10. Erkenow, M.M.
Periodic deposits in concrete
Baustoffindustrie, January 1965, Vol. 8, No. 1, pp 1-3.

11. Figg, J.W.
Chloride and sulphate attack on concrete
Proceedings, Institute of Concrete Technology, Symposium on "Durable Concrete", 7th International Congress of the European Ready Mixed Concrete Organisation, London 23 May 1983, 16 pp.

12. Ariizumi, A., Kondo, O., and Makida, M.
Measurement of the neutralisation of concrete with radioactive carbon dioxide
Semento Konkuriito, 1962, Vol. 184, pp 14-18
[Chemical Abstracts 58: 1228e]

13. Palmer, D.
Alkali-aggregate (silica) reaction in concrete
Cement & Concrete Association, Wexham Springs, Slough, Advisory Note 45.033, December 1977, 9 pp.

14. French, W.J.
Reactions between aggregates and cement paste
- an interpretation of the pessimum
Quarterly Journal of Engineering Geology, London, 1980 Vol. 13, No. 4, pp 231-247.

15. Iliffe, C.J., and Newton, R.G.
Using triangular diagrams to understand the behaviour of medieval glasses
Verres et Refractaires, January/February 1976, Vol. 30, No. 1, pp 30-34.

16. Idorn, G.M.
The relevance of research on alkali-aggregate reactions to precautions in contemporary engineering practice
Proceedings, 5th International Conference on alkali-aggregate reaction in concrete, Cape Town, South Africa, 30 March-3 April 1981, Paper S252/16, 7 pp.

17. Figg, J.W.
Preliminary appraisal of problem areas and reactive aggregates with appropriate preventive measures.
Proceedings, 2nd International Symposium on Alkali-Aggregate Reaction and Preventive Measures, Reykjavic, August 1975, Icelandic Building Research Institute, Publication No. 16, pp 245-255.

18. Fookes, P.G., Comberbach, C.D., and Cann, J.
Field investigation of concrete structures in south-west England, Part II.
Concrete, April 1981, Vol. 17, No. 4, pp 60-64.

19. Bache, H.H., and Isen, J.C.
Model determination of concrete resistance to popout formation
Journal of the American Concrete Institute, June 1965, Vol. 65, pp 445-450.

EDUCATION FOR EFFECTIVE UTILIZATION OF ALKALIS IN CONCRETE

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ABSTRACT

Contemporary concrete deserves to be considered a continuously reacting system which must be monitored all the way through its processing from the mixer to load application. Alkalis have gained noticeable influence throughout the chemical processes. It is proposed to recognize this development by appertaining changes in engineering education and in research.

The availability of blast-furnace slag and fly ash improves the opportunities for higher social and industrial return on investments with concrete works if educations are updated.

KEY WORDS: Alkalis, Education, Chemistry, Engineering

INTRODUCTION

Recent research, Wu and Roy /1/, Regourd /2/, suggests that the alkali content of concrete made with blast-furnace slag (or fly ash) may significantly influence the workability of the fresh cement paste.

Numerous workers have during the last twenty years shown that alkalis in concrete act as activators of the hydration of blast-furnace slag and fly ash during the curing of concrete.

And several workers, referred to elsewhere in the conference papers, have shown that blast-furnace slag and fly ash may contribute higher denseness and longer term strength development to concrete than portland cement alone can supply.

These impacts on the characteristics of concrete: both in the fresh state and during the curing and performance are inseparably interconnected and time dependent in such ways that the concrete production engineer must count with the changes continuously during the entire duration of the processing: transport, placement, compaction, curing and load application.

The technology must in other words throughout become based upon the dynamic character of concrete as a reacting system. This is not different from the ways in which a cement plant engineer must operate, or for that sake engineers in paper, plastic, margarine and other industries. But it is a change which will not come easy for civil engineers engaged in concrete production.

In actual practice the fresh concrete is still largely controlled by the slump test specified as one figure though frequently to be repeatedly checked for ensuring that the slump stays as specified.

The curing of concrete is still predominantly checked by compressive strength test specimens cured at room temperature; sometimes at intervals, when early strength is desirable, and to ensure that the figures attained per duration of curing periods comply with the specifications.

Beyond such "figure-compliance" concrete quality depends usually on the workmanship of the labour forces involved. Their capability grows from experience, often to thorough knowledge about how to maintain specified, homogeneous quality of concrete throughout its making. But it is not founded upon explanatory research, and prone to miss knowledge of how to adjust the technology, when mechanisation and new materials bring radical changes to the technology.

The influence of alkalis is a neglected feature in this theatre. This is because, beyond the threat of deleterious reactions, the alkalis are too insignificant constituents in concrete to attract any attention at all in the conventional comprehension of technology. Therefore, the need for much new knowledge is now appearing suddenly, unpredicted.

EDUCATIONAL CONCEPT

To make new knowledge effectively applicable in contemporary concrete technology requires education at all levels.

Evidently, the following categories of people ought to become alerted:

- The research community could improve its assistance to the technology development by making value analyses of current requirements to concrete the basis for selection of R&D program priorities.

It also needs cooperation with advanced practice in order to make communication of new findings attractive for technology application.

It might find it rewarding to train post-graduates to become advance technology instructors for practice.

- The civil engineering community needs education to become trained to use relevant chemical knowledge, in particular when this is approaching application for on-line monitoring of the workability (rheology) of fresh concrete and of the curing process (reaction kinetics). One fruitful approach might be to use chemical engineers for the processing of concrete. But even then, the civil engineer needs an improved basis of chemical knowledge for his comprehension of research findings.

- The educational institutes should be encouraged to intensify the training of technicians, foremen, workers etc. in accordance with the technology development.

- The authorities and regulatory agencies should be alerted to flexibility concerning the development, so as to facilitate improvements of the general resource household, and to increase employment opportunities and the return on the investments for the industries.

Within the outlined framework there seem to be major educational objectives for:

- Chemical and civil engineering university departments in cooperation,
- Business school departments,
- Association-based training as instituted for instance by the Cement and Concrete Association in UK, the American Concrete Institute, the Danish Concrete Society and the Danish Concrete Institute etc.

EDUCATIONAL THEMES

As topical issues which ought to be discussed for incorporation in courses (with adjustments of the theoretical matters involved) the following examples are regarded suitable for stimulation of further consideration:

Concrete Materials

1. Cement, blast-furnace slag, fly ash, pozzolana, silica fume.
   - Crystalline/glassy structure
   - Chemical composition
   - Fineness, particle size distribution
   - Alkali-content
2. Aggregates
   - Mineralogy/geology
   - Siliceous and carbonate rock types emphasized
   - Alkali susceptibility
   - Pore characteristics
3. Chemical admixtures
   - Surface chemistry applied

Fresh Concrete

1. Basic rheology theory and principles
   - Surface chemistry applied
   - Time dependence
   - Measurement methodology
2. Monitoring of workability in practice
   - Primary factors of variation
   - On-line monitoring

Curing

1. Cement hydration in practice
   - Pure Portland cement
   - Blended cements
   - Thermal and alkali activation
2. Curing technology systems
   - Development of dissemination of heat
   - Development of strength, elasticity, stresses
   - On-line monitoring systems

Hardened Concrete

1. Denseness: porosity/permeability/diffusivity
2. Incorporation of alkalis in the cement paste morphology
3. Strength and chemical resistance as related to denseness
4. Convergence towards thermodynamic equilibrium