Outline of concrete and cement research proposed by the Division of Building Research

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SUBJECT Outline of Concrete and Cement Research Proposed by the Division of Building Research

NOTE

This is a report given by E. G. Swenson to the meeting on Concrete and Cement Research in Canada held on September 11, 1951. It forms part of the Proceedings of this Meeting, issued by the Division of Building Research as PC Report No. 3 dated March, 1952.

4. OUTLINE OF CONCRETE AND CEMENT RESEARCH PROPOSED BY THE D.B.R.

The tentative program for research outlined by Mr. Swenson consisted of four separate, long-term projects. These do not include the ad hoc problems which, for the most part, will be integrated into the long-term projects.

The first two will be concerned with investigations of an applied nature. They are: survey of materials, including aggregates, cement, pozzolans and related materials, and lightweight aggregates; and field studies of concrete structures. The third project will be a basic study of the action of water in concrete. This will involve among other things, moisture movement effects, and freezing and thawing. The fourth is an educational project designed to make available to the public information on the best concreting techniques and materials.

Mr. Swenson then dealt with each of these projects in more detail.

1. Survey of materials

In order that the Division develop along national lines, the sources and properties of materials across the country must be ascertained. This, of course, is an extremely ambitious step and not one that will be completed in a short time. Data on materials will be accumulated, however, incidental to the investigation of specific problems. As previously mentioned, the Division does not intend to duplicate work done by other organizations, but rather its work will be complementary and related to concrete research specifically.

Mr. Swenson then told the meeting about D.B.R. plans for research on the 3 general classes of materials - cements, aggregates, and pozzolans and related materials.

Cements.- Mr. Swenson said that his own research, prior to joining the Division had been in the chemistry of cements and cement compounds, under the direction of and in collaboration with Dr. Thorvaldson. Because of this, he hoped that he could continue certain phases of this work when plans have been finalized and staff requirements have been met. As a beginning, however, in the work on cements, study will be confined to certain factors in the composition of cements in conjunction with D.B.R. research on concrete problems. In this way, it is hoped that gradually experience and technique will be developed in order to handle specific problems in cement research.

Aggregates.- Preliminary plans have been made for collecting sand, gravel, and crushed stone from selected sources across Canada. A thorough study of the properties of these materials will be made, with the help of information available from other organizations. The study of certain special properties of these aggregates will be of immediate concern in this investigation.

As a first unit project Mr. Swenson proposed the investigation of the prevalence of alkali-reactive aggregates in Canadian mate ials. While it appears that, in Canada, no wide occurrence of this problem is experienced, such as occurs in the U.S. for example, nevertheless it is likely, from geographical proximity, that the problem may exist in Canada but is unrecognized. Answers are required, whether positive or negative, and the experience gained will be useful in diagnostic field work. In this project, mortar-bar expansion tests would be made on samples of these aggregates which contain materials known to be reactive. A series of cements, ranging in alkali content from values below the so-calle critical point to values well above this point, would be used. This will require a study of alkali content of Canadian cements. Aggregates which show a positive reaction would then be subjected to c nfirmatory testing, and finally remedial measures would be attempted, such as the use of Canadian volcanic ashes, diatomaceous earths, and so on.

It is hoped that when problems occur in certain areas, more exhaustive research can be done by local organizations which are directly concerned. This constitutes an important part in the planning of Canadian concrete and cement research. Mr. Swenson suggested that a committee of experts, such as those at the meeting, could be set up to co-ordinate and direct the research required on any such problem when it appears.

Mr. Swenson stated that this was as far as detailed thinking by D.B.R. on aggregates had progressed. It is expected that work on other aggregate problems will start shortly, as the present status of lightweight aggregate research is not very satisfactory. It is probable that some of the first ad hoc problems of D.B.R. will be concerned with this question.

If co-ordination of research on concrete and cement is to be achieved in Canada, Mr. Swenson stated that the first need would be the establishment of a standard aggregate. He hoped that from the ensuing discussion, some suggestions might be made on this topic.

Summing up D.B.R.'s study of aggregates, Mr. Swenson said that certain aspects would be studied first rather than an overall investigation. Eventually, it is hoped that D.B.R. should be able to accumulate valuable information on aggregates and gain the necessary knowledge and experience to deal with problems as they arise.

Canadian pozzolans and related materials.- Mr. Swenson pointed out that Canada has been slow in utilizing volcanic ashes, fly ashes, diatomaceous earth, and slag in the concrete industry. On the other hand, the use of many questionable admixtures is permitted, particularly in block manufacture. Because of this, one of the studies of D.B.R. will be a long-term investigation of both natural and processed pozzolans and related materials with reference to their use in mortars, plasters, and concrete.

