ASIAN JOURNAL OF CIVIL ENGINEERING (BUILDING AND HOUSING) VOL. 13, NO. 6 (2012)
PAGES 765-781

INFLUENCE OF ADDITION DUNE SAND POWDER TO CEMENT, ON THE PROPERTIES PHYSICAL-MECHANICAL AND DEFORMABILITY OF CONCRETE

S. Guettala*, B. Mezghiche and M. Mellas
Research Laboratory Civil Engineering R.L.C.E.B, University of Biskra, 07000 Biskra, Algeria

Received: 5 September 2011, **Accepted**: 10 February 2012

ABSTRACT

This experimental work has focused on studying the possibility of using the dune sand powder (DSP) as a part mass addition to Portland cement. The incorporation of dune sand powder form substitution to Portland cement yields a new variety of cement compound with physical-mechanical properties superior to those of Portland cement.

The results obtained show that the contribution of addition dune sand powder to the cement binding activity resulted primarily from three effects: Physical, physical-chemical and chemical. These effects act simultaneously and in a complementary way on the properties physical-mechanical and deformability of concrete.

Keywords: Portland cement; dune sand powder DSP; concrete; physical-mechanical; deformability

1. INTRODUCTION

The recent studies which considered the influence of the mineral additions on the properties of cementing materials showed that those additions by their fineness are more or less significant reactivity with the cement can generate in certain cases significant modifications in the rheological and mechanical properties. The mechanisms at the origin of these modifications appear particularly complex, but several studies in this field agree to distinguish three principal effects which are superimposed to influence the properties of the cementing materials in the fresh or hardened state : a granular effect, a physico-chemical effect and a chemical effect [1, 2, 3, 4 and 5].

A granular effect becomes positive and leads either to improve the consistency of the fresh mixture content of water is steadily reducing the content of water for a given consistency by improving the compactness of the mixture and the mechanical performance of hardened

* E-mail address of the corresponding author: guettalasalim@yahoo.com (S. Guettala)

material [6]. Similarly Kronlof [7] showed by studying the effect of ultra-fine aggregates on concrete strength, the incorporation in concrete three additions of different fineness of quartz leads to the decrease of water requirement in relation to the amount and fineness.

A physical-chemical effect that alters the course of hydration during the setting and hardening, and the physical properties of hardened cementitious materials. Other authors argue that the presence of mineral additions in a cement mixture leads to the acceleration of hydration process or that it provided a better dispersion of cement grains, leading to a structure of cement matrix more efficiently [2 and 5]. Similarly, Care et al [8] have also shown by studying the effect of inert mineral additions on hydration of mortars, the degree of hydration for short-term of mortars containing chemically inert additions were always higher than that of the reference mortars and have confirmed the improvement of the hydration of cement with inert additions. In the same context the mineral additions play a role of nucleation sites during reactions of cement, this nucleation is a physical process, causes a chemical activation of cement hydration and depends on the fineness of particle additions, the content addition into the mixture and nature of the addition powder with the cement hydrates [4 and 9]. The physico-chemical effect concerns on a general all additions of their mineralogical nature.

A chemical effect specific to certain additions in cementing medium, which acts during the hydration of cement, which interacts strongly with the physical-chemical effect. The chemical effect is closely related to their mineralogical composition and on the capacity additions characterized by pozzolanic and/or hydraulic properties, reacts with water and constituents anhydrous or hydrated cement to form new mineral phases that may contribute the evolution of strength as well as the hydrated cement products [3]. Similarly Benezet and Benhassaini [10] have shown by studying the influence of particle size of quartz in the pozzolanic reaction, the quartz crystal powder, can react with portlandite to form stable hydrates. The reactivity of quartz powder, measured in a static medium (not activated) heat (test at 20°C), hitherto attributed to amorphization of the grain surface, resulting from the presence of very fine grains adsorbed on the surface of larger grains. Similarly, analysis by X-ray diffraction revealed the pozzolanic role of DSP. Indeed, the small content of portlandite detected in the cement pastes in the presence of DSP reflects the partial pozzolanic reaction, which contributes to increasing the strength and improves the compactness of the paste, and also shows that the DSP consists of tiny grains of quartz SiO_2 well crystallized quartz type α [11 and 12]. Unlike earty-age 7 days, the mechanical strength at higher ages 90 days, of concrete based addition of DSP by substitution beyond that of the control concrete, which means that addition a pozzolanic role leading to the formation of calcium silicate hydrate C-S-H II second generation. The kinetics of formation of C-S-H II by additions depends on their fineness of their silica content and their structures [12].

The dune sand is a material of a great availability in Algeria. This material is practically not exploited, in spite of the possible characteristics which it presents. The contribution of addition DSP on the cement binding activity results primarily from two effects: a physical-chemical effect and a chemical effect. On one hand it change the hydration process of cement as well as the structuring of hydrated products, on the other hand, it reacts on the cementing medium and develops new hydrated products. These effects act simultaneously and in a complementary way on the properties of cements and concretes. A third physical effect which is the granular effect related to the changes induced by the presence of the fine particles in the solid skeleton of the mixture [13 and 23]. In the light of what was evoked previously, the required objective is to evaluate through experimentally the combined contribution of physical effect, physical-chemical and chemical of addition the dune sand powder to cement, on the properties physical-mechanical and deformability of concrete.

2. CHARACTERISTICS OF MATERIALS

This is a crushing of dune sand and clinker. The crushing is carried out using a conventional ball crusher. After that, sifting is carried out.

