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Aar in Precast Concrete Wall Elements

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Abstract

This paper investigates defects (pop- outs) in precast concrete facade, caused by Alkali- aggregate reaction (AAR) on insulated wall elements, which were produced in Lithuania and shipped to Sweden. Links between climate data and AAR were found, samples from the site taken and studied with optical microscope. Information about concrete composition, aggregate granulometry and AAR risk discussed. Finally, possible AAR preventive measures for such production technique discussed and repair of the facade described.

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Keywords: Alkali- aggregate reaction, precast concrete walls, reactive aggregates, climate data

1. Introduction

1.1. AAR in Lithuania

Lithuania has a long history with alkali- aggregate corrosion of concrete. First cases were reported during 1969-1975 in precast concrete elements for residential construction (walls and floor slabs). Scales sizing from 1 to 5 centimeters started to pop out from the surface of concrete and whitish thick liquid was leaching to the surface, forming dripstone on the ceiling [1]. This process damaged facing of interior walls and stopped only after concrete was fully dry. On 1997 in depth investigation of AAR was finished in Kaunas Technological University by

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Gumuliauskas A. and Navickas A. and all aggregate quarries of Lithuania were checked for reactive aggregates [2,3]. Same year, Lithuanian standard for evaluating quantities of reactive SiO_2 in aggregates was released [4]. Researches showed, that average quantities of reactive SiO_2 (mostly Opoka and some Flint) in Lithuanian aggregate quarries do not exceed 2% for coarse and 4% for fine aggregates. Important to note, that there are national requirements in Lithuanian concrete standard LST 1974:2012, stating that equivalent content of Na and K oxides ((Na2O)ekv =Na2O + 0.658K2O) in CEM I should be less than 0.8% (by mass) and in the concrete mix should not exceed 3 kg/m3 .

If above mentioned requirements for alkaline content are met, there is no risk for major map cracking or decrease of compressive strength due to AAR in concrete with aggregates from quarries of Lithuania. But pop- out defects are quite common in concrete floors [5] and in some cases occur in external layer of precast concrete wall elements. Such case was reported on 2013 in Sweden, city Hellsinborg on precast concrete wall elements which were manufactured in Lithuania and delivered to Sweden (Fig. 1). Deffects were investigated and are described further in this paper.

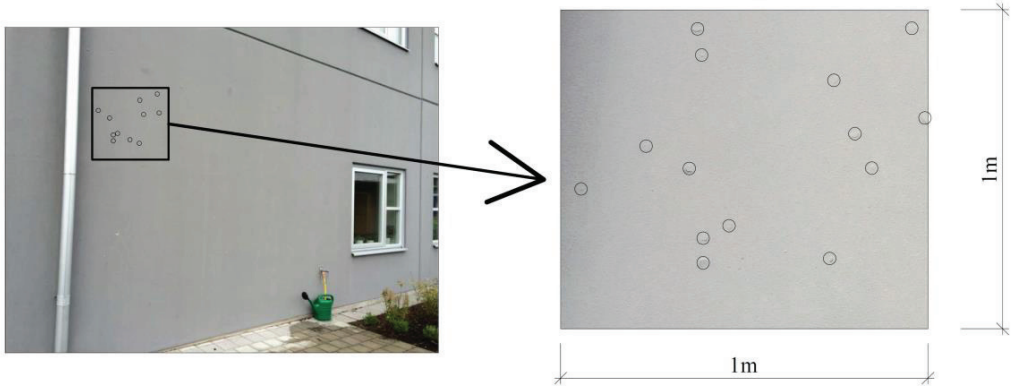

Fig.1. Defects in external layer of precast concrete insulated wall elements

1.2. Principles of AAR

Alkali- Aggregate Reaction (AAR) is one of the main concrete corrosion mechanisms, leading to structural and aesthetical damage throughout the history of Portland cement [6]. The reaction forms a hygroscopic gel which imbibes water and swells. The swelling forces generated may be sufficient to disrupt aggregate particles and the surrounding concrete, causing expansion and cracking [7-9].

For AAR reaction to start in concrete, three conditions must be satisfied: presence of potentially reactive aggregates; high alkali concentration in the concrete pore solution, and high humidity of the environment [10].

Minerals, present in the aggregate react with ions (OH-, Na+ and K+) from hydrated cement paste, forming a hygroscopic gel that expands by uptake of moisture. Water is released and the cations (Na+ and K+) attracted to counterbalance the negative charges, forming Siliceous gel. Calcium ions are also involved in reaction [11]. The product of reaction is alkali- silica gel, composed of Na, K, Ca and Si, which forms around and within the aggregate (figure 2). Alkali silicate reaction is accumulated in the aggregate to give an expansive pressure enough for cracking the aggregate and the surrounding concrete.