All Sciences Proceedings
http://as-proceeding.com/

5th International Conference on Applied Engineering and Natural Sciences

July 10-12, 2023 : Konya, Turkey

https://www.icaens.com/

The effect of finely ground dune sand on the properties of self-compacting concrete

Rachid RABEHI[1,2,*], Mohamed AMIEUR [1] and Mohamed RABEHI [2]

[1]National School of Built and Ground Work Engineering, ENSTP, Alger, Algeria
[2]Laboratory (LDMM), Civil Engineering Department, University of Djelfa, Algeria.

[*](rachid.rabehi@univ-djelfa.dz)

Abstract – Self-compacting concrete (SCC) is a unique concrete that has been developed over the past thirty years. They have the distinct characteristic of being very fluid. SCC differs from conventional vibrated concrete (CVC) in that it is incredibly fluid and doesn't require vibration. In order to reduce the amount of cement required by the increase in paste volume required to allow the concrete to flow, self-compacting concretes require a large volume of mineral input. The main goal of this research was to ascertain how replacing cement with crushed dune sand (Sd) affected the SCC's physical and mechanical characteristics. The outcomes show that using crushed dune sand in self-compacting concrete produces interesting outcomes in terms of water absorption and compressive strength.

Keywords – Self-Compacting Concrete, Crushed Dune Sand, Water Absorption, Compressive Strength.

I. INTRODUCTION

Undoubtedly, the most frequently used material in all of construction is concrete, with its variety of types. Among the most important of these types is self-compacting concrete, and the beginning of its use was from the end of 1988 until now [1–3].

It is characterized as fluid concrete; It is placed under the influence of its own weight without the contribution of any vibrations [1–3]. Concrete is a synthetic material created by combining a binder (typically cement), water, aggregates (usually sand and gravel), and possibly an adjuvant. This concrete is prone to cracking, which can be brought on by a variety of things, including chemical reactions, mechanical stresses, or shrinkage. Adding steel fibers is one remedy for preventing these cracks. Steel fibers in concrete limit the growth of cracks while also offering a more effective solution to the issue of concrete's brittleness, increasing its durability and resistance.

The construction industry and various public works, such as bridges and roads, have developed quickly in recent years in the world as a whole, and Algeria is one of these countries. However, this industry now faces two a priori contradictory requirements: cutting costs while simultaneously raising quality. It is crucial to utilize and valorization the natural resources in our area [4–6].

The availability of local resources, specifically the sand from the dunes, which make up a sizable portion of Algeria's territory (more than 60% of the country), allows for their exploitation and commercialization in the construction and public works industries.

This article investigates the beneficial effects of using crushed dune sand as a cement additive on the behavior of SCC in fresh and hardened states.

II. MATERIALS AND METHOD

II.1 MATERIALS USED

We used organic and regional materials that were readily available All of the concrete was made with the same raw materials. Table 1 lists the components used, and Table 2 provides a summary of the physical-mechanical traits of the gravel and sand.

Table 1. Materials used.

Materials used	Nature
Cement	Portland
Sand (0/4)	Alluvial
Gravel (8/15) and (3/8)	Limestone
Water	Potable water
Superplasticizer MEDAPLAST SP-30-	Water reducer

Table 2. Sand and gravel's physical-mechanical characteristics.

Properties	Size range		
	0 / 4	3 / 8	8 / 16
Apparent volume mass (g/cm^3)	1,57	1,38	1,37
Absolute density mass (g/cm^3)	2,59	2,67	2,67
Porosity e (%)	41,00	46,50	49,8
Degree of absorption (%)	0,33	0,24	0,097
Coefficient Los Angeles (%)	-	23.2	23,7
Fineness modulus	2,3	-	-
Sand equivalent (%)	90	-	-

II.2 CRUSHED DUNE SAND USED

In our work, well-ground sand was used to be fine and have diameters not greater than 80 micrometers. Table 3 summarizes all the characteristics of the sand used.

Table 3. Crushed dune Sand used.

Addition	Color	Absolute density mass (g/cm^3)	Apparent density mass (g/cm^3)	Remarks
Finely ground dune sand (Sd)	Gray clear	2,769	1,31	The dune is finely crushed intended

III. FORMULATION OF SELF-COMPACTING CONCRETE

Conventional vibrated concrete (CVC) is made using the Dreux-Gorisse method; however, self-consolidating concrete cannot be made using this method because it does not account for the super-plasticizer or additions, which are crucial components of SCC [8]. The vast majority of SCC formulas are currently developed empirically. Therefore, the formulation is based on knowledge that has recently been discovered. By adhering to the rules, we were able to guarantee self-consolidation while basing our compositions on those recommended in the specialized literature. Choosing the component proportions for 1 m3 of concrete requires having comparable data for the following parameters [9]:

<u>With Crushed dune Sand:</u>

Gravel (G) + Cement (C) + Water (E) + Crushed dune Sand + Air (A) +Sand (S) = 1000 liters.

