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Research Article

Influence of the structure on the capillary suction of the micro concrete

Akanho Chakirou TOUKOUROU [1], Gontrand Comlan BAGAN [1], Alain VAUTRIN [2]
[1]Laboratoire d'Energétique et de Mécanique Appliquée (LEMA), Ecole Polytechnique d'Abomey Calavi, 01 BP 2009 Cotonou, Benin.
[2]Département Mécanique et Matériaux (M&M / ENS-ME), 158 Cours Fauriel 42023 St-Etienne France.

***Corresponding author**
Akanho Chakirou TOUKOUROU
Email: potemat@yahoo.fr

Abstract: The micro concrete is a variable water and cement aggregate mix, following quite precise standards. It is an extremely fragile, but very significant heterogeneous material for the implementation of the tiles and the plates in many countries. The aim of the study was to investigate the influence of the microstructure of the micro concrete on its capacity of suction. The results showed that the capacity of suction decreased with the increase in the coarse sand rate of the cementing matrix.
Keywords: Micro concrete, brittle material, porosity, hydrous absorption power.

INTRODUCTION

Manufactured starting from sand, cement and water, the micro concrete has properties which vary in function not only according to quality of the basic raw materials, but also of their quantity and proportions. In the current study the influence of the granular composition on the mechanical properties of this material particularly interesting for the manufacture of the tiles is investigated.

Experimental procedure

The micro concrete is manufactured starting from the aggregates resulting from two sands distinct of siliceous nature: the average sand noted (S) and coarse sand noted (G).

Considering the recommendations in force for the manufacture of the tiles in micro concrete, we limit the characterization of sands to the granulometric analysis and the sand equivalence.

- Average sand is composed of grains with dimension going from 0.4 to 1.6 mm.
- Coarse sand is composed of grains with dimension going from 1.6 to 6.3 mm.

Within the framework of these investigations, average sand used is of marine origin and the coarse sand of alluvial origin. Both sands were washed beforehand to be removed from the salt which they contain.

The table 1 presented the distribution of the grains presented figure 1 illustrated the distribution of the grains .

Table 1:Granulometric distribution of sands

Aggregates diameters (mm)	0.08	0.16	0.315	0.63	1	1.25	2	2.5	5	8
Sieve Module AFNOR X11-501 and P18-304	20	23	26	29	31	32	34	35	38	41
Filtered (fine sand) in % cumulated	0.07	0.81	11.1	66.65	97.53	99.89	100	100	100	100
Filtered (coarse sand) in % cumulated	0.1	0.62	3.52	9.1	17.1	22.97	49.72	66.07	96	100

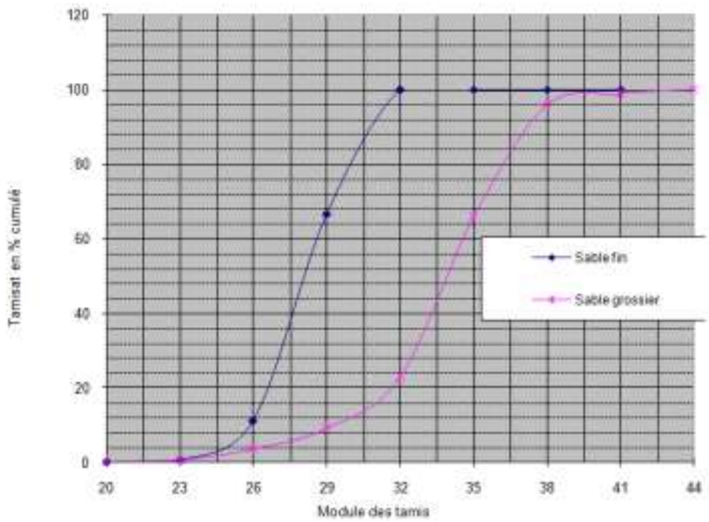

Fig-1: Grading curves of the aggregates

The sand equivalent (Es) of each sand is higher than 0.90. The standard in force requires a minimum of 0.85.

In addition to the aggregates, cement CPJ 325 and water were raw materials used for the placement of material. The proportion in volume of cement compared to sands was 1/2, according to the recommendations in force [4].

Seven samples were made according to process presented above. They differed essentially by their granular composition, presented in table 2.

