THE INFLUENCE OF DREDGED OF NATURAL WASTE ON SHRINKAGE BEHAVIOR OF SELF COMPACTING CONCRETE

Nasr-Eddine Bouhamou[1], Fouzia Mostefa[2], Abdelkader Mebrouki[3], Nadia Belas[4]

[1]*Laboratory of Construction transport and Protection of Environment "LCTPE", Mostaganem University, Algeria, nbouhamou@yahoo.fr.*

[2]*Laboratory of Construction transport and Protection of Environment "LCTPE", Mostaganem University, Algeria,mostefa.f@outlook.com.*

[3]*Laboratory of Construction transport and Protection of Environment "LCTPE", Mostaganem University, Algeria, mebroukiaek@yahoo.fr.*

[4]*Laboratory of Construction transport and Protection of Environment "LCTPE", Mostaganem University, Algeria,belaribi2001@yahoo.fr*

Abstract: Every year, millions of cube meters are dredged from dams and restraints as an entertaining and prevention procedure all over the world. These dredged sediments are considered as natural waste leading to an environmental, ecological and even an economical problem in their processing and deposing.

Nevertheless, in the context of the sustainable development policy, a way of management is opened aiming to the valorization of sediments as a building material and particularly as a new binder that can be industrially exploited and that improve the physical, chemical and mechanical characteristics of the concrete.

This study is a part of the research works realized in the civil engineering department at the university of Mostaganem (Algeria), on the impact of the dredged mud of Fergoug dam on the behaviour of self-consolidating concrete in fresh and hardened state , such as the mechanical performance of SCC and its impact on the differed deformations (shrinkage). The work aims to valorize this mud in SCC and to show eventual interactions between constituents. The results obtained presents a good perspectives in order to perform SCC based in caclinated mud.

Key words: sediment, calcination, reuse, self-consolidating concrete, fresh state, hard state, shrinkage

1. Introduction

This work is integrated in a general problematic concerning durable development .The search for of new building materials indicates that the research axes go in the way of reuse industrial and natural waste as an alternative of the present used materials which will become scarce in the near future.

River sediments coming from dragged dams can be seen as an environmental and economical threat. The big quantities generated by the siting up phenomena, make perplexed the authorities about its deposing in nature.

Valorization possibility of these sediments in civil engineering domain was proven by research led in this way as building materials (brick, Aggregates and cementitious material).

Although these studies are in their first step, the reuse of sediments in concrete is poorly documented, and particularly in self-consolidating concrete.

We know that SCC contain a very high volume of paste which requires the use of great quantity of cement; so, a partial substitution can be a solution for the reduction of an important use of cement.

2. Identification of Fergoug dam

Considered as one of the most sited up dams in Algeria, the dam of Fergoug (fig.1) gave rise to the interest of several Algerian researchers who contributed by their various studies to highlight the causes making it a disastrous dam.

These studies were primarily interested to explain the phenomenon of silting while trying to find solutions to solve it and emit the possible solutions of valorization of the dredged sediments (Remini, 2002) (Semacha, 2006).

During its existence, the dam knew several operations of dredging, the first was carried out during the years 1984 and 1986 where more than 10 million m^3 of mud were recovered. A second operation of dredging was carried out on 1992 where 6.5 million m^3 of mud was evacuated. The last one was launched in 2005, the operation which costed 800 million DA which represents 130 Da /m^3, was carried out by the National agency of the dams.

In spite of these various attempts, the rate of current silting and according to the bulletin published by Agency Hydro Channel Chergui (ABHC, 2007) is estimated at 97,77%.

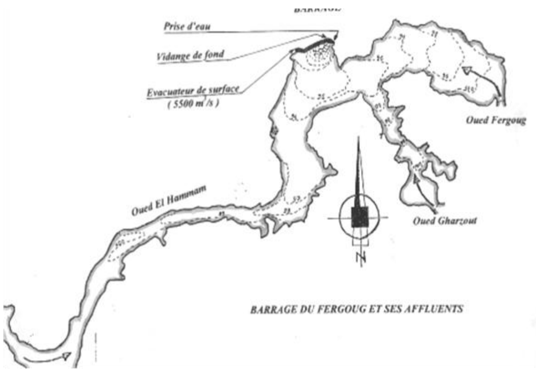

Fig 1 : Fergoug’s Dam and its effluents

3. Experimental Setup

3.1.Used materials

a. Cement

Cement used is a CEM I 42.5, coming from the Zahana factory (west of Algeria). The physical characteristics and the average chemical analysis of this cement are given in table 1.

		Cement
Physical properties		
Apparent density	(g/cm^3)	1.18
Absolute density	(g/cm^3)	3.13
Blaine specific area	(cm^2 / g)	3180
Chemical analysis		
SiO_2		20.90
CaO		63.93
MgO		1.45
Fe_2O_3		5.93
Al_2O_3		5.10
SO_3		0.86
Na_2O		0.17
K_2O		1.34
Loss on ignition		0.86
Carbonates		-
C O_2		-
H_2O		0.6

Table 1. Physical properties and chemical analysis of cement

b. Mud (waste)

The mud was taken downstream from the dam (photo.1), and activated thermically by calcination in a slow oven at temperature of 750 $\pm$ 5 C° regulated with 5 C° /minute during 5 hours after it is steamed, crushed and sieved to 80 µm (photo, 2). The calcined mud (photo.3) was recovered and preserved away from the air and any moisture. The physical and chemical characteristics of the vase are presented in tables 2 and 3.

