN DIMENSION'S ON THE EXPANSION OF ALKALI REACTIVE AGGREGATE IN CONCRETE

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1. ABSTRACT

Experiments demonstrate that the cross-section of the specimen can have a great influence on the expansion. It was found that the larger the cross-section, the larger the expansion. In the mortar-bar test method (ASTM C 227) for the determination of the potential alkali-reactivity of cement aggregate combinations, specimens are used with a cross-section of 1 by 1 inch. Recommendation to increase the cross-section to at least 40 x 40 mm is made on the results of the investigation in order to increase the susceptibility of the test method.

Key words: dimension of test specimen
alkali-reactive aggregates

2. INTRODUCTION

At the Research Institute of the Dutch Cement Industry research has been carried out into the behaviour of blastfurnace slag cement with respect to the alkali-silica reaction. During this work expansion measurements have generally been performed on prisms with dimensions 40 x 40 x 160 mm, as are used in the Netherlands in cement testing according to the RILEM recommendations. On several occasions measurements were performed on smaller prisms with dimensions 20 x 20 x 160 mm, which equal more or less the dimensions prescribed in ASTM C 227. It was found that the measurements on smaller prisms did not always accord with the results found on other occasions with larger prisms. As the expansion is usually given as the increase in length per unit of length it is suggested that the expansion is independent of the cross-section of the specimen of which the length change is measured. Because of the above mentioned conflicting results some research was undertaken into the effect of test specimen dimensions on the expansion.

3. LITERATURE

A great number of factors that influence the amount of expansion have been investigated during the last decades. Little has been published in literature about the influence of dimensions. The only experiments on the influence of dimensions of test specimens were reported by Davis /1/. Davis compared mortar prisms 1 x 1 x 11¼ inch with mortar prisms 2 x 2 x 11¼ inch and found an increase in expansion with increasing cross-section (see table 1).
Locher /2/ mentioned a greater susceptibility of the RILEM prisms (40 x 40 x 160 mm) compared with the ASTM prisms. However, the grading of the aggregate was adapted to the larger cross-section.
A clear conclusion as to the effect of the dimension can therefore not be taken from these experiments.

Alkali Content of Cement (%)	Opaline Rock in Fine Aggregate (%)	A 1 year	B 1 year	A 2 years	B 2 years	A 4 years	B 4 years
1.18	5.0	115	143	150	194	215	302
1.00	5.0	123	168	145	211	239	297
0.85	5.0	90	108	113	166	157	229
0.70	5.0	70	68	99	94	128	152
0.60	5.0	24	34	38	62	44	74
0.50	5.0	1	1	4	6	11	40
0.40	5.0	- 1	0	0	0	0	0
0.30	5.0	- 1	1	0	0	0	2
0.20	5.0	- 1	0	- 1	0	0	- 1
1.18	2.5	122	136	141	156	143	167
1.00	2.5	122	151	151	178	153	195
0.85	2.5	139	161	172	197	178	224
0.70	2.5	112	144	155	179	175	216
0.60	2.5	99	123	155	184	173	216
0.50	2.5	64	60	106	124	139	217
0.40	2.5	19	3	40	25	77	69
0.30	2.5	0	1	0	1	1	2
0.20	2.5	- 2	0	- 1	0	0	0

Table 1: Expansion of mortar prisms (according to Davis)
A prisms 1 x 1 x 11¼ inch
B prisms 2 x 2 x 11¼ inch

4. EXPERIMENTS

Experiments have been carried out with changes in the cross-section size as a primary factor, viz.

20 x 20 x 160 mm
40 x 40 x 160 mm
100 x 100 x 160 mm

Secondary factors chosen were: cement type, aggregate grading and storage temperature.
Honig opal a reactive aggregate, grain size 0 - 250 µm, from Australia was added to the quartz aggregate. The composition of the mixes are reproduced in table 2. The alkali content of the cement was increased by adding Na_2SO_4 (0.6% Na_2O eq.). The expansion measurements were carried out on specimens stored at 20 and 40°C.
The results of the expansion measurements carried out according to ASTM C 227 are given in figures 1 - 8.