Mr. Swenson again stated that D.B.R. does not intend to duplicate work done by others, nor enter the development field, but familiarity with the properties of these materials must be gained in order to study their performance as related to building problems. The value of a good pozzolan is unquestioned. Mr. Swenson said that it had been reported on good authority that the incorporation of limited quantities of such a material in concrete has the following advantages: improved workability, increased ultimate compressive strengths, reduced permeability to water, reduced heat of hydration, increased resistance to sulphate action, and expansion due to alkali-aggregate reaction counteracted. There are disadvantages, however, and these can be listed as follows: reduction of early compressive strengths, increased drying shrinkage and reduction of durability to freezing and thawing. Mr. Swenson continued by saying that Prof. Raymond Davis and others had shown that when entrained air is incorporated along with a pozzolan, the shrinkage is reduced to a value lower than that for ordinary concrete and the durability to freezing and thawing became superior to that for regular air-entrained concrete.

In spite of the extensive work in the U.S. on pozzolans, in Mr. Swenson's opinion Canadian deposits of pozzolanic materials require individual study. In addition, Canadian cements are less finely ground than U.S. cements. Because of this, it would seem that an investigation into the properties of concretes made with Canadian materials would be of value to the building industry.

Mr. Swensen said that there are many sources of fly ash which could be utilized in concrete products. In Nova Scotia, for example, there is at least one large deposit of diatomaceous earth, a material which, when finely ground, is one of the most reactive pozzolans known. When it is used in the raw state, the water requirement is increased to the point where shrinkage difficulties discourage its use in concrete. If it is finely ground, however, and used with entrained air, it has been shown that shrinkage is even less than for ordinary concrete. Durability to freezing and thawing is also increased beyond that for ordinary air-entrained concrete.

Other materials, such as calcined shales and clays, would eventually find use in concrete, and the Division should be prepared to study these when the need arises.

The tentative plan for research into pozzolanic materials by the D.B.R. is a long-term investigation with reference to their use in concrete products. Mr. Swenson said that a modest start had been made in this regard. Samples of such materials have been collected and, using recognized testing techniques, pozzolanic values only have been investigated. As a next step, these materials will be incorporated in test specimens for a study of the properties they confer upon concrete, such as durability to freezing and thawing, permeability, and resistance to sulphate action. Besides these investigations, no plans have been made by D.B.R. other than the preparation for investigation of new materials as they arise.

2. Field Studies of Concrete Structures

Mr. Swenson said that much of the D.B.R. field work would be concerned with special problems which will be dealt with according to their special needs. Long-term exposure tests are also planned for testing concrete under various conditions. This investigation will be integrated closely with D.B.R. laboratory research and will involve long-term studies of certain properties, such as resistance to sulphate action, and resistance to freezing and thawing. No attempt has been made up till now to plan in detail this type of field research. As the research program gets underway, however, it will be developed.

Investigations have already started on another type of field work, Mr. Swenson said. These consist of recording case histories of carefully selected concrete jobs. Mr. Swenson said that this idea had been borrowed from a research program now underway in Montreal. Briefly, this study involves the selection of a job in a certain locality where a certain type of concrete failure occurs for which there is no apparent explanation. During concreting operations on the job, samples of the cement, aggregate and any other materials used, are collected for future testing if necessary. Complete data are obtained on proportioning, mixing, placing, finishing, and curing, as well as exposure and subgrade conditions. Periodically, the structure is examined for development of trouble. If the structure fails, it should be possible from all the records and additional testing to ascertain the reasons for failure. Of course, there will be disappointments in this procedure. Mr. Swenson told of a case where two contractors had used exactly the same materials and specifications on similar jobs. One maintained excellent control and the other appeared t use sloppy methods. In spite of this difference, after 10 years there appears to be no difference between the two jobs!

Though there are these uncertainties, Mr. Swenson thought that over a period of years, much information could be gained from such records. In any case, the time involved in such work is almost negligible compared with a conventional researc program. As a trial of this method, Mr. Swenson said that in Ottawa, several such case histories of sidewalk construction have been recorded. The results of this indicated that if concreting followed Ottawa practice then educational research is of vital importance.

