Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 11-2023
DOI: 10.5281/zenodo.10123856

DEVELOPMENT OF HIGH-PERFORMANCE CONCRETE (HPC) FROM LOCAL MATERIALS

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Abstract

Based on experimental work we performed a practice labor to find a combination of high-quality practice to produce high-performance concrete (HPC) with local aggregates, an introduction to research was conducted on locally available aggregates, combined with a dune sand in the town of Beni-Abbas of the Wilaya BECHAR (south-western Algeria). A comparative study between ordinary concrete and its equivalent high-performance concrete (H.P.C) has also been established. We conducted several experiments in LMPC laboratory of Mostaganem university, where we used local materials (cement, gravel, sand, Sahara sand, added chemicals) to lead well the work, we prepared different mixture of specimen where is formulated by local materials, the specimen S2 mix with Sahara sand is favorable of resistance 59Mpa relatively at specimen S1, S3 mix with brick clay and Sahara sand addition brick clay.

Keywords: HPC; Local materials; Sahara sand; Brick clay.

1. INTRODUCTION

The difficulty that our country is facing in terms of local development, has led us to study research to improve concrete with local materials and this for applications in structures and rigid pavements; We opted for the choice to do some tests on a topical concrete that continues to make progress known as "High Performance Concrete" or HPC for their high resistance.

These concretes are hydraulic concretes (Sand+ Gravel+ Cement+ Water) to which adjuvants (fluidizers or plasticizers) are added to increase their performance, including resistance.

However, the high compressive strength is not the only and main property of HPCs, because several other properties are improved, such as very low permeability or low porosity, therefore increased durability.

In this paper, we are interested in the resistance according to the additions in the HPC which brings multiple advantages compared to the ordinary concrete quote, for example its application in:

- Workability is increased without risk of segregation during application.
- The durability of structures is improved by the high compactness of concrete with reduced air and water permeability, resistance to attack and better resistance to alkali-reaction, greater resistance to abrasion and better resistance to freeze/thaw cycles.
- It makes it possible to design thinner structures thanks to the increase in mechanical characteristics (compression), both at a young age and at term.

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- However, the improved properties of HPCs can only be obtained thanks to several simultaneous provisions concerning:
- The aggregates must be of good quality, the strength of the concrete being limited by that of the aggregates themselves, we use aggregates: gravel: 2/6 and 6/15, sand: 0.315/0.63 dune sand: 0.15/0.315, waste brick or chamotte: 1/2.
- The use of mineral additions such as silica fume, specific additives, in particular water-reducing super plasticizers.
- The use of economical class 350 cements.

Recent years have seen the use of concretes with increasingly high HPC compressive strength of up to 50MPa. In our article, using the additions of dune sand and silica fume, we were able to find compressive strength values of around 60Mpa.

2. MATERIALS AND METHODS

The uni-axial compressive strength of concrete has been the most studied from all the mechanical stresses, presumably because it generally projects an overall picture of the quality of a concrete, since it is directly related to the structure of the concrete. Hydrated cement paste. Additionally, the strength of concrete in compression is almost invariably the key consideration when designing concrete structures and when establishing compliance specifications.

A concrete is defined by the value of its characteristic compressive strength at 28 days, fc_{28}. The compressive strength of concrete is measured by the load leading to crushing by axial compression of a cylindrical specimen: H=2D (32 x 16).

The specimens are loaded until rupture in a Tony-Technic 1000Kg compression machine from the materials and construction processes laboratory of the University of Mostaganem (Algeria) for compression testing, the maximum load reached is recorded and the compressive strength calculated:

$$f_c = F/A \qquad [1]$$

With fc the compressive strength, expressed in Mega Pascal, A the area of the section of the specimen in mm2 and F the maximum load in Newton.

- **Concrete Formulation**

The study of the composition of a concrete consists in defining the optimal mixture of its various components (aggregate, water, cement) to produce a concrete whose qualities are those sought (resistance, consistency, modulus of fineness). Recourse in this case to methods for determining the proportions of the various components, inspired by the classic method for ordinary concrete.

