Contribution to the Mechanical Study of Cement Intended for Aggressive Environments with Mineral Additions

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Abstract. The Portland cements are increasingly used for the manufacture of cement materials (mortar or concrete). Sighting the increasing demand of the cement in the field of construction, and the wealth of our country of minerals. It is time to value these local materials in construction materials and in the manufacture of cement for the manufacture of a new type of cement or for the improvement of the cement of characteristics for several reasons either technical, or ecological or economic or to improve certain properties to the State fees or hardened.

The uses of mineral additions remain associated to disadvantages on the time of solidification and the development of the mechanical resistance at the young age [8]. The objective of our work is to study the effects of the incorporation of additions minerals such the pozzolan (active addition) [3], slag of blast furnace (active addition) [4] and the sand dune powder (adding inert) on the mechanical properties of compositions of mortar collaborated compositions according to different binary combinations basis of these additions. This will allow selecting of optimal dosages of these combinations the more efficient, from the point of view of mechanical resistance as well. The results of this research work confirm that the rate of 10% of pozzolan, slag or powder of dune sand contributes positively on the development of resistance in the long term, at of this proportion time, there is a decrease in the latter except for the slag (20 - 40%) [4] Seems the more effective resistors and physical properties.

Keyword: cement, clinker, pozzolan, slag of blast furnace, dune sand, mortar, aggressive

1. INTRODUCTION

Currently in Algeria, and in front of the growing demand in habitat materials, the construction is going through a critical phase where arise together, several issues relating to the costs, the implementation deadlines, availability of construction materials, to the fluidity of their distributions and of materials adaptation opportunities to the climatic context of each region. The valorization of local resources and the search for a new range of construction materials can solve at least in part the problems outlined above. It is for this context that opens the reflection on the valorization of local materials in the construction materials. The use of local materials and industrial waste recovered and recycled, such that the industrial waste and the natural deposits as the pozzolan and the dune sand, as products of partial substitution of Portland cement allows the manufacture of a new material (cement) less expensive and sustainable.

This experimental work allows you to value and to study the effect of dune sand powder, the pozzolan and the slag with the clinker on the mechanical properties behavior of clinker and minerals mixture we varied the percentage of these last (0 to 40%) [4,5,10], with a view to obtaining cement with some different properties.

2. MATERIALS USED

In our work; we have used the following materials:

- clinker CRS from the cemetery of ZAHANA MAASCARA.
- natural pozzolan extracted from the deposit of BOUHAMIDI in south of BENISAF.
- slag of blast furnace obtained from the plant of steel EL-HADJAR.
- the dune sand crushed provenance of dune sand of AIN BEIDA OUARGLA.

The compositions of materials used are shown in the following table.

Table 1: chemical composition of materials used

	CaO	SiO_2	Al_2O_3	Fe_2O_3	SO_3	K_2O	Na_2O	MgO	RI	PAF	Cl	SSB cm^2/g	ρ g/cm^3
clinker	66,59	22,07	3,58	5,91	0,06	0,41	0,428	1,29	0,13	0,27	-	4100	3.250
pozzolan	31,73	30,53	9,91	0,09	1,12	1,39	3,00	1,36	-	10,25	-	4500	2.590
Slag	14,96	39,72	15,76	12,44	0,36	1,495	2,31	-	-	11,66	0,008	4322	2.920
Dune sand crushed	3.7	89,67	0.24	0.25	1.03	0.07	-	0.61	-	1.09	0.02	4600	2.660

Table 2: mineralogical composition of the clinker

C_3S	C_2S	C_3A	C_4AF
70.18	6.93	0	17.97

3. PREPARATION OF THE CEMENT STUDIED:

The experimental study of our work allows you to substitute the additions such minerals-that the pozzolan, slag and dune sand with the clinker then characterized the composite material. The table below shows the different compositions of cement to study.

