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# Valorization of the Sand of Dune of the Western Erg (Algeria) in the Formulation of the UHPC

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**Abstract:** The present study deals with the use and the valorization of the sand of dune of the Western erg of the western south of Algeria in the development of the formulation of the Concretes with ultra high performance UHPC. Mainly, if we think that meadows of 6% of the surface of the Algerian Sahara are covered by its sands.

**Key words:** UHPC, BPR, formulations, silica fume, sand, fibers, stoving

## INTRODUCTION

The present work carried out formulation manufacture of the concretes has allowed the development concrete with ultra high performance (UHPC) which presents mechanical properties and of durability remarkable (Malier, 1992; Richard and Cheyrezy, 1995).

However these concretes are employed little and their implementations are still exceptional, primarily because of their high costs.

The matrix of the concrete with ultra high performances consists of cement CEM I 52, 5, of siliceous sand, silica fume (dmoy = 250 μm), of crushed quartz (dmoy = 10 μm), as well as superplasticiser and of water (Richard and Cheyrezy, 1995). These materials can be drying ovens at temperatures higher than 90°C.

The silica fume is ultrafine powerful. Its large smoothness gives him a very good capacity of filling and combined with its amorphous structure, the strong pozzolanic reaction which results from this allows an increase in resistances of the concrete and an improvement of its durability (Abdul Razak and Wong, 2005). Because of its exceptional characteristics and properties, the statute of the silica fume passed from industrial waste to that of top-of-the-range product whose request is constantly with the rise on the market. It results from it that the product is rather expensive and that the availability is limited to the output of industries of silicon. The least expensive silica fume is presented in the form of a rather dark gray powder. Its use can thus be proscribed when the esthetic considerations require a clear color. There are also silica fume of precipitation, of white color, but which is much more expensive.

Proportioning in silica fume used for the manufacture of a UHPC is generally very high 150 to 250 kg m$^{-3}$, (10 to 30% compared to the mass of cement) (Freyssinet, 1936; Malier *et al*., 1995). The economic considerations mentioned before are thus all the more important. During this exploratory study, a sand of dune of the Western erg of Algeria was tested with an aim of reducing the costs of the UHPC. This sand of dune has a very fine granulometry of about 200 μm and is constituted of silica 98% of a hardness of 7 Mohr. A material clean, pure, of abundance, does not require any industry and which undoubtedly improves compactness of the concrete. Its exploitation is free compared to the sand crushed to employ in the formulation of the UHPC.

The formulations were also tested after thermal treatment temperatures of 90 and 150°C. Indeed the heat treatment constitutes for the UHPC, a means of improving their performances mechanical (Feylessofi *et al*., 1996; Matte and Moranville, 1999). Beyond 100°C the amorphous hydrates are transformed into crystalline products. Some of these products have poor mechanical properties ($C_2SH_\alpha$); others on the contrary, make it possible to obtain improved resistances (tobermorite, xonotlite).

## MATERIALS AND METHODS

### Materials used

**Cement:** A Portland cement CEM I 52,5 NR PMES CP2 was used whose physical and chemical characteristics are presented in Table 1 and 2.

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Table 1: Chemical characteristics in%

| Materials | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $Na_2O$ | $K_2O$ | $SO_3$ | Loss on the ignition |
|---|---|---|---|---|---|---|---|---|---|
| Sand | 97.33 | 0.830 | 0.24 | 0.07 | 0.41 | 0.09 | 0.04 | 0.18 | 0.40 |
| 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 | - | - | - |
| Crushed quartz | 98.50 | 7500 ppm | 450 ppm | 300 ppm | - | - | 5500 ppm | - | 0.20 |

Table 2: Physical characteristics

| | Sand | Cement | Silica Fume | Crushed quartz |
|---|---|---|---|---|
| Specific surface BET ($cm^2\ g^{-1}$) | 115 | 3390 | 23 (20 to 26) | 6900 |
| Average dimension, D50 (μm) | 200 | - | - | 11 |
| True density | 3 | 3.16 | 2.24 | 2.65 |
| Hardness | 7 | - | - | 7 |