2.1 Dune sand powder

The choice of an addition relative to another is generally following the local availability at acceptable costs, focused on the high silica content. We used dune sand in the region of Biskra.

Chemical analysis

Table1 contains the chemical analyses which were carried out in the laboratory of the cement factory of Ain Touta (Batna, Algeria). From a chemical stand point, the important observation to note is the presence of a high percentage of silica SiO_2; is greater than 74%, and therefore the dune sand is siliceous sand.

Table 1: Chemical analysis of dune sand powder (%)

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	K_2O	Cl^-	PAF
74.61	1.35	0.86	17.3	0.29	0.04	0.47	0.005	5.04

Mineralogical nature

The analysis by X-ray diffraction using the powder method, finds its main using in identifying minerals. Each body crystalline product indeed a spectrum or diffractogramme X which reflects its internal structure and nature of minerals. To this end, we analyzed by X-ray diffraction: First dune sand powder to highlight their mineralogical nature. The test results are shown in Figure 1. Thereafter, we followed the kinetic fixing lime depending on the time of paste mixtures have been previously stored in PVC tubes at 20±1°C sealed tightly.

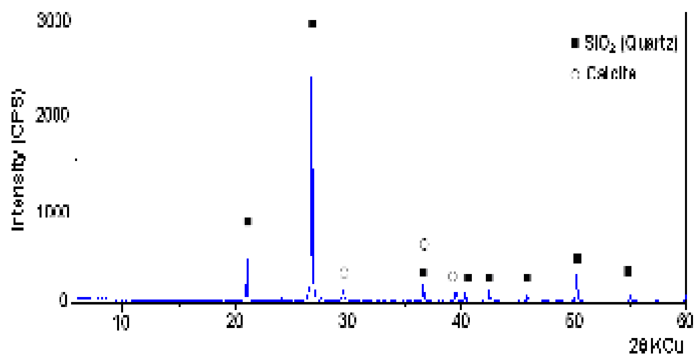


Figure 1. X diffractogram (DSP)

Figure 1 shows that the DSP presents a crystalline structure siliceous (low-quartz). The crystalline silica presents a regular three-dimensional structure; the basic reason is a tetrahedron, an oxygen atom and the centre occupies each summit by a silicon atom. [14].

According to De Larrard [15] (nothing is ultra-fine inert. Thus quartzes crushed deemed crystal, are amorphised on surface. They can therefore be associated with lime according to reactivity pozzolanic classic). The dune sand powder is siliceous, can have the same physical benefits and pozzolanic than other additions, despite its crystalline character [16].

Physical property
Apparent density = 1300 kg/m^3
Specific density = 2770 kg/m^3
Fineness Blaine = 4000 cm²/g

2.2 Portland cement
The Cement that was used is an ordinary Portland cement OPC class 42.5 Mpa; it is composed of 95% clinker and 5% gypsum, for the regularization of the setting. The clinker is from the cement factory of Ain Touta (Batna).

Chemical and mineralogical analysis
Chemical analysis of clinker shows that it conforms to standard NFP 15-301 namely: % (CaO+MgO (free))<5%. The potential mineralogical composition of the clinker is calculated according to the empirical formula of Bogue [17]. Chemical and mineralogical compositions are presented in tables 2 and 3, respectively.

Table 2: Chemical composition of clinker (%)

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	IR	SO_3	Free CaO	LOI
22.00	5.02	2.94	64.36	2.07	0.73	1.94	0.30	0.64

Table 3: Mineralogical composition of clinker (%)

C_3S	C_2S	C_3A	C_3AF
51.28	24.68	8.33	8.94

Physical property
Apparent density = 1120 kg/m^3
Specific density = 3050 kg/m^3
Fineness Blaine = 3200 cm²/g

2.3 Water
The water is drinking water that contains little sulphate and having a temperature of 20±1°C,

its quality conforms to the requirements of standard NFP 18-404.
The results of chemical analysis of water are given in Table 4.

Table 4: Chemical analysis of water (mg/l)

Ca	Mg	Na	K	Cl	SO_4	CO_2	NO_3	Insol	PH
116	36	80	3	140	170	305	5	786	7.9

2.4 Sand

The sand used is from the region of Biskra (River Oued-Djedi). It with is noted that the grading curve of our sand fits in the spindle recommended by the current concrete. The grading curve of sand is given in Figure 2.