Table 2: Granular composition of the samples

Samples	**2080**	**3070**	**4060**	**5050**	**6040**	**7030**	**8020**
Proportion of coarse sand [G/(S+G)] in %	20	30	40	50	60	70	80

To study the microstructure of the sample, a method of observation which consists in passing the image of the directly prepared sample to acquisition using the device represented on figure-2 was used. Seen under the optical microscope or the binocular magnifying glass, with a factor of enlarging equal to 5, the samples were presented in the form of a crystal network with pores of variable sizes, which coats the various aggregates. Of a random distribution the pores appeared black (Figure 3).

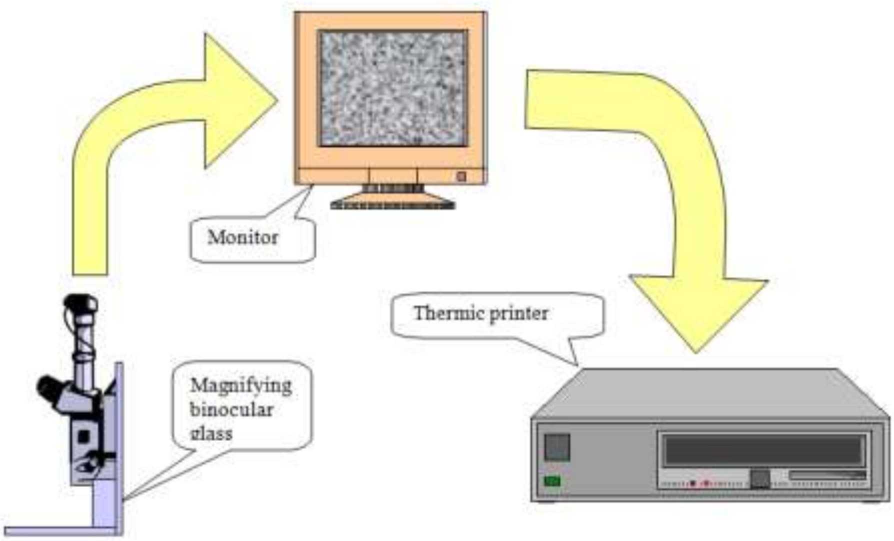

Fig-2(A): The device of image acquisition

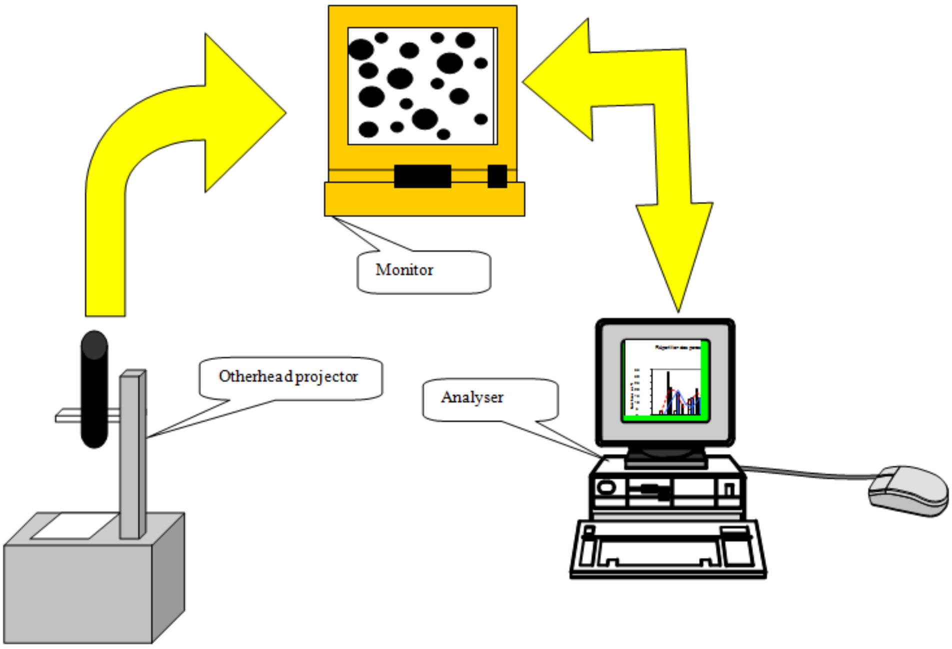

Fig-2(B): Device of image processing

RESULTS AND DISCUSSION

The acquisition of the images of the various samples makes it possible to notice that the diameter of the visible pores varies from 5 to 550 microns. The total distribution of the pores is represented by the curves of figure 4.