Mix	Cement type	Na_2O eq.	Cement content	w/c	a/c	grading	% opal
1	OPC	1.41	510	0.5	3	sand < 4 mm	5
2	BFC	1.76	510	0.5	3	sand < 4 mm	5
3	OPC	1.41	427	0.5	4	sand + gravel < 8 mm	3.8
4	BFC	1.76	427	0.5	4	sand + gravel < 8 mm	3.8

Table 2: Mix composition

5. DISCUSSION OF THE RESULTS

From the measurement results it can be concluded that the cross-section of the specimen can have a great influence on the expansion. The same mix can give expansion and wide cracks when used in prisms of 40 x 40 x 160 mm and no cracks and hardly any expansion with prisms of 20 x 20 x 160 mm. Of course, this effect need not always be as extreme as was found here, but, when testing unknown materials, one does not know beforehand, whether the cross-section has such an effect or not. It is recommended therefore that the specimen cross-section be increased in tests for reactive aggregates to decrease the risk of "missing" such an aggregate in expansion tests.
It is remarkable that the distance between the cracks in the larger specimens is about 20 mm, which is the dimension of the cross-section of the smaller specimen. It can be concluded that to build up an internal stress by diffusion of alkalis and water the dimension of the cross-section should not be smaller than the distance between cracks.
The fact that no influence on expansion is found with blastfurnace cement confirms the findings that addition of slag creates a nearly impermeable concrete /3/.

6. CONCLUSIONS

The cross-section of the test specimen when testing the alkali-reactivity of aggregates can have a great influence on the amount of expansion. To decrease the risk of "missing" reactive aggregates the cross-section employed should be larger than used in ASTM C 227.

REFERENCES

/1/ Davis, C.E.S., "Comparison of the expansion of mortar and concrete" Austr. Journn. Appl. Sci. 8 (1957), p. 224 - 234.

/2/ Locher, F.W., "Ursache und Wirkungsweise der Alkali-reaktion", Schriftenreihe der Zementindustrie, 40 (1973.

/3/ Bakker, R.F.M. "On the cause of the increased resistance of concrete made from blastfurnace cement to the alkali-silica reaction and to sulphate resistance", Thesis, R.W.T.H. Aachen, (1980).

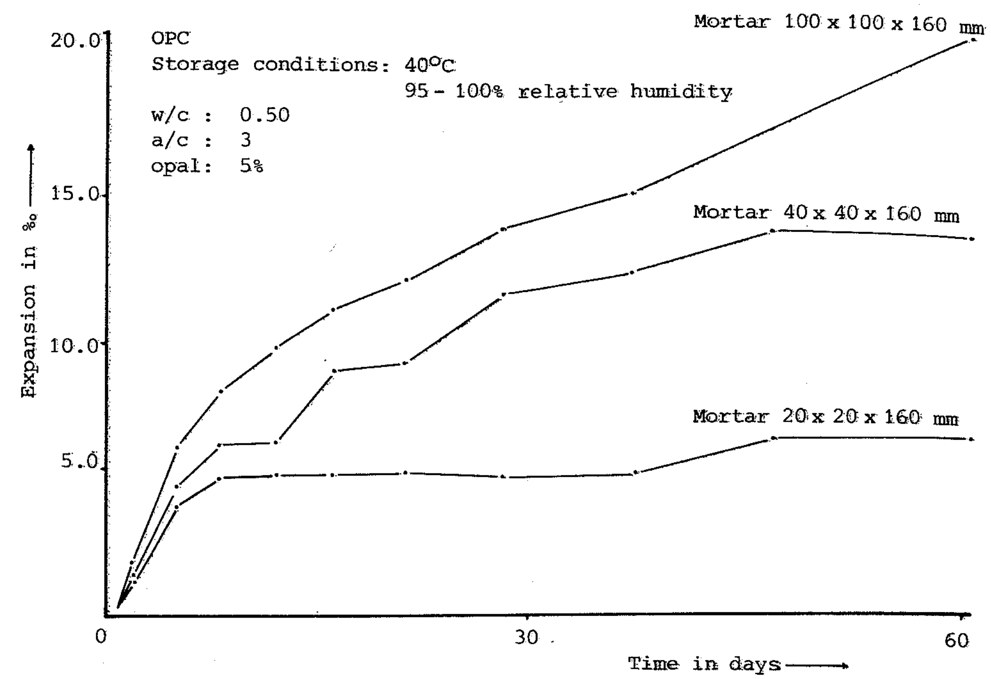

Figure 1: Expansion of mortar prisms with different cross-sections (OPC 40°C)