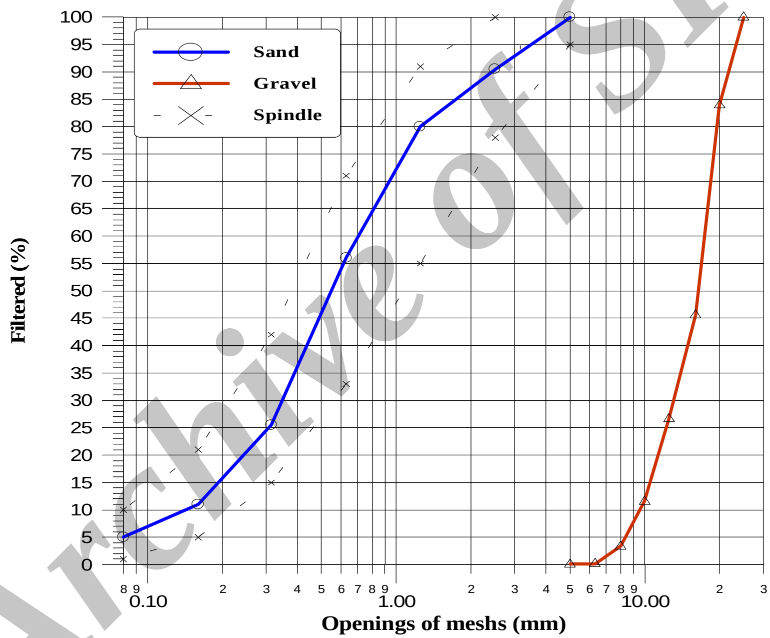


Figure 2. Grading curve of sand and gravel

Physical property

Apparent density = 1440 kg/m^3
Specific density = 2500 kg/m^3
Fineness modulus = 2.37 (preferential).
Sand equivalent (sight) = 75 (Slightly argillaceous sand of acceptable cleanliness for concretes of current quality).
Sand equivalent (test) = 70

2.5 Gravel

We used crushed stone fraction 7/15 and 15/25 region Ain-Touta (Batna). The grading curve

of gravel is given in Figure 2.
Physical property
Apparent density = 1420 kg/m^3
Specific density = 2610 kg/m^3
Los Angeles coefficient = 21% (hard)

3. RESULTS AND DISCUSSIONS

3.1 Reactivity pozzolanic of dune sand powder
The superposition of X diffractograms shows that the dune sand powder does not change the nature of hydrate after 14 days of hydration. Figure 3 shows that the portlandite formed during reactions of cement hydration in the presence of DSP has been partially consumed. Indeed, the peak corresponding decreased compared to the reference (peak appearing at 9°θCu Kα (P is centered in the reticular distance d = 4.9Å)). The choice of this stripe is the fact that it is distinct from those of other minerals. The higher the percentage of DSP content in the paste increases the intensity of the line corresponding to 4.9Å increases. This result confirms that the DSP is not inert and participates in training new C-S-H II that make the paste thicker and more compact. The dune sand powder, despite its crystalline nature, presents a partial pozzolanic reactivity [13 and 23].

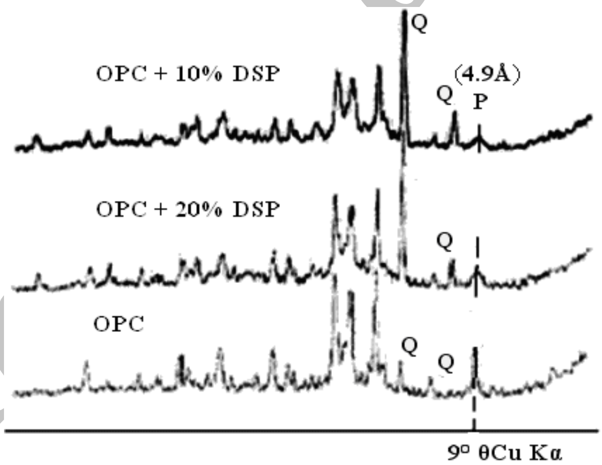


Figure 3. X diffractograms of cement pastes in the presence of DSP in 14 days

3.2 Physical properties of cements
The choice of the optimal composition of premixed cement dune sand powder is based on physical properties. We studied the normal consistency, setting and volume stability.

Consistency and setting time
The cement pastes were prepared in a mixture standard EN 196-1 by following the procedure described by EN 196-3 relative the normal consistency of pure paste. Table 5 gives the consistency, initial and final setting time of mixtures. According to the results obtained one

notices that the content of the addition, DSP% did not generate significant modifications on the setting time of mixtures. By cons the addition significantly decreased their initial consistency (the pastes become more fluid). Because of their superior fineness than that of cement OPC the intergranular vacuum reduce. Therefore the dune sand powder plays a role of lubricant [18 and 23].

Table 5: Physical properties

Tests (T = 27°C)	**OPC + DSP %**				
	0%	5%	10%	15%	20%
Normal consistency (%)	27	26.7	26.5	26.3	26
Setting initial (min)	99	100	105	105	105
Setting final (min)	240	229	227	225	225
Hot swelling (mm)	1.20	1.15	1.10	1.10	1.10

Volume stability

The hydration reaction is accelerated by heat treatment of the paste, so you can see the expansion (swelling) any cement in a very short-term. A test ensures that the cement does not contain substances that can cause a dangerous expansion over time. The purpose of this test is to measure the distance between the ends of two needles of the apparatus of Le Chatelier.

From table 5, the premixed cement DSP has a stability of volume because the values of heat swelling of less than 10 mm [18].

3.3 Compressive strength of cements

Studying in parallel the effect of different percentages of dune sand powder DSP and the influence of the ratio (W/(C + DSP) = 0.4, 0.3 and 0.25) on the compressive strength of cement pastes, we selected four mass percentages (5%, 10%, 15% and 20%) for addition to cement OPC and obtain a new variety of cement compound (optimisation of the cement content in DSP).

We used cubic specimens (2×2×2) cm^3 pure pastes for six specimens per test. The preparation of specimens is performed in accordance with the terms of the standards NFP 18-404 and NFP 18-405. The tightening was under natural conditions, the specimens are subjected to a cure in drinking water at 20 ± 1°C [19]. The results obtained are shown in Figures 4 and 5.