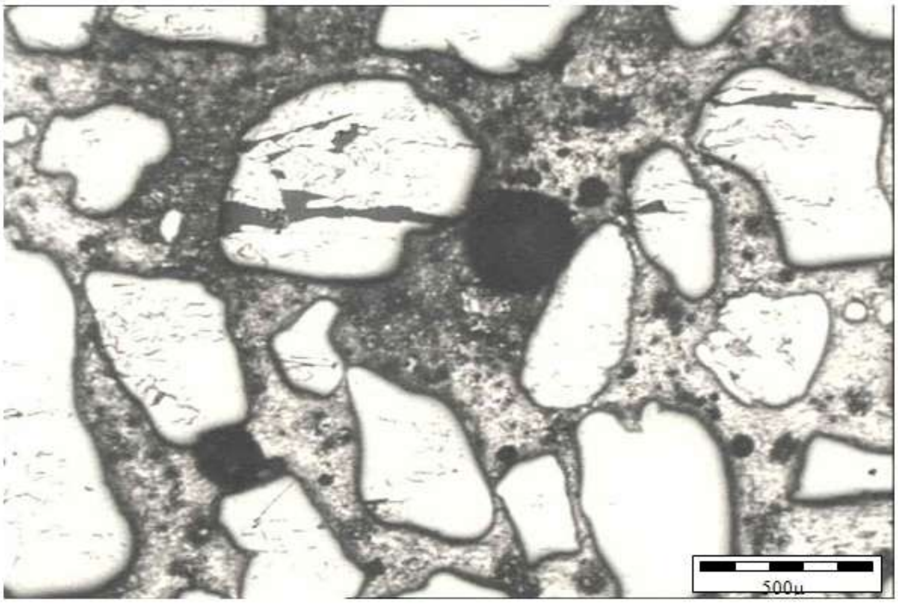

Fig-3: Morphology of the microconcrete

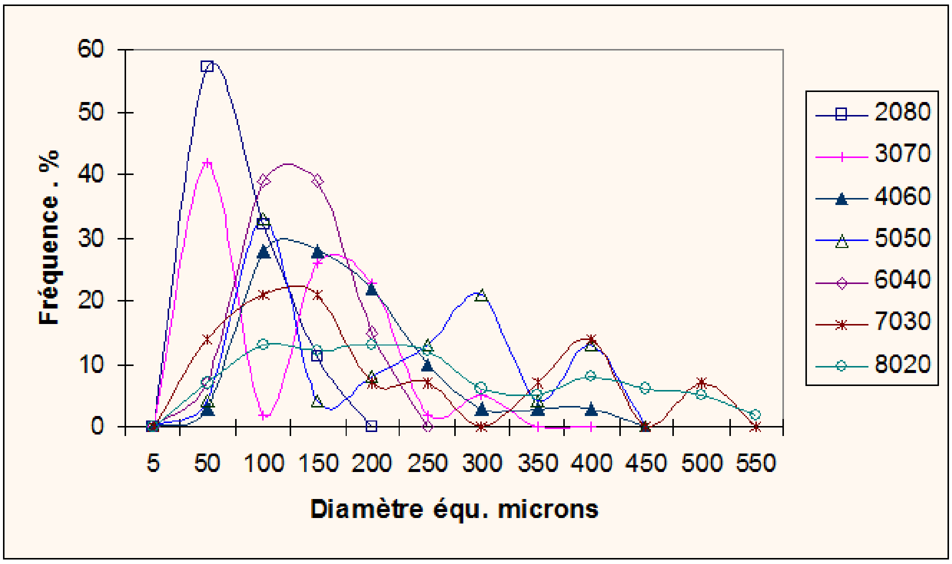

Fig-4: Global distribution curves of the sample's pores

One can notice that higher the coarse sand rate was, fewer were the low-size pores. On the other hand, with the coarse sand increase it appears more and more of large pores.

The equation of Kelvin allows to study the phenomenon of absorption, in order to measure dimensions and the distribution of the pores. It expresses the balance of the vapor pressure of a covered surface, similar to a liquid in a capillary or pore [2] and [4]:

$$(P-P_o) = (RT/Mv).\ LnH \qquad (1)$$

Where:

P: pressure of capillary water;
Po : atmospheric pressure;
R: Constant of perfect gases, R=8.3 J/mole/°K;
T : ambient temperature;
M : molar masse;
V mass volume;
H: hygroscopy relating to the surrounding air.

