# Preparation of papers for the 3rd *fib* Symposium on Concrete and Concrete Structures

# (The Impact of Amorphous Calcium Aluminate Powder on the Durability of Blended Concrete System)

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**Abstract**
In this paper, amorphous calcium aluminate (ACA) was used in blended mixtures of ordinary Portland cement OPC with two different mix proportions as well as the reference to find out its impact on the durability of concrete. Moreover, the properties of this mixture, fresh properties tests (slump) and hardened properties tests, compressive and splitting strength tests, were investigated. In addition, durability tests, rapid chloride migration tests, natural chloride penetration, sorptivity, and water absorption were carried out. The results showed that a smaller percentage of ACA could improve durability and achieve an early high strength, however, it approaches to strength of the reference mixture at later ages, while a higher percentage of ACA leads to delay hydration, thus leading to decrease strength and durability.

## 1 Introduction

Amorphous Calcium Aluminate Cement (ACA) is one of the latest developments in cement chemistry. it's considered a rapid hardening component of cement and shows remarkably high reactivity compared with crystalline calcium aluminates [1]. Amorphous calcium aluminate is used as an accelerating agent for Portland cement, it also can be used as rapid-setting cement with high early strength. In combination with Portland cement, a higher reactivity and efficiency are obtained, where it can be used as a main ingredient in quick-setting agents for shotcrete and hardening accelerators for concrete [2]. Also it can be used in highway repair work, and produces ettringite in their early stages of hydration[3]. Many of the rapid hardening types of cement increase the formation of ettringite for fast setting and development of strength[1]. This study aims to investigate the influence of blended ACA on the durability of concrete.

## 2 Materials

### 2.1 Cement

The main cementitious material used is Iraqi Ordinary Portland Cement Type I or CEMI-R, it's traditionally called (Mass). It is satisfied the Iraqi Standard Specification (NO.5/2019)[4]. The main oxides of the OPC are shown in Table1.

### 2.2 Amorphous Calcium Aluminate

It's a new kind of fast-hardening accelerator produced by Kaifeng Datong Refractory in China. Its main components are calcium and alumina, its appearance is light gray green. This product was appropriately added to ordinary Portland cement by mass of cement [5], in amounts of 3.5% and 7% . The compound composition of ACA is shown in Table 2.

### 2.1 Aggregates

Two kinds of aggregates are used in the concrete mixture: fine and coarse aggregates. Fine aggregates are natural sand available locally from the Al-Akhaider area were used. The grading of fine aggregate used is shown in Figure 1, and the sulfate percentage is 0.33%, it was found that the fine aggregate is located within the third gradient zone and conforms to the Iraqi Standards Specification (IQS No. 45/1984)[6].

Table 1 The compound composition of OPC cement and ACA.

| Compound composition | OPC | ACA |
|---|---|---|
| **Lime (CaO)** | 61.52 | 47-49 |
| **Alumina (Al2O3)** | 5.33 | 45- 47 |
| **Silicate (SiO2)** | 21.67 | 3.5-4.0 |
| **Iron oxide (Fe2O3)** | 3.31 | Below 2.0 |
| **Mole ratio C/A** | 11.5 | 1.04 |
| **Sulfate content%** | 2.45 | 0.093 |

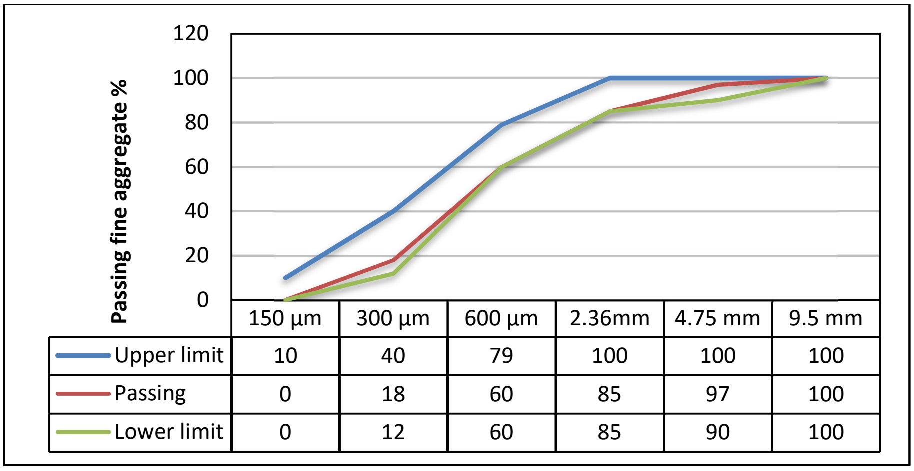


Fig. 1 The grading of fine aggregate.

