THE FORMULATION OF NEW CONCRETE FROM SAND DUNE OF THE WESTERN ERG OF ALGERIA

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Abstract - The southern Algeria is known for its huge sand dunes that cover part of its territory (Sahara). This sand has features that allow a glimpse of a recovery in the construction field in the form of Ultra High Performance Concrete (UHPC). This type of concrete using a large amount of silica fume, ultra fine addition that gives very high performance but is also relatively rare and expensive. Replacing it with another addition to equivalent properties,such as metakaolin, can also be considered. The objective of this study is to both enhance the sand dunes of Erg south west western Algeria but also reduce manufacturing costs of Ultra High Performance Concrete to incorporating metakaolin to instead of silica fume. Performances to determine mechanical performance are instantaneous, compression and bending. Initially, we characterized the Algerian sand dune. Then, we have to find a formulation of UHPC, adequate in terms of implementation and to replace silica fume by metakaolin. Finally, we studied the actual value of the sand dune. Concrete obtained have very high mechanical performance, up to a compressive strength of 250 MPa, a tensile strength of 45 MPa by bending with the method of heat treatment. This study shows that the enhancement of dune sand studied is quite possible in UHPC, and in particular UHPC bundles and the replacement of silica fume by metakaolin do not alter the properties of these concretes.

Keywords - Ultra High Performance Concrete in, sand dune, formulations, silica fume, metakaolin, strength.

I. INTRODUCTION

South west Algeria is known for its sand dunes, which decorate postcards and are tourist destinations, but also that gobble up land and palm trees and invade some oasis. However, this sand which occupies 6% of the surface of the Algerian Sahara is not currently valued [1]. Many researchers in various scientific topics, seeking to exploit this type of sand, clean and present in abundance. Its use may be related to its very high silica content, material at the base of applications in electronics and optics, for example. In civil engineering, this sand is also of great economic and environmental benefits for Algeria. Indeed, the growing demand of building sand in Algeria, the inability of the Algerian quarries to supply sand and the sleep timer using the beach sand, which led to a major problem for ecological and tourist Algeria, are all reasons why the valuation of this product. We're interested in promoting this type of sand. Given its size (very fine sand, of course less than 0.5 mm), its morphology, its cleanliness and its hardness, we focused on its valuation in the Ultra High Performance Concrete in (UHPC), from concrete recent research (1980) and still not developed in Algeria. However, these concretes have mechanical properties and durability remarkable allow specific uses, whether in the field of construction (joists, beams) and civil engineering (bridges, pipes), that of mechanical engineering (tools, molds stamping) [2, 3]. The UHPC result of basic research on the arrangement and granular crystalline structure. UHPC matrix consists of cement CEM I 52.5, silica fume, silica sand selected (dmoy = 250 µm) of ground quartz (dmoy = 10 µm), and superplasticizer and water [4, 5]. These materials can also be baked at temperatures above 90°C to improve their performance. Indeed, heat treatment is UHPC for a way to improve their mechanical performance due to the transformation above 100 ° C hydrate amorphous crystalline products (tobermorite, xonotlite) that achieve improved resistance [6, 7]. However, these concretes are still little used and their implementation are still exceptional, largely because of high costs associated with the extensive use of expensive components (silica fume, cement, superplasticizer, and to a lesser extent, silica sand fine and pure). The use of sand dune would be a first step in cost reduction. With very low water / binder ratio, the presence of silica fume is causing the performance of UHPC. His finesse gives a very good filling capacity, and, combined with its amorphous structure; its strong pouzzolanicity allows an increase in concrete strength and improved durability [8]. Due to its characteristics and unique properties, the status of silica fume rose from industrial waste to that of high-end product for which demand is constantly rising market. As a result, the product is quite expensive and its availability is limited to the production capacity of silicon industries. The dosage of silica fume used in the manufacture of a UHPC is generally very high, around 150 to 250 kg/m3 (10 to 30% of the mass of cement) [9]. In addition, silica fume is the cheapest in the form of a very dark gray powder. Its use can be proscribed as aesthetic considerations require light shade. There are also precipitated silica fume, white but are more expensive. Economic considerations mentioned earlier are more important. We can reasonably assume that the replacement of silica fume by another

ultrafine a lower cost, the availability of which would not pose any particular difficulties, promote the development of UHPC in the concrete industry [10]. There are several types of ultrafine worth your interest with characteristics and performance variables according to their origin. In this study, a metakaolin obtained by calcination in a fixed bed of kaolinite, natural clay exists in large quantities in all continents, was tested in comparison with silica fume [11].