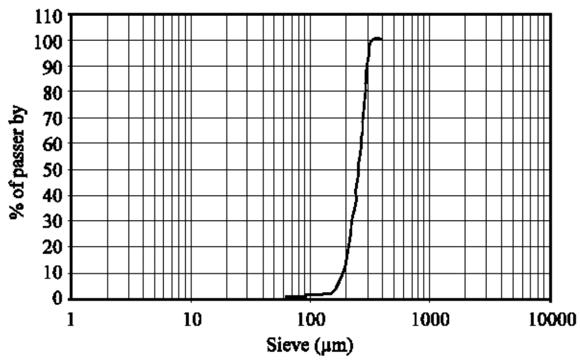


Fig. 1: Granulometry by sieve analysis of sand of dune

**Additions:** The addition used is:

- The powder silica fume marketed under the name Condensil (Table 1 and 2).

**Aggregates:** Quartzose sand of dune of the Western erg of the western southern area of Algeria whose chemical granulometry and characteristics are given in Fig. 1 and Table 1 was used (Tafraoui *et al*., 2006).

**Water:** The water used for the construction of the mortars is drinking water of the network.

**Additive:** The superplastifiant high reducer of water used in conformity with standard

- NF EN 934-2 is containing acrylic copolymer, of new generation not chlorinated.

**Fibers:** Metal steel fibers 13 mm in length and diameter 160 μm were employed.

**Formulation:** A formula of reference was cast. The detail of the formula is given in Table 3.

Table 3: Formulation of UHPC

| Components | Formula (kg $m^{-3}$) |
|---|---|
| Cement | 691 |
| Siliceous sand | 759 |
| Silica Fume | 172 |
| Crushed quartz | 276 |
| Metal fibers | 138 |
| super plasticizer | 22 |
| Water | 187.3 |
| E/C | 0.27 |
| MV reality (kg $m^{-3}$) | 2450 |

### Tests

**Construction of the specimens:** All the concretes are mixed in a mixer with mortar with vertical axis of 10 L, for the fluxing of the mixture and the homogenization of the powders. The total duration of malaxation is higher than that of the conventional concretes. The sequence of malaxation is:

- Malaxation of the dry powders: 2 min.
- Introduction of the water and half of superplastifiant: 2 min.
- Introduction of the second part of superplastifiant, malaxation until fluxing.
- Introduction of fibers, malaxation at high speed: 1 min.

The time of manufacture of a UHPC does not exceed the 7 min.

The 2 sec time of flow of the UHPC was measured on a mortar maniabilimeter according to standard (NFP 18-452).

The UHPC are cast in six moulds 40×40×160 mm, the moulds are then preserved in a room at 20±1°C without exchange of moisture during 24 h. After release from the mould part of the specimens is placed in water with 20°C during 28 days.

**Stoving of the specimens:** The other part of the specimens undergone after 4 days of cure to 20°C in a wet chamber either a thermal 90°C treatment, or a thermal 150°C treatment according to cycles presented on Fig. 2.

**Mechanical behavior:** The mechanical behavior of these concretes was studied in flexural 3-points and axial compression plain on specimens 40×40×160 mm. (EN 196).

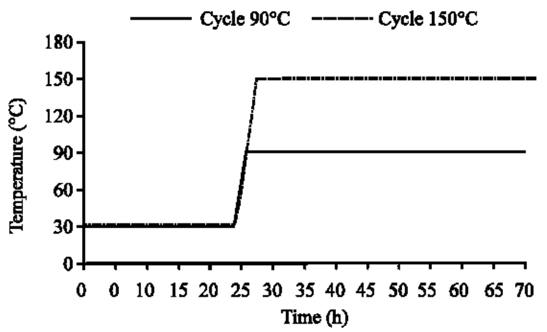


Fig. 2: Steam curing cycle

Three samples are tested by sample and deflection test same per test of compression on a press (compression, flexural) AMSLER of 600 KN. The mechanical tests for the concretes not drying ovens were made at 28 days after a cure with 20°C, tandisque for the concretes drying ovens they were carried out after the phase of cooling during 24 h is at the 5 days limit.

## RESULTS AND DISCUSSION

**Flexural strength:** The results presented in Table 4 show that the flexural strength for the concretes containing of the sand of dune of the formula studied from the concretes not drying ovens, of the concretes drying ovens to 90°C and those of the concretes with 150°C are identical to those of the concretes with ultra high performance to study and presented by Jianxin and Schneider (2002).

The flexural strength of the concretes fibers progress regularly according to expiries' (1, 7, 14 and 28 days) (Fig. 3).

**Compressive strength:** The results of the compressive strength presented on Table 6 progress regularly dice the first days and reached values which exceed the 100 MPa and brings closer the 170 MPa at 28 days.

With the heat treatments employed, we could highlight concretes of reactive powders BPR200 starting from the sand of dune without pressing which reaches a value of maximum resistance equal to 254 MPa.

The mechanical resistances of the concretes to study preserved at 20°C regularly increases up to 28 days (Fig. 4). Resistance in compression of the specimens treated with 90°C and 150°C reaches a maximum value at once after the heat treatment to show on Table 5. Resistance in compression measured to 28 days for a temperature of cure of 20°C accounts for approximately 60 to 70% of resistance obtained with the heat treatment to 90°C and in the case of 150°C.

Table 4: Flexural strength (Mpa)

| Concrete | | Flexural strength |
|---|---|---|
| Not drying ovens | $Rf_{28j}$ | 33 |
| Drying ovens 90°C | $Rfe_{90}$ | 35 |
| Drying ovens 150°C | $Rfe_{150}$ | 45 |

Table 5: Compressive strength (Mpa)

| Concrete | | Compressive strength |
|---|---|---|
| Not drying ovens | $Rc_{28j}$ | 169 |
| Drying ovens 90°C | $Rce_{90}$ | 243 |
| Drying ovens 150°C | $Rce_{150}$ | 254 |

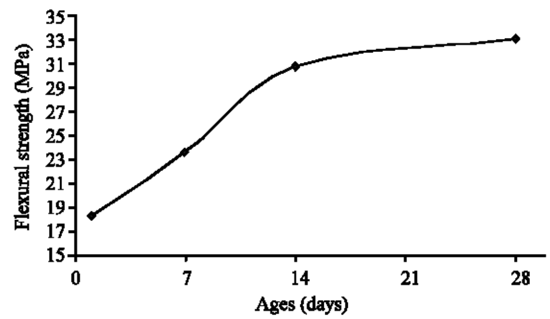


Fig. 3: Evolution of the flexural strength

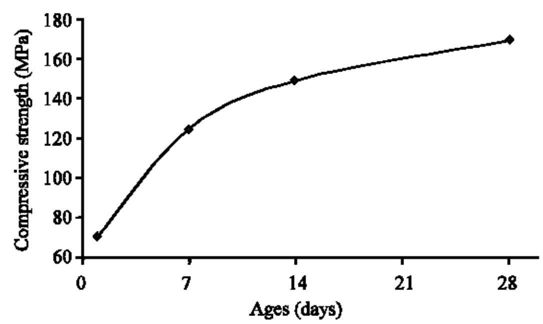


Fig. 4: Evolution of the compressive strength

The pozzolanic reaction which is accelerated during the thermal 90°C treatment (150°C) is responsible for the increase in resistances of this type of concrete. The criteria of homogeneity and compactness which covers the granular composition and the manufacturing process, characterize the quality of the samples obtained after catch.

All the concretes carried out under the heat treatment are BPR200. Thus one succeeded in highlighting a BPR200 starting from the sand of dune of the Western erg and ultrafine silica Fume. The tables presented clearly show the increase in the values of the mechanical resistances of the studied formula.

The principal experimental results obtained on the formula studied for the sand of dune implemented without pressing, reveals us the valorization of this sand in the development of the concretes with ultra high performance.

## CONCLUSIONS

The results obtained with the sand of dune indicate that its use in manufacture and the development of the UHPC could be interesting. The mechanical properties obtained are comparable with those obtained by (Jianxin and Schneider, 2002).

In this study, we manufactured UHPC who exceeds the 200 MPa going up to 254 MPa of compressive strength and 45 MPa of flexural strength containing of the sand of dune.

Then this type of sand used during this study is revealed to be promising. This sand is with abundance, its availability thus does not pose a problem.

It would be important to study the microstructure and the durability of the concrete with ultra high performance containing of the sand of dune. Another prospect for research in relation to local materials of the western south of Algeria like (cement, métakaolin, limestones fillers) remains to develop and apply to the new concretes.

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