ADDENDUM - THE EFFECT OF CEMENT MIXTURES ON ALKALI EXPANSION

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Further to the data presented at the Reykjavík Symposium[1] we are now able to make a minor addendum.

Firstly, it may be mentioned, that we have continued measuring our mortar bars, and found that little change has taken place in the volume of our pozzolanic mortar prisms. All the tested samples proved to be of effective pozzolans as far as reduction in mortar bar expansion is concerned; yet there is a decisive difference in the strength increase (see Fig. 1).

It is clear that the scale used for expansion in Fig. 1 greatly exceeds the exactness of measurements; it may though in all fairness be stated that a 25% pozzolan replacement of the cement in the reference sample reduces its 12 months expansion from approximately 0,2 to about 0,02% (0,179 to 0,021 ave.).

Contrary to what is often stated we find no correlation between the acidity of the pozzolans and their activity. Moreover, some of the most basic samples have proved to posess the strongest pozzolanic properties (No 14). Sæmundsson[2] has classified the rocks into basaltic, andesitic/dasitic and rhyolitic composition, as shown in Fig. 1; but neither this nor other sequence arrangements have revealed direct conformity. All slections of materials must therefore be subject to imperial test results.

If, however, the results illustrated in Fig. 1 are compared with those obtained from the ISO/863-1968 (E) - Recomended tests, a fairly good agreement is observed[1] (Fig. 2). The samples appearing on or near the border parameter (3, 11, 5) in the ISO-diagram also show the lowest increase in strength;

and those that fall lowest on the diagram are also the strongest pozzolans according to the mortar bar tests.

We mentioned the gravity of our domestic situation last year; since we were producing cement of very high alkalinity and using reactive glassy aggregates. However, we had not suffered extensive damage, and pointed out that the wet and cool climate might be our safeguard. Sidney Diamond and Harold Vivian[3] pointed out to us that the viscosity of the gel formed in our concrete might be lessened by the very high alkalinity, and this could then explain the minimal damage. A partial use of low-alkali-cement might therefore bring about a pessimum alkali content and disruptive damage. We therefore carried out the examination we illustrate in our 3rd Fig. Expansion appeared in this examination to be in direct proportion with alkali content. Such studies however need to be carried further.

Even though alkali-aggregate damage cannot be said to be common it certainly exists locally. This may be seen on Fig 4 to 7, which show damage to exterior walls to a bungalow in the Reykjavík area. Even though these damages originate primarily from exceedingly reactive aggregate particles, they certainly serve to remind us of the grave situation we face.

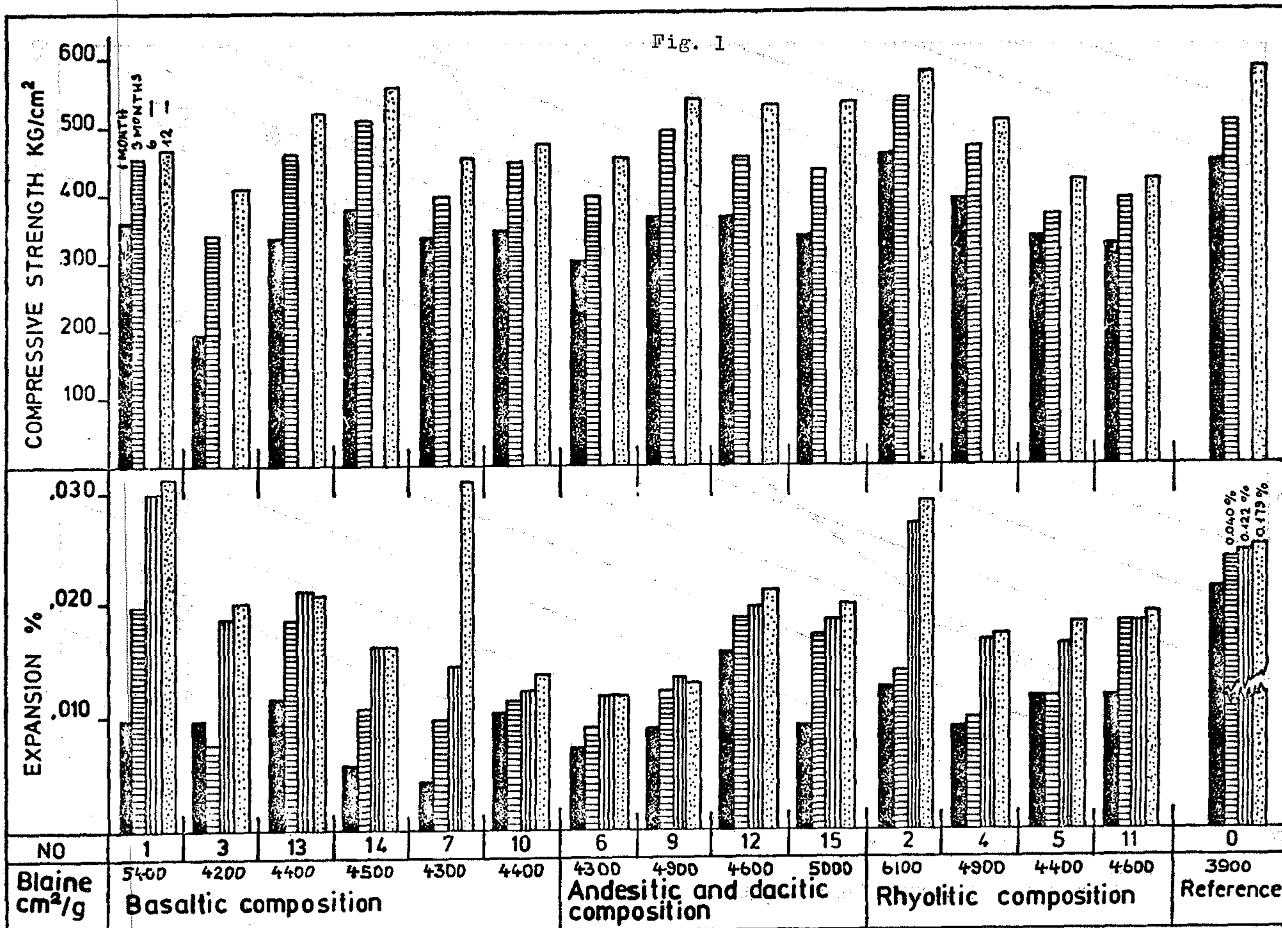
References:

1) G. Gudmundsson, Investigation on Icelandic Pozzolans, Symposium on Alkali-Aggregate Reaction, The Building Research Institute, Reykjavík, August 1975, p. 65-76.

2) K. Sæmundsson, Geologic Prospecting of Pozzolanic Materials in Iceland, ibid, p. 77-86.

3) H. Ásgeirsson, An Epilogue, ibid, p. 269-270.

Fig. 1


COMPRESSIVE STRENGTH KG/cm²
600
500
400
300
200
100
1 MONTH
3 MONTHS
6
12
EXPANSION %
,030
,020
,010
0.040 %
0.422 %
0.479 %
NO
1
3
13
14
7
10
6
9
12
15
2
4
5
11
0
Blaine cm²/g
5400
4200
4400
4500
4300
4400
4300
4900
4600
5000
6100
4900
4400
4600
3900
Basaltic composition
Andesitic and dacitic composition
Rhyolitic composition
Reference

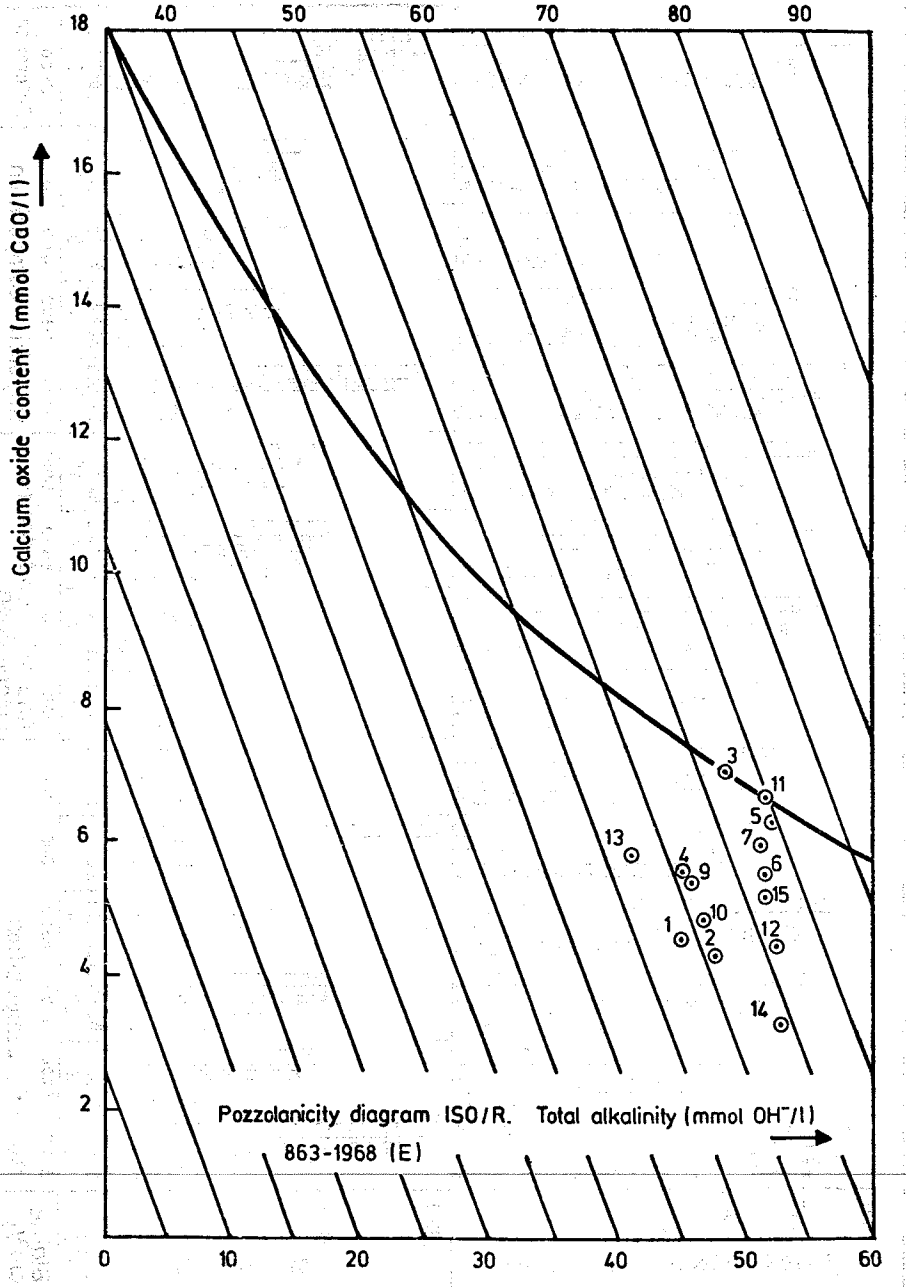

Calcium oxide content (mmol CaO/l)
Pozzolanicity diagram ISO/R. 863-1968 (E)
Total alkalinity (mmol OH⁻/l)
40
50
60
70
80
90
18
16
14
12
10
8
6
4
2
0
10
20
30
40
50
60
1
2
3
4
5
6
7
9
10
11
12
13
14
15