So the formulation of an Ultra High Performance Concrete from sand dune and metakaolin would significantly reduce construction costs and open new opportunities for civil engineering companies in Algeria and elsewhere

II. MATERIALS, FORMULATION AND TESTING

A. Materials

- **Cement**

The cement used is Portland cement CEM I 52.5 N PMES CP2 whose chemical and physical characteristics are presented respectively in the Table I and Table II. This cement is chosen for its mechanical properties (name CEM I 52.5) and low C3A (PMES name) and high specific surface area [12] which allows both a sharp reduction in water content and adjuvant handling constant, and also limits the risk of incompatibility with certain adjuvant.

Table I: Chemical composition of the materials

Compound (%)	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K2O	SO3	Loss on ignition
Cement	22.50	2.00	2.80	67.30	0.75	0.19	0.19	2.10	3.00
Silica fume	> 95.00	-	-	-	-	0.60	-	-	-
Metakaolin	58.10	35.14	1.21	1.15	0.20	0.07	1.05	0.03	1.85
Crushed quartz	98.50	0.75	0.05	0.03	-	-	0.06	-	0.20

Table II: Physical properties of the materials

Properties	Cement	SF	Metakaolin	Crushed quartz
Blaine fineness (m^2/g)	0.339	20 to 26	15 to 30	0.690
Pouzzolanique index (lime mg per g)	-	-	610 ± 60	-
Average particle size, D50 (µm)	-	0.3	12.0	11.0
Specific gravity	3.16	2.24	2.50	2.65

- **Additions**

Silica Fume

Silica fume is a gray powder, and after the manufacturing industry of ferrosilicon. Its chemical and physical characteristics given respectively in Table 1 and Table 2.

Metakaolin

The metakaolin has a used in this study particle size shown in Fig. 1. These chemical and physical characteristics are presented respectively in Table 1 and Table 2.

The ground quartz

Ground quartz used for heat-treated formulations has a particle size shown in Fig. 1.

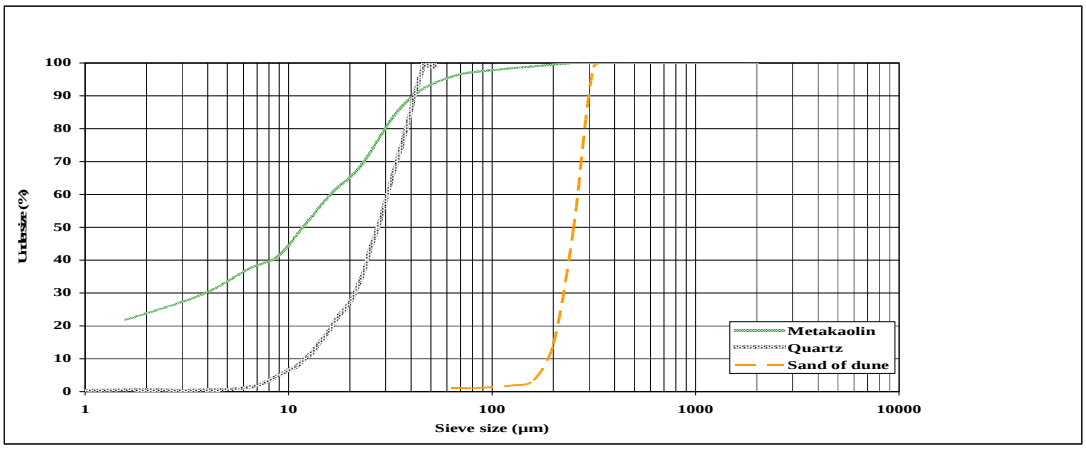


Fig. 1. Grading of quartz sand and crushed quartz.

The physical and chemical characteristics are given in Table I and Table II.

- **Aggregates**

A quartz sand dunes of Erg western region southwest of Algeria with a high purity (SiO2> 98.5%), with a particle size and chemical characteristics are given in Fig. 1 and Table I. In addition, ground quartz was used. Its characteristics are given in Table I and Table II.

- **Adjuvant**

The high water-reducing superplasticizer used in accordance with standard NF EN 934-2 [13], is based acrylic copolymer, Next Generation chlorine-free.