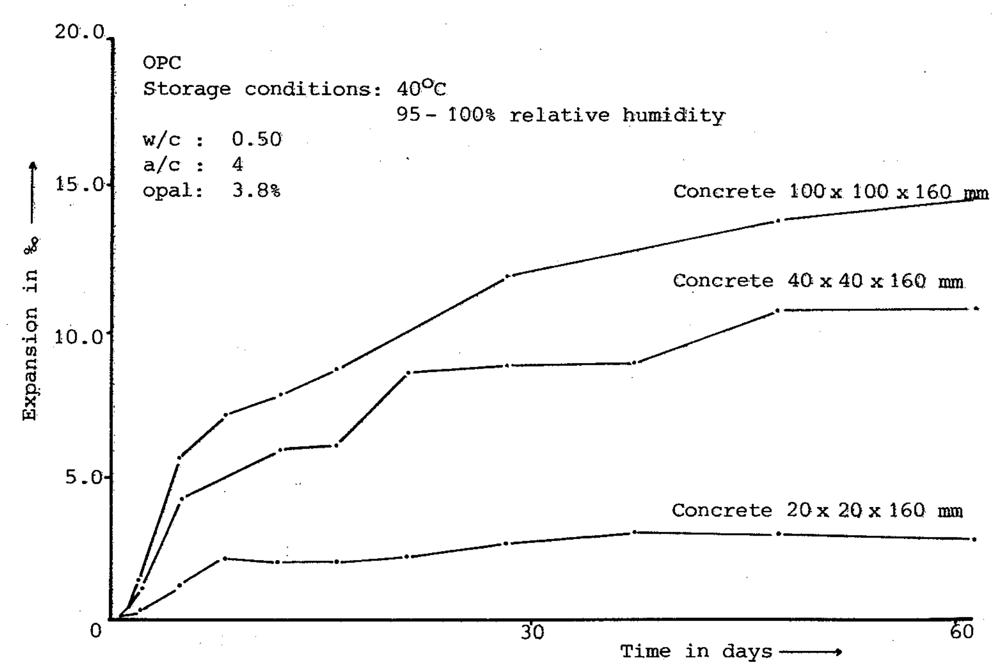

Figure 2: Expansion of concrete prisms with different cross-sections (OPC 40°C)

