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The deformability of a high performance Concrete (HPC)

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Abstract

The current tendency in the world is to find new materials at lower cost which can guarantee better performances during their incorporations in the concretes. Our study lies within the scope of the valorization of local materials. Among these materials we find the high performance concrete, which has become the object of the several researchers for a few years.

This study consists the development and the mechanical and elastic properties of a concrete with high performances (HPC) starting from materials existing on the Algerian market.

Three mineral additions: limestone, the sand of dune and the waste of polishing of tiling are incorporated a cement with various contents (5%, 10%, 15% and 20%). instead of the fume of silica or fly-ashes.

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Keywords-. High performance concrete - Formulation - Mechanical - additions – elastic.

1. Introduction

The concretes of high performances (HPC) were initially called “concretes of high resistance”, because of this easily measurable characteristic which made spectacular progress. It passed from 30 to 35 MPa a few years ago with more than 100 MPa for the concretes with very high performances (VHPC), even more than 200 MPa for concretes of the laboratory. The profits of resistance are not the only advantages of these concretes which draw their properties from a strong reduction of their porosity. They are also the most resistant to the aggressive agents, with the phenomenon of freezing thaw and, in a general way, the HPC is much more economical in certain applications on a basis of original cost, and also in point of view the durable upkeep, and more ecological than the usual concrete, because it is possible to build an equivalent structure with less formwork, less concrete and less reinforcements, it is also possible to support a load given with less cement, and of course, less aggregate. Moreover, the lifespan of a high performance concrete is estimated at two or three times than on a usual concrete when a high performance

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concrete reached the end of its lifespan, it could be recycled two or three times before being transformed into basic aggregate to build roads.
The concretes HP make it possible to realize structures subjected to high constraints or works undergoing a severe environment (climate, marine aggressions, and the effects of freezing).
They bring also resistances early high to the concrete, which makes it possible to accelerate the production rates in factory and on building site.

2 Materials used

2.1 Cement: cement used is CPJ-CEM II/42.5, (Algerian).
2.2 Aggregates: the gravels used are the crushed of calcareous nature. They are the classes 3/8, 8/15 and having a unit weight of 2,65, an impurity of 3,70% and a moisture of 0,3% with a coefficient of Los Angeles 19%. As for sand, it has a unit weight of 2,70 and a fineness modulus of 3,2.
2.3 Additive: the additive used is a local superplastifiant of type " MEDAFLOW 30 " It is a solution of Polycarboxylates, dry extract 30%, yellowish color and a pH = 6-6,5.
2.4 fillers: three additions were used:
2.4.1. Limestone: limestone used was provided to us by the cement factory of Chlef, it is a rock crushed in the form of stones of granulometry (20/100 mm), with a Blain specific surface of 11.000 cm_{22}/g (after crushing), and primarily consisted of calcite ($CaCO_3$)
2.4.2. Tiling polishing wastes: we have re-used this waste like filler with an aim of recycling this polluting waste. This material is made up gray limestone cement (23%) and a crushed (77%). This filler is characterized by a very weak presence of harmful elements with a specific surface 9000 cm_2/g
2.4.3. crushed sand of dune : It is about a sand of dune of the area of Djelfa, characterized by its real density 2.43 and of a specific surface (Blaine) of 8230 cm_2/g, the chemical analysis shows that their nature is siliceous (94,51% of silica SiO_2).

3 Composition of the concretes

The development of the concretes was carried out in order to obtain a mixture in two phases: a concrete approaching, as much as possible a massive rock having the weakest porosity and consisted the inner skeleton (gravel and sand) determined by the method Dreux Gorisse, while optimizing the maximum diameter of the coarse aggregates [1].
While the second phase presents the flexible paste (cement, superplastifiant, water and additions). This last was optimized by experimental purées [2].

The final compositions of the four mixtures of the concretes used after optimization are deferred on table (1).

Table 1. Final compositions of the used concretes.

Constituent \ Concretes	OC	LC	WPTC	SDC
Superplastifiant (1.5%)	0	25	25	25
Water/Binder	0,50	0,26	0,26	0,26
Cement (Kg/m^3)	450	404.5	382.5	382.5
Sand (0/5) (Kg/m^3)	670	670	670	670
Gravel (3/8) (Kg/m^3)	200	200	200	200
Gravel (8/15) (Kg/m^3)	905	905	905	905
CPJ42.5 + 10% Limestone (kg/m^3)	-	45.5	-	-
CPJ42.5 + 15% Waste of polishing of tiling (Kg/m^3)	-	-	67,5	-
CPJ42.5 + 15% Sand of dune (Kg/m^3)	-	-	-	67,5