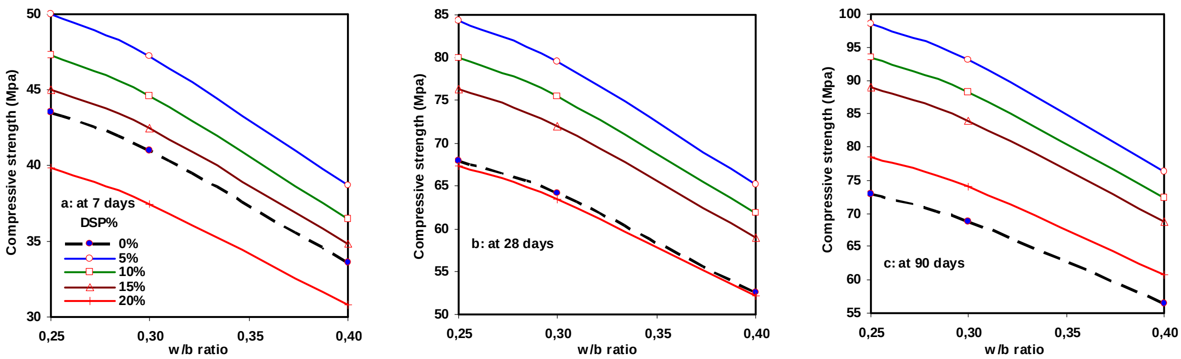


Figure 4. Variation in compressive strength as a function of time and W/B ratio [23]

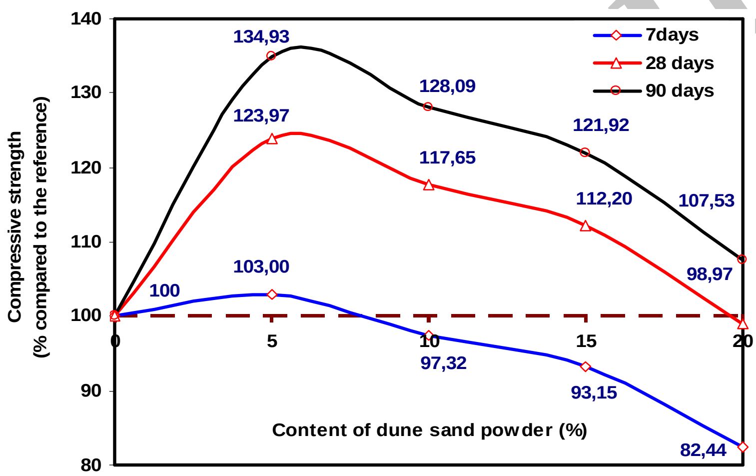


Figure 5. Effect of content of dune sand powder on the compressive strength (w/b = 0.25) [23]

The rate of development of the compressive strength of OPC alone to 28 and 90 days, compared to 7 days, is 56% and 68% respectively, the compressive strengths of the binders to 5 and 20% of dune sand powder develop a rate equal to 69% for 28 days and 97% to 90 days respectively, that translated the chemical effect played by dune sand powder in the long-term, therefore confirms the pouzzolanic activity [13 and 23]. The results obtained show that contribution of addition the dune sand powder to the cement binding activity resulted primarily from three effects: physical, physico-chemical and chemical. These effects act simultaneously and in a complementary way on the compressive strengths of cement pastes: [23].

Physical effect: an improvement of the compressive strengths by a thickening of the cement pastes. Improving the consistency of fresh mixture (paste becomes more fluid).

Physico-chemical effect: a physical process produces a chemical activation of cement hydration and depends on the content and fineness of the dune sand powder, which acts on the evolution the compressive strengths at earty-age. The presence of dune sand powder accelerates the reaction of cement hydration. This accelerating effect of dune sand powder on the hydration combined with the physical effect, due to their fineness, can lead to better short-term compressive strengths.

Chemical effect: lime provided in the case of Portland cement and consumed by the pozzolanic reaction, caused by the addition of dune sand powder to cement, it improved the compressive strengths of cement pastes at average and especially at long-term.

According to the results obtained, we note that the cement with 5% of DSP presented the maximum strength to compression with a ratio W/(C+DSP) = 0.25. The incorporation of 20% DSP with a fineness of 4000 cm²/g, substitution form to Portland cement provides a new variety of compound cement with a compressive strength comparable to those of ordinary Portland cement. Concerning the influence of water/binder ratio (w/b), we see clearly that the compressive strength of all hardened cement pastes at any age, decreased with the increase of w/b ratio. The w/b ratio exerts a great influence on the porosity of the cement paste hydrated (network of pores finer and more discontinuous). That is why cement pastes with w/b ratio low: developing very quickly their compressive strength by a high concentration in C-S-H [23]. Another advantage is that it makes it possible for cement to continue its development of compressive strength even after the 28 days period [13 and 23].

3.5 Study of concrete

Formulation

Optimizing the formulation of concrete based on several criteria that are often a compromise between them: consistency, strength, durability and economy. Before the multiplicity of methods used to determine the composition of concrete was used that gives accurate results and seems to be the least known. This is the method of B. Scramtaiv. This method relies on the fact that the sum of the absolute volumes of original material in a cubic meter is equal to the volume of the composition of tamped concrete [19]. We want to make a concrete whose average strength R_{b28j} = 36 Mpa and whose consistency is such that its cone slump of 7 ± 0.5 cm. In all tests the $W/B \geq 0.4$, $A = 0.6$, $D_{max} = 25$ mm and $S/G = 0.42$. The compositions of the three mixtures of concrete are reported in Table 6.