While the coarse aggregate that used were crushed and washed gravel from the (Al-Nabai'i area). Figure 2 shows the gradation of coarse aggregate. Through the results of the examination, it was found that the coarse aggregate conforms to the Iraqi standard specifications (IQS No.45/1984)[6]. the values of absorption, sulfate content, and specific gravity are 0.75%, 0.09% and 2.74 respectively.

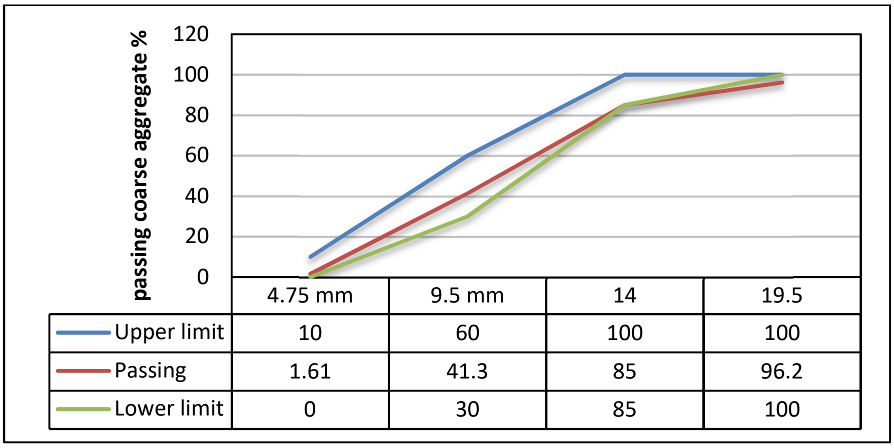


Fig. 2 The grading of coarse aggregate.

## 2.2 Water

Mixing water used for all the mixtures and curing was normal tap water from the domestic water supply. So, it was clear of residual and organic materials that could have impacted concrete properties.

## 2.3 Super Plastizer

During this study a range of water redu-cing and superplactizing admixtures for concrete was utilized and is called Sika's ViscoCrete 180G that achieves the requirements of (ASTM C-494)/2015 Type F [7] which con-sidered to be used with Portland cement. It was added, by mass of cement, in amounts of 1%.

## 3 Mix Proportions

An overall of three mixtures were designed and cast in the laboratory at the water-to-binder ratio (w/b) of 0.45. The mixtures are organized using ordinary Portland cement OPC and Amorphous calcium aluminate ACA as partial replacement from cement by (3.5 and 7 wt%), the mixtures proportions are presented in (Table 2).

Table 2 The mixing proporions of concrete.

| Mix symbol | ACA (%) | w/cm | Content (kg) per cubic meter ($m^3$) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Cement | ACA | Water | Sand | Gravel | Super plasticizer |
| C | 0 | 0.45 | 420 | 0 | 189 | 624 | 1140 | 4.2 |
| ACA1 | 3.5 | 0.45 | 405 | 14.7 | 189 | 624 | 1140 | 4.2 |
| ACA2 | 7 | 0.45 | 390.6 | 29.4 | 189 | 624 | 1140 | 4.2 |

## 4 Curing and Testing

The concrete mixtures in this study were cast as specimens to examine the concrete property using the molds as follow:

- To obtain the compressive strength and water absorption, cubic specimens (100×100×100) mm were used according to BS EN 12390-3 [8]and BS EN 12390-7 [9] respectively.
- (200×100) mm cylinders to obtain the splitting tensile strength test according to BS EN 12390-6. [10]
- (100×50) mm slice of cylinder to determine rapid chloride migration test RCMT and sorptivity test according to NT-Build 492[11] and ASTM C 1585 [12]respectively.
- (200×100×100) mm prisms to determine natural chloride penetration test .

After casting, the specimens were covered with plastic sheets for the first 24 hours at a laboratory temperature of about 25±2°C, then the specimens were removed from the mold and kept in the curing tank at 25°C until the test ages.

## 5 Results and Disscution

### 5.1 Results of Fresh Properties

The workability of freshly mixed concrete was measured by using the slump-flow test according to BS EN 12350-8:2019 [13], the results of the slump test are presents are presented in Figure 3. The concrete workability decreased as the replacement by ACA increases in concrete mixes. The concrete mix made with concrete only showed that the value of slump (15cm), while slump decreased up to (12cm) for mix made with 3.5% ACA. However, the concrete workability decreased to (10cm) for mix made with 7% ACA. This can be attributed to that the decrease in the workability is due to high specific surface of them, lead to an increase in water demand to maintain mixing and control the concrete workability as well as the activety of ACA to hyrate.