The test-tubes were made in accordance with the standards in force (malaxation, tightening...), are various geometries according to the test carried out (l0xl0×10)cm3 and (10xl0x40)cm3 , they are preserved after release from the mould in water at 20 C°
The following abbreviations are used:
HPC: High performance concrete
OC: Ordinary concrete
LC: Limestone concrete
WPTC: Waste of polishing of tiling concrete.
SDC: Sand of dune crushed concrete.
W/B: Water/Binder
η: Constraints

3 Results and discussion

3.1 Mechanical resistance to the compression

Figure (1) gives example of results obtained under an ambient temperature with respective ages 28, 90 and 270days. We can to read, that for a report W/B equalizes to 0.26 the concretes made with cement CPJ42.5 which closes again to 10% of the limestone fine, 15% of the waste of polishing of tiling and 15% of the sand of dune present powerful properties.
The resistance of the concretes with additions presents a double value than the ordinary concrete

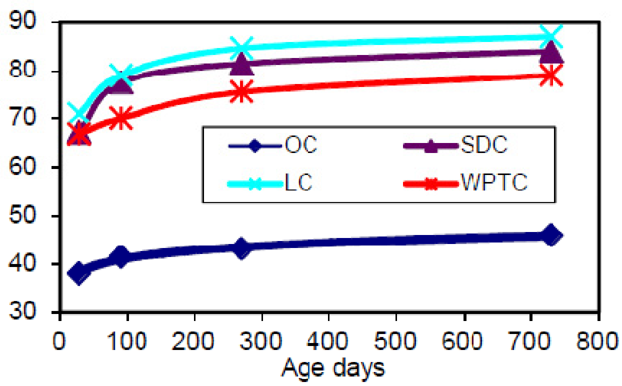

Figure 1. Compressive strength of the conretes

The factors the most responsible for this increase would be of course the choice of the types of the additive, the large smoothness of the additions used and another factor very significant it is the reduction in report W/B, this parameter is favoured the formation of the internal products of hydration which are characterized by a very fine texture and which resembles to a compact phase having an amorphous appearance. But this increase in resistance seems to be almost linear, i.e. between 28days, 90days and 270days, the process of hydration continued in a way almost as intense as the first days. This could be a consequence of the cure applied to the concretes.

3.2 Deformability

To study the influence of the additions on the deformability of concrete, we have made a series of prisms of (10x10x40) cm3 for the various mixtures of concrete,
The tests in compression are carried out after 1 year of natural hardening (these test-tubes are being preserved in water), using a press [3].

The deformation was measured by means of indicators with dial having the value of a division of 0.01 mm which are installed using suitable frameworks on a surface of 200 mm2 and 100 mm in the transverse and longitudinal directions, comprising studs of measurement (distant of 20 cm). (Figures 2 and 3).

Figure 2: The site of the executives and indicators on the test-tube

Figure 3: Deformations measured on the test-tube during compression

The total evolution of the deflection elastic - instantaneous total longitudinal and transversals of the concrete, deformability module and elasticity module of the concrete according to the relative constraints η for the series of prisms: OC, SDC, LC and WPTC will be presented at the figures (4, 5, 6 and 7).

3.2.1 Constraint longitudinal deflection

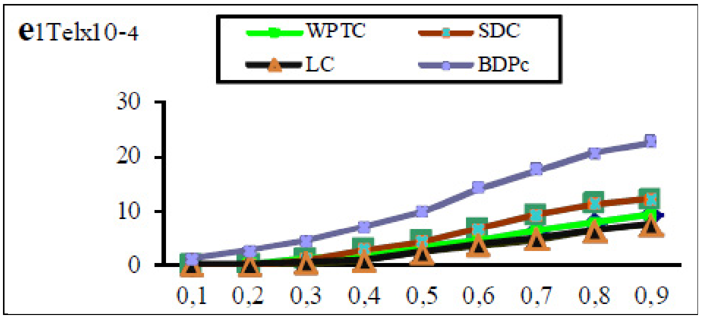

Figure 4. Elasto-instantaneous longitudinal total detection

On the figures above, we notice that the forced curve –longitudinal deflections of the concretes having a compressive strength which exceeds 80 MPa is very linear, and the deflection of the BHP to the rupture is larger than the ordinary concrete.
The behaviour of the concrete in post-rupture is not studied (press working with controlled load), which prevented us to calculate the ductility of the high-strength concrete.
Concerning the behaviour in compression the forced curve-deflection is divided into two parts:
Part 1: (0,1-0,3), to announce that the value of the longitudinal deflection in compression is small i_e. the concrete elastically behaves when the effort is removed, it returns in its origin, either the pre-existent microscopic cracks are not propagated, or the new formed microscopic cracks are contained after relaxation.
Part 2: (0,3-0,9), to note that the value of the deflection is large and especially the calcareous concrete, therefore concrete being micro cracked especially with the interface mortar aggregates,