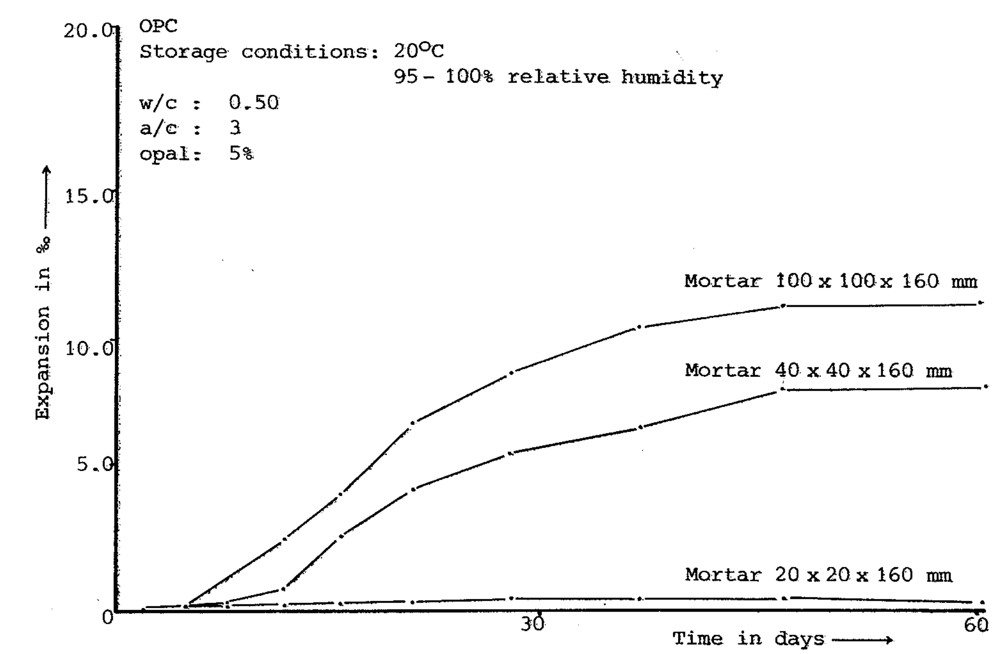

Figure 3: Expansion of mortar prisms with different cross-sections (OPC 20°C)

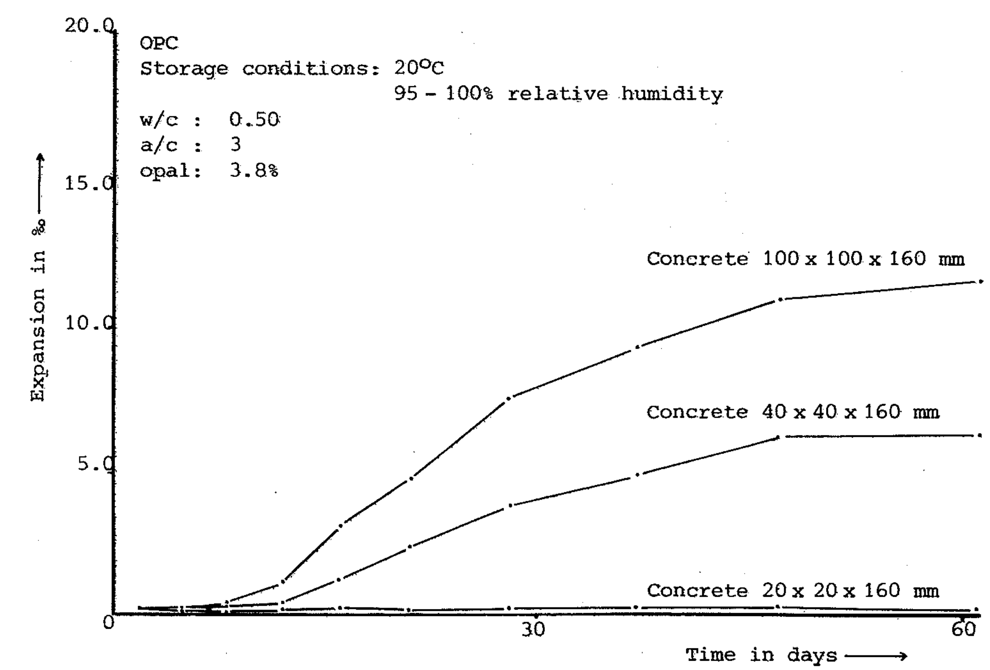

Figure 4: Expansion of concrete prisms with different cross-sections (OPC 20°C)

