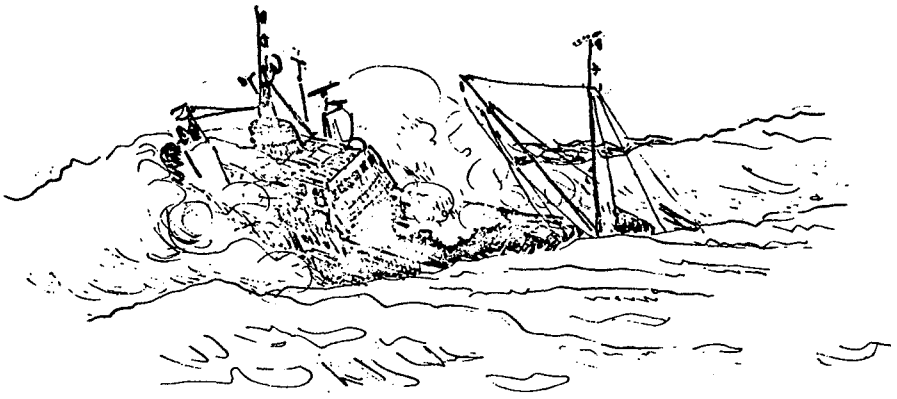
ALKALI – SILICA REACTIONS

1975 and onwards

G.M. Idorn

Reykjavik, August 1975



Iceland – Aug 75
GMI.

I don't think it is widely known that the 1975 Reykjavik Seminar on alkali-silica reaction was conceived on a cold day in February 1956. While attending the RILEM Symposium in Copenhagen on Winter Concreting, Haraldur Asgeirsson visited the so-called »horror chamber», i.e. the laboratory at the Technical University of Denmark, which was working for the Danish Committee on Alkali Reactions.

The unpleasant laboratory designation was fair enough. It possessed a spectacular collection of Danish and foreign specimens of deteriorating concrete, reactive or susceptible aggregates, photograph of cracking concrete at all stages of disruption and crumbling, and photo micrographs exhibiting the symptoms of the diseases under exploration.

Surely, the permanent laboratory exhibition was there, because there was no space for storage except on the desks etc., but it also served the purpose to create interest in industries and among authorities for sponsoring the research. In other words, »concrete» demonstrations were a means by which we could get money in those days - and mostly so from month to month only. If we look back from now to these »horror chamber» conditions for research work, I think one can rightly say that we really did not get the support due to any frigthening effects of the exhibitions, but rather because the sponsors, even without understanding these new problems and methods and theories, got confider in our desire to explore, in the courage to persist and take risks, and to much youngish imagination to conceive and to create concerted research efforts, for which the practical aspects were entirely accept however difficult new thinking became necessary.

Neither do I think that we had fulfilled our tasks, and been here to-day to discuss recent research on alkali-silica reaction, had we not in the course of 1956 to 1960 presented satisfactory applicable results of the work in Denmark and the combination of it with the more comprehensive research elsewhere.

Also, I don't think we could have this gathering in 1975, had there not now been sincere needs and desires for deeper studies by means of up-to-date methodologies and new scientific knowledge

At the present time we are discussing the engineering consequences of deleterious alkali-silica reactions inDenmark, because more cases of rapid concrete deterioration than before are being - right or wrongly - ascribed to alkali-silica reactions as the primary cause of distress or failure of concrete in structures, and alkali-silica reactions have been observed to occur in types of concrete structures, whe they were not experienced earlier.

When alkali-silica reactions were found in concrete structures in Denmark in the early 50'ies, it was concluded by means of comprehensive research and field investigations that deleterious reactions were rare, but that Danish concrete aggregates in general were alkali reactive, and Danish cements were of medium alkali contents, that means not too much up or down about 0.7% eqv. Na_2O. A low alkali cement was therefore produced, and a special low alkali/pozzolanic cement was made available. Innocuous aggregates were also accessible on request.

Authority agencies, business and engineering bodies dealing with building and structural responsibilities agreed that we should have no compulsory specifications so as to request safeguards against deleterious alkali-silica reactions, but that research and advisory activity should make everybo in each individual design procedure concerned about their choice. It be one or another safeguard, or none.

This policy has been maintained *unopposed* since then.

It is my firm conviction that had we not made Danish research in those days to exploit the specific factors and conditions of alkali-silica reactions in engineering practice, then we would have had the safeguards introduced in our country, which were already established abroad - and with this also forever the tedious and complex problems about getting standard specifications adjusted or more thoroughly changed in the course of the changing environments and technologies.

Therefore, and that is what I particularly want to stress as an introductory comment to our meeting: *Research and advisory specialists took upon them a far reaching responsibility about twenty years ago.*

Let us have a look at how it went.

The premium to be paid by the cement consumption for applying safeguards would have been about 40% addition to the cement price over the years.

In 1956 this premium would probably have comprised about 40% of the Danish cement consumption; in 1975 about 20% of the Danish cement consumption. For 1975 this would amount to about 50 mill.d.kr., to which must be added the costs of extra design work, materials testing, approbation, committee work on standards etc., say all together 60 mill.d.kr.

Summarized back over 20 years, one attains a total of 300 to 500 mill.d.kr. (1975 d.kr.) as the order of magnitude of expenses saved by not introducing compulsory alkali-silica safeguards in 1956.

