Overview

This symposium was organized to provide a forum in which recent work with regard to the use of carbonate additions to cement could be brought to the attention of producers and users of cement. During the past few years, ASTM Committee C-1 on Cement has been considering recommendations that cement specifications be modified to include the possible use of carbonate additions, in a manner similar to that permitted in the Canadian Standards and by many countries in Europe. Interest in the use of carbonate additions has been sparked by the possibility of its use as a partial substitute for gypsum as a set controller, some reduction in the energy costs of a grinding clinker, and improvements in some characteristics of the hardened concrete.

The Sponsoring Subcommittee on Portland Cement of ASTM Committee C-1 proposed, in 1985, that ASTM C 150, Specification for Portland, Cement, provide for the optional use of up to 5% carbonate addition, based on the following rationale:

> *Rationale:* Available data indicate that when up to 5% limestone is interground, carbonate derived from the limestone is an active ingredient in portland cement; shrinkage of mortars and concretes made with cement containing carbonate additions are not greatly affected; pack set is moderated substantially by the addition of limestone to cements; carbonate additions increase the resistance to sulfate attack and do not affect mortar and concrete strengths to a significant degree; deicer scaling tests (C672) show that carbonate additions provide either an improvement or no significant change; and freezing-and-thawing tests (C666) show an insignificant effect of carbonate additions.

The proposal received a sufficient number of negative votes to hold off adoption at this time. It was apparent that more technical information was required to permit a wider expression of opinions. Obviously, such information has to be made readily available to committee members to assist them in arriving at an informed judgment relative to the advantages and disadvantages of carbonate additions. The symposium held in June 1988, and this volume are a first step in this direction.

The paper by *L. L. Mayfield* appeared originally in ASTM's *Cement, Concrete and Aggregates,* Vol. 10, No. 2, Summer 1988. It is reprinted here as an introductory paper which presents a compact history of the development of cements—from ancient times to the present—and culminates in an historical perspective relative to the impetus for the use of carbonate additions in cementing systems.

Ingram, Poslusny, Daugherty, and Rowe present a description of test methods that can be used to analyze the calcium carboaluminates which form during hydration of cements containing carbonate additions. Their tests show that a reaction does occur and that the various forms of calcium carboaluminate can be identified and monitored by XRD (X-ray diffraction).

Neto and Campiteli studied the effect of carbonate additions on the rheological properties and water retention characteristics of portland cement slurries, noting that the fine limestone powder used increased the "lubricity" of the paste, but had no effect on water retention. Such information is of interest relative to masonry construction.

Campiteli and Florindo describe studies which indicate that carbonate additions can influence the optimum gypsum content of the resulting cement system. Optimum gypsum content is an important aspect of cement production, aiding in proper strength development and helping to minimize drying shrinkage. These studies showed that the optimum gypsum content decreased significantly with an increase in the amount of carbonate addition, and the authors emphasized the need for each producer to evaluate this effect for his materials (clinker, gypsum, and limestone).

Adams and Race found that limestone additions in the amount of 2 and 5% by mass of cement increased the drying shrinkage of portland cement mortars, using both ASTM C 596 and California Department of Transportation Method 527 to evaluate shrinkage. They call attention to the need for cement producers to evaluate this tendency for their materials and to effect other changes that can be made to the cement to offset such a tendency should it occur.

Bédard and Bergeron describe a study of the influence of steam curing on the compressive strength and other properties of concretes made with high early strength cements containing carbonate conditions. Under such a curing regimen used extensively in precast concrete operations, carbonate additions contributed to the development of compressive strength of the concrete. Such additions were found not to be detrimental to length change or to the resistance to freezing and thawing. The authors call attention to the need to determine the optimum amount of carbonate addition for different cement clinker compositions.

Klemm and Adams present a discussion of past research on the formation of calcium carboaluminates during the hydration of cementing systems, together with an extensive list of references. Following this discussion of past research, the authors present the results of their own tests on hydrating pastes, utilizing six different cements. They call attention to the complexity of the calcium carboaluminate and calcium sulfolaluminate reactions and that such complexity can lead to formation of different amounts of these different products, thus influencing the performance of concrete and the apparent findings of different investigators. Their studies also show that after about four months of hydration, approximately 80 to 90% of the limestone (or calcium carbonate) remained unreacted.

In the final paper, *Hooton* presents information on the effect of carbonate additions on the heats of hydration and sulfate resistance of three pairs of cements with and without carbonate additions. The three commercially produced cements without the carbonate additions met the requirements of ASTM C 150 and CSA CAN 3-A5. Sulfate resistance appeared to be unaffected by carbonate additions and was primarily influenced by C_3A content. The effect of the carbonate additions on heat of hydration was not consistent. The same was the case for autoclave expansion and for setting times.

The symposium was well attended and produced questions to the speakers and discussions. It is hoped that the symposium and this volume will be followed by a continued effort to broaden the availability and dissemination of additional data and understanding to enable a more informed consideration of future changes to cement specifications in this regard.

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