Symposium on Alkali Aggregate Reaction - Preventative Measures Summary

by S. Diamond

Ladies and Gentlemen:

This has been an extraordinarily pleasant and fruitful Conference. But in one sense we have not done so well. The subject of this meeting was originally given as "Alkali Aggregate Reaction - Preventative Measures". Specifically, we have had not one paper on "preventative measures", although of course a number of papers skirted the question.

But we have, indeed, have had a good meeting. For the first time, we have a volume of written papers - papers of permanent value, or at least a permanent documentation of where we are now.

Where are we now?

Well, we know, generally the kind of reactions we have to deal with, the mechanisms by which the damage is done, the kinds of aggregates that participate in the reactions, etc.

We have been fortunate in securing the written general review by Harold Vivian, who unfortunately could not be present. We have also the overview and many details supplied by Jack Gillott, and his useful classification of practical interest into categories of alkali-silica reaction, alkali silicate reaction, and alkali-carbonate reaction. Finally, we have the magnificantly detailed bibliography (58 pages) compiled by John Figg. All of these are not only helpful tools in shaping our present thinking, but solid documents useful in the future.

Moving to more specific details, we have been fortunate in having a number of presentations of "case studies" - detailed records of the kinds of rocks and of the circumstances causing troublesome reactions in specific cases. First I should mention the papers of local import here in Iceland. Our chairman, Haraldur Asgeirsson, has presented us with an excellent overview of the local situation with respect to alkali reaction in Iceland. This has been ably supplemented by Saemundsson in his detailed discussion of local geology and of the propecting procedures used to find sources of pozzolan, and by Godmundsson in his detailed exposition of the behavior of these pozzolanic materials. I guess this is pretty close to the "preventative measures" title.

But as we know, alkali-aggregate reaction is rather widespread, and we are fortunate to get several thoroughly documented expositions from widely-separated places. Alan Poole's study of the structural deterioration of a jetty in Cyprus was most informative. The rather detailed survey of alkali-aggregate reactivity in New Zealand, contributed by Kennerly, St. John, and Smith was of great interest, and we regret that these co-workers could not be with us. The same statement holds for the somewhat briefer expose of alkali aggregate reactions in Turkey contributed by Dr. Kocacitak.

This local or case-study information is extremely valuable and helpful to us, but obviously we need to move into consideration of the details of the reactions that are more or less common to all occurrences to understand what is going on.

We have a number of papers that can be classified, I think, into papers specifically considering the aggregate, specifically considering the cement or cement paste, or specifically concerned with the combination.

With respect to the former, we have had considerable insight brought to us, I think, on possible methods for identifying and classifying reactive aggregates - Ludmilla Dolar-Montuani's discussion on new extensions of optical measurements and their potential uses, Dieter Hirche's ideas on infrared absorption methods, and the electron-induced cathodolumiscence technique described by Alan Poole - all are useful to us, and represent lines of advance from paste practice.

Further, in connection with aggregates, I think we have been very well favored by a particularly clear set of slides contributed by K. Mather, which should establish once and for all time the fact that quartz is not an inert material in the context of alkali reaction. We have had the evidence before our eyes, and I think that is very helpful.

At the other end of the business, that is, the cement end, we have been equally favored by the contribution of Mr. Nielsen on the cement production processes and the effect of plant configuration, if we would call it that, on the alkali content of the resulting cement. I suppose the general conclusion is, that we will be living with high alkali cements for the indefinite future. This is both interesting technically and should act as a spur to our efforts to solve the main problem that we know we are going to have to solve in a serious way before too long. Having then had some information on aggregates and cement we can talk about the combination. Here Michael Ozol has done yeoman service in pointing out again the importance of the pessimum proportion and in setting up an analytical model for it. I am not sure sll of us understood the details of it but fortunately it is available in written form. This is the sort of thing that I am sure you have got to puzzle over for a couple of days; it represents serious thought and requires serious thought to understand.

Thus we have information presented on the reactive aggregates, on the cement, and on the combination and methods of assessing the combination.

Another group of papers has been presented which describe details of the reaction and expansion process. I am sure they were not planned this way, but they fit together so neatly that if each of the papers represented mature work instead of early-stage work, we would really have the process thoroughly understood. In this group we have my own paper on the chemistry of pore solution, which is very preliminary; the paper by Niels Thaulow on the process of the reaction and the formation of the gel; Hanne Krogh's exposition of the properties of the gel, once formed, that govern its behavior with respect to its attracting water and retaining its mechanical competence, as indicated by adsorption/desorption and by viscosity measurements. Finally given that the gel is formed, mechnically competent, attracts water, and expands, we have at least preliminary notions contributed by Ervin Poulsen on how this affects the surrounding concrete, i.e. how the cracks are generated. As I said, these things fit together very nicely - we have the attacker, the process of attack, the properties of the product that does the damage, and finally the mechanics of the damage production process.

The only trouble is that in all four stages of this we are all still at the beginning. We don't really understand what is going on in detail. Hopefully, before too many years, we will.

Even though we don't understand all of the details, we must in practice leave the realm of theory or of laboratory study and go into the real world of concrete. Here again we have contributions which offer considerable food for thought.

As indicated by Smolcyk, the diffusion of sodium ions into concrete is pretty much a function of the kind of concrete; it seems to be very different for ordinary concrete than it is for concrete made from blast-furnace slag cement. There seems to be a peculiar relationship between sodium ion diffusion and chloride ion diffusion that has to be explained somewhere along the line. Maybe in the explanation we will get some additional insight in the overall process. Certainly as Nate Greening reminds us, this is not all new - there are in fact existing PCA data describing the mobility of sodium ions leaching extensively out of ordinary concrete, but much less extensively out of pozzolanic concrete, a physical chemical response that just cries for further investigation.

Finally, we come to another perhaps most important group of contributions, to my way of thinking. I refer first to the model or pattern provided us by Dr. Sprung on how most of these factors of alkali aggregate reactions can be integrated and applied in practical concrete technology. We know that this operational pattern is tailored for conditions in Germany and thus is not exportable without modification. We have other conditions in other countries. But he has provided a sensible, clear pattern for operating a viable concrete industrial technology in the light of alkali aggregate problems that are only partly understood. We have got to take advantage of the portion of the understanding of the problem that we already have. Of course none of this happens in a vacuum. We are fortunate to have had the very fine introductory assessment of the overall problem of the alkali aggregate reactions by our chairman. Further, we have the benefit of Gunnar Idorn's advanced thinking on the implications of the problem and our knowledge of it in

terms of the implications on research policy and on management of the cement and concrete industries. We cannot afford to lose sight of that. Our research activity and the application of our results depend very much on economic and political considerations, even though we are scientists and engineers. For our work to be fruitful, we must have people keeping an eye out on these effects for us, or do that sort of thing ourselves, in addition to our other activities.

Perhaps I have already taken too much time, but let me say in summary that this has been a most successful conference. We have had a wide distribution of subjects covered, we have outlines of where we are in this problem and where we need to go from here, and at least in some cases, we have considerable specific detailed information in written form that we can carry away with us.

So far as the other end of the conference is concerned - I am referring here to the social activities and the hospitality - it has been an absolute delight. I would like to say "Thank you" to our hosts, and thank you all very much.