The grain size analysis of the mud was carried out at laboratory SIBELCO (France). The results of the analysis of this mud are shown by the grading curve of the fig 2.

Photo.1 Wet mud

Photo.2. crushed and sieved mud

Photo.3. calcined mud

Test	Calcinated mud
Apparent density (g/cm^3)	0.53
Absolute density (g/cm^3)	2.62
Blaine specific area (cm^2 / g)	7964.00

Table 2 : Physical characteristic of calcinated mud

Composant	Content
SiO_2	54.69
CaO	14.25
MgO	3.08
AL_2O_3	15.49
Fe_2O_3	7.50
SO4	-
Loss on ignition	1.87

Table 3 Chemical composition of the calcined mud

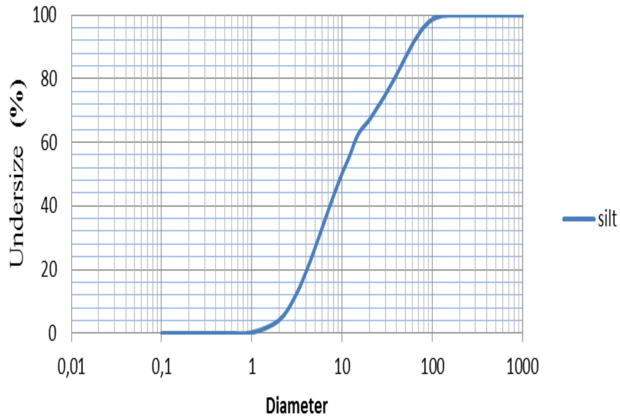

Fig 2 : Fergoug mud grain size distibution (labo SIBELCO France ,2011).

c. Aggregates

Aggregates used are broken up particles of limestone with well graded distribution, coming from the career of Kristel (Oranian area), and a sand of siliceous sea, coming from the career of Sidi Lakhdar (area of Mostaganem). Table 4 gives the characteristics of the aggregates for the whole of the compositions.

	Sea sand (Ss)	Career sand (Sc)	gravel (G)	
Class	0/2	0/3	3/8	8/15
Nature	silicious	limestone	limestone	limestone
Density (g/cm^3)	2.56	2.68	2.66	2.66
Absorption (%)	-	-	0.86	0.40
Fineness modulus	1.64	2.63	-	-
Sand equivalent (ES)	83.18	88.96		

Table 4. Physical characteristics of different aggregates

e. Admixture

The admixture employed is a superplasticizer provided by GRANITEX Society, a high water reducer, containing polymers of synthesis combined according to the standard NF EN 934-2. The MEDAFLOW113 allows obtaining concretes and mortars of very high quality, maintaining workability and avoiding segregation. Its density is of 1.12 and its proportioning can vary from 0.8 to 2,5% of the binder weight.

f. Concrete mixtures

Four self-consolidating concretes were made to study the substitution effect of cement by the calcined mud on the behaviour in a fresh and hard state of the SCC. The concretes were made by adopting the method of volume of paste. The admixture proportioning is calculated in order to limit the segregation and bleeding, and to obtain a spreading out ranging between 60 and 75 cm.

Aggregate proportioning (G/S), the ratios Water/binder (W/B) and volume of paste were kept constant for all the compositions of SCCs. Tests were carried out on concretes containing various percentages of mud in substitution with respect to volume of cement i.e: 10%, 15% and 20%. The compositions of the various mixtures are presented in table 5.

3.2. Tests at fresh concrete

The characterization in a fresh state of the concretes was limited to the tests recommended by AFGC (AFGC, 2000) such as slump flow, L-box, sieve stability and bleeding.

Mix proportion (kg/m^3)	Concrete mixes			
	SCCR	SCCM10	SCCM15	SCCM20
Cement	450	420	408	395
Calcinated mud	-	35	52	66
Water	225	218	216	213
Adjuvant	5.7	7.5	8.3	9.8
W/B	0.5	0.5	0.5	0.5
Ss	560	560	560	560
Sc	251	251	251	251
Gravel (3/8)	333	333	333	333
Gravel (8/15)	499	499	499	499

SCCR : Reference Concrete (0% calcined mud)

SCCM 10: Concrete with 10% calcined mud

SCCM 15 : Concrete with 15% calcined mud

SCCM 20 : Concrete with 20% calcined mud

Table 5. Mix proportions of the concretes

3.3. Tests on hardened concrete

3.3.1.Mechanical strength

Mechanical compressive strength is an essential characteristic of the concrete material and a fundamental parameter of our study. Consequently, its evolution was measured for all the formulations of concrete studied within this work.

Samples used to determine mechanical compressive strength of the various studied concretes, are cylindrical test-tubes with a diameter of 11 cm and height of 22 cm. Once removed from the mould, they are preserved in water until a definite term (1 day, 7 days, 28 days and 90 days). To measure tensile strength, an average of three samples (7x7x28) were broken at various ages by means of the three points bending tensile tests.