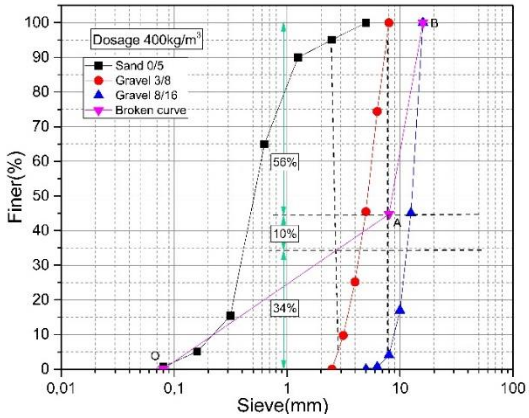

Fig. 1. Granulometric curves of gravel and sand.

To be able to compare the performances, the capillary water absorption, and the compressive strength of the CVC and the SCC studied with crushed dune sand and the same material, we set a few parameters for all the SCC tested.

- ♦ ratio Gravel/Sand = 1;
- ♦ ratio W/L (Water/Cement) = 0.50;
- ♦ cement C= 400 kg /m^3;
- ♦ 20 % Crushed dune Sand;
- ♦ 3.00 % of s superplas ticizer.

Conventional vibrated concrete and two SCCs were created. Table 4 lists the various compositions of concrete. The SCC was established in accordance with the most recent recommendations [10].

Table 4. Composition of the all concrete

Composition	Concrete		
	(CVC)	(SCC)	(SCC)$_{Sd}$
Cement (kg/m^3)	400.00	400.00	320.00
Sand dune (kg/m^3)	-	-	80.00
Sand 0/5 (kg/m^3)	607.81	855.77	851.81
Gravel 3/8 (kg/m^3)	184.09	295.26	293.88
Gravel 8/16 (kg/m^3)	1030.26	590.49	587.75
Water (kg/m^3)	200.00	200.00	200.00
Sp (kg/m^3)	12.00	12.00	12.00
W/(C or L) (kg/m^3)	0.50	0.50	0.50

IV. OVERALL RESULTS AND DISCUSSION

IV.1. CHARACTERISTICS IN A FRESH STATE

The characteristic tests on freshly mixed concrete were carried out right after mixing. The recommendations [10] suggest using the slump test for spreading, the box in L for flow, and the sieve for stability. They are used to calculate material fluidity and static and dynamic segregation. The characteristics of the various types of concrete tested in their fresh state are summarized in Table 5 for convenience.

Table 5. Summary table of the test results in a fresh state.

Concrete	(CVC)	(SCC)	$(SCC)_{Sd}$
Spreading out (cm)	-	66.8	67.9
L-box (%)	-	80.94	86.54
Weight of milt Π (%)	-	7,64	7.05
Subsidence (cm)	7,46	-	-

It is observed that the characteristics of the SCC and SCC_{Sd} in their fresh states are acceptable.

IV.2. CHARACTERISTICS IN A HARDENED STATE

Cubic test tubes (101010) cm^3 were used to create the formulations for all the concretes under investigation. We perform the subsequent actions: The samples were kept in two different curing regimes: in water for 28 days, and in the open air under laboratory conditions.

IV.2.1. TEST OF ABSORPTION

The term "absorption of water" describes how liquid moves through a porous substance as a result of surface stresses in the capillaries. The amount of water that will be absorbed by capillary increase inside the no-slump concrete depends on its open porosity and porous networks. Using concrete test tubes that have been submerged in water without pressure for 28, 60, and 90 days, this test is intended to determine how quickly those test tubes absorb water through capillary suctions. Prior to taking the sorptivity readings, the samples will be packaged in the drying oven at a temperature of about 105 °C until they reach a constant mass. The concrete test tubes are weighed to determine their masses both prior (M_{con1}) to and following (M_{con2}) an hour of water absorption, i.e [7]:

$$A_{bi} = [(M_{con2}-M_{con1}) / S_u (t_i)^{0.5}] \quad (1)$$

S_u: surface of the base (10x10) cm^2;
t_i: time (1 hour).

After sixty minutes, the amount of water absorbed per unit area is retained as a measure of the volume of the most voluminous capillaries in the skin area [11, 12], which are the most effective.

