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Pozzolan (poz) effects on self-compacting concrete fresh properties

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Abstract – The issue of concrete durability has become a matter of global significance, as the presence of inadequate quality and strength has led to structural failures in various countries, including Algeria. Academic researchers are currently engaged in efforts to enhance the overall quality of conventional concrete and develop alternative concrete products. Self-compacting concrete (SCC), an innovative development in the construction sector, was first introduced by Japanese researchers during the 1980s. The self-compacting concrete (SCC) possesses distinctive characteristics, including its capacity to surmount hindrances and compact itself, which can solely be attained by means of methodical optimization of its composition and components. This research examines the attributes of self-consolidating concrete (SCC) through the incorporation of pozzolan as a means to enhance the fines content, reduce cement consumption, and enhance workability. The findings indicate that self-compacting concrete (SCC) demonstrates favorable performance under ambient conditions, taking into account the impact of pozzolan (poz).

Keywords – Pozzolan, Self-Compacting Concrete (SCC), Fresh Properties.

I. INTRODUCTION

SCC, or self-compacting concrete, is in fact an innovative material in the field of construction [1]. It is designed to flow freely into molds without requiring vibration or manual compaction. This improves construction quality by allowing more even distribution of concrete, reduces labor costs by eliminating the need for compacting concrete, and improves job site safety by reducing worker exposure to harsh, potentially dangerous activities.

To improve the quality of self-compacting concrete, several methods are used, including adding steel fibers, improving the quality of the gravel used, adding cement additives, and adding improver chemicals [2-9].

It is important to note that the choice of BAP constituent materials, including the type of addition used, must be carefully considered based on the specific project requirements, cement quality, and desired performance. The proportions and characteristics of the materials in the SCC mixture must be precisely adjusted to achieve the desired results in terms of workability, strength, and durability.

Several researchers, including Rachid et al. [2-9], have studied self-compacting concrete in order to find the best results.

In this research, we are working on a study of adding pozzolan to self-compacting concrete. Pozzolan is a material of volcanic origin that is often used as an additive in the manufacture of BAP to improve its performance. The particular particle size characteristics of pozzolan, i.e., particle size and distribution, can have several

beneficial effects on BAP in the fresh state, such as improving fluidity, which is essential to ensure that it can flow freely without obstructions or particle segregation. This contributes to the ease of installation and to obtaining a smooth and homogeneous surface.

In its cured state, pozzolan can improve the durability of BAP by reducing the permeability of the material, making it more resistant to the penetration of water and harsh chemicals. This can extend the life of the concrete structure.

The primary objective of this experiment is to investigate the impact of incorporating pozzolan on the flow characteristics of self-compacting concrete (SCC). The research process comprises a series of systematic procedures, including the selection of appropriate components, determination of optimal proportions, thorough mixing of materials to ensure uniformity, and subsequent evaluation of the final product to assess various properties.

II. MATERIALS AND COMPONENTS UTILIZED

Pozzolan, superplasticizer, cement, sand, gravel, and water are the ingredients. The materials are compiled in Table 1.

Table 1. The ingredients used

Materials and their characteristics	Type
Cement	CPA- CEM I / 52,5
Sand	(0/5)
Gravel	(3/16)
Water	Potable
Superplasticizer	MEDAPLAST SP-40

Table 2. Sand and gravel physical-mechanical properties.

Physical property	Size range		
	0 / 5	**3 / 8**	**8 / 16**
Apparent volume mass (g/cm^3)	1,54	1,37	1,36
Absolute density mass (g/cm^3)	2,58	2,68	2,68
Porosity e (%)	40,06	48,56	48,89
Absorption (%)	0,328	0,235	0,095
Water content (%)	-	0,1568	0,0967
Los Angeles Coefficient (%)	-	23,13	23,64
Modulus of fineness	2,26	-	-
Sand equivalent (%)	89.8	-	-

A. Pozzolan (poz)

The diameter of the pozzolan used is less than 80 micrometers, and this is after grinding. Table 2 summarizes their characteristics.

Table 3. Pozzolan used.

Addition	Pozzolan (poz)
Absolute density mass (g/cm^3)	2,44
Apparent density mass (g/cm^3)	1,29
Blaine's specific surface area (BSS) cm^2/g	> 4000
Remarks	The natural pozzolana used is a powder produced by crushing pozzolanic slag after steaming for 24 hours at 105°C to eliminate its humidity, then grinding.

B. Utilized formulation for SCC

The Dreux-Gorisse method is deemed unsuitable and inapplicable to self-compacting concrete (SCC) due to its failure to consider the significant components of admixtures and additions [10]. At present, the formulation of most SCC formulas is primarily based on empirical methods.