It is hoped by the D.B.R. that they will be able to go a step further by inducing contractors and owners to let them place the concrete in a small unit of a structure, according to D.B.R. specifications. This would serve two purposes -- reference would be obtained from this unit in which certain on-the-job variables would be eliminated and it would serve as a means of trying out remedial measures in the field, such as air-entrainment. In addition to this, actual field demonstrations of experimental mixes would be obtained and these could be used to advantage in promoting good concrete practice.

Mr. Swenson said that he hoped to receive comments and suggestions on the merit of such a research scheme.

3. Basic Research

This phase of the work by D.B.R. will be developed carefully and given proper emphasis. Long-term basic studies will be continued despite continual pressure for applied research.

Considering building materials in general, it was felt that the proper starting point for basic research would be the action of water in materials for it is believed that moisture in one form or another is involved, directly or indirectly, in the troubles experienced with nearly all building material.

On this premise, a member of the staff of the D.B.R., Mr. P. J. Sereda, has been assigned to the investigation of the effect of water on the durability of building materials in general. Mr. Sereda's first concern will be the development of a method, or methods, for the determination of moisture content in a material, using non-destructive techniques. Mr. Swenson said that the apparent lack of such methods had hampered studies involving moisture distribution and moisture flow through a wall, for example. When suitable techniques have been developed, Mr. Swenson said that Mr. Sereda would study the basic mechanism of moisture movement in materials. It may be that the fundamental aspects of the problem as far as concrete is concerned, may be more readily revealed by work on a more simple material.

The behaviour of water in concrete requires special study. Mr. Swenson said that there were two aspects of such an investigation which the D.B.R. would look into. The first is the mechanism of breakdown of concrete as a result of freezing and thawing. Mr. Swenson said that T.C. Powers of the Portland Cement Association had developed the hydraulic pressure hypothesis for cement pastes, but so far there appeared to be no agreement as to the relative effects of varying freezing and thawing cycles in testing concrete for durability. It appeared, therefore, that more work is required on the determination of the role played by pore size, supercooling, and pore surface area, to mention a few. It is hoped that the D.B.R. will be able to start basic work on this problem reasonably soon.

The second aspect of the moisture problem that D.B.R. workers hope to investigate is moisture movement in concrete as influenced by variations in temperature, humidity and wetting and drying. Problems of moisture penetration, condensation, and efflorescence are all too common to-day and to be able to solve them, the mechanism of moisture movement must be understood.

Mr. Swenson said that he and Mr. Sereda hoped to work together on the basic research of this problem with reference to concrete. If a satisfactory method for the non-destructive determination of free water content in concrete is developed, the value of surface coatings, integral water-proofers and air entrainment will be assessable in a practical way.

Mr. Swenson said that his outline of proposed D.B.R. basic research on concrete had been general at this formative stage since the Division was concerned with the moisture question from the point of view of all building materials. He hoped that the ensuing discussion would offer suggestions and criticisms on this matter.

4. Educational Research

Mr. Swens n told the meeting of the Building Practice Group of the D.B.R. which was made up in part of the Publications Section, the Library and the Inquiry Section. These Sections are engaged in processing and disseminating information on building problems, information gained not only from D.B.R. investigations but also from literature available in the Library.

In the case of concrete, Mr. Swenson said that they hoped to extend this procedure by the periodic publication of special bulletins on the various aspects of good concreting. Many such publications are available, but, it is known that for one reason or another, they are not being used to the best advantage. The D.B.R. would like to have the opinions of this group on what their course of action should be in order to reach the user and maker of concrete. Mr. Swenson said that a first bulletin in the "Better Building Bulletin" series of the D.B.R. on concrete was in the draft stage.

In conclusion, Mr. Swenson said that although the early efforts of the Division must necessarily be on a small scale, nevertheless a pattern had been set, which, it was hoped, would provide a sound basis for a research group devoted to the improvement of concrete in Canada. In addition to the proposed work he had outlined, Mr. Swenson mentioned the following projects which might be investigated when both time and help are available:

1. Effect of air-entrainment in concrete on volume changes, permeability, adsorption, and resistance to wear;

2. Investigation of properties of dry mixes, with reference to block making;

3. High-pressure steam curing;

4. Segregation studies:

   effect of frequency of vibration on distribution of sand sizes in fresh concrete;

   strain-development as a result of segregation, remedial measures;

5. Relation between fineness of cements and autogenous healing;

6. Artificial activation of aggregate surfaces;

7. Surface phenomena in capillaries and pores;

8. Fire rating of concrete with reference to materials and mix designs;

9. Salt action - using radioactive techniques;

10. Wetting and drying tests;

11. Consistency tests.