Table 6: Compositions in concrete (kg/m^3)

Constituents \ Concretes	OC	C10	C20	
Water/Binder	0.52	0.49	0.46	OC: Ordinary concrete based OPC
Cement OPC	350	315	280	
Sand 0/5	538	538	538	C10: Concrete OPC + 10% DSP
Gravel 7/15	446	446	446	
Gravel 15/25	828	828	828	C20: Concrete OPC + 20% DSP
10 % DSP	-	35	-	
20 % DSP	-	-	70	

Physical properties

consistency

It is important to know the properties of concrete in fresh state before setting and hardening. Among these properties, consistency can be defined as the ease of implementation of concrete.

The slump test to Abrams cone NF P 18-451 is currently in use worldwide, it provides reliable measurements of small variability. Depending slump obtained, class consistency of different concrete is plastic (slump varies from 5 to 9 cm).

Porosity

Galle [20] indicates that the water porosimetry may be a more realistic porosimetry by mercury intrusion. Indeed, porosimetry water takes into account the micro-capillary porosity (pores whose average diameter is between 0.8 and 2μm) and porosity of C-S-H (interlayer volume) because water can penetrate into spaces as small as 0.5 microns. From the volume of the specimen, we can calculate its porosity representing the ratio of the pore volume to its total volume.

On an experimental basis, either by hydrostatic weighing of a saturated specimen, it then determines the total volume of the specimen (fraction porous and solid) and calculates its porosity, εexpé from the following relation:

$$\varepsilon_{exp}\,(\%) = ((M_{SDS} - M_S) / (M_{SDS} - M_D)) \times 100\%$$

Where:

ε_{exp}: Porosity determined experimentally by hydrostatic weighing, excluding the volume of trapped air and/or trained (%).

M_{SDS}: Mass of saturated surface dry specimen (g).

M_S: Dry mass of specimen (g).

M_D: Mass of saturated surface dry specimen, weighing in water (g).

The procedure for evolution the porosity is as follows: The specimens are dried in an oven at 105°C for 24 hours, and then immersed in water for 48 hours, the sample is then placed in a boiling water bath for 5 hours, and the tubes are withdrawn to be weighed in air and water (hydrostatic weighing). The method used in this test is that established by ASTM designation C 624 [21]. The porosity is estimated after 28 and 180 days of hardening on cubic specimens (10×10×10) cm^3. The results obtained are shown in Figure 6. The porosity of the material is the first indicator of durability, because porosity is the seat of external aggression, the material is more porous, more penetration of agents is facilitated, and therefore its durability is limited.

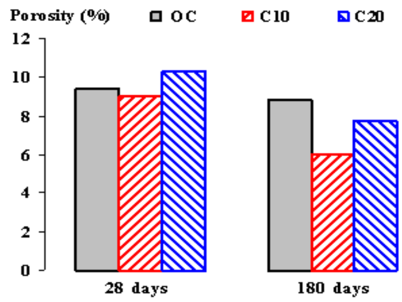


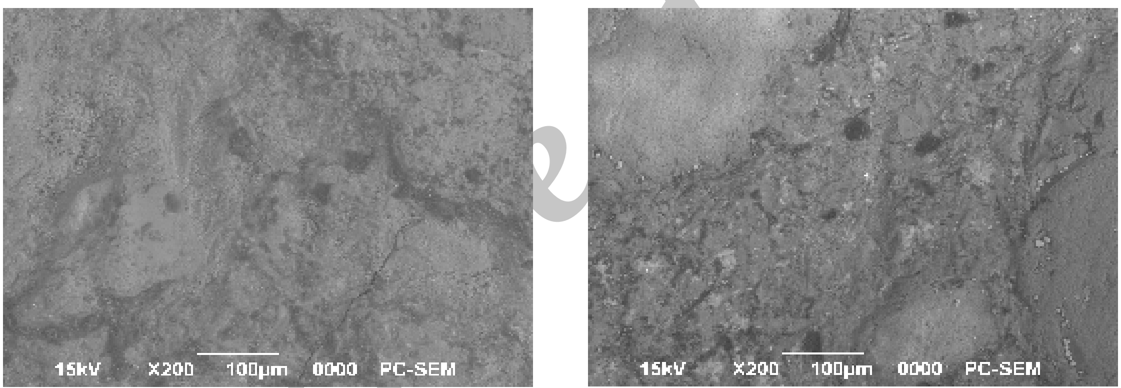
Figure 6. Porosity of concrete as a function of time

The results show that: At 28 days, the concrete porosity C10 is lower than other concretes, which is explained by the high quality of the interface mortar/gravel. At 180 days, the porosity decreases to values shown in Figure 6, the addition of 10% DSP caused a reduction of 32% porosity compared to ordinary concrete. Concrete porosity improve their long term confirms the continuity of hydration reactions, leading to the development of the internal structure by production of new hydration products which precipitate to close the pores existing in the structure, making reduce the number of large pores and increase the small pores.

Interface mortar/gravel

The interface mortar/gravel is often described as an area whose thickness varies from 10 to 50 microns, depends mainly on properties of pozzolanic mineral additions. This area has a high porosity which induces poor mechanical properties. It is often advanced that the adhesion between the gravel and mortar determines the strength of concrete [22].

To examine the interfacial transition zone at 180 days concretes OC and C10, we conducted a larger (×200) using a scanning electron microscope SEM. Notably, the sample must be cut and polished to present a flat surface. The quality of analysis is therefore directly linked to the quality of polishing. The surface analysis is $(2\times2)=4cm^2$ and thickness of the sample should not exceed 1.5cm. Photos obtained are shown in Figures 7a and 7b.