3.3.2. Shrinkage deformation :

We are interested here in deformations on hardened material (beyond 24 hours). In this context, two series of samples were produced and preserved in two different environments with and without hydrous exchange with the medium external. The tests performed were to measure the deformations of the total and endogenous shrinkage. Deformations of shrinkage were measured with a retractometer on prismatic test-tubes of 7x7x28 cm size placed in a air-conditioned room with 20 ± 1C° and 50 ± 5% of relative humidity, according to the two conditions:

- With hydrous exchange of material with environment: the total shrinkage is obtained
- Without hydrous exchange with environment by wrapping the test-tubes covered with one or two sheets of self-adhesive aluminum paper: the endogenous shrinkage is measured.

Once removed from mold, the six test-tubes relative to each concrete (three for the total shrinkage and the three others for the endogenous shrinkage) were tested in the very short term at the beginning and the periodicity of measurement will increase with time.

4. Experimental Results

Indices and coefficient activity of calcined mud

The indices of activity noted I, is defined as the ratio of compressive strength $f_p(t)$ and $f_0(t)$, respectively standardized mortar strength containing a fraction 25% of calcined mud as a noted cement substitution p and the reference mortar strength (with cement only) (table 6).

$$I(p) = \frac{fp(t)}{f_0(t)} \qquad (1)$$

	$f_0(t)$ Mpa	$f_p(t)$Mpa	I(p)
28 days	47,4	39,20	0,83
90 days	52,30	45,08	0,86

Table 6 : Results of the tests of crushing’s in compressive

4.1.Fresh states

The characterization results carried out on the made concretes are presented in table 7.

Concrete	SCCR	SCCM10	SCCM15	SCCM20
Slump flow Ø(cm)	66,5	65,4	63,6	63,3
$T_{50\ cm}$ Slump flow(s)	3,5	3,3	3,1	3,2
L Box H_2/H_1	0,85	0,83	0,82	0,80
T_{40} L Box H2/H1 (s)	3,4	3,5	3,7	3,6
%	8,47	7,55	6,90	4,55
Bleeding ‰	1,25	1,18	1,12	1,15

Table 7 : Workability Test Results

a. Workability (Slump Flow test)

We can note that the whole of the SCCs comply with the criteria of flow spread, the specified values are between 63.3 and 66.5 cm (fig. 3), reproducing a less viscosity. Although no limit is given for times of flow spread, times measured to reach 50 cm diameter (T50) are close to the values usually met i.e: 3 seconds.

b. Flowability (L box test)

The L-box test is used to assess the filling and passing ability of SCC. This is a widely used test suitable for laboratory as well as site use. The concrete can be accepted if the fill ratio (H2/H1) of the L-box is higher than 0.8 (AFGC, 2000), times of flowing can be measured in order to appreciate the viscosity. The obtained results show clearly that concrete present satisfying ratio between 0.80 à and 0.85. Figure 4 shows clearly the amount of mud effect. We see that more this last increase, more the ratio decreases.

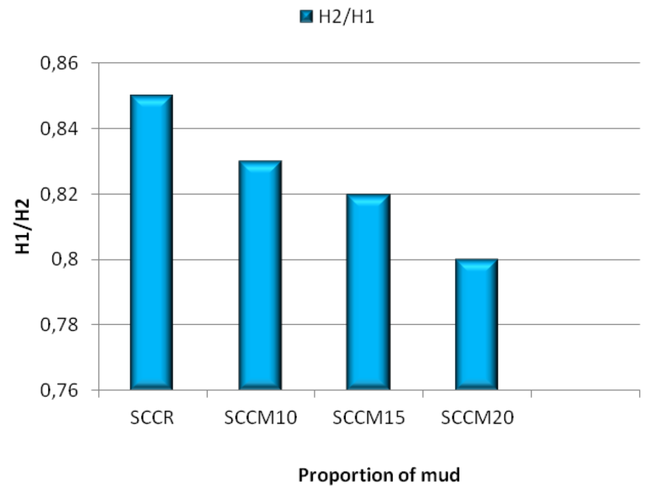

Fig.4 Histogram of ratio H2/H1 according to proportion of mud

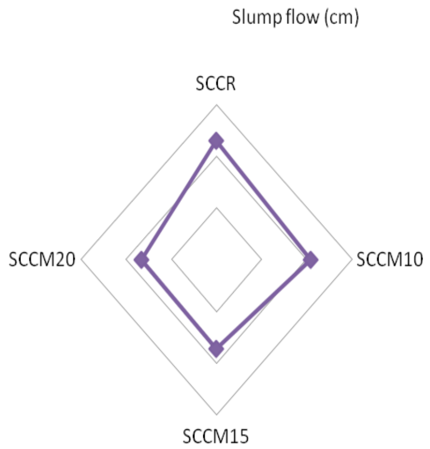

Fig.3. Diagram of the diameter of slump flow

c. Sieve stability test

For this test, fig 5 shows that all SCCs have a segregation rate under 15% which express a good stability (AFGC, 2000). Announcing as when 0⩽ Π ⩽ 5%, resistance to the segregation is known as "too important" it is the case of the SCCM20 or the paste is too viscous to run out through the sieve (Cussigh et al,2003).

