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The effect of supplementary cementing materials on alkali-silica reaction: A review

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ABSTRACT

This paper reviews studies on the effect of supplementary cementing materials (SCM) on alkali-silica reaction (ASR). SCMs control expansion due to ASR by binding alkalis and limiting their availability for reaction with alkali-silica reactive aggregate. The efficacy of the SCM is dependent on the composition of the SCM. Increased amounts of SCM are required to control ASR as its calcium and alkali content increase, as its silica content decreases, as the alkali contributed by the Portland cement increases and as the reactivity of the aggregate increases. There is evidence that the alumina content of the SCM also affects its alkali-binding capacity, however, the precise role and contribution of the alumina is not clear.

Contents

1. Introduction

The first published report on the phenomenon that later became known as alkali-silica reaction (ASR) appeared in the Engineering News Record in February 1940 [49]. In December of the same year the American Society of Civil Engineers (ASCE) published a second paper by Stanton [50] that most would consider to be the first definitive work on ASR. In this paper he not only demonstrated that damaging reaction would only occur if there was a sufficient quantity of alkalis in the Portland cement and reactive silica in the aggregate, but also that expansion was reduced when a pozzolanic cement was used. Ten years later, Stanton [51] further demonstrated that partially replacing Portland cement with a sufficient quantity of pozzolan (pumicite or calcined shale) eliminated deleterious expansion whereas replacement with similar quantities of ground quartz (Ottawa) sand did not, indicating that the beneficial action of the pozzolan extended beyond merely diluting the cement alkalis. In the early 1950s, various studies [2,7,12] showed that other supplementary cementing materials (SCM), namely fly ash and slag were also effective in reducing expansion.

Since these early studies there have been literally hundreds of studies and technical papers dealing with the effects of SCM on ASR and it is now generally recognized that the use of a sufficient quantity of a suitable SCM is one of the more efficient preventive measures for controlling expansion when a deleteriously reactive aggregate is used in concrete [60]. This paper reviews selected published works dealing with (i) the mechanisms by which SCM controls ASR, (ii) the effect of SCM composition on its efficacy in this role and (iii) test methods for determining the amount of SCM required to minimize the risk of damaging expansion to an acceptable level.

2. ASR mechanism and role of alkalis

The first stage of the alkali-silica reaction is the reaction between the hydroxyl ions (OH^-) in the pore solution and reactive silica in the aggregate; the silica is not directly attacked by the alkali metal cations (Na^+ and K^+). The alkalis contribute initially to the high

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