(a) Ordinary concrete containing OPC (b) Concrete based OPC + 10% DSP

Figure 7. SEM observation of the interfacial transition zone

Figures 7a and 7b respectively represent the SEM observation of the contact point mortar/gravel concretes OC and C10. One can see that the interfacial transition zone is almost nonexistent for the C10 concrete, mortar is in direct contact with the gravel. However, a layer about 30 µm between the gravel mortar for ordinary concrete OC.

The microstructure of concrete differs mainly in the degree of detachment at the interface mortar/gravel, the degree of detachment at the interface area to the ordinary concrete OC is always greater than that which prevails in the case of concrete C10. For concrete C10, cracking is literally slowed to interface mortar/gravel by the presence of DSP.

See Figure 7b. The pozzolanic reaction can increase strength to interface mortar/gravel. Indeed, the portlandite crystallizes on the surface of aggregates; the reaction with the DSP can eat it and create hydrates C-S-H type II second generation property related aggregates.

Mechanical properties

The strength is expressed by the power of concrete to resist destruction under the action of stresses due to different compressive loads, flexural and tensile. In this section, this test compression, flexural and tensile splitting on cubic specimens, prismatic and cylindrical, respectively [19]. We crafted three kinds of concretes OC, C10 and C20, each set includes three samples. The specimens were stored in water to prevent water exchange with the outside temperature was kept constant at 20 ± 1°C. The results of strength to 7, 28, 90 and 180 days, are illustrated in Figure 8.

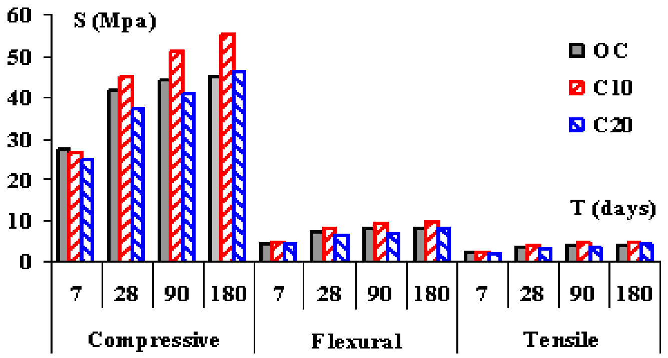


Figure 8. Compressive strength, flexural and tensile strength of concrete as a function of time

Variation of strength with time and type of cement

The evolution of strength as a function of time (7 to 180 days) shows that during the early ages, the strength is low for all samples, whereas the following periods, the strength increases significantly. See Figure 8. This is due to the kinetics of the reaction of cement hydration and reaction of dune sand powder with portlandite.

The presence of dune sand powder accelerates the hydration reaction of Portland cement, this accelerating effect on hydration combined with the effect of filling due to their fineness, can lead to better strength of concrete. The compressive strength, concrete shows that C10 is clearly higher than concretes OC and C20; this also reduces the cement content for strength and a given slump. This last feature is very interesting from an economic standpoint, since cement is the most expensive ingredient in the composition of concrete. Another advantage is that it allows the concrete to continue its mechanical performance even after the period of 28 days.

The effect of dune sand powder on the flexural strength and tensile splitting is similar to that of compressive strength. As noted also that the tensile strength is about 10 times lower than the compressive strength [18].

Variation of compressive strength depending on the porosity

The compressive strength of concrete is inversely proportional to porosity. The contribution of the dune sand powder to improve the compressive strength is much more significant than that on filling the porosity. The mineralogical composition of dune sand powder affects this contribution appears to be the result of a structuring effect improving the mechanical strength of the bonds mortar/gravel.

Deformability

In order to study the influence of dune sand powder on the deformability of concrete at 180 days of hardening, we crafted three kinds of concretes OC, C10 and C20, each series consists of three prismatic specimens (10×10×40) cm^3. The strain was measured using dial indicators with the value of a division of 0.01 mm that are installed using the appropriate forums on a surface of 200 mm in the longitudinal direction and 100 mm in the transverse, including plots of measurement (20 cm apart). The test will focus on the plates of the press as a test failure in compressive [19]. See Figure 9. Following the results of tests were constructed graphs showing the evolution of the relation between the strain modulus of concrete in compressive, the elasto-instantaneous strain longitudinal (t) and relative total (t+Δt) with increasing relative stress.

The results obtained are shown in Figures 10, 11, 12 and 13.

Figure 9. Strain measured during compressive

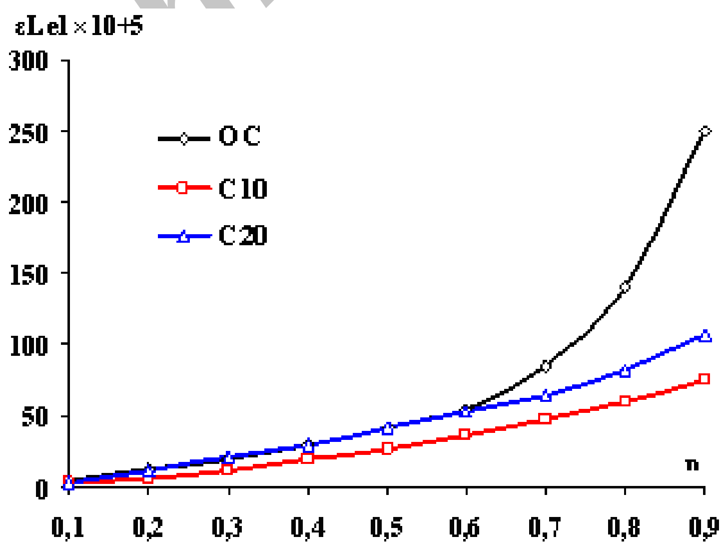


Figure 10. Elasto-instantaneous strain longitudinal of concrete as a function of relative stresses

