Discussion

on papers published in the
Magazine of Concrete Research
Volume 29, Number 99 : June 1977

Some properties of flint particles and their behaviour in concrete*

A. R. Roeder

Contribution by H. C. Erntroy

Cement and Concrete Association

I was particularly interested in this valuable paper since I have, in the past, been concerned with a similar problem (pop-outs on the surface of paving slabs after exposure to winter conditions) and would like to elaborate specifically on one point.

Mr Roeder concludes on page 93 that "although there is no clear correlation between the freezing resistance of concrete and the water absorption of the aggregate, this property appears to give a general guide to the over-all quality of the aggregate". In a later paragraph he indicates that "the method in BS 812 was used for the determination of . . . water absorption". This Standard requires, of course, that the prepared test sample be immersed in water for 24 ± 0.5 h before surface drying and it is perhaps not surprising that this test gives only "a general guide to the over-all quality of the aggregate" in respect of the freezing resistance of concrete made with it. I would like to suggest that a more appropriate criterion would be the *rate* of absorption of water by the aggregates, as is indeed implied by Mr Roeder's statement on page 93: "The rate at which the aggregates in concrete become critically saturated is also a factor determining the inability to withstand freezing and thawing conditions".

Mr Roeder shows in Table 1 that the white flint particles in his sample had a 24 h water absorption in

excess of 10% and indicates in conclusion⁽⁵⁾ that these particles lead to a greater tendency for pop-outs to occur. Whilst this is undoubtedly a high figure, other aggregates, particularly of the sandstone type, may have similar values. However, the rate at which they reach the critical saturation may well be different.

In an attempt to resolve a similar problem, a small scale ad hoc investigation was undertaken some years ago on a basis similar to that reported by Mr Roeder. A sample of a Thames Valley aggregate, of 10 mm nominal maximum size, was hand-sorted into particles of white flint, dark (black or brown) flint and sandstone. The results of tests according to BS 812, given in Table I, may be compared with those in Table 1 of the paper.

TABLE I: Properties of Thames Valley aggregates tested by the contributor.

Material	Specific gravity (relative density)			24 h water absorption (%)
	Oven-dried	Saturated and surface-dried	Apparent	
White flint	2.22	2.36	2.60	6.7
Dark flint	2.55	2.58	2.62	1.0
Sandstone	2.10	2.24	2.43	6.4

*Pages 92 to 99 of MCR 99

It may be seen that these water absorption values for a Thames Valley source were lower than those reported by Mr Roeder for a Hampshire gravel, but, in particular, that the figure for the white flint particles was very similar to that for the sandstone particles.

In addition to this BS procedure, the rate of water absorption of each of these aggregates was obtained over a period of immersion of about 5 min to 24 h. The results are illustrated on a logarithmic time basis in Figure I. This shows that, although the 24 h values were similar for the white flint and the sandstone particles, the initial rate of absorption was apparently markedly different.

Thus the white flint particles attained about 90% of their saturated value after about 7 to 8 min. This may well be associated with the higher porosity values, reported in Table 5 of the paper, for these particles. However, the sandstone material (and the dark flint) required 25 to 30 min to reach the same degree of saturation. When the material has been incorporated into concrete, these periods will obviously be extended, depending upon the quality and quantity of the protecting mortar layer, as indicated by Mr Roeder, but it seems likely that, in similar practical circumstances, the white flint particles will be saturated more rapidly and, over a given time span, more frequently, than the sandstone particles.

In order to verify the hypothesis, two concrete prisms nominally $250 \times 75 \times 37.5$ mm were made with each of the three types of aggregate (in the dry condition) and were subjected to freezing-and-thawing tests. The specimens made with the dark flint and with the sandstone successfully withstood 160 cycles (when the tests were terminated) without loss of weight or of flexural resonant frequency, whereas those made with the white flint aggregate started to disintegrate after about 80–120 cycles. (Although this may be considered to be an acceptable life, Mr Roeder has found considerable variability of the white cortex material and some particles with exceptionally high porosity may lead to the phenomenon of isolated pop-outs, particularly where aggregates are used in the wet condition.) Thus, in spite of similar 24 h water absorption values, the sandstone particles produce a concrete with a substantially better freezing resistance than with the white flint particles.

Conversely, dry shrinkage and moisture movement tests showed that the use of white flint particles in

Figure I: Relationship between water absorption and period of immersion for the Thames Valley aggregates in Table I.

concrete led to dimensional movements similar to those obtained with the dark flint particles, whereas the use of sandstone particles resulted in values about 50% greater. These results confirmed that the white flint particles did not produce concrete of unusually high shrinkage or thermal expansion values.

It would thus seem that the 24 h absorption value obtained in accordance with BS 812 gives little indication of the effects of an aggregate upon the properties of concrete in respect of freezing resistance or of dimensional stability. Further tests may well show that an assessment after a shorter period of immersion, perhaps 10 min, would be more meaningful, as an addition to, or replacement of, the current BS 812 procedure. It may be noted from Figure I that the rates of absorption of the dark flint and the sandstone particles were similar, although their 24 h absorption values were very different. Thus consideration might usefully be given to the ratio of, say, 10 min water absorption to 24 h water absorption as particles to frost attack on concrete made with them.

Reply by the author

I would like to thank Mr Erntroy for his interesting contribution. I was aware that this work had been carried out but, since it had not been previously reported, it was difficult to refer to. I do agree that the rate at which an aggregate absorbs water may give a

better indication of its suitability for freezing and thawing conditions and would be easy to determine. The idea of a ratio of 10 min water absorption to 24 h water absorption is an interesting one and requires further investigation.