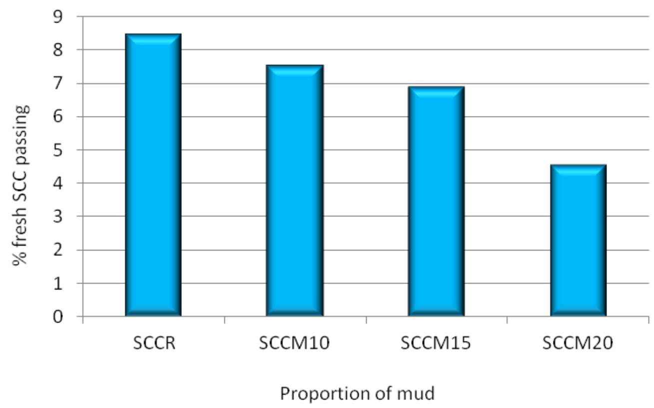

Fig.5. Histogram of the percentage of fresh SCC passing according to proportion in mud

d. Bleeding test

The results indicate that all the concretes respect the recommended value. The values obtained vary between 1.12 and 1.25 ‰. (fig 6)

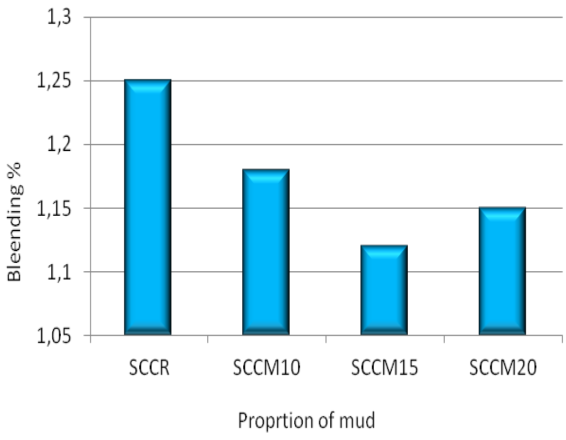

Fig.6. Histogram of bleeding according to the proportion of mud

4.2. Hardened state

4.2.1. Evolution of mechanical compressive strength

According to the obtained results and curves represented in the fig.7; it is clear that the SCCR displays good compressive performances for various testing age compared to the substituted concretes (SCCM). We note that at short terms, the concretes have similar amplitudes, on the other hand, at long terms, their amplitude starts to move away from that of the SCC; except for the SCCM10 which displays a trend close enough to the SCCR from 28 up to 90 days.

The evolution of compressive strength with respect to time shows that during the short-term period, the evolution rate of strength of concretes SCCM is developing more slowly than that of the SSCR, nevertheless we note that variation between the measured values is slightly different, especially for the SCCM10.

Measured values indicate that the SCCR has reached respectively 48%,60% and 82% of its compressive strength at 28 days for the testing age of 3, 7 and 14 days. However, the SCCM10, SCCM15 and SCCM20% reached between 48 to 51% at 3 days, 64 and 65% at 7 days and 89 to 92% at 14 days, which can be explained only by the effect of densification, the calcined mud played a filler part, by filling the pores and by increasing the compactness of the cementitious matrix.

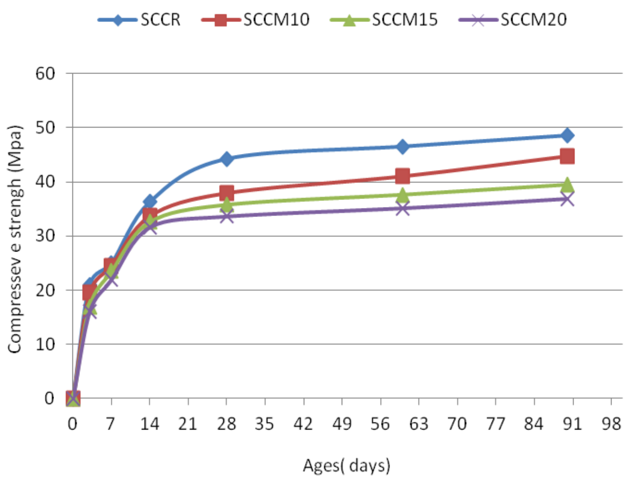

Fig. 7. Compressive strength of concretes versus time

On the other hand, between 28 and 90 days, it is the SCCM10 which evolves distinctly from the other SCCM, for these testing ages, the effect of the pozzolanic activity on the concretes can be distinguished. We can also clearly note the evolution of this compressive strength on the histogram represented in fig 8 which shows also the effect of variation of ratio M/C (proportioning in mud) on the evolution of strengths.

However, it is interesting to note that even with 20% of substitution, compressive strength remains within reasonable limits of 30 Mpa recommended by the various specifications of construction for the building concretes.