- **Fibres**

Steel metal fibers 13 mm long and 160 microns in diameter were used.

B. Formulations

Table III presents the formulas chosen after optimization of the granular skeleton and the dosage of superplasticizer, from the dune sand reinforced with steel fibers, silica fume or metakaolin [11].

Table III: Proportions of concrete mixture (kg/m3) with silica fume and metakaolin

Materials	UHPC with SF	UHPC with MK
Cement	691	691
Siliceous sand	759	759
Silica fume	172	0
Metakaolin	0	172
Crushed quartz	276	276
Metal fibers	138	138
Superplasticizer	22.0	22.0
Total water	187.3	187.3
Density theoretical (kg/m^3)	2399	2442
Water/Cement (W/C)	0.27	0.27
Water/Binder (W/B)	0.22	0.22
(SF or MK)/C (%)	25	25

C. Testing

- **Production of UHPC**

All concretes were mixed in a mortar mixer with a vertical axis of 10 liters, for blending and homogenizing the mixture of powders [12, 14]. The total duration of mixing is higher than that of conventional concrete. The sequence of mixing is:

1. Mixing of dry powders: 2 minutes.
2. Introduction of water and half of the superplasticizer: 2 minutes.
3. Introduction of the second part of the superplasticizer, mixing until thinning.
4. Introduction of fibers, mixing at high speed 1 minute.

It is noted that in all cases, the time for making a UHPC from sand dune does not exceed 8 minutes. This can be explained by the rounded grains of sand dune and cleanliness. We also note that the replacement of silica fume by metakaolin leads to a slight increase in mixing time, which may be related to the shape of the ultrafine grain less favorable to the workability. Finally, the addition of fibers requires a larger mixing time for a similar handling [15].

- **Implementation of UHPC and preservation methods**

The UHPC was introduced by gravity in different molds for the different tests. However, mussels were shaken manually to make bubbles of air trapped in the material. It should be noted that waiting too long (more than 30 minutes) between the manufacturing and molding can cause a significant reduction in handling, making it difficult to set up.

The molds are then covered with plastic film to prevent excessive departure of free water in concrete by evaporation. They are then kept in a room at 20°C ± 1°C without moisture exchange for 24 hours. After release, a group of specimens immersed in water at 20°C until maturity test (1, 7, 14, 28 days). A second group is subjected to heat treatment at 90°C or 150°C for 3 days after a course of 4 days at 20°C in wet room.

- **Heat treatment of specimens**

In this study, the specimens were submitted after 4 days of curing at 20°C in a moist chamber, with two types of heat treatment for 3 days in the cycle of Fig. 2: either to heat treatment at 90 °C or 150°C.

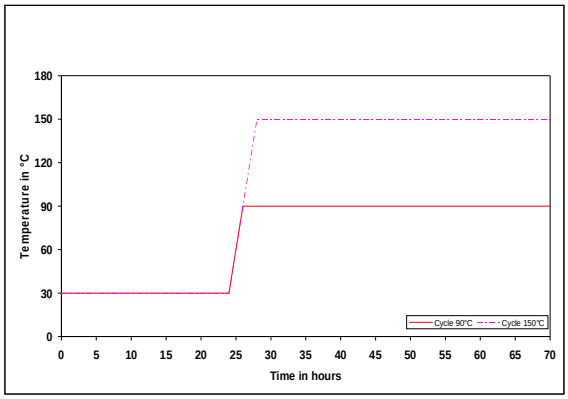


Fig. 2. Steam curing cycle

Initially, the specimens are placed in an oven at minimum temperature of 30°C for 24 hours to stabilize the entire section of the specimens at this temperature. Then, the temperature at 90° C or 150°C at a controlled rate of increase (up to 20°C / h according to Taylor [16]) and held for two days. Samples are then allowed to cool naturally in the oven for one day after turning it off.

- **Characterisation tests**

Test spreading and flow

The test is done to spread using the mini cone mortar. Fig. 3 (a) and (b) provides an illustration of the spread

obtained, shape and color, depending on the type of fine.