Table 3 compositions of cement studied

	Marking	K (%)	PZ (%)	L (%)	SD (%)
C01	Witness	100	0	0	0
C02	PZ 10	90	10	0	0
C03	PZ 20	80	20	0	0
C04	PZ 30	70	30	0	0
C05	PZ 40	60	40	0	0
C06	L 10	90	0	10	0
C07	L 20	80	0	20	0
C08	L 30	70	0	30	0
C09	L 40	60	0	40	0
C10	SD 10	90	0	0	10
C11	SD 20	80	0	0	20
C12	SD 30	70	0	0	30

C13	SD 40	60	0	0	40

K : clinker
PZ : pozzolan
L : slag of blast furnace
SD : dune sand powder

We have effectuated the following tests:

- Loss at the fire
- Density of cement (according to the ASTM standard C 188-72)
- Mechanical resistance (according to the Standard NF EN 196-1)

All tests are carried in the laboratory of the cemetery plant of Ain Touta BATNA under conditions normalizes to 20±2° of temperature and humidity higher than 65%,

4. FORMULATION OF MORTARS

We will use the normal mortars prism 4x4x16 cm^3, according to the standard NF P15-403 whose composition is the following:

- 450 g of cement, the additions always being introduced in substitution of the cement [7].
- 1350 g of sand normalized. (this corresponds to a sand report /cement equal to 3) [7].
- The rate of the mixing water was kept constant for the whole of the spoiled (E/C=0.50) [7].

The Mortar normal is mixed with an automatic mixer in a tank of five liters responding to the characteristics of the standard NF P15-411.

5. EQUIPMENT REQUIRED FOR THE DETERMINATION OF THE MECHANICAL RESISTANCE

The whole is described in detail by the standard NF EN196-1. It is enumerated above [7].

- A room maintained at a temperature of 20 °C ± 2 °C and a relative humidity greater than or equal to 50%.
- A room or a wet cabinet maintained at a temperature of 20 °C ± 1 °C and a relative humidity greater than 90%.
- prismatic molds normalized to 3 alveolus, to square section 4cm×4cm and 16cm length (these tubes are called "SPECIMENS 4×4×16cm^3").
- A device to shocks to apply 60 shocks to the mussels in the fall from a height of 15mm±0.3mm to the frequency of a drop per second during 60 s.
- A testing machine of resistance to bending three points to apply loads with a speed of release for load of 50 N/s ± 10N/s.
- A testing machine of compression to apply loads up to 150 KN (or more if the tests require) with a speed of loading of 2400 N/s ± 200 N/s. This machine is equipped with a compression device.

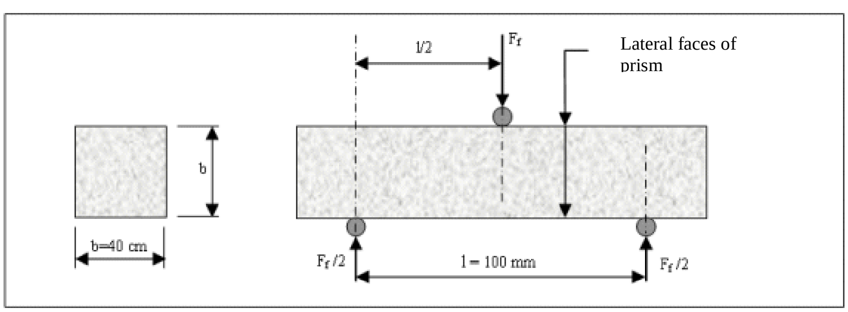

Figure 1 device for the test of resistance to bending [8]

If F_F is the breaking load of the test piece in bending, the moment of rupture calculated with the Equation (01) and the flexural stress is calculated with the equation (02):

$$M_F = \frac{F_F \times L}{4} \quad \dots \dots \dots \dots \dots (01) \qquad\qquad R_f = \frac{1{,}5 \times F_F \times L}{b^3} \quad \dots \dots \dots (02)$$

This constraint is called the resistance to bending. Taking into account the dimensions B and L, If F_F is expressed in Newtons (N), this resistance expressed in Mega Pascals (MPa) is worth (equation 03):

$$R_F(MPa) = 0{,}234 \times F_F \quad \dots \dots \dots (03)$$

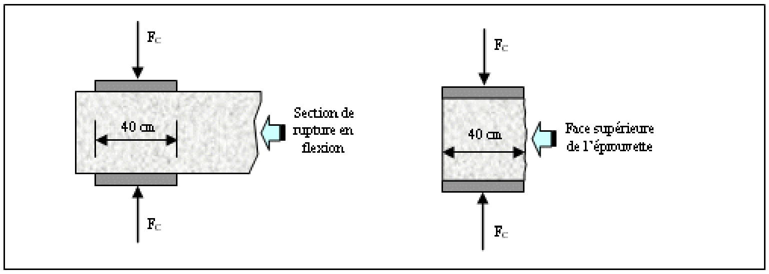

Figure 2 Device of rupture in compression [7]