After this phase the rupture occurs rather brutally without warning by induced cleavage or significant deflection, translating a very fragile behaviour. According to Rossi " the HPC would be more fragile than the OC, lengthening with the max of constraints is a little more significant than for an ordinary concrete and the transversals deflections are qualitatively of the same type as those of the witness, with a weaker increase in volume " [4]

3.2.2 Constraint transversal – deflection

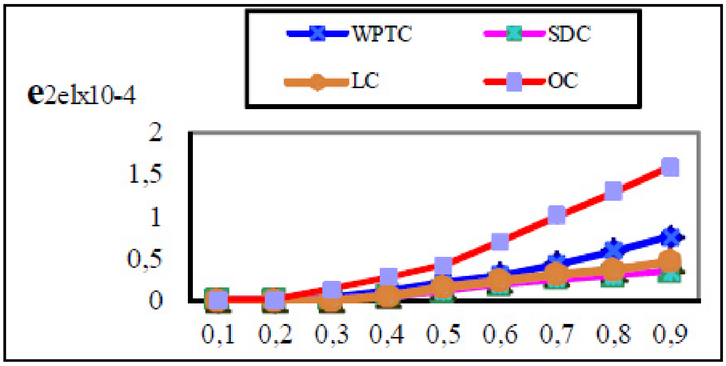

Figure 5. Elasto-instantaneous transveral total deflection

From the two figures above, we notice that the ordinary concrete has transversal deformations (ε 2 el) and (ε 2 such) higher than those of the other types of the concrete contrary to the longitudinal deflections (ε 1 el) and (ε 1 such), where they are represented by low deflections.

3.2.3 Deflection module and elasticity module

The evolution of the deflection module and elasticity module according to the, relative constraints η for the series of prisms: OC, SDC, LC and WPTC, is represented on the figures (6, 7).

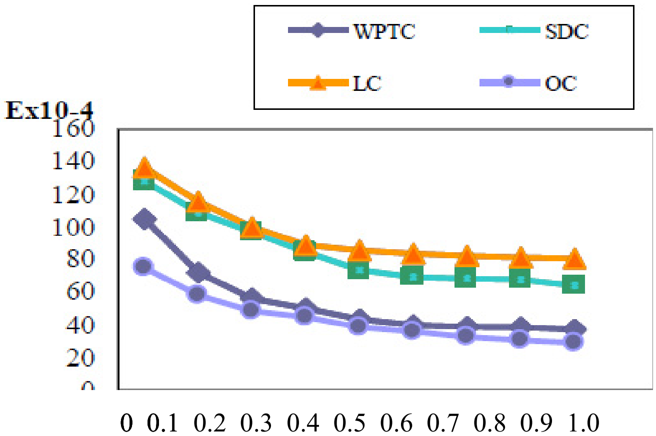

Figure 6. Deflection module

The deflection module of the concretes with additions presents a deflection module higher than the pilot concrete, is probably related to their great compactness.

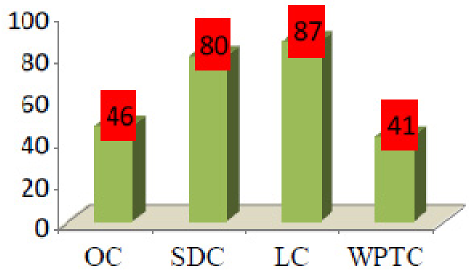

Figure 7. Elasticity module

The largest module of elasticity it that is obtained with LC=45MPa, follow-up with the SDC and the WPTC we are respectively recorded the following values 42 MPa, and 41MPa and lately OC had a module of elasticity of 35MPa. But there is not a great significant difference between the module of elasticity of the concretes additions and an ordinary concrete because the module of deformation and module of elasticity represent a stable state of the hardened concrete, even in the case of the considerable increases in the constraint.

4. Conclusion

-Marking local HPC containing materials is allowed to have a concrete of 80 MPa in 28 days.
To obtain a level of raised resistance, it is necessary:
- to lower the water / binder to the surrounding from 0,25 to 0,30,
- to use one superplastifiant of high quality.
- all the ingredients of the concrete must be of very good quality.

The module of elasticity of the hardened concrete is according to its mechanical resistance. However, the factors acting on the module of elasticity are the same ones as those acting on resistance.
The effect of the mineral additions on the evolution of the module of elasticity is significant. Consequently, it is noticed that the concrete containing an addition, always presents a module higher than that the pilot concrete, which is related to their great compactness.

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