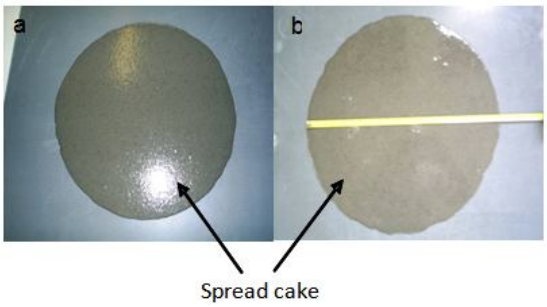


Fig. 3. Spreading UHPC with (a) silica fume or (b) metakaolin

Flow test of workability

The flow test of workability is measured by the standard (NFP 18-452) [17]. For all formulations studied.

Measurement of the amount of air entrained

According to standard EN 12350-7 [18], we can estimate the amount of entrained air in fresh concrete using a hydrometer to concrete (or mortar) with a capacity of at least 1 liter.

Determination of bulk density and porosity

The bulk densities and porosities accessible to water various concrete in the hardened state are determined from the experimental mode described as recommended by the AFGC-AFREM [19].

III. RESULTS AND DISCUSSIONS

A. Instantaneous behavior

- **Behaviour in spawning condition**

Test spreading and flow

Spreading the values and flow measured for the two formulations are presented in Table IV for the two types of fine silica fume and metakaolin.

Table IV: Results of rheological UHPC

Specimen	with SF	with MK
Spreading [cm]	48	41

The differences seem to indicate a water demand and a higher viscosity in the presence of metakaolin in comparison with the material incorporating silica fume. However, even if the metakaolin reduces the workability of our UHPC, it remains in proportions that still allow a good development. The AFGC does not endorse any specific recommendations vis-à-vis the handling of UHPC. It is still advisable to conduct a document proving that the non-segregation of fibres [20]. This may indeed be problematic in cramped and forms confined often used for applications such elements slender and thin why are these concretes. In the case of our UHPC, we have not found excessive heterogeneous distributions of the fibres. This can be explained by their small size fibres (13mm) and the friction generated limited with aggregates of small size also.

Flow test of workability

Maneuverability obtained is equivalent to the time of 2 seconds of flow measured at the mortar workability. These results in very short time a large flow of our materials that we cannot distinguish the type of influence or of fine sand on the flow, contrary to what was noted in the test spread. The UHPC studied have a rheological behavior similar to that described by Bonneau [21]. They are easy to mold self-compacting materials and well adapted to prefabrication. They can be used to produce shapes of varying complexity and obtain an excellent reproduction of detail thanks to their fluidity and quality of surface without bubbling [22].

Measurement of the amount of air entrained

The amount of air entrained the two formulations studied in the fresh state is between 1.8% and 2.0% respectively for samples with silica fume and those with metakaolin. These values are the same as those of ordinary concrete. They also correspond to the magnitudes of the measured values of the UHPC by Rougeau (3%) [23] and BPR200 Roux et al (1%) [24].

Determination of bulk density and porosity

Table V presents the results.

Table V: Apparent density and porosity of the various formulations

Specimens	with silica fume	with metakaolin
Bulk density (g/cm^3)	2.382	2.362
Porosity (%)	6.3	7.1

Note that the bulk densities of our materials are virtually identical. However, there is a slight difference in porosity between the concrete incorporating silica fume (6.3%) and those with metakaolin (7.1%). The larger amount of voids in the UHPC with metakaolin, associated with higher density compared to the ultrafine silica fume in the same dosage, could explain the fact that the densities are equivalent. Overall, these pores are in the top of the range of values (between 1.5% and 6%) usually obtained for UHPC [25], which constitute the family of the most compact concrete. However, it is known that the porosity accessible to water is highly dependent on the technique used and, among other things, the vacuum samples during testing.

- **Compressive Strength**

Compressive strength without heat treatment

The results of the compressive strength of two formulations of UHPC without heat treatment

correspond to the average of six trials on two pieces of three prismatic specimens (40×40× 160 mm) previously tested in bending. They are presented in Table VI for the four maturities of 1, 7, 14 and 28 days.

Table VI: Compressive strength without heat treatment [MPa]

Specimens	with SF	with MK
Time (days)	Compressive strength [MPa]	
1	70	52
7	124	108
14	149	133
28	169	184

On expiry of 7 days, all concrete develops compressive strengths exceeding the value of 100 MPa. At 28 days, the UHPC have reached maximum strength, 184 MPa, is the UHPC with metakaolin.

Compressive strength according to the heat treatment

The results obtained for the two heat treatments for drying at 90°C and bake at 150°C are summarized in Table VII.