- **Experimentation-Matériaux**

The making of high-performance concrete is made from three samples made up of different materials included in the caliber intervals: D/d (mm):

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- Gravel: A: 2/6-B; 6/15.
- Sand Sa: 0.63/0.315; Equivalent to sand ES= 43%.
- Dune sand Sd: 0.315/0.15; ES= 83%
- Chamotte: 1/2mm
- Local laboratory tap water at 20°C
- Local silica fume

Plasticizer: the company Granitex (Algiers) markets two major types of medaflow 145 fluidifying admixtures (which are part of the family of super plasticizers which are generally used in the manufacture of H.P.C). Named SF and SFA based on naphthalene sulfonates, and secondly SP medaplasts based on melanin resin.

Cement: class CPJ 350, dosage 420kg/m3 of concrete, the compressive strength is taken as an average of 3 values for each type of the 3 samples.

We compare the average values of the compressive strengths of the three types of samples with the average value of the 3 values of the compressive strength of the ordinary control concrete (bot) which is composed without dune sand, without chamotte, without plasticizer and without silica fume.

3. RESULTS AND INTERPRETATION

➢ Ordinary Concrete Control

The control ordinary concrete (COC) is determined by the values of the average compressive strength Rc as a function of the age of the concrete according to the table and the curve below

Table 1: The average strength of the COC as a function of age.

Age (day)	**7**	**14**	**21**	**28**
Rc (MPa)	17.66	29.33	34.2	38

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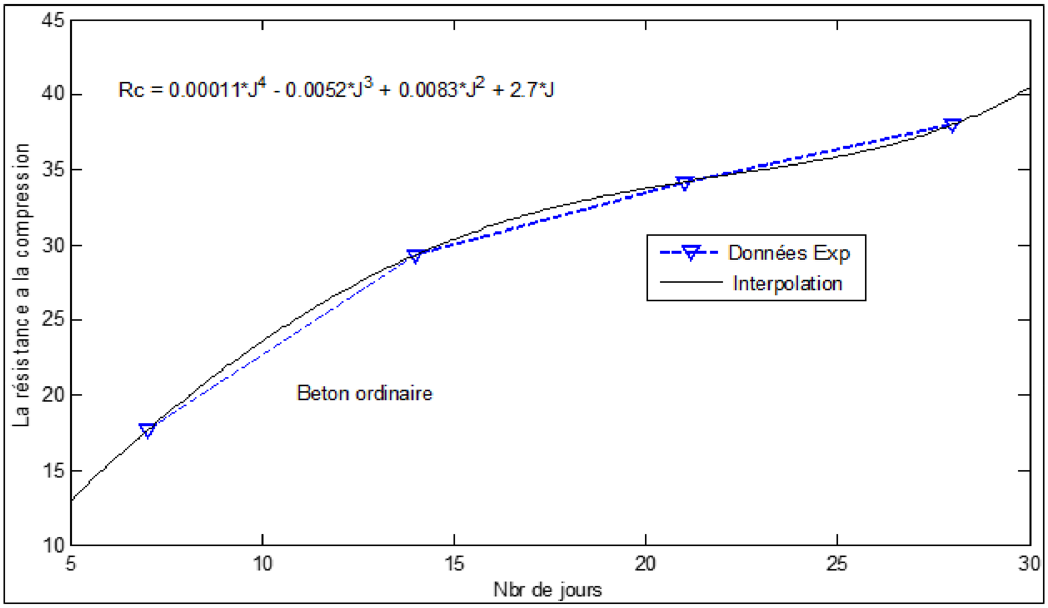

Figure 1: COC R_c curve as a function of age (number of days).