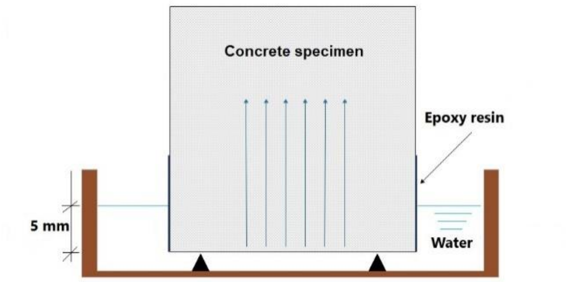

Fig. 2. Test of concrete's capillaries' ability to absorb water.

A_{bi} is the absorption of water after sixty minutes of suctions (1 h) ((kg/(m^2.$h^{0.5}$)), and the rate of gain for all of the concretes is shown in Table 6 and shown in Figure 3.

$$A_{bi} = \left| \frac{A_{bi_{j\,(without\ cure)}} - A_{bi_{j\,(cure)}}}{A_{bi_{j\,(without\ cure)}}} \right| \quad (2)$$

Table 6. Initial water absorption coefficients (A_{bi})

Age	Curing	Type of Concrete		
		(CVC)	(SCC)	$(SCC)_{Sd}$
28 days	Air	2,77	2,66	2,01
	Water	1,75	1,76	1,50
	Rate in A_{bi} (%)	37,05	34,08	25,00
60 days	Air	2,67	2,56	1,75
	Water	1,58	1,58	1,20
	Rate in A_{bi} (%)	41,01	38,20	31,43
90 days	Air	2,33	2,03	1,70
	Water	1,49	1,50	1,25
	Rate in A_{bi} (%)	36,16	26,31	26,47

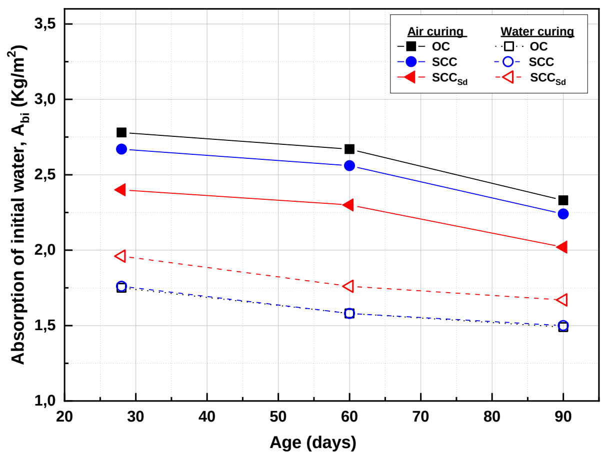

Fig. 3. Absorption of initial water (A_{bi}) of the various concretes

Figure 3 shows the results of the (A_{bi}) of all the concretes. Note that absorption decreases with age. We note that by substituting part of the cement with finely ground dune sand, we obtain less A_{bi} compared to SCC without addition. This means that SCCsd are less porous, and their transport properties are improved compared to SCCs. This is explained, on the one hand, by a reduction in the porous network; the greater compactness provided by crushed dune sand and its great fineness provide a physical filling effect (filler effect) [13]. For conventional vibrated concrete, the initial water absorption A_{bi} is relatively higher than that of other self-compacting concretes.

IV.2.2. UNIAXIAL COMPRESSION TEST

The compression test is carried out in accordance with the regulations (NF P 18-406) [15]. It consists of exposing the concrete test tube to axial compression. It is necessary to constantly refill until the test tube breaks. Figure 4 shows the results of the direct compression tests at all ages.

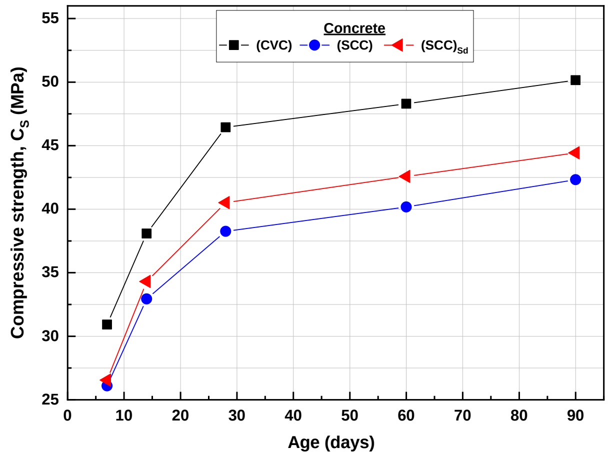

Fig. 4. The compressive strength (C_s) of concretes and their evolution over time.