Fig. 2

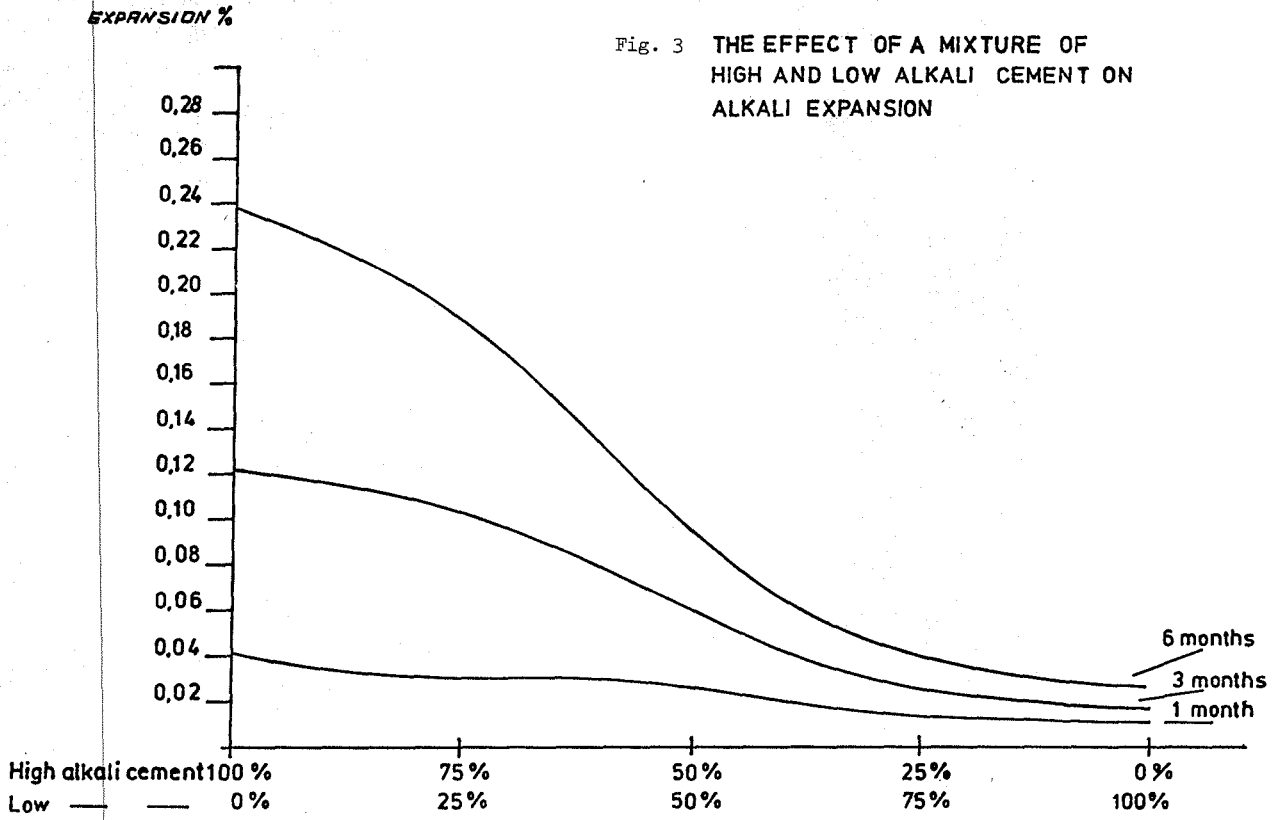


Fig. 3 THE EFFECT OF A MIXTURE OF HIGH AND LOW ALKALI CEMENT ON ALKALI EXPANSION

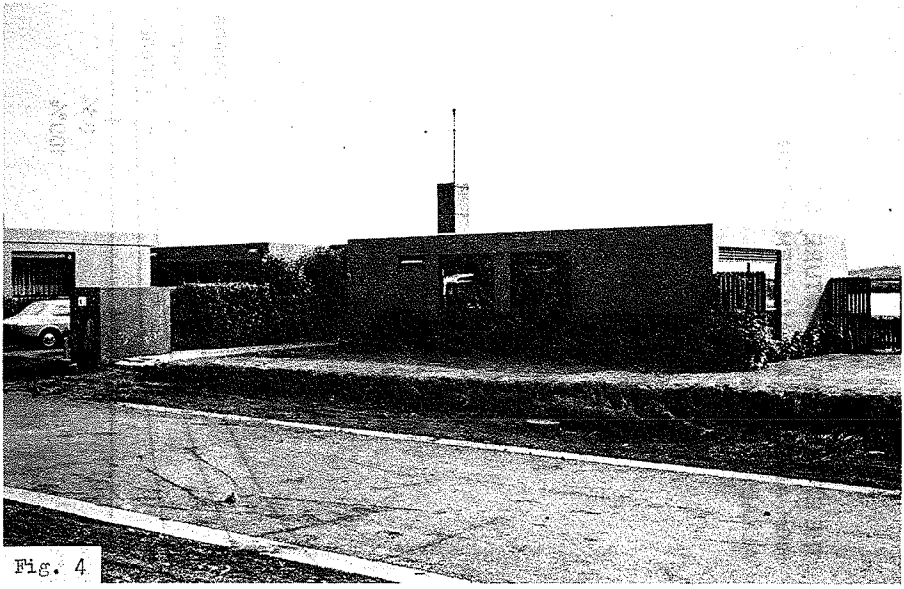


Fig. 4

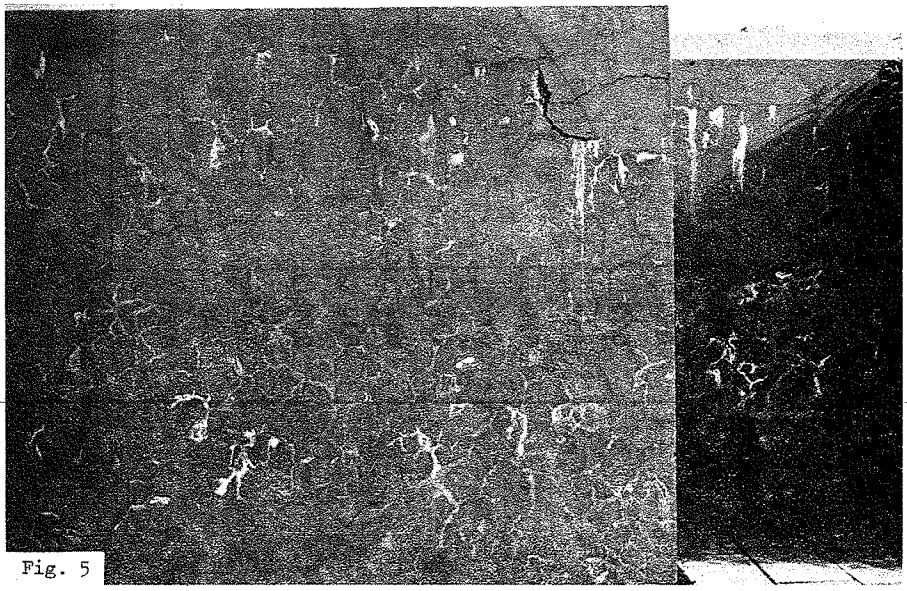


Fig. 5

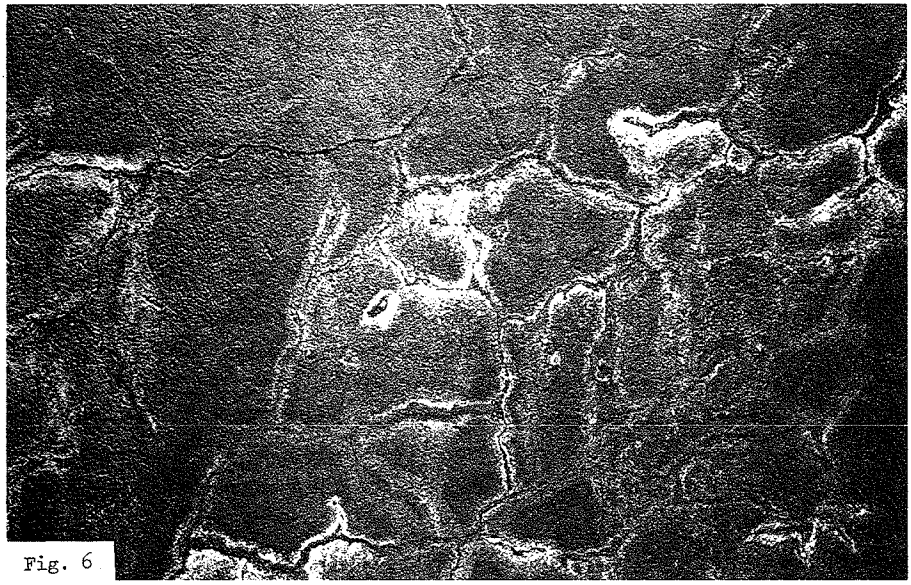


Fig. 6

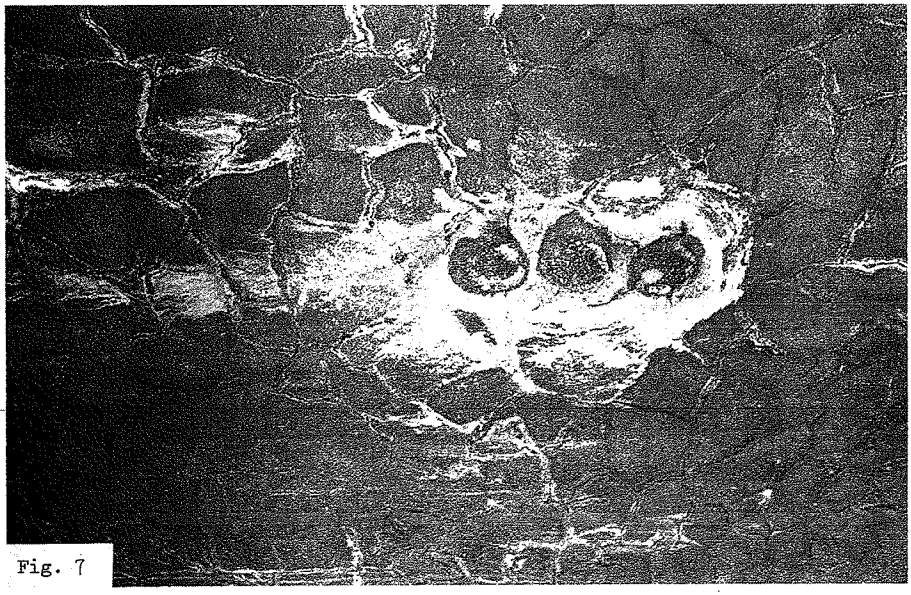


Fig. 7

Mr. D. St.John

Did you check your pozzolans used for tests by water demand tests, or carry out any particle size distribution measurements. It has been our experience that surface area does not adequately characterise a fine material.

Dr. H. Asgeirsson

In reply to the various enquiries arising from discussion I would like to record that the high alkali cement contained 1.5% sodium equivalent and the low alkali cement about 0.35%. The cement content was approximately 350 Kg/m^3 and that Smidt Hammer and core tests proved that the strength of the concrete is still quite high in spite of the cracks. No data is available on the tests suggested by Mr. D. St.John.

The Ladies Party at C. & C. A.