➢ Composition of High-Performance Concrete Samples

We chose to appreciate the effect of sand variation-controlled factor, namely the use of local sand for the first mixture, the use of dune sand for the second mixture and the association of local brick waste or lastly, grog with dune sand. We will take for the fixed and constant factors, the cement dosage at 420 kg/m^3 of concrete class 350 cement and a fixed rate of silica fume F.S equal to 8% of the cement weight. The W/L weight ratio of water in relation to the binder (L=C+F.S) and the water dosage. Knowing that for all the experimental plans carried out, the water dosage takes as extreme levels 181.44 l/m^3 with a W/L ratio = 0.40, the other components of the formulation are at a constant level. We have a super-plasticizing or thinning adjuvant medaflow 145 available on the market to start this phase. Inert materials (aggregates) are considered as constant factors. Their proportions were estimated using the standard method for ordinary concrete.

Table 2: Composition of the three types of samples HPC

Materials or components	S1	S2	S3
Cement C (kg)	0.882	0.882	0.882
Silica fume S.F (8% C) (kg)	0.07056	0.07056	0.07056
C + S.F (kg)	0.95	0.95	0.95
Fluidizer F (5% C) (l)	0.044	0.044	0.044
Mixing water W(l)	0.38	0.38	0.38
W/ (C+S.F)	0.40	0.40	0.40
W + F (l)	0.424	0.424	0.424
Sand Sa (kg)	1.52		
Dune Sand Sd (kg)		1.52	0,76
Brick or chamotte waste (kg)			0,76
Gravel A 2/6 (kg)	0.74	0.74	0.74
Gravel B 6/15 (kg)	1.94	1.94	1.94

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➢ **Compressive Strength Values**

We determined the average compressive strength of high-performance concrete for three samples of each type S1, S2, S3. The specimens studied are subjected to an increasing load until failure. The compressive strength is the ratio between the breaking load read in the indicator and the cross section of the specimen Tony Technik 1000 bar compression machine from LMPC.

Figure 2: Tony Technik compression machine

Table 2: Average values of the compressive strengths of the three samples

Specimen	Rc (MPa) at 14d	Rc (MPa) at 28d	Apparent volumetric mass (g/cm3)	Abrams cone sag (cm)	Porosity (%)
S1	42	45	2,40	15	3,5
S2	57	59	2,49	17	3
S3	43	45	2,42	16	3,3

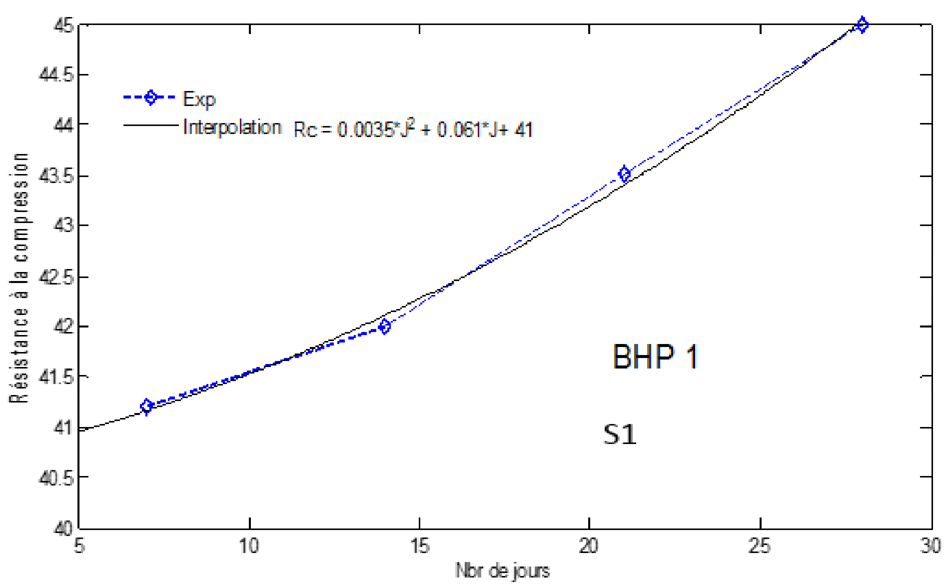

Figure 3: R_c curve as a function of the age of the S1.