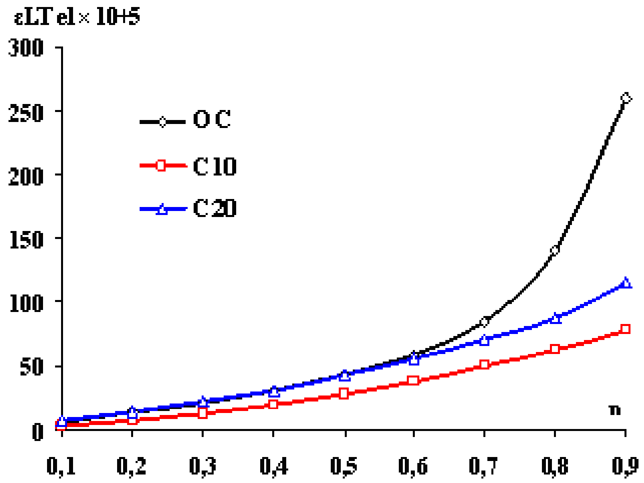


Figure 11 Elasto-instantaneous strain total longitudinal of concrete as a function of relative stresses

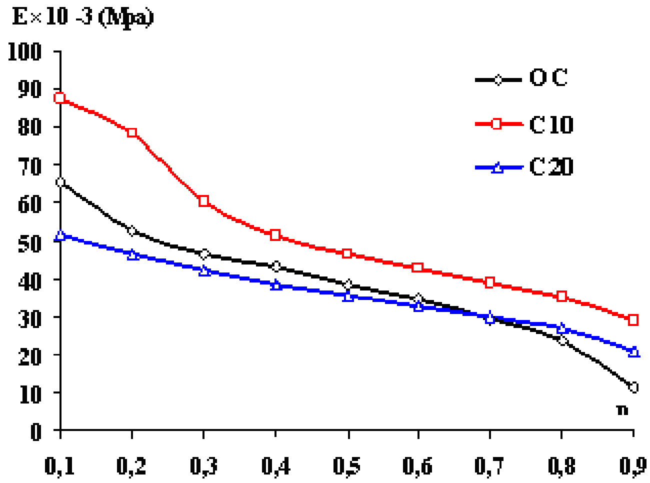


Figure 12. Deformability modulus of concrete as a function of relative stresses

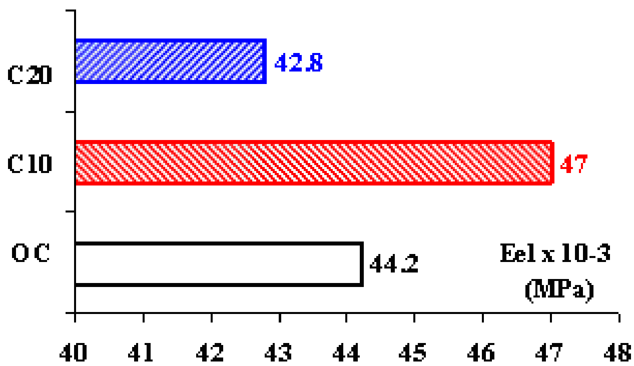


Figure 13. Elasticity modulus of concrete

This study allowed us to highlight the influence of dune sand powder on the strain of concrete in compressive, and specifies a number of points:

The relation between relative stress η and elasto-instantaneous strain of concrete is a straight character in the range η = 0.1 - 0.6, indicating a linear elastic behavior.

The relation between relative stress η and elasto-instantaneous strain is curvilinear in the range η = 0.6 - 0.9, which indicates the development in concrete strain irreversible.

The dune sand powder exerts a significant influence on the evolution of elasto-instantaneous strain longitudinal and relative total a solicitation for short-term. The lowest values of relative total strain own concrete C10, the macrostructure is very compact.

The deformability modulus decreases with increasing relative stress as and as the relative stress increases on the deformability modulus of concrete C10 is higher than that of concretes OC and C20. The elasticity modulus of concrete C10 is higher than that of concretes OC and C20. The elasticity modulus increases as the compressive strength increases, but there is no consensus on the exact form of this relation. The only thing certain is that the increase of elasticity modulus is gradually slow the increase in compressive strength. For transverse strain show trends similar in longitudinal strain.

4. CONCLUSION

The use of dune sand powder in substitution of the clinker in Portland cement is an excellent example of reducing carbon dioxide CO_2 emissions; improve the compressive strengths and even the consistency of fresh mixture (the pastes become more fluid). One can generally observe that after 14 days, the compressive strength at 5, 10 and 15% DSP is superior to Portland cement, with an optimum effect for a percentage of the order of 5% to 10% DSP. The results proved that up to 20% DSP as Portland cement replacement could be used with a fineness of 4000 cm^2/g without affecting adversely the compressive strength.

