DURABILITY INVESTIGATIONS

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SYNOPSIS

The purpose of this paper is to show the need for a rather comprehensive investigation of the phenomena relating to durability of concrete. At the present time, freezing and thawing tests are made in different laboratories, but the methods differ widely and they give different results. Similarly, aggregates are tested with various forms of artificial accelerated soundness tests. It is believed that certain factors regarding aggregates and regarding conditions of exposure are being overlooked in connection with laboratory investigations of soundness. Attention is called to some of these phenomena with the purpose of stimulating discussion which may lead to a clarification of the needs in connection with soundness testing.

For years we have been testing the durability of aggregates by the use of sodium sulfate and more recently with magnesium sulfate with the idea that the action of these salts in crystallizing within the pores of the aggregate will simulate the action of ice. We apparently haven't been any too sure of just how these tests should be made, for we have changed the methods several times and suggestions for still further changes have been made within the past year. Further—the correlation between these tests and service records doesn't seem to be any too consistent and in fact at times they do not correspond at all.

Similarly, we have been struggling with freezing and thawing tests over a long term of years and we still find widely different ideas as to how an accelerated freezing test should be performed. We use different rates of freezing and of thawing, different sizes of specimens, widely different kinds of apparatus and we don't seem to pay much attention to the kind of freezing the structure will get in service. After we get the test results we wonder what they mean in terms of the prospective performance of the aggregate or concrete for the particular conditions for which it is intended.

It is an easy matter to be arbitrary and simply decide how these tests should be made and then decree what test limits represent failure. That, in large degree, is what we have done in the past and we shall be forced to continue our arbitrary methods until we obtain some really fundamental and comprehensive information upon which to base our tests and specification limits.

But learning the proper method for performing accelerated soundness tests is only a small part of the information needed in connection with the durability of aggregates and of concrete. We should undertake a basic study to find out what are the various influences affecting durability.

When concrete fails upon exposure to the weather, it has been subjected to internal stresses greater than those it can withstand, or its constituents may have suffered chemical change. While it is true that the expanding action of ice within the pores of concrete or of aggregate may exert a disrupting effect, this expansion phenomenon does not tell the full story of the cause of disruption. Let us ask ourselves some questions which seem to bear on this subject.

1. Freezing and thawing are accompanied by temperature change in the concrete. How important may temperature change alone be in causing failure?

   (a) By virtue of different coefficients of expansion of constituent materials.

(b) Because of differential stresses between the surface and the interior of the concrete.

2. May not rapidity of change in temperature be highly important?

3. What about the effect of type of water exposure? Concretes have different exposures such as continuous intermittent wetting and drying, exposure on one side to moisture and the other side to freezing.

4. How important is the thermal expansion of ice within the pores of concrete after it has once formed? Ice, while increasing in temperature up to the melting point expands about four times as much as concrete. Its coefficient of linear expansion is 0.000028 as against only 0.000006 for concrete. Is this important and under what circumstances?

5. Sudden changes in temperature can cause high stresses and cracking of concrete surfaces. How significant is this phenomenon in producing failure?

6. Should we consider other characteristics of aggregates as well as freezing resistance in connection with durability studies? For instance, how is the bond between mortar and aggregate affected by smoothness of surface, by thermal expansion and by shrinkage and swelling of the mortar under changing moisture conditions?

7. Some aggregates have compounds which expand upon long exposure to moisture. Surely something different than sodium sulfate or freezing and thawing is needed to detect that kind of unsoundness.

These are only suggestions as to a very few of the phenomena which might influence failure. There are many more. They indicate the probability that some failures attributed to freezing and thawing may be due to other factors. They suggest that a single standard test for making an accelerated weathering test of aggregates may be woefully lacking and this applies to concrete also. They also show that the degree and kind of exposure need taking into account in considering the degree of durability necessary in concrete or in aggregates.

It would seem desirable that we begin to study durability in its fundamental aspects so that we might be able to write accelerated test methods which will be significant and which we might use with confidence in our investigations and in our specifications. Such a study will not be simple. It will require many separate studies of many different kinds. Steps leading to this study are already being considered by the American Society for Testing Materials and in this effort the Highway Research Board should play its part also. A large cooperative study of the basic causes of lack of durability is surely needed and it is urged that the Department of Materials organize investigations in this field.