The half-prisms of the test piece obtained after a rupture in bending will be broken in compression as shown on the Figure 2. If F_C is the breaking load, the constraint of rupture will be worth:

$$R_c = \frac{F_c}{b^2} \quad \dots \dots \dots \dots \dots (04)$$

This constraint is called resistance to compression and, if F_C is expressed in Newton, this resistance expressed in Mega Pascals is worth:

$$R_c(MPa) = \frac{F_c}{1600} \quad \dots \dots \dots (05)$$

RESULTS AND INTERPRETATIONS

The figures above show the evolution of the resistance to compression and bending of different binary combinations.

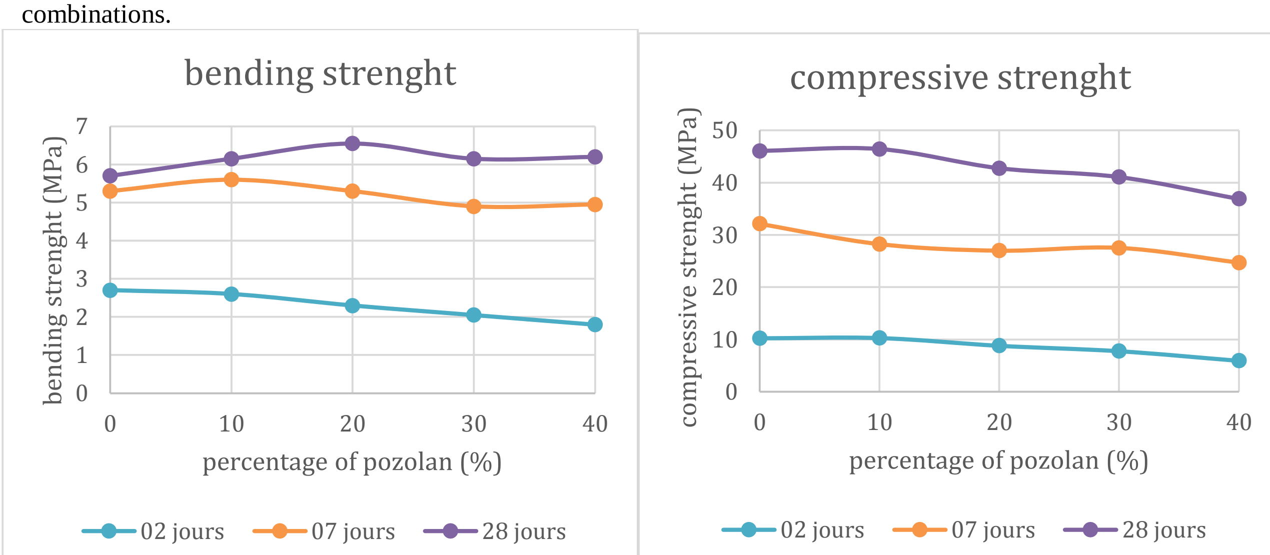

