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Acoustic properties of light concrete of natural pozzolans of Ambohinaorina

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Abstract

Pedological study is essential because it contributes to improve our knowledge on materials used to construct buildings of which lifetime is in compliance with the norms in force. Our study is based on the acoustic properties of the pozzolan concrete of the Ambohinaorina (Vakinankaratra region-Madagascar). The numerous experimental results obtained in this article demonstrate that pozzolan can be used to produce lightweight concrete in taking into account the volumetric composition of aggregates (cement included) which has to be optimum.

1. Introduction

Since the advent of Queen Ranavalona first (1828-1861) with the technical support of Jean Laborde (first French technician in the service of the Queen), the socio-economic development of Madagascar, allows to engage the exploitation of mineral resources and building materials. This commitment is undertaken in the context of the rapid and sustainable development of the country, through which the State prioritizes areas with high economic potential. Currently, three main axes have been defined as priority poles and receive funding from the World Bank through the flagship project Integrated Growth Poles or ICP: the Antananarivo-Antsirabe axis (cities of the central Malagasy highlands), Nosy-Be (first tourist town Malagasy) and Fort-Dauphin (new port city of the extreme south-east Malagasy). In particular, we will focus on the Antsirabe-Betafo area, as this area is Madagascar's second industrial area and still offers several under-exploited potential.

This work is part of the implementation of natural mineral resources Malagasy. It aims to minimize the cost of construction through the use of proper technique and materials. More specifically, this work studies natural pozzolana aggregates from the Ambohinaorina Madagascar region. The current trend in the individual building, is to favor light products able to fulfill several uses.

Under the term "light concrete" is grouped all concretes whose density is lower than that of ordinary concrete (equal to about 2.4). Such a density can be obtained by substituting conventional aggregates (sand, gravel) with lighter, often artificial aggregates such as, inter alia, expanded polystyrene beads [1], and the processed palm nut shell [2]. The characteristics of the aggregates are decisive in the performance of lightweight concretes, as shown by, among others, the experimental work of L. H. Nguyen [3].

The choice of materials and their positioning are essential from the acoustic point of view. The materials can be classified according to three broad categories according to their acoustic property: diffusing, reflecting or absorbing. A good knowledge of these factors will help specialists to design and economically build walls with high levels of acoustic performance. The approach that interests us is proposed by Maa [4]. His theory has been repeated many times and applied to absorbent systems comprising micro-perforated plates [5] [6]. Each study was undertaken on plate absorptions, but most of them were based more particularly on radiation, [7] namely, vibration and sound radius formation.

The originality of this work concerns the specific characteristics of natural pozzolana concrete. This specificity is due to the properties of each constituent as well as the resulting microstructure of the mixture thereof. In this context, the exploitation of the experimental results facilitates the definition of the reformulation of pozzolan concretes.

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2.Materials and method

2.1. Materials

The following materials were used to produce the various concretes considered in the experimental program.

2.1.1. pozzolan

The site located in the Ankaratra Madagascar massif to carry out this study was opted for the following reasons:

- The Ankaratra Massif is located in the Malagasy Central Highlands;
- Ambohinaorina's pozzolana is the most used and is exploited by the HOLCIM cement plant.

The Ambohinaorina volcanic cone is the best preserved of all volcanic cones in the Betafo region. Its main mass, which has never been evaluated, consists of projection products, of which the slag largely dominates. They are usually purplish black, but also found in brick red. The figure 1, n°1 was elaborated by a software GIS (Geographic Information System) from a map which represents the zone. All the elements represented are the synthesis of this map

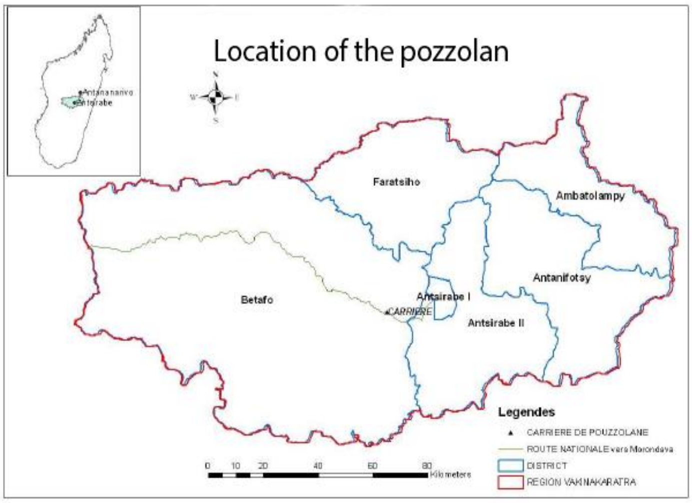

Fig.1. Site of Ambohinaorina

For a certain precision on the location, we indicated on the table n ° 1, the national road (RN) and the kilometric point (PK) of the quarries in which the samples are taken.

There is a great variety of volcanic rocks but their industrial use as raw materials is not always known precisely (especially for pozzolans). It is therefore essential to subject the collected pozzolan granules to rigorous identification and characterization studies. If the mineralogical and chemical composition of pozzolans are favorable, they can be used as additions in the manufacture of a number of cements or as aggregates for the manufacture of concrete. Chemical analysis is applied to powdered pozