ION-EXCHANGEABLE SODIUM IN CONCRETE AGGREGATES

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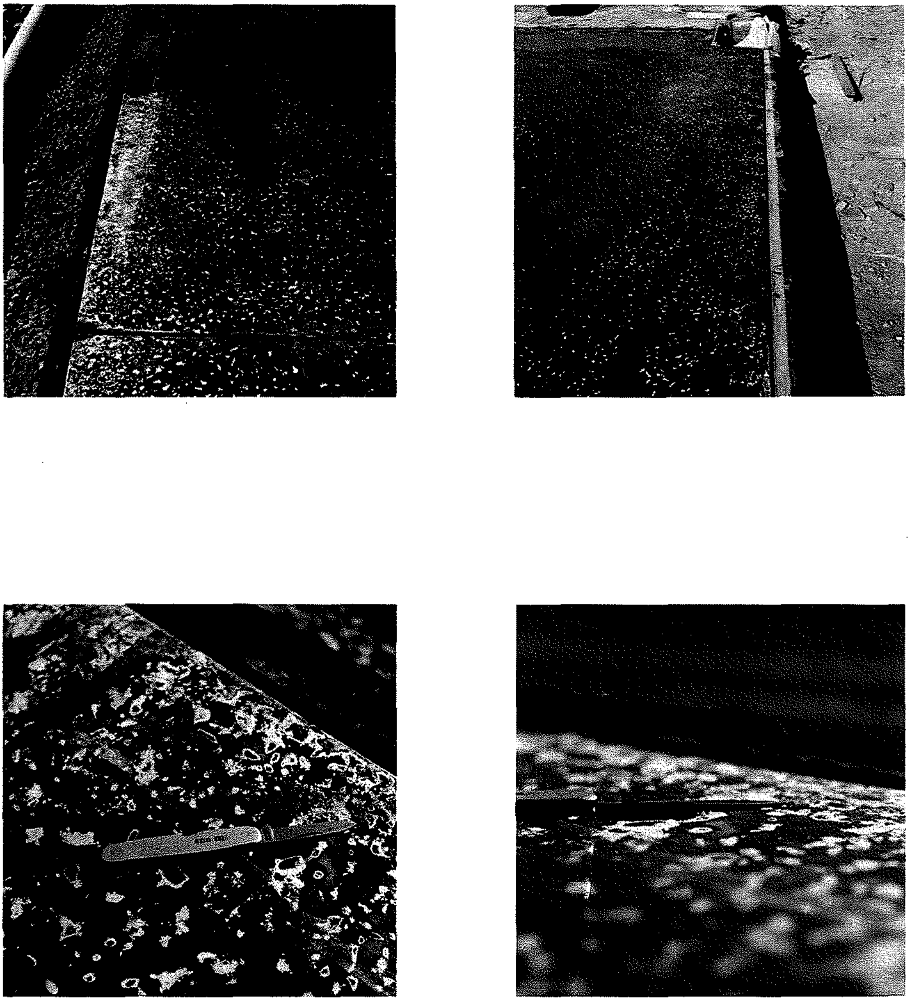
This phenomenon was evidenced due to the coincidence of very unusual weather conditions and concreting techniques.

A call was received from a major concrete customer at approximately 2:30 in the afternoon, describing that the slab which he had poured some two hours previously, was now covered in white snowflakes. The temperature was 43°C, the relative humidity approximately 25% with a 15 knot wind and the major part of the eucalypt forest 25 miles to the windward of the area was on fire. After suggestions that the snowflakes were woodash were badly received, a trip was made to the site and the attached photographs were taken.

The photographs show that very large areas of the slab, which had just passed the stage of final set by Proctor Penetrometer, were covered in white growths of very fine pure white micro-crystalline material, in many cases standing up above the slab by up to 3 and occasionally 4 mm. Most of these white deposits were in the form of rings clearly outlining aggregate particles presumed to be in the proximity of the surface of the slab. The phenomenon was intriguing and careful sampling of the white material was carried out and proved to be rather difficult as it was very similar to attempting to sample snowflakes but probably of an even lower bulk density. Areas of the slab which had been poured later and which had not "fully set", were still showing growth of the white material. A rapid attempt at analysis of the white powder indicated some 23% Sodium Oxide (Na_2O), together with less than 1% of Calcium Oxide (CaO), and about 7% of Sulphur Trioxide (SO_3). The rest of the material was organic producing a strong odour of burning wood on charring and ignition. Initial reaction was that a mis-delivery had been made of Sodium Ligninsulphonate instead of Calcium Ligninsulphonate, but this evinced a strong denial by the suppliers and quick evidence that the assumption was incorrect. Certainly the white crystalline powder contained the sodium salts of ligninsulphonate and probably some other sodium organic compound, and the trace of calcium was probably due to sampling contamination. The distribution of the white rings immediately suggested that bleed water, initially retained beneath pieces of aggregate, was seeping up to the surface especially around the edges of the aggregate, carrying with it the white soluble material which was then deposited by evaporation on the surface due to extreme temperature and humidity conditions.

The cement which had been used was well-known to be very low in sodium oxide and the source of the apparent large quantity of sodium was a puzzle although it will be appreciated that a mass balance was not possible.

The aggregate used was one very commonly used in the Sydney area at that time, being classified as a basalt with some parts more or less vesicular. On enquiry, it was discovered that the quarry was a well-known source of large botryoidal masses of prehnite but there was no evidence in any of the aggregate in the supplier's bins of any such material. Tests on the aggregate which were made by suspending it in, first, cement suspensions and later, in order to avoid "blanks", in hydrated lime suspensions, quickly showed that considerable amounts of sodium oxide were liberated into solution, in the extreme representing 3 and 4 times the amounts which would have been liberated in the same time by a cement suspension of concentration equivalent to that in a typical concrete. It was then assumed that the phenomenon was due to such ion-exchange reaction from other zeolites occurring, followed by crystallization of the least soluble sodium salts accumulating in the rising bleed water. Tests on several other commercially available basalt aggregates in Australia have shown similar potential for ion-exchange reactions to occur whilst a fluid phase exists capable of ion migration.



Photographs illustrating the white micro-crystalline growths