A consequence of this equation is [5]:

$$Ln\frac{P}{P_0} = -\frac{2v\bar{V}}{rRT}\cos\theta \qquad (2)$$

where

P: pressure of liquid in the pore of ray R;
P_0 : pressure of the same liquid on a plane surface;
$\bar{V}$: surface tension;
V : molar volume;
ɵ: angle of damping (figure 5)

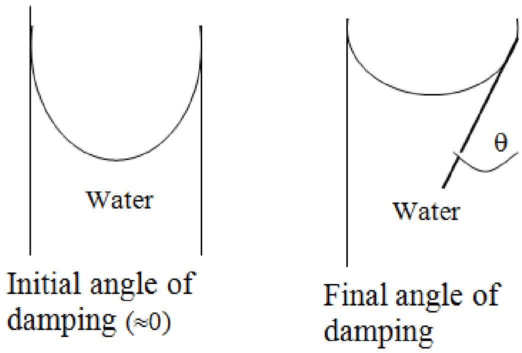

Fig-5: Representation of angle of damping

In the thermodynamic direction, the equation of Kelvin considers that a dn quantity moles of vapor is transferred with the liquid mass to the P_0 pressure in a pore where the pressure of balance is P.

This process was carried out in three stages: evaporation starting from the liquid mass, expansion of the vapor of P_0 to P and condensation in the pore.

Only to the third stage there is free energy exchange describes by the following equation:

$$dG = [RT\ \ln(\frac{P}{P_0})]dn \qquad (3)$$

The capacity of suction is proportional to the surface density of the pores able to absorb and retain water in the capillaries.

To be closer to the conditions for application of the model of Kelvin, then in order to make a logical comparison, one will hold account for the continuation of this study only of the pores of dimensions varying between 5 and 50 microns.

The results obtained after acquisition and image processing of the population of pores of size ranging between 5 and 50 microns were presented in table 3. They were graphically illustrated by the curves of figure 6.These curves represent the distribution of the pores according to the equivalent diameter.

Table 3: Distribution of the pores by sample

Designation	Diameters of pores in microns	Frequencies of Diameter Equiv. %
Sample 2080	5 -- 10	4
	10 -- 20	18
	20 -- 30	31
	30 -- 40	47
	40 -- 50	0
Sample 3070	5 -- 10	36
	10 -- 15	40
	15 -- 20	14
	20 -- 25	5
	25 -- 30	3
	30 -- 35	2
	35 -- 40	0
Sample 4060	5 -- 10	30
	10 -- 15	40
	15 -- 20	17
	20 -- 25	7
	25 -- 30	3
	30 -- 35	3
	35 -- 40	0
Sample 5050	5 -- 10	25
	10 -- 15	36
	15 -- 20	22
	20 -- 25	9
	25 -- 30	3
	30 -- 35	2
	35 -- 40	2
	40 -- 45	1
Sample 6040	5 -- 15	52
	15 -- 25	41
	25 -- 35	5
	35 -- 45	1
	45 -- 55	1
Sample 7030	5 -- 10	14
	10 -- 15	47
	15 -- 20	28
	20 -- 25	5
	25 -- 30	4
	30 -- 35	2
	35 -- 40	0
	40 -- 45	0
Sample 8020	5 -- 15	63
	15 -- 25	25
	25 -- 35	8
	35 -- 45	4

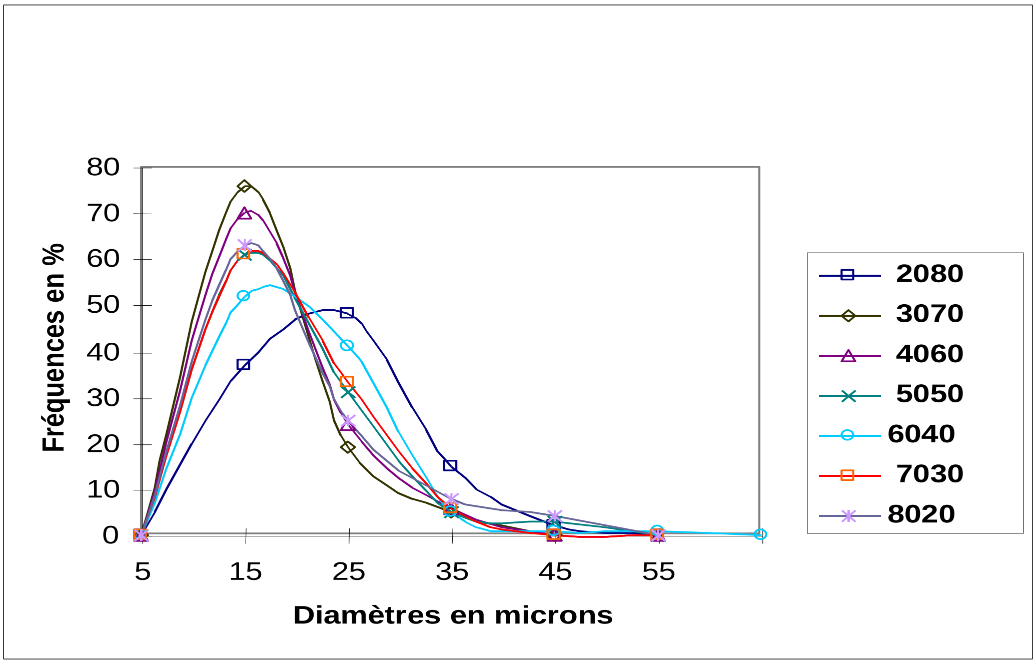

Fig-6: Curves of pattern of the settlements of pores of dimensions 5 to 50 microns

It is noted that the populations of pores of size ranging between 5 and 50 microns have a distribution quasi-normal. Table 4 gives of them the parameters characteristic with a threshold of 68,27% and one confidence coefficient equal to 1 [2].

Table 4: Parameters of distribution of the pores.

Samples	$\overline{\Phi} = \Sigma\Phi_i n_i/N$	Pores density.10^4	Standard deviation σ
2080	11.90	2.88	7.83
3070	12.67	2.77	5.55
4060	12.09	2.07	5.35
5050	12.58	2.28	6.25
6040	13.20	1.93	6.63
7030	13.85	1.93	5.42
8020	13.85	1.38	6.30

The analysis of the distribution of the density of pores compared to the rate (G/(S+G)) of coarse sand contained in the microconcrete according to the curve of figure 7 indicates that the number of pores of diameters ranging between 5 and 50 microns tends towards a constant value from 50%.

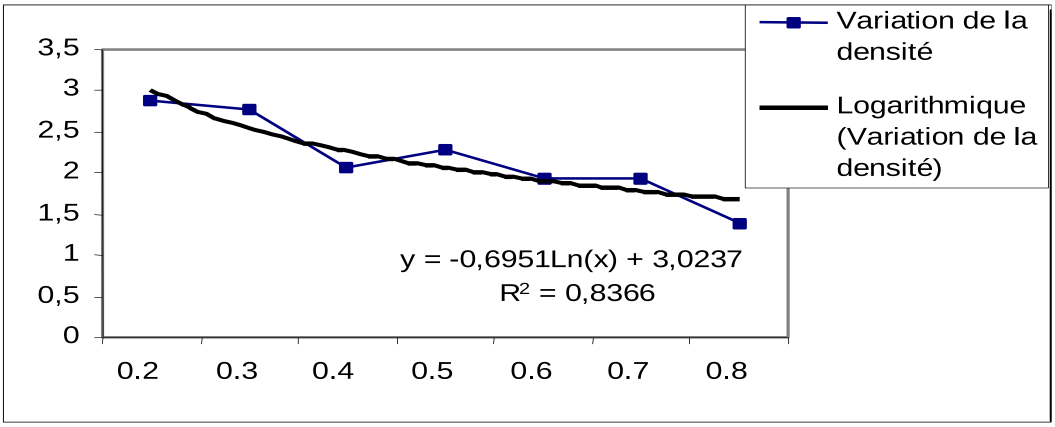

Fig-7: Variation of the density compared to the coarse sand rates

CONCLUSION

The micro concrete under the optical microscope with a suitable enlarging reveals aggregates and a cementing network in which swarm a multitude with variable pores of dimensions. This study made it possible to note that the population of pores of diameter ranging between 5 and 50 microns is less and less dense when the rate of fine gravels increases. In the same way the results of this work show as this decreasing tends towards a limit from 50% of fine gravels. This is in perfect agreement with the rate of 2/3 used in tileries.

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