Through strict adherence to established guidelines, we ensured the achievement of self-compactability in our concrete mix designs, while also relying on recommendations provided in specialized literature. The determination of component proportions for 1 cubic meter of concrete necessitates the availability of data that is comparable for the following parameters, as indicated in references [11, 12]:

Without Pozzolan (poz):

Cement (52.5) + Sand (0/5) + Gravel (3/15) + Water (W) + Air (A) + Superplasticizer = 1000 liters.

With Pozzolan (poz):

Cement (52.5) + Sand (0/5) + Gravel (3/15) + Water (W) + Additions Pozzolan (poz) + Air (A) + Superplasticizer = 1000 liters.

In order to conduct a comparative analysis of the fresh properties of self-compacting concrete (SCC) with pozzolan (poz) and similar SCC without pozzolan, specific parameters were established for the concretes under investigation.

The prescribed mix design proportions entail the following ratios: gravel to sand (Gravel/Sand) = 1, water to addition (Water/Addition) = 0.5, cement dosage (cement) = 400 kg/m3, a variable pozzolan content ranging from 5% to 25%, and a consistent superplasticizer dosage set at 2.2% of the total cementitious content.

A total of six (06) mixtures were formulated, and Table 4 presents a comprehensive overview of the different self-compacting concrete compositions. Based on the international recommendations guidelines, the SCC was established [13].

Table 4. All-SCC composition expressed in kg/m^3.

Composition	SCC					
	(SCC)	$(SCC)_{5\ Poz}$	$(SCC)_{10\ Poz}$	$(SCC)_{15\ Poz}$	$(SCC)_{20\ Poz}$	$(SCC)_{25\ Poz}$
Cement	400	380	360	340	320	300
Pozzolan (5%)	-	20	-	-	-	-
Pozzolan (10%)	-	-	40	-	-	-
Pozzolan (15%)	-	-	-	60	-	-
Pozzolan (20%)	-	-	-	-	80	-
Pozzolan (25%)	-	-	-	-	-	100
Sand 0/5	855.73	855.72	855.71	846.95	851.86	843.01
Gravel 3/16	885.76	885.76	885.67	876.68	881.57	872.56

III. SCC FRESH STATE CHARACTERISTICS

Immediately following the concrete mixing process, the distinctive evaluations were conducted in accordance with the guidelines prescribed by international reference [13].

These evaluations encompass the deployment of the slump test for measuring the concrete's spreadability, the assessment of flow using the L-box and the J-Ring apparatus, and the evaluation of stability through the employment of a sieve. These evaluations serve the fundamental objective of estimating the fluidity of the self-consolidating concrete (SCC) and discerning its static and dynamic segregation characteristics.

The ensuing section outlines the specific characteristics observed in the fresh state of various SCC mixtures, and these findings are cataloged in Table 5.

Table 5. Table containing summary of test results in the fresh state

Composition	(SCC)	$(SCC)_{5\ Poz}$	$(SCC)_{10\ Poz}$	$(SCC)_{15\ Poz}$	$(SCC)_{20\ Poz}$	$(SCC)_{25\ Poz}$
Slump test (mm)	672	675	685	692	705	745
Time T_{50} (s)	2,6	2.6	2,5	2,5	2,4	2,3
J-Ring D (mm)	660	670	673	677	699	720
L-box (%)	84	84	85	86	88	90
Weight of milt Π (%)	7,5	8	8,2	8,5	9	9,9
V-funnel test (s)	7.1	7.2	7.5	7.8	8.1	8.3

Visual observation and the test results shown in Table 5 indicate the fresh properties of the self-compacting concrete (SCC) mixtures fall within acceptable ranges for successful performance. All SCC formulations exhibited adequate flowability and deformability based on slump flow, J-ring, and L-box measurements conforming to recommended criteria. The spreading profile and surface appearance of the concrete after slump flow testing showed no discernible defects for all mixtures, providing further qualitative evidence of proper filling capacity and stability. Taken together, the comprehensive rheological and stability characterization program demonstrates these SCC mixtures possess suitable workability, passing ability, filling ability, and resistance to segregation in the fresh state for proper self-consolidating behavior.

Furthermore, it was observed that an increase in the amount of pozzolan resulted in higher values, which consistently fell within the range of internationally recommended standards [13]. This positive outcome was observed.

Further testing on the hardened concrete properties will determine if the positive fresh concrete performance translates to durable, homogeneous SCC elements after casting and curing.

IV. CONCLUSION

The research presents the results obtained for the self-consolidating concrete (SCC) both without and with the inclusion of pozzolan. The key findings are:

- The self-compacting concrete that was examined exhibits properties that align with the specifications outlined in international guidelines [13].

- The utilization of pozzolan with cement in our research study can yield advantageous outcomes for self-consolidating concrete (SCC). These benefits include enhanced stability and fluidity of the concrete mixture, as well as a reduction in the likelihood of segregation.
- Replacement of the cement with 20 and 25% produced the best results. To know the ideal percentage, you must then compare the results of the solid-state tests.

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