Figure 3 evolution of resistance with Substitution of natural pozzolan

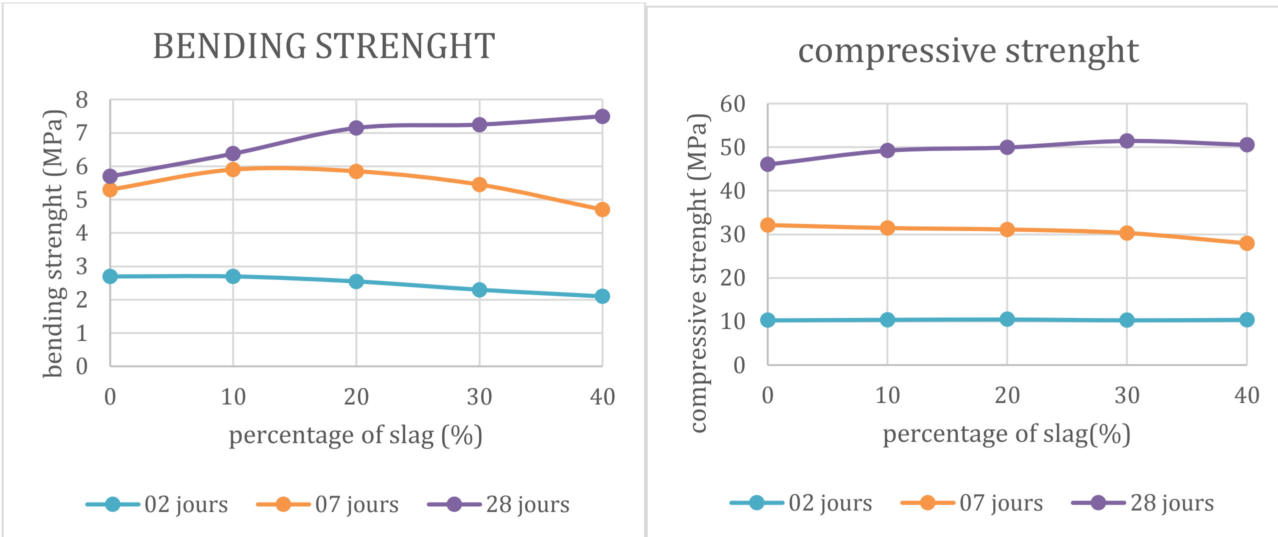

Figure 4 evolution of resistane with Substitution of slag to blast furnace

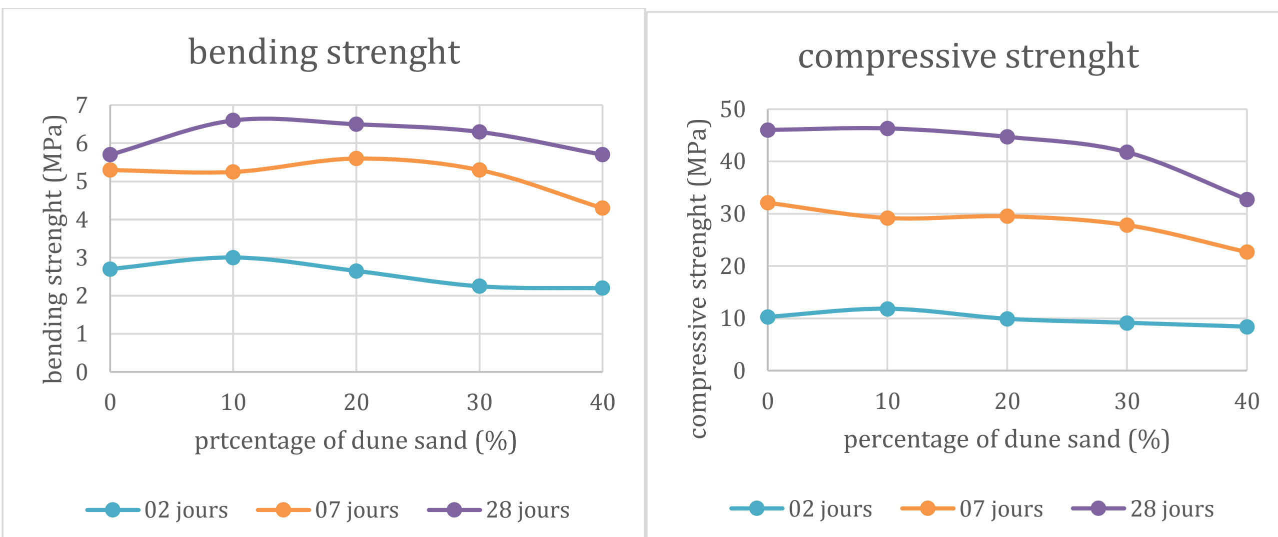

Figure 5 evolution of resistance with Substitution of dune sand crushed

Table 7 Physical Characteristics of the compositions

	Witness	To the pozzolan				To slag of blast furnace				To the powder of dune sand			
	0	10	20	30	40	10	20	30	40	10	20	30	40
Density (g/cm^3)	3.25	3.18	3.08	3	2.97	3.19	3.12	3.1	3.04	3.12	3.08	3	2.91
PAF (%)	0.55	0.84	1.77	3.76	3.98	0.37	0.41	0.48	0.56	0.66	0.85	1.02	1.34