Table VII: Compressive strength [MPa]

Specimens		with SF	with MK
No steamed	fcm28j	169	184
Steamed at 90°C	fcm e90	243	197
Steamed at 150°C	fcm e150	254	246

These resistances were measured after one day cooling, which corresponds to a maturity of 8 days after casting, and are the average score of 6 tests per formulation (on specimens 40×40×160mm).

In accordance with the interim recommendations of the AFGC on UHPC [25], following this process, we can consider that our concrete has reached final maturity, without waiting 28 days as for conventional concretes. We can observe that the resistance values of UHPC steamed exceeds 200MPa in the dispersion of results about (only with metakaolin UHPC approach this value up to 197 MPa after drying at 90°C). This observation allows us to assign the name reactive powder concrete RPC200 to all of our heat-treated UHPC at 90°C and 150°C. These results show that steaming improves the compressive strength of UHPC and that this increase in resistance is much higher than the baking temperature is important. This phenomenon has been observed in other studies of these types of concretes incorporating silica fume and crushed quartz [5, 21, and 26]. It has been linked to the formation of new crystalline hydrates tobermorite namely (C6S6H5) and xonotlite (C6S6H) (beyond 200°C) [27, 28]. The addition of silica fume, in addition to its ability to accelerate the pouzzolanique reactions, and ground quartz helps promote the formation of good crystalline hydrates and thus achieve great resistance. It seems to be the case with the metakaolin.

- **Modulus of elasticity and Poisson's ratio**

The modulus of elasticity in compression of the various Ecm concrete was determined from measurements of strain gauges in the simple compression tests. The results of elastic modulus and Poisson's ratios are presented in Table IX. In terms of concrete steamed, only the modulus of elasticity of concrete heat-treated at 150°C were determined.

Table IX:Values of the modulus of elasticity, experimental and calculated according to Eurocode 2 and BPEL99 regulations, and values of Poisson's ratios of the various concretes, with and without heat treatment at 150°C

			with SF	with MK
28 days non heat-treated	Average compressive strength fcm [MPa]		169	184
	Characteristic resistance in compression fcj [MPa]		153.6	167.3
	Modulus of elasticity [GPa]	Experimental	42.7	42.6
		BPEL99	58.9	60.6
		EC2	51.4	52.7
	Poisson’s ratio		0.21	0.22
treated at 150°C	Average compressive strength fcm [MPa]		254	246
	Characteristic resistance in compression fcj [MPa]		230.9	223.6
	Modulus of elasticity [GPa]	Experimental	39.0	39.4
		BPEL99	67.5	66.7
		EC2	58.1	57.5
	Poisson’s ratio		0.19	0.17

The experimental values of the modulus of elasticity are compared with the values calculated by model BPEL99 [29] and Euro code 2 (EN 1992-1-1) [30] from the measured compressive strengths: Formula Euro code 2 (EN 1992-1-1):

$$E_{cm} = 22\left(\frac{f_{cm}}{10}\right)^{0,3} \quad (1)$$

Where:

Ecm is the instantaneous modulus of elasticity of concrete at 28 days fcm is the average resistance measured at 28 days. In the case of concrete oven at 150°C, since we consider that the concrete reaches maturity after the heat treatment, the calculation of regulatory modules of elasticity will be made from the values of compressive strength measured at 8 days (after 1 day cooling). BPEL99 formula [29]:

$$E_{i28} = 11000 \left(f_{c28} \right)^{1/3} \quad (2)$$

Where:
Ei28 is the instantaneous modulus of elasticity of concrete at 28 days fc28 is the characteristic strength of concrete at 28 days. In accordance with Article 2.1.2 of this regulation, the value of fc28 is taken as the value of the average compressive strength measured divided by 1.10. Concrete not have steamed modulus of elasticity comparable (42.7 and 42.6 GPa, regardless of the formulation). After heat treatment at 150°C, there was a decrease in modulus of elasticity in similar proportions for all concrete, while the compressive strength is significantly improved for both concretes. This result, surprising at first glance, could be explained by the different type of hydrates formed with or without heat treatment. The degree of hydration of the dough, potentially variable depending on the temperature of treatment, could also affect the modulus of elasticity, if one based on the result of Vernet et al [31] have shown that anhydrous particles, representing approximately 50% of the total amount of cement, could be regarded as micro-aggregates of elastic modulus of 120 GPa. The modulus of elasticity of our materials are lower than the value of 49 GPa obtained by Bonneau [21] on a UHPC kept in water at 90°C for 3 days and compressive strength of 217 MPa. But a more detailed literature survey shows, for a class of compressive strength data, a significant dispersion of results of the mechanical characteristics likely due to changes in formulations and cure. Thus, Dugat et al [26] measured the elastic modulus between 60 and 66 GPa for UHPC heat-treated at 90°C for compressive strengths between 190 and 200 MPa. Comparative analysis with the design rules can be seen that the measured values of modulus of elasticity are lower than those calculated, especially with the BPEL99 which tends to overestimate high modulus of elasticity, while the predictions of the Euro code 2 are they more accurate. Inaccuracies of the model BPEL99 have already been observed for other industrial UHPC according to the document interim recommendations of the AFGC [25]. It is also concluded that these formulas are not conclusive for these new materials. The modulus of elasticity depends on parameters related to the formulation, but also seems influenced by the heat treatment and type of treatment. The lack of consideration of these factors could cause inaccuracies of the models. Faced with the lack of predictive performance formulas, the AFGC [25] recommends that "if nothing is known in the preliminary phases of the project" to consider the standard value of 55 GPa. This value seems excessive and unsafe in the case of our formulations.
The recommendation to estimate the module from experimental testing seems currently the best solution. The Poisson's ratios vary little between different formulations (between 0.17 and 0.22).

As the modulus of elasticity, heat treatment tends to reduce the Poisson's ratios reaching values slightly below 0.20, a value recommended by the AFGC. However, regardless of the formulations and the different types of heat treatment and mode of treatment, this ratio appears to have a more limited variability (between 0.19 and 0.22), as the modulus of elasticity (between 40 and 70 GPa) [23].

- **Flexural strength**

Flexural strength without heat treatment

Table IIX presents the results of mechanical tests of flexion of the two formulations for the four maturities of 1, 7, 14, 28 days.

Table IIX: Flexural strength without heat treatment [MPa]

Specimens	with SF	with MK
Time (days)	Flexural strength [MPa]	
1	18	20
7	24	25
14	31	32
28	33	32

Concrete studied have values of resistance to bending close, regardless of the date of the test. The most consistent differences appear in one day (range 18 to 20 MPa). At 28 days, the resistors are slightly higher than 30 MPa. The Comparisons with the results of literature calling for a careful reading because the formulations, type of treatment and heat treatment vary between studies of these new materials. Thus, we can estimate that the flexural strength can change between 30 MPa and 60 MPa. One of the main reasons for this wide range of values is most likely the type (geometrical and mechanical characteristics) and the amount of fiber used. These values are comparable to those published by CSTB [32, 34, 35, 36] for non heat-treated fiber Ductal (bending tensile strength equal to 30 MPa). From the results of bending tests, we can deduce the tensile strength. Indeed, the bending test is relatively simple to implement a direct tensile test. The AFGC [25] proposes, based on the approach of the code for calculating the CEB-FIP, to evaluate the tensile strength from the results of the bending test on prismatic test not cut by the through the following formula to take into account the scale effect.

$$R_t = R_{fl} \cdot \frac{2{,}0 \cdot \left(\frac{h}{h_0}\right)^{0{,}7}}{1 + 2{,}0 \cdot \left(\frac{h}{h_0}\right)^{0{,}7}} \quad (3)$$

Where:

Rt: Tensile strength due by bending (MPa) Rfl: Bending strength (MPa) h: Height of prism (mm) and h0 = 100 mm

The bending strength Rfl is equal to the value of the tensile stress in bottom fiber at mid-span, calculated from the value of the applied force Ffiss corresponding to the loss of linearity of the elastic behavior. Unfortunately, the test device used in the press did not allow us to develop a sensor boom. The use of tensile strength in bending cannot be achieved in the absence of accurate assessment of the strength Ffiss. The breaking load indicated by the press is obviously greater than this value. Applying the formula taking into account the geometry of our samples, we find that the coefficient of scale effect is equal to 0.51. This means that the tensile strength is less than half the flexural strength measured. It could therefore estimate that the selected tensile strengths are approximately in the range between 10 and 15 MPa, significantly higher values than those of concrete.