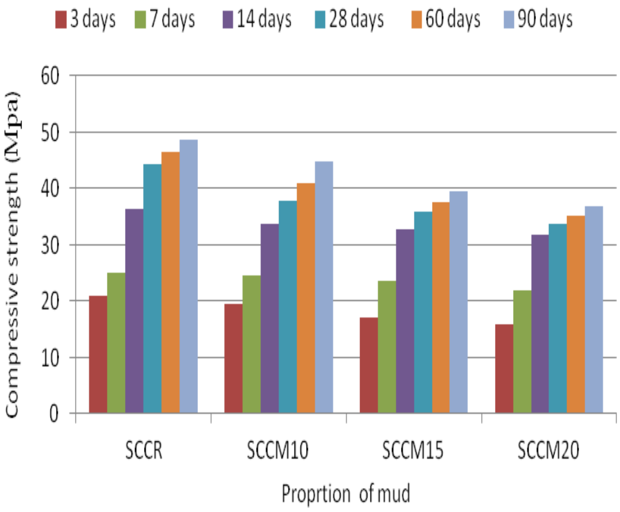

Fig.8. Histogram of evolution of the compressive strengths with respect to the proportion of mud

4.2.2. Evolution of mechanical tensile strength

It is known that the factors influencing the evolution of the compressive strength also influence the evolution of the tensile strength of a concrete. The obtained results show that concretes SCCM developed low strength compared to the reference SCCR.

According to the fig.9, we note that the development of the tensile strengths follows the same trend of compressive strength, the evolution of the strengths to the young age is identical; which confirms the hypothesis of the role of filler effect played by the mud.

We can note also on fig 9, the tensile strength of the SCCM10 displays a convergence towards that of the SCCR as of 28 days with respect of the two other concretes which indicate enough attenuated amplitude.

The fig. 10 shows clearly that the reference concrete presents best performances followed by the SCCM10. In general the loss of resistance in compression or traction does not exceed the mean value of 25% compared to the reference concretes whatever the age and the rate of substitution.

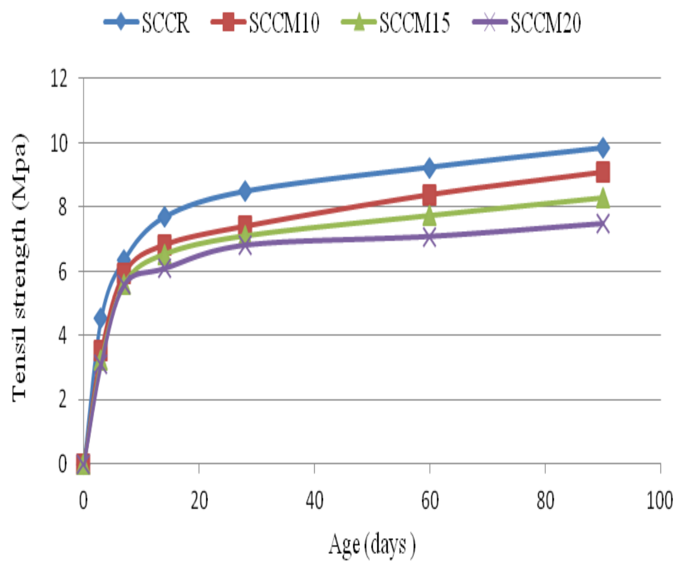

Fig 9. Evolution of tensile strength at different ages

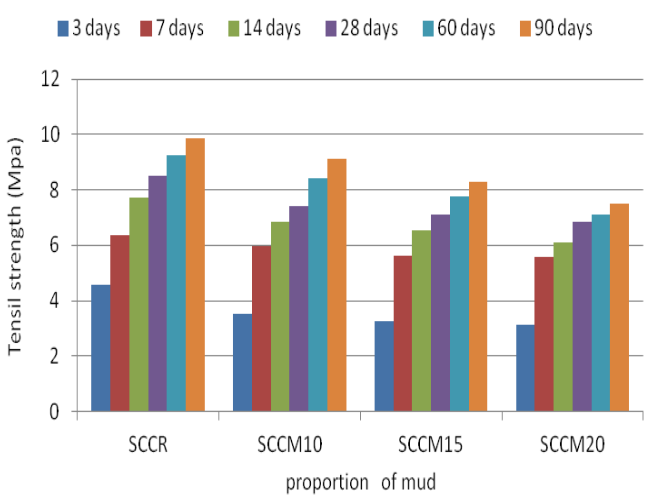

Fig10 . Histogram of evolution of the tensile strengths with respect to the proportion of mud

4.3. Differed deformation

We know that the element the more influencing shrinkage it is the quantity of water used, for that and in order to better determining the problem, we kept the ratio W/B = 0.5 fixed. The SCC tested are different in their composition only by proportion from substitution from cement by the calcined mud, we will understand that all differences in behaviour between the concretes will be obviously attached only to this parameter.

4.3.1. Autogenous Shrinkage

The autogenous deformations measured since the first day are displayed in fig 11. The kinetics of the deformations of the autogenous shrinkage of the concretes are rather similar, they take forms similar and almost identical to the first ages and begin to be different as we go forward in time.

Since this shrinkage is a consequence of hydration phase (Andra, 2005) (Yurtdas, 2003) which gives evidence of its kinetics and the quantity of formed hydrates. We can note that during the period from 28 to 90 days the orders of magnitude of the SCCM approached to those of SCCR in comparison with the values displayed with the young age. At 28 the SCCM displayed reduced values varying between 5.5 to 15.5% compared to the SCCR, on the other hand, between 60 and 90 days they are reduced by 4.6 to 12,45% compared to the SCCR which shows that deformations evolve in the same spindle, whereas the bringing together of the values is a revelation of a pozzolanic activity of the mud which began a priori after 28 days.