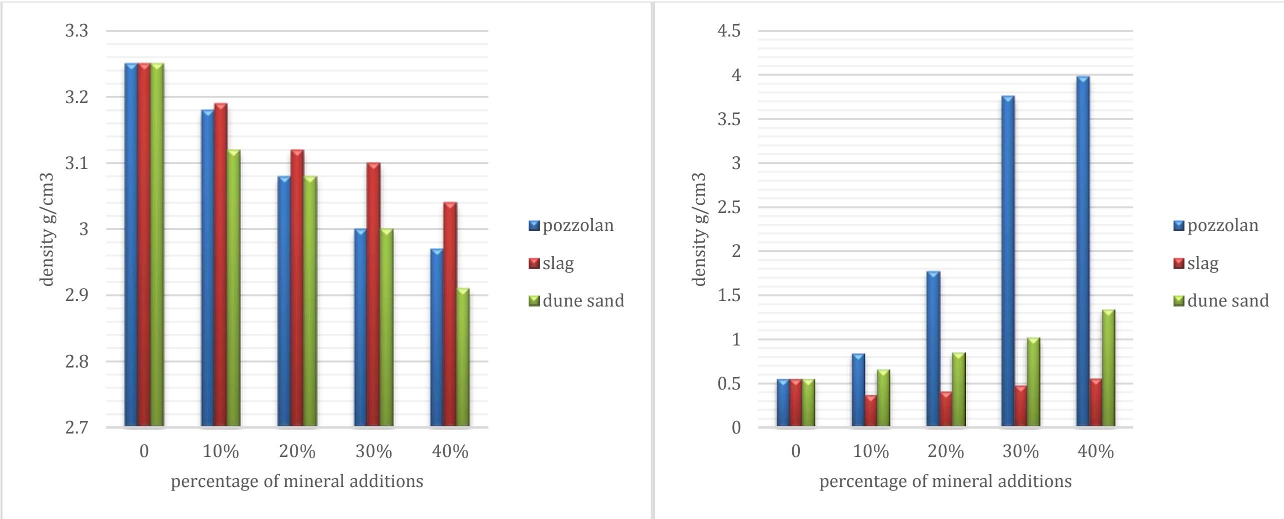

Figure 6 evolution density and loss in fire by substitution of mineral additives

According to the results of the tests of physical we note that:

- The evolution of resistance to compression of mortar of powder of dune sand always gives resistance that remains low to that of mortar witnesses.
- The resistance to compression to 28 mortar rounds in the basis of pozzolan still remains lower than that of mortar witness, and the substitution of 10% of PZ severe to the more effective resistance by report of the Mortar witness. The substitution of slag shows that the resistance to compression evolves to the more effective resistance to the composition of 40% L. as the same for the bending.
- The use of mineral additions can improve the cement characteristic (increased maneuverability, decrease of permeability and capillarity, reduction of the fissurability, adhesion, mechanical resistance, the density…….). This is shown in the table of the physical characteristics of the different combination.
- The substitution of 10% SD gives the most effective resistance to compression and bending.
- The influence of C_3A and SO_3 on the cement obtained, which we have noticed in the course of preparation of test specimens that the cement characterized by a time of slow socket and of the resistance has short term low.
- The fall of the resistance of the compositions in the long term is influenced by C_3S low proportion that is responsible for the resistance in the long term.
- The substitution of slag of blast furnace gives us the best results in the density and resistance, in proportions below 30%

CONCLUSION:

The experimental study of Mortars mechanical behavior made of different combinations, allows us to move forward some conclusions:

The experimental study of the behavior mechanical Mortars made of different combinations, allows us to advance some conclusions. The mechanical resistance of the mortars to basis of powder of slag of blast furnace that either in compression or in bending increases at the function of time and gives us the most effective resistance.

The compositions of 10% of pozzolan and composition of 10% of dune sand powder show the optimum resistance in relation to the composition witness, beyond this percentage there is a decrease in resistance

The use of mineral additions can improve the physical and ecological properties of cement obtained. Normal consistency improved material and little dense. For the improvement of the time taken and the resistance at the young age of cement obtained, we must increase the rate of C_3A and of SO_3 by the addition of Percentage of gypsum between 0 to 5%.

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La substitution de laitier d'haut fourneau nous donne des meilleurs résultats dans la densité et de résistance, dans des proportions inférieurs à 30%.