On the one hand, the findings shown in Fig. 4 demonstrate a definite evolution and increase in the compressive strength of the various types of concrete produced in accordance with age. Our analysis led us to the conclusion that $(SCC)_{Sd}$, a concrete made with crushed dune sand, has a higher compressive strength than all SCC and (CVC). These results are explained by the consequences of crushed dune sand on the increase in the compactness of the solid skeleton.

V. CONCLUSION

The article presents the results of SCC with cement alone and of SCC with boyed dune sand and conventional vibrated concrete. The main results are:

- The self-compacting concrete made with cement alone and the other made with cement and 20% crushed dune sand has characteristics that comply with civil engineering standards.
- In particular, by enhancing the SCC's sieve stability, fluidity, and lowering the risk of segregation, crushed dune sand can be advantageous.
- Age has no effect on the compressive strength of tested self-compacting concretes; it actually increases. Compared to (SCC), this resistance is higher for $(SCC)_{Sd}$. SCC has even lower compressive strength than regular concrete.
- You can get a more uniform and compact granular skeleton by using dunesand. The introduction of additions alters the open porosity, which in turn affects the SCC's mechanical and physical properties.

REFERENCES

[1] H. Okamura, M. Ouchi, Self-compacting concrete. Development, present use and future. In Self-Compacting Concrete: Proceedings of the First International RILEM Symposium (pp. 3-14). Cachan Cedex, France: Rilem Publications (1999, September).

[2] H. Okamura, K. Ozawa, M. Ouchi, Self-compacting concrete. Structural concrete, 1-1 (2000) 3-17.

[3] H. Okamura, M. Ouchi, Self-compacting concrete. Journal of advanced concrete technology, 1-1 (2003) 5-15, https://doi.org/10.3151/jact.1.5

[4] P. Nanthagopalan, M. Santhanam, Fresh and hardened properties of self-compacting concrete produced with manufactured sand. Cement and Concrete Composites, 33-3 (2011) 353-358, https://doi.org/10.1016/j.cemconcomp.2010.11.005

[5] P. Nanthagopalan, M. Santhanam, Experimental investigations on the influence of paste composition and content on the properties of self-compacting concrete. Construction and Building Materials, 23-11 (2009) 3443-3449, https://doi.org/10.1016/j.conbuildmat.2009.06.029

[6] K.H. Khayat, J. Assaad, J. Daczko, Comparison of field-oriented test methods to assess dynamic stability of self-consolidating concrete. Materials Journal, 101-2 (2004)168-176,

[7] W. Deboucha, N. Leklou, A. Khelidj, M.N. Oudjit, L'effet des fillers calcaires sur la résistance à la compression et l'absorption capillaire du béton, citedub3. Alger, (26 et 27 Septembre 2016).

[8] N. Su, B. Miao, A new method for the mix design of medium strength flowing concrete with low cement

content. Cement and Concrete Composites, 25-2 (2003) 215-222 https://doi.org/10.1016/S0958-9465(02)00013-6
[9] H. J. H. Brouwers, H. J. Radix, Erratum to" Self-Compacting Concrete: Theoretical and experimental study" (Cement and Concrete Research 35 (11) (2005) 2116-2136. Cement and concrete research, 37(9), 1376-1376. (2007), https://doi.org/10.1016/j.cemconres.2005.06.002
[10] French association of Civil engineering (AFGC), provisional Self compacting concrete recommendations, scientific and technical Documents, AFGC, (July 2003).
[11] J. P. Balayssac, C. H. Detriche, J. Grandet, Interest of the test of absorption of water for the characterization of the concrete of coating. Materials and Structures, 26-4 (1993) 226-230, https://doi.org/10.1007/BF02472615
[12] M. Rabehi, B. Mezghiche, S. Guettala, Correlation between initial absorption of the cover concrete, the compressive strength and carbonation depth. Construction and Building Materials, 45 (2013) 123-129, https://doi.org/10.1016/j.conbuildmat.2013.03.074
[13] E. J. Sellevold, The function of condensed silica fume in high strength concrete. In Symposium on Utilization of HSC, Trondheim, Norway, ISVN (pp. 82-519). (1987, June).
[14] S. Guettala, B. Mezghiche, Effect of Addition the Dune Sand Powder on Development Compressive Strength and Hydration of Cement Pastes. (2012).
[15] Norme francaise NFP 18-406, Beton : Essai de compression, AFNOR Paris (1981).