The reduction in the autogenous shrinkage in the presence of calcined mud can be explained with the fact that some hydrates obtained (calcium aluminate) via the pozzolanic reaction between the silica and the portlandite, are slightly expansive (Courard, 2001), which compensate the dimensional variations due to the shrinkage (Brook, 2001). The shrinkages present the same development according to the mechanical compressive strength (Person, 1997), the auto-desiccation known as a principal phenomenon which governs the autogenous shrinkage growing under the influence of a high strength.

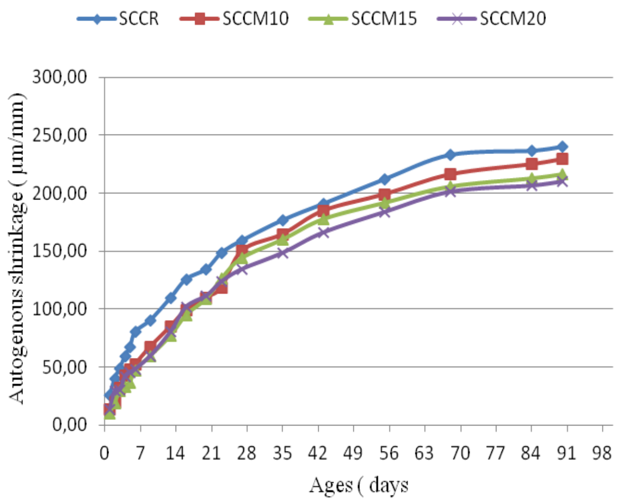

Fig.11. Evolution of the autogenous shrinkage versus time

4.3.2. Drying shrinkage

This Shrinkage develops from surfaces exposed to external environment, it is calculated by the difference between the total shrinkage and the autogenous shrinkage and it will be presented with respect to time and weight loss. The Figure 12 shows that the curves obtained for the SCC appear in a spindle, deducing that the component due to drying is not practically modified by the ratio V/C. During the first phase, the values of the shrinkage of the SCCM decrease compared to the SCCR with percentages varying between 21 to 52% at 7 and 28 days. On the other hand, in the second phase the evolution starts to slow down until becoming almost constant up to 90 days. Thus, we can note that the difference between the measured values decreased compared to the first phase, it varies between 16 to 30% which proves that the amplitude of the shrinkage starts to stabilize.

Nevertheless, whatever is the age, the SCCR always presents the highest values, on the contrary for the SCCM, their values decrease with the increase in the rate of substitution in calcined mud.

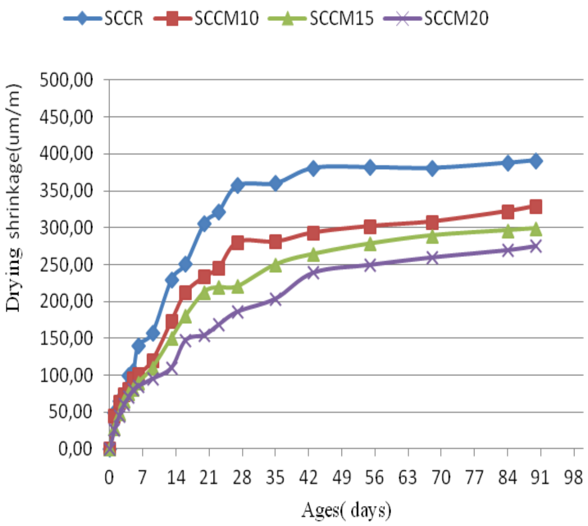

Fig.12. Evolution of the drying shrinkage versus time

4.3.3. Weight loss

In order to try to apprehend better the drying shrinkage, we have in same time carried out the follow-up of the test-tubes masses of shrinkage in order to quantify the hydrous exchanges.

Curves of fig 13 show that the weight losses are in agreement with the evolution of the drying shrinkage, the values of weight loss are very high and almost identical as of the first days for all the concretes, the curves start all by a linear part whose slope seems to decrease slightly with the age. In the intermediate zone the curves are strongly nonlinear, which explains a reduction due to evaporation to reach a low value. After 60 days, the weight losses start to decrease very slightly, there are weaker for a concrete of substitution mud - cement than for reference concrete. Finally an effect of ratio M/C is undoubtedly to change the hydrous pressures development of curve with respect to the degrees of saturation (Trurky, 2004).

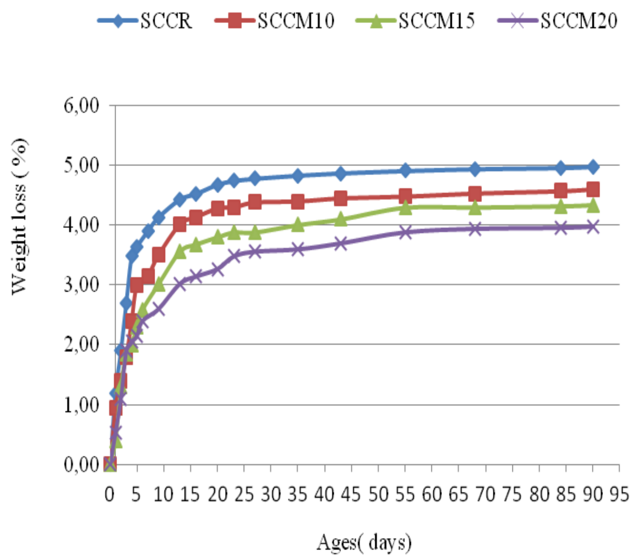

Fig.13. Evolution of loss of mass versus time

Fig 14 also shows that the various drying shrinkage evolution curve with respect to the weight loss, are represented in two phases; the first schematizes a first water departure without consequence on the shrinkage, the second schematizes evolution of the shrinkage with the water loss. The explanation would come from the existence of the type from water and two families of pores: the water contained in the large pores would leave without causing shrinkage whereas that contained in the small pores would generate the contractions of the materials (Neville, 2000).