Flexural depending on heat treatment

Table X presents the results of measurements of mechanical strength in bending at 28 days and those treated at 90°C and 150°C for UHPC tested.

Table X: Flexural strength [MPa]

Specimens		with SF	with MK
Not cured	Rfl28j	33	32
Cured at 90°C	Rfle90	36	33
Cured at 150°C	Rfle150	46	40

These results show that, as the compressive strength, heat treatment increases the flexural strength of UHPC, probably due to the formation of new crystalline hydrates. Furthermore, no distinction is significant difference between the behaviors of concrete both in terms of values of resistance or strength gain as a function of baking temperature.

Other researchers have obtained similar values like Ductal with 32 MPa of flexural strength after heat treatment [32]. In a comparable manner, a UHPC formulation similar to those of our materials [23], having undergone a heat treatment at 90°C, has developed a flexural strength of 46 MPa for a compressive strength of 220 MPa. Finally, unlike the elastic modulus, whose values vary for similar compressive strength, tensile strength, through the bending strength, is highly correlated with compressive strength as is the case for conventional concretes. The pouzzolanique reaction is accelerated during the heat treatment at 90°C (150°C) is responsible for the increased resistance of this type of concrete. The criteria of homogeneity and compactness that covers the granular composition and method of manufacture, characterize the quality of the samples obtained after taking [33].

IV. SYNTHESIS

From the perspective of behavior instant, the main conclusions obtained are as follows:

Fresh and consistent formulation, sand dune leads to a smoother mixture. Consideration could be given to improve the formulation or by decreasing the dosage of adjuvant (to lower the price) or by decreasing the dosage of water (to increase the mechanical performance); Fresh, replacement of silica fume, metakaolin by the results in a (slight) decrease in the fluidity of the mixture; The levels of air and bulk densities are equivalent between UHPC tested. For cons, the porosity of metakaolin with UHPC is slightly higher than that of silica fume UHPC (respectively 7.1% and 6.2%); Mechanical strength in compression without heat treatment is better at 28 days (175 MPa) while they were lower at 1 day in presence of metakaolin (52 MPa). In addition, the sand dune appears to react better with metakaolin (184 MPa at 28 days); With heat treatment, the compressive strength of different concretes is relatively close and exceeds every 200 MPa (consistent with historical data). Systematic way, the concrete with silica fume leads to resistance slightly higher than those with metakaolin; Modulus of elasticity of different UHPC comparable non-heat treated (41 GPa) and down a dozen% with heat treatment. These modules are relatively lower than those indicated by the AFGC [25] (55 GPa), or calculated from the BPEL 99 [29] (58 MPa) or Eurocode 2 [30] (50 MPa); The Poisson's ratios vary little according to the formulations (0.19 to 0.24), corresponding to the AFGC recommendations [25] (0.20). After heat treatment, they decrease slightly but remain close to the value of 0.20; In the absence of heat treatment, the flexural strength (3 points) of different UHPC is equivalent (32 MPa at 28 days) even though the kinetics may differ. With heat treatment at 90°C, these resistances do not change as they increase with heat treatment at 150°C to over 40 MPa). If these resistances are slightly higher with silica fume, we do not find significant differences with the metakaolin.

CONCLUSION

This work was devoted to the development of sand dunes of Erg Western abundant material and little valued in southern Algeria. Given its characteristics, this sand has emerged as a potential component that

can be used in the manufacture of ultra high performance concretes (UHPC or in the presence of fibers). Our results also demonstrated the benefit of the substitution of silica fume, metakaolin and confirmed by the respective interests of the presence of fibers, ground quartz and heat treatment to achieve very high performance. The study was conducted on mechanical Fiber-reinforced concretes and the parameters studied were sand dune, the type of addition (metakaolin or silica fume) and heat treatment (without, 90 and 150°C). It focused on the resistance to compression, bending 3 points. The results show that the sand dune is a very promising material because it provides both a good flow of UHPC and also the best mechanical strength when combined with metakaolin. Its behavior vis-à-vis the steaming is also very favourable, all the results obtained in compression above 200 MPa. Thus, at the end of this work, we demonstrated that it was perfectly possible to make UHPC or BPR by using sand dune and metakaolin. So we found a very interesting way of recovery for the sand of the western erg both technically and economically. This type of material could be considered in the manufacture of structural components such as beams, or even entire books, such as prefabricated bridgesΠ.

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