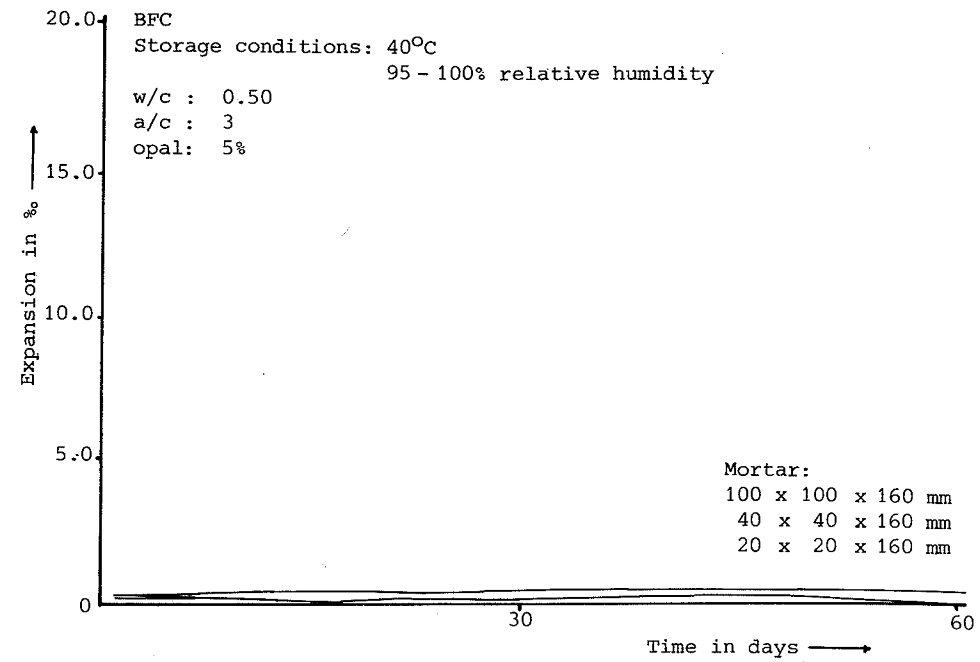

Figure 5: Expansion of mortar prisms with different cross-sections (BFC 40°C)

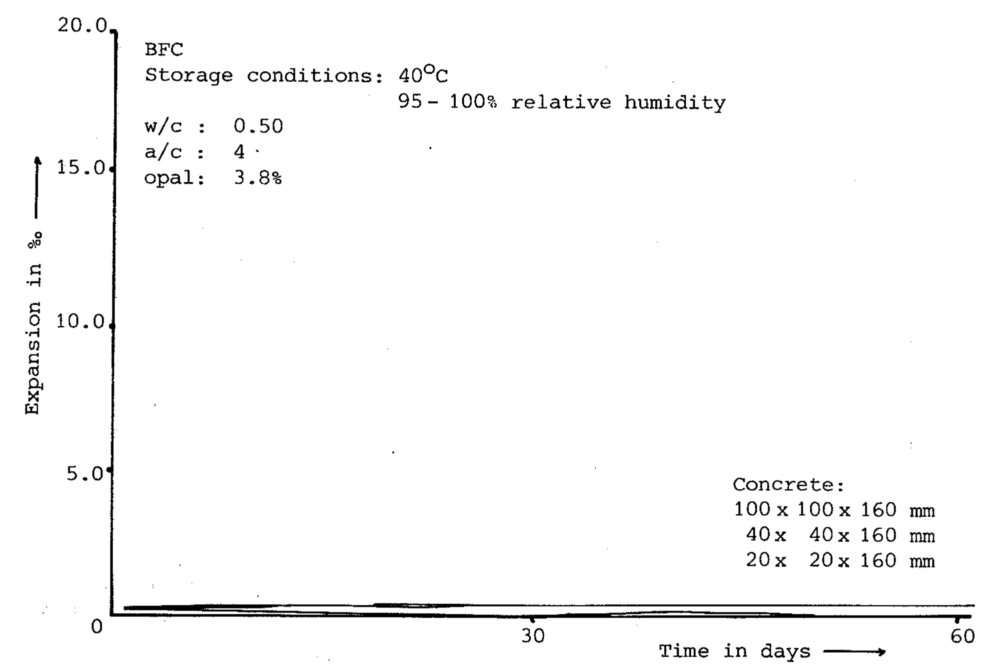

Figure 6: Expansion of concrete prisms with different cross-sections (BFC 40°C)