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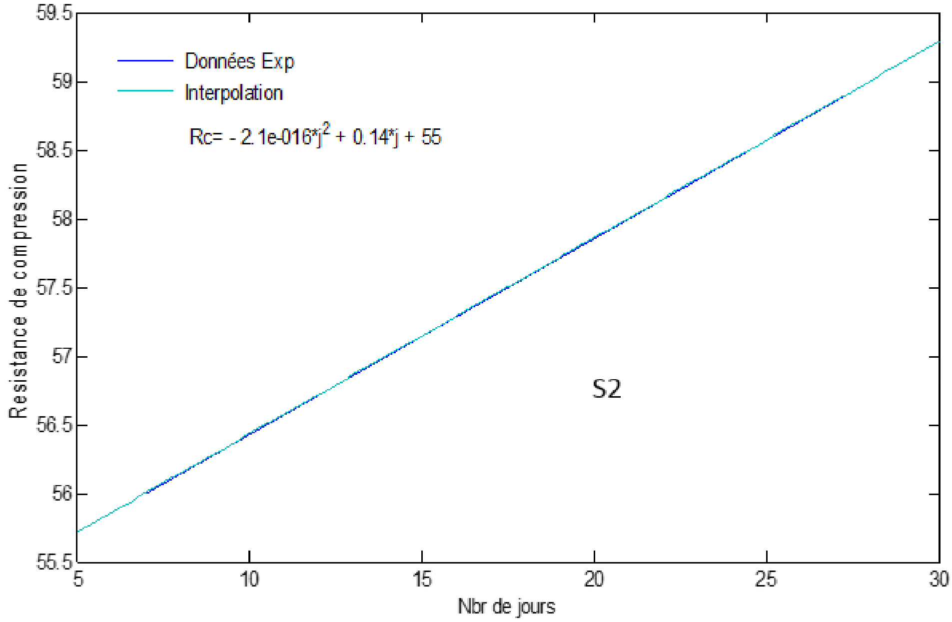

Figure 4: Rc curve as a function of the age of the S2.

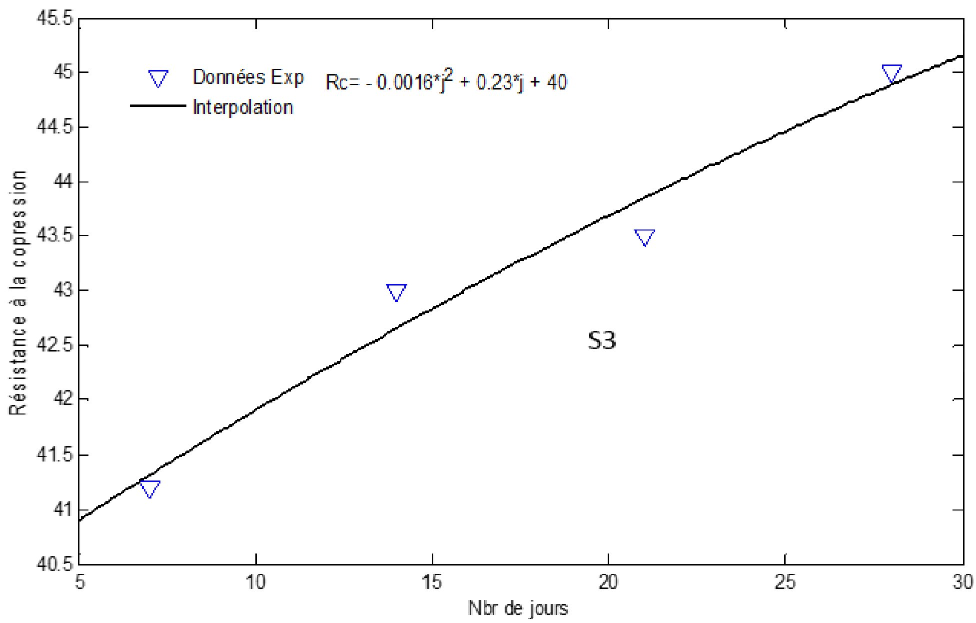

Figure 5: Rc curve as a function of the age of the H.P.C 3(E3)