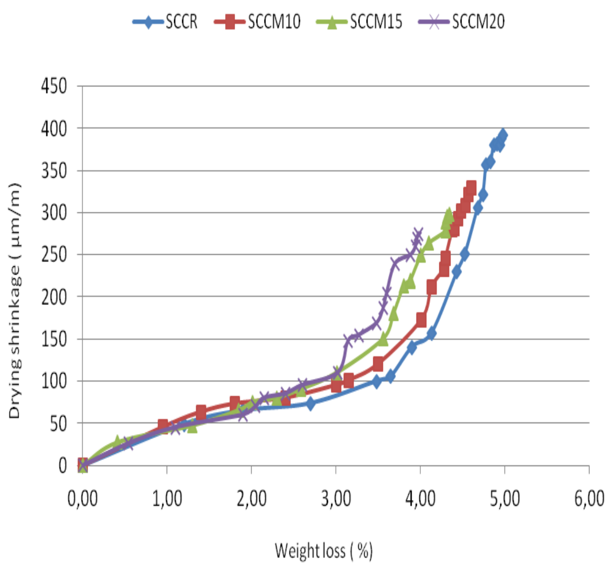

Fig.14 : Drying shrinkage versus loss of mass.

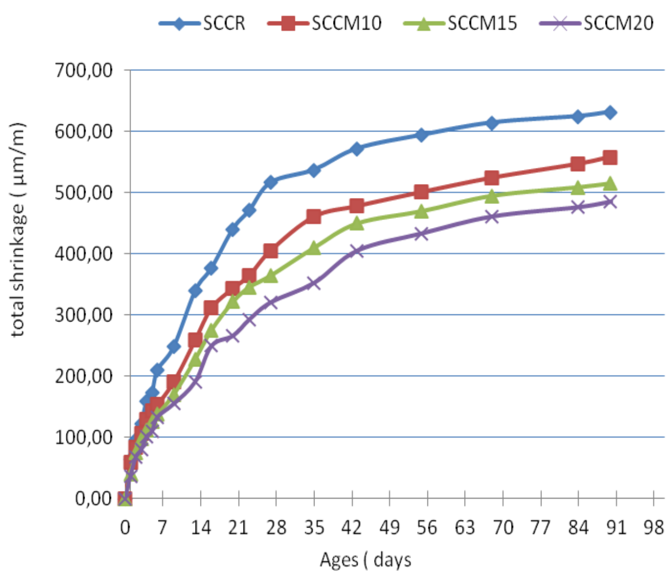

FIG.5. Evolution of the total shrinkage versus time

4.3.4. Total shrinkage

It evolves very quickly for all the types of test-tubes preserved in the air because of their sizes which makes the desiccation more favorable. At the young age, the shrinkage is almost independent of the composition of the concrete. The values of shrinkage are concentrated in the same spindle and the effect of the addition appears only after the first week with a light superiority for the SCCR. At the long term, the presence of the mud decreases the final shrinkage with respect to the proportioning of substitution.

Fig 15 shows a similar evolution of deformation for all the SCCs. It is because that at the very young age, we have difficulty to distinguish between the representatives graphs of each concrete. The order of magnitude at 7 days presents reductions which vary from 14 to 36% for the SCCM compared to the SCCR. Beyond 7 days, the shrinkage of the reference SCC evolves much more quickly and is distinguished from the others until 90 days of age, with similar amplitude.

We also note that for this shrinkage, the reference SCC shows the highest values at all the ages.

On fig 16, we traced with respect to the log (t) scale, the total shrinkage, rather than the drying shrinkage which is only a low estimate. Three phases appeared, during the first, the shrinkage gradually increases, during the second, it evolves linearly with the logarithm of time and during the third, the curve of shrinkage inflects towards an asymptotic value.

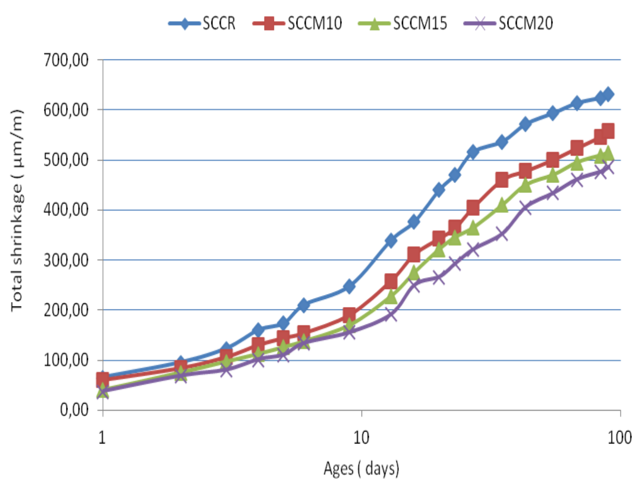

Fig.16. Total shrinkage according to the logarithmic scale

5. Conclusions

Our study made it possible to confirm possibility of the valorization of the mud resulting from the dam Fergoug as a partly substitutable material to cement. Principal conclusions obtained are as follows:

1-The study of the behaviour of the SCC in a fresh state according to the proportioning of the calcined mud allows to draw the following observations:

- The results indicate that the SCC containing calcined mud are more viscous and less workable compared to the reference concrete, because beyond a critical proportioning, the viscosity of the concrete increases with substitution.
- Only the SCCM20 which presented a too important segregation according to the sieve test.
- In addition to the test of bleeding, obtained values with the tests of simple flow, L-box and sieve stability, decreases when proportioning in calcined mud increases.
- The densification of the microstructure played a favorable effect by decreasing beelding what can give an idea on the improvement of the interface paste aggregates.

2-At the hardened state, the mechanical tests of evaluation of compressive and tensile strength carried out on test-tubes made with self-consolidating concretes to various percentages of mud in comparison with a reference concrete made with cement alone, gave the following results:

- Evolution of strength is influenced by the ratio M/C (the rate of substitution of cement by the calcined mud), the results indicate that compressive and tensile strength decrease with the increase in calcined mud content, these values are very tolerable for concretes employed for buildings constructions.

- Best values of compressive and tensile strength for the SCCM are obtained with the SCCM10 %, but it always remains that the SCCR presents the highest values. Indeed the use of mineral addition involves the formation of a new CSH which fills the pores of the hardened cement paste, densifies the structure of the paste and leads to a reduction in porosity. These effects lead to an improvement of the mechanical strength.

4- The tests of differed deformations, carried out on the same concretes, consisted in following the evolution in time of the free deformations at autogenous and drying conditions. The obtained results show that the calcined mud tends to slightly decrease the differed deformations; we concluded that their kinetics are associated with the physicochemical mechanism so:

- The autogenous shrinkage decreases with the increase in the proportioning of substitution of the calcined mud.
- The compactness of the microstructure and the refinement of the pores lead to a fall of permeability and prevent the diffusivity of water and consequently decrease the drying shrinkage and the weight loss.
- The total shrinkage follows the same principle, being influenced by the autogenous shrinkage more than that of drying, it also decreases according to the ratio M/C and goes in the direction where the total shrinkage is an intrinsic phenomenon of the concrete.
- The analysis of the phenomenon of the shrinkage in the presence of calcined mud indicates that this addition contributes to decrease of the shrinkage amplitudes compared to the reference concrete. The content of 20% of substitution, seems best indicated as a choice for its contribution to the improvement of the microstructure and finally to decrease the effects of shrinkage.

Finally, it is deduced that the calcined mud by its reactivity and fineness influences the mechanical and differed properties of the concretes:

- pozzolanic reaction starts to be perceptible at long-term by improving compressive and tensile strengths.
- substitution of 10% of cement is an optimal content to give the best mechanical performances for 15 and 20% respectively.
- the shrinkage and the weight loss are less high for an optimal content of 20% of substitution because of an improvement of the microstructure, returning the matrix more compact and minimizing the diffusivity also followed by 15 and 10%.

In conclusion we can deduce that a substitution of 15% of cement by the mud is the most interesting content which proves to be optimal, since it is the average rate which satisfied the two criteria of strength improvement and shrinkage reduction.

References

Neville, A., .Propriétés des bétons. Centre de recherche international du béton, Editions Eyrolles, 2000.

Andra . Référentiel des matériaux d'un stockage de déchets à haut activité et à vie longue . Tome 2 : matériaux cimentaires, 2005

AFGC, Bétons Auto-Plaçants Recommandations provisoires", Association française de Génie Civil, 2000.

Courard.l., A. Darimont, M. Sschouterden, F. Ferauche, X. Willem, R. Degeimbre, Durability of mortars modified with metakaolin », cement and concrete research, 33 (2003), pp 1473-1479.

Brook JJ .MA Megat Johar. Effect of metakaolin on creep and shrinkage of concrete. cement and concrete research composite ,23 (2001) pp.495-502.

Persson . B , Self desiccation and its importance in concrete technology., materials and structures, 30, 1997, p 293-305

Cussigh, F., Sonebi, M., and Schutter, G. Project testing SCC-segregation test method", Proceedings of the third international, RILEM conference on SCC, Reykjavik, Islande, Août 2003, pp 311-322

Remini, B., .Qualification du transport solide dans le bassin versant de l'oued Isser .Application à l'envasement du barrage de Béni Amrane", 2eme CMEE Alger, Oct 2002

ABHC, "Agence du bassin hydrographique Chott-Chergui de l'ouest". 2007

Semcha, A., .Valorisation des sédiments de dragage Applications dans le BTP, cas du barrage de Fergoug, Thèse de doctorat, Université de Reims Champagne-Ardenne, Décembre 2006

Turcry Philippe. Retrait et fissuration des bétons autoplaçants : influence de la formulation,. Thèse de doctorat, école centrale de Nantes, février 2004.

Yurtdas .I. Couplage comportement mécanique et dessiccation des matériaux à cimentaire: étude expérimentale sur mortiers. Thèse de l'université des sciences et technologie de Lille, 2003