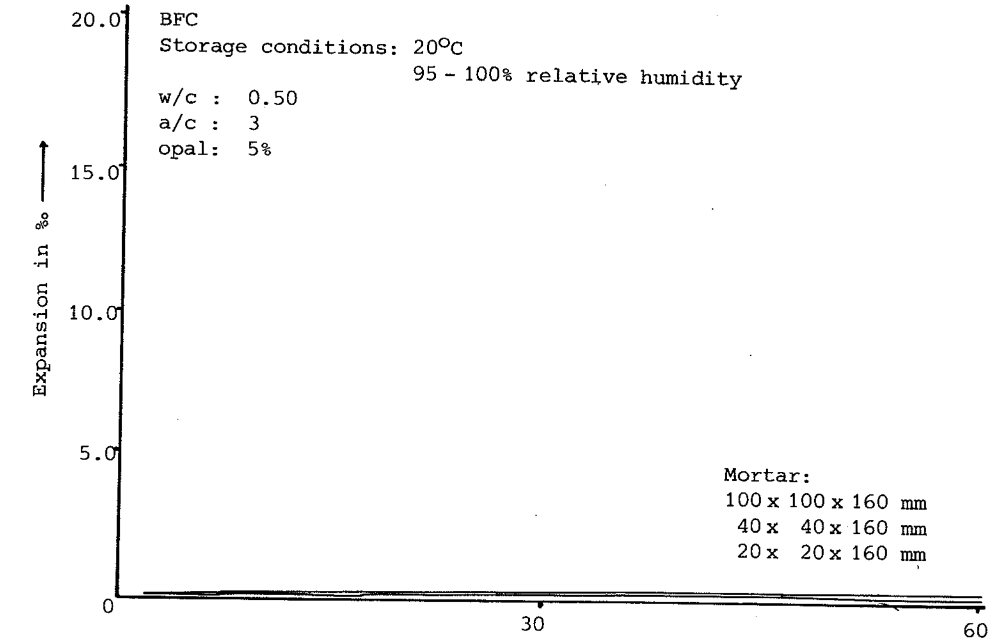

Figure 7: Expansion of mortar prisms with different cross-sections (BFC 20°C)

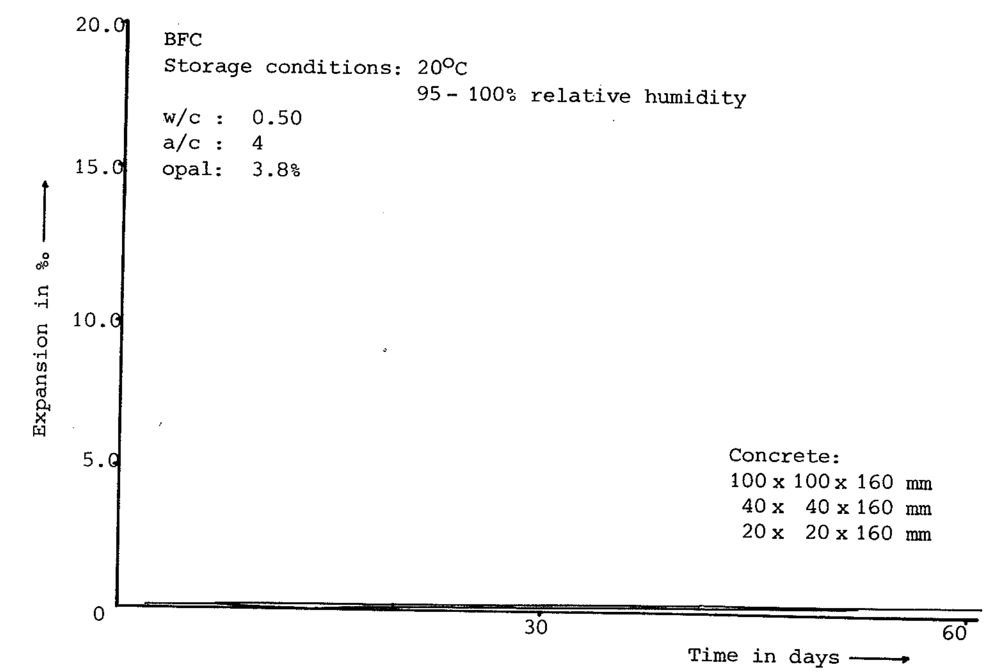

Figure 8: Expansion of concrete prisms with different cross-sections (BFC 20°C)