The dune sand powder presents a crystalline structure siliceous (low-quartz). The XRD analysis revealed the role of pozzolanic DSP. Indeed, the small content of portlandite detected in the cement pastes in the presence of the DSP, reflects the partial pozzolanic reaction, which contributes to increased strength and improves compacting cement pastes by three effects: physical, physical-chemical and chemical. The compressive strengths at earty-age develop due to the acceleration of cement hydration, combined with the physical effect, while those at average and especially long-term develop through the partial pozzolanic effect, which cause the replacement of lime by the calcium silicate hydrate C-S-H semi-crystallized of second generation and transformation of large crystals of lime CH into a product of hydration slightly crystallized (refining of the grains).

The use of the dune sand powder improves overall porous structure of concrete and also contributes to the thickening of the interface (mortar/gravel). Thus, the dune sand powder change the fracture characteristics (deformability), this allows an increase net in durability of concrete. These results justify well the interest that presented valorization of the dune sand.

REFERENCES

1. Benezet JC. Réactivité pouzzolanique dans le système quartz-oxyde de calcium-eau . Thèse de Doctorat, Université de Montpellier II. 1997.
2. Cyr M, Lawrance P, Ringot E. Efficiency of mineral admixtures in mortars, quantification of physical and chemical effects of fine admixtures in relation with compressive strength. *Cement and Concrete Research*, **36**(2006) 264-77.
3. Kara Ali R. Influence des additions minérales sur le besoin en eau et les résistances mécaniques des mélanges cimentaires. Thèse de Doctorat de l'université de Cergy pontoise, 2002.
4. Lawrence P, Cyr M, Ringot E. Minéral admixtures in mortars, effect of inert materials on short-term hydration. *Cement and Concrete Research*, No. 12, **33(**2003) 1939-47.
5. Lawrence P, Cyr M, Ringot E. Mineral admixtures in mortars, effect of type, amount and finesses of fine constituents on compressive strength, *Cement and Concrete Research*, **35(**2005) 1092-105.
6. Felekoglu B, Tosun K, Baradan B, Altun A, Uyulgan B. The effect of fly ash and limestone fillers on the viscosity and compressive strength of self compacting repair mortars. *Cement and Concrete Research*, **36**(2006) 1719-26.
7. Kronlof A. Effect of very fine aggregate on concrete strength, *Materials and Structures*, No. 1, **27**(1994) 15-25.
8. Care S, Linder R, Baroghel Bouny V, De Larrard F, Charonnat Y. Effet des additions minérales sur les propriétés d'usage du béton-Plan d'expérience et analyse statique. LCPC, Ouvrages d'art OA 33. Février 2002.
9. Cheng-Yi H, Feldman RF. Hydration reactions in Portland cement silica fume blends. *Cement and Concrete Research*, No. 4, **15**(1985) 585-92.
10. Benezet JC, Benhassaine A. Influence de la taille des particules sur la réactivité pouzzolanique de poudres de quartz, *Bulletin des laboratoires des Ponts et Chaussés*, No. 219, pp. 17-28. 1999.
11. Arroudj K, Oudjit MN. Influence du sable de dune finement broyé sur l'hydratation des ciments, 2éme Colloque Maghrébin en génie civil, Biskra, Algérie les 10 et 11 Décembre, 2002, pp. 119-127.
12. Arroudj K, Oudjit MN, Lanez M, Carayon MT. Mise en évidence par diffractométrie aux rayons X des C-S-H de seconde génération, 1ére séminaire sur les technologies du béton, le béton, perfection et incertitudes, 18-19 Septembre, Alger, 2004, pp. 1-8.
13. Guettala S, Mezghiche B, Mellas M. Adding finely crushed dune sand to cement on the evolution of hydration of Portland cement paste, *Asian Journal of Civil Engineering (Building and Housing)*, No. 2, **11**(2010) 241-51.
14. Bouchouika A. Etude physico-chimique et mécanique des bétons à hautes performances à base de matériaux locaux, Thèse de Magister, ENTP, 2002.
15. De Larrard F. Formulation et propriétés des bétons à très hautes performances, *Rapport de Recherche L.P.C No. 149*, Laboratoire Central des Ponts et Chaussées, Paris, France. Mars 1988.
16. Pascal P., Nouveau traité de chimie minérale (Silicium). Tome VIII, 2éme fascicule. Paris, Masson, pp. 2-90 et pp. 423-445, 1965.

17. Bogue R.H., *Chemistry of Portland Cement*. New York, Reinhold. 1955.
18. Guettala S, Mezghiche B and Chebili R. Interest and effectiveness of the addition of the sand of dune finely crushed to cement, on the properties of the concrete, Sun light publishing CANADA, *World Journal of Engineering*, No. 1, **4**(2007) 45-53.
19. Mezghiche B. Les essais de laboratoire des matériaux de construction. Publication Universitaire Biskra, 120. 2005.
20. Gallé C. Effect of drying on cement-based materials pore structure as identified by mercury intrusion porosimetry. A comparative study between oven-, vaccum-, and freezedrying, *Cement and Concrete Research*, **31**(2001) 1467-77.
21. AFPC-AFREM, Méthodes recommandées pour la mesure des grandeurs associées à la durabilité, Compte rendu des journées techniques du 11 et 12 Décembre, Toulouse, 238. 1997.
22. Gao JM, Qian CX, Liu HF, Wang B, Li L. ITZ microstructure of concrete containing GGBS, *Cement and Concrete Research*, No. 7, **35**(2005) 1299-304.
23. Guettala S, Mezghiche B. Compressive Strength and Hydration with Age of Cement Pastes Containing Dune Sand Powder. *Construction and Building Materials-Elsevier*, No. 3, **25**(2011) 1263-69.