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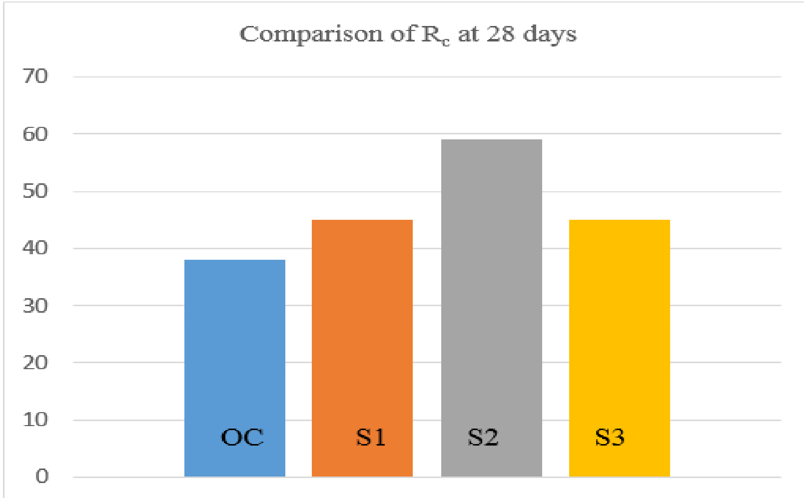

Figure 6: Comparison of average compressive strengths of high-performance concrete and ordinary concrete

The addition of silica fume and dune sand contribute to improving the mechanical characteristics of HPC (Rikioui, 2006), in particular the compressive strength.

HPC has interesting technological advantages over ordinary concrete. Its durability is improved in the face of aggressive physic-chemical agents (reduced permeability or low porosity), and its mechanical resistance is also increased, resulting in a good compactness determined by the apparent density. From these properties of HPC derives a great advantage in terms of long-term maintenance, as well as its workability determined by the sagging of the Abrams cone, greatly facilitates its placement even in areas of high reinforcement density. An increased final strength after hardening makes it possible to reduce the dimensions of the structures. All this translates into saving space, time and cost.

According to our research, the use of HPC can have positive, technical and economic repercussions in Algeria compared to ordinary concrete regarding the cost compared to the dosage of cement, which is 420 kg/m3. By way of indication and not limitation, we cite two examples of application, to highlight the technical and economic advantages of HPC.

The durability of high-performance concretes is significantly higher than that of ordinary concretes. The comparison of the permeability to chlorine ions of high-performance concretes and ordinary concretes shows the clear superiority of high-performance concretes [19] and, consequently, the possibility of escaping repetitive and short-lived repair work.

4. CONCLUSIONS

The analyzing of obtained results during the tests carried out at the LMPC laboratory of the University of Mostaganem, although the choice of aggregates that we used are available locally in Mostaganem (sand, dune sand, gravel, silica fume, super-plasticizer,

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tap water at 20°C). The second specimen or sample 2 of high-performance concrete, formulated with the addition of 0.315/0.15 caliber dune sand and silica fume gave us satisfactory results with an average compressive strength of 59Mpa, around 60Mpa, relative to an average compressive strength of ordinary concrete.

The physic-chemical and mechanical properties of local aggregates such as gravel and sand which are sufficiently suitable for traditional concrete, they have proven themselves in HPC especially for dune sand and the addition of silica fume, thus ensuring improvement in porosity of 3%, bulk density of 2.49g/cm^3 and Abram's cone sag of 17cm. We can deduce that the cleanliness of adding dune sand who's equivalent of sand ES= 83%, and its fineness caliber resulting in a fluidity whose Subsidence A=17cm improved the mechanical quality of HPC concrete in the sample 2, compared to the addition of chamotte in the 2 other samples, although the values of the mechanical resistances to the compression of the latter are better improved compared to an ordinary concrete.

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