Durability of Fly Ash Concrete

Dr. Hadassa Baum and Prof. Arnon Bentur, 2003

National Building Research Institute, Technion

Abstract

In recent years several changes are taking place which will influence the concrete industry in Israel. A new standard for concrete structures (Israeli Standard 466) is being approved, and intensive effort is on the way to adopt the new European Standard for concrete material, EN 206.

In order to assure effective and economic use of mineral by-products such as fly ash, there is a need to set limits on concrete compositions which will take into consideration the local climatic conditions. For that purpose there is a need to determine the efficiency factors of such materials, especially the requirements for minimum cement contents when they are present in the concrete. In the local climatic conditions the requirements may be different than those set in the European Standard.

With this view in mind the purpose of the present study was to investigate the behavior of concretes with two types of fly ashes, defined as low quality (LOI of 7.5%) and high quality (LOI of 4.1%). The performance of these concretes was evaluated under condition simulating chloride and carbonation exposures, to assess the life cycle of the steel in the concrete. The concretes were exposed to different types of curing conditions, simulating deficient and high quality curing in local conditions which are hot and dry. The curing procedures simulated intermittent water spray for 3 and 7 days, and under water curing for 7 and 28 days. The range of compositions covered cement contents of 170 to 320 kg/m^3 with fly additions in the range of 60 to 150 kg/m^3.

The main conclusions derived and the recommendations for the standards are presented below, with separate reference to carbonation and chloride exposures.

A. Carbonation

The efficiency factors were 0.5 to 1.1 in the range were fly ash was to replace up to 30 to 40 kg/m^3 of cement. This is the range of interest for mixes in which the minimum cement content specified by the standards is 200 to 270 kg/m^3. In this range the efficiency was not sensitive to the curing conditions. However, for replacement of larger contents of cement, of 60 kg/m^3 and more, the efficiency factors were very sensitive to curing, and replacement at this level is feasible only when the curing applied is under water curing for 28 days. This is unrealistic in field conditions, although it is the standard in the laboratory.

It should be noted that in this range, the effect of deficient curing on shortening of the life cycle is much greater than the effect of the composition with respect to fly ash content. Also, it was found that for equal strength, the life cycle under carbonating conditions was shorter for the mixes containing fly ash. This reflects the lower efficiency factors for carbonation relative to strength.

B. Chlorides

In order to achieve any reasonable efficiency for the fly ash in chloride conditions there was a need for a minimum level of curing of 7 days under water. Below that (i.e. intermittent water spray) the efficiency factor was zero. This implies much greater sensitivity to curing than for the case of carbonation. Also, the efficiency factors for chloride permeability were greater than for chloride life cycle, by a factor of 2 to 3. These differences reflect the fact that chloride ingress is sensitive mainly to pore structure, whereas in the case of life cycle there is an additional influence of the cement content which determines the critical content for chloride corrosion.

The results indicate that for mild chloride exposure efficiency factors of 0.40 and 0.50 were applicable for the low and high quality fly ash, respectively. In both cases the limit for replacement were up to 40 kg/m^3 of cement. For harsher chloride conditions the efficiency factors were smaller, being 0.20 for the higher quality ash. The efficiency for the lower quality fly ash was very low at this range.