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Discussion

A discussion of the paper “Characteristics of pastes from a Portland cement containing different amounts of natural pozzolan” by Adnan Çolak[☆]

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The paper by Çolak [1] examines the influence of natural pozzolan on the physical, mechanical and durability properties of blended Portland cement pastes. I like to celebrate the study on the use of natural pozzolans that are the more extended source of mineral admixtures in the developed countries. I agree with some parts of the paper, but I have some commentaries that I would like to point out.

From the experimental procedure, it is understood that the author has used paste specimens to determine the compressive strength on cement, although it is not a usual practice in cement standard around the world (i.e., ASTM C 109, EN 196-1). In addition, the author has tested the specimens in wet and in dry conditions. To determine the compressive strength, the specimens should be saturated in water according to standard.

The author reports that addition of natural pozzolan produces an increase on the total porous volume, but he should have taken account that the addition of natural pozzolan produces a shift of large capillary pores by numerous fine pore, called pore size refinement by Mehta and Monteiro [2].

However, my main disagreement with the author is about the sulfate performance of blended cement. The author describes that “Resistance to chemical attack caused by Na_2SO_4 decrease considerably when increasing the natural pozzolan content in the blend. Increasing the Portland Cement replacement by natural pozzolan from 20% and 40% leads to decrease the time of failure from 14 to 7 days”. In the conclusion, the author attributes this worse performance of blended cements to the ettringite formation.

The author remarks the importance of C_3A and C_4AF on the sulfate resistance of Portland cement, assuming that

some hydrated compounds of cement paste react with sulfate ions and cause expansion when they are exposed to sulfate environments. The Portland cement used in this research have 9.1% of C_3A and 9.4% of C_4AF , as calculated by Bogue. According to the results presented in the paper, plain cement paste specimens, with or without superplasticizer, performed in good condition during the sulfate test. However, blended cements containing a natural pozzolan ($\text{S} + \text{A} + \text{F} = 80.6\%$ —Class N, according ASTM C 618) performed worse.

Commonly, the causes of worse performance of concrete containing natural pozzolan in sulfate environment are attributed both to the increase of water demand or the presence of reactive alumina in its composition. The results show that the incorporation of natural pozzolan used in this research causes an increase of water demand from 34% to 38.3%, and the use of superplasticizer allows to reduce the water/cementitious ratio for a 60:40 mixture. Then, the worse performance could not be attributed to the increase of water demand. Finally, the author suggests that it could be attributed to the ettringite formation and the high alumina provided by the cement or natural pozzolan into the pore solution. If the cement has 9.1% of C_3A content and the natural pozzolan has an Al_2O_3 content of 2.82% (see Table 1 of Ref. [1]), I would like to know, who provides more alumina during its hydration to the pore solution? The dilution effect on Al_2O_3 content produced by the addition of natural pozzolan cause a decrease of alumina bearing phases in the blended cement. I like to point out that the suggestion proposed by the author is wrong.

I believe that the worse performance of blended cement may be attributed to the salt crystallization phenomenon [3,4] or to salt hydration distress phenomenon as called by Hime et al. [5]. In contrary to chemical sulfate attack, which manifest itself by the formation the gypsum or/and ettringite, this type of attack is strictly a physical nature caused by

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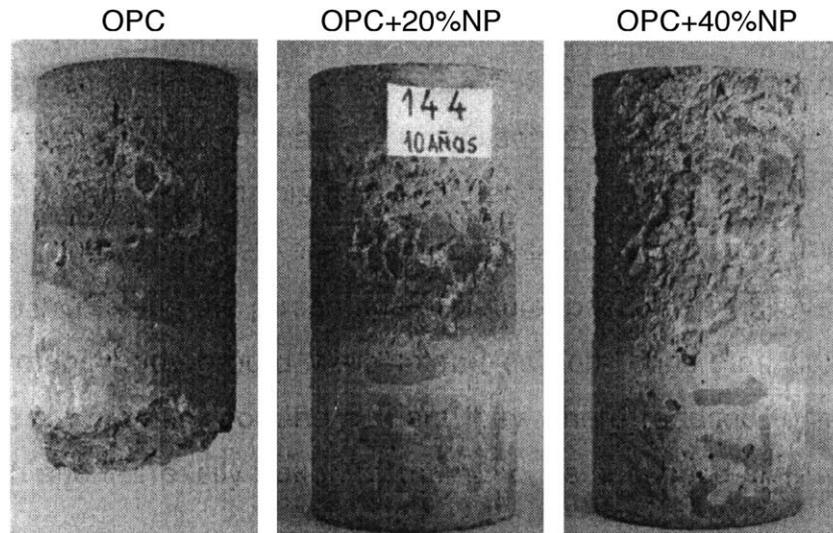


Fig. 1. Visual aspect of half buried specimens in sulfate soil for 10 years.

changes in the $\text{Na}_2\text{SO}_4\text{-H}_2\text{O}$ system related to the variation in the temperature or relative humidity [6].

In his research, the author used a wetting and drying test, similar with what was used for ASTM C 88, to prove the soundness of aggregates by use of sulfate salt. In this test, the main mechanism of attack is salt crystallization. In the wetting–drying cycles, the specimens are exposed to changes in the temperature and/or the relative humidity that causes the transformation of thenardite (anhydrous form of sodium sulfate) to mirabilite (decahydrated form of sodium sulfate). This reaction cause a large expansion and the salt distress is largely extended when specimens present a fine pore structure. For example, some limestones are considered unsound in the ASTM C 88 tests due to fine porous network.

In the test used by Çolak, [1] the sodium sulfate solution ingress into the pores during wetting, and then, when specimens are dried the salt precipitate in the anhydrous form. Subsequently, the salt is rehydrated when the specimens are immersed in sulfate solution. Obviously, this test is inappropriate to evaluate the sulfate chemical attack on cement paste, mortar or concrete produced by ettringite and gypsum formation.

To corroborate my viewpoint, Fig. 1 shows three half-buried concrete specimens made with ordinary Portland cement (OPC– C_3A = 8.5%; w/c = 0.52), 20% of natural pozzolan (OPC + 20% NP) and 40% of natural pozzolan (OPC + 40%NP) exposed to high permeable soil for 10 years. In this field experience [7], it can be observed that

the upper portion of specimen at soil level were affected by salt crystallization. In addition, the damage increases when increasing the percentage of natural pozzolan. However, the portion of concrete specimens underground were intact for both concrete containing natural pozzolan, while for ordinary Portland cement, they were reduced to a puttylike mass without strength and it is easily broken by the hand, as described by Mehta [8].

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