This must be balanced against:

1. The expenses to research and technical service work. Over the years this amounts to about 5 - 8 mill.d.kr., including the costs involved in cooperation with research in other countries (which, accumulated, amounts to many times the costs of Danish research).
2. The expenses to maintenance or replacement of deteriorated concrete or structures. So far, the records show that the quantity of concrete annually being repaired or removed in Denmark because of proven alkali-silica reactions is negligible in the total picture of concrete being repaired or removed, and this is negligible compared with the quantity of concrete annually made.
3. The expenses to precautionary measures, when and where applied. We know that also these expenses have been negligible over the years.

Obviously, neither research nor practice or authorities have made records year for year to establish the above economic picture. But broadly speaking: For Danish engineering and for the society as such, it is clear that the liberal policy regarding precautions against alkali-silica reactions has paid off very well until now. Nobody will question that.

I am quite certain that the conditions in Denmark involve very special features.

If we for instance consider Iceland, it seems convincingly reasonable that having found aggregates to be used in large dams reactive, the authorities decided upon a clear no-risk policy, i.e. low alkali cement or pozzolanic cement of proven safeguard effects. Whereas, in more general use, e.g. in house building, the Icelandic concrete behaves excellent when made with the local high alkali cement.

Or one can look at countries or regions where low alkali cement can be had for no premium of costs in manufacture, and therefore compulsory precautions to fend off possible ill effects by using susceptible aggregates may be found the technical economic optimum.

And so forth: Research cannot distil a global standard solution to the alkali-silica reaction problem. It has to be evaluated with due regard to the considerable variability of its technological and economic parameters.

To this comes at least as far as Denmark is concerned that the concrete technology and concre use is now changing remarkably, and also that in all countries we are under pressure to comply with a growing tendency to standardize and internationalize all sorts of rules and specifications, rather than to graduate these in accordance with the accumulation of research and technology developmer This tendency is especially pronounced in areas of technology, where research is not in strong progr and that is, generally, true for concrete research in many countries at the present time.

One may ask then what research wishes to do, and confront this with what practice thinks tha research ought to create knowledge about.

Let me therefore dwell upon the need to establish a dialogue between these two inseparable partners in development: research and practice.

Firstly, there are some simple and well established facts which need to be communicated again and again, because implementation of research is a continuous process of education, not a one-time act of presentation:

1. The widely accepted o.6% eqv. Na_2O limit of alkali content in cement ought to be applied only in relation to the cement content of concrete.
2. Potentially reactive aggregates may not necessarily lead to deleterious reaction. Field examinations may often reveal a reliable probability for safe use of such aggregates without prescription of safeguards.
3. High temperatures together with adequate moisture accelerates alkali-silica reaction. High temperatures combined with low water content and drying prevents alkali-silica reaction.
4. Low temperatures slow down alkali-silica reactions. In cold regions sometimes almost or practically indefinitely.
5. Alkali-silica reaction might be only a minor reason in cases of concrete failure, though the one leaving the most spectacular visual evidence of destructive reaction.
6. Some special cements are low in alkalies, though not generally sold and known as such.

Secondly, beyond these general advisory statements, which to a large extent can be quantified engineering practice of to-day, there are the new aspects of development of concrete technology to consider.

In view of the increasing weight of responsibility on engineering for the future,alkali-silica rea need thorough reassessment regarding their fundamental nature and behaviour oriented towards application for instance in:

1. Highly compacted concrete
2. Impregnated or »sealed» concrete
3. Concrete with new types of admixtures and additives
4. Fibre reinforced concrete
5. Concrete with new types of synthetic aggregates

This framework of technology represents only a fraction of what is now being imposed as dev opment on engineering and building, but it involves alkali-silica reactions under circumstances that are different from what was established by the earlier mass concrete and empiric research basis.

I do not intend to devaluate mass concrete, actual engineering or empiricism in research as such. But the present demands on energy savings, exploitation of new energy resources and increasing restrictions in general on natural resources request much refinement in constructural engineering and in the urbanization sector. Higher safety and utility must be obtained together with reduced consumption of materials. These demands are already felt in functional requirements to off-shore and nuclear power plant constructions, in design of dwellings, especially in the colder regions, in sanitation constructions, etc.

This means that improved data for empiric interpretation will be requested by practice along with intensive exploratory research aiming at establishing new theoretical models of alkali-silica reaction, which are applicable in the developing of concrete technology. Thus, there is a difficult but challenging dualistic approach before us.

The newer works on alkali-silica reaction as presented in recent years in the international literature are very encourageing, and a meeting like this in Reykjavik represents an excellent opportunity for collegial exchange without any formal obligations to follow. On the other hand, we are also free to discuss that the present fragmentation of concrete research is undesirable in view of the demands on new applicable knowledge. This is surely true with regard to alkali-silica reaction. Therefore, to any degree the meeting can stimulate further cooperation it will be useful beyond the mere presentation and discussion of each other's work.

Iceland demonstrates itself such a cooperative policy, because the present Icelandic regulations regarding alkali-silica reaction in concrete are established on the basis of a fruitful dualistic combination of national research and international exchange.

This policy is therefore, beyond these remarks of introduction to our meeting, in itself the best possible real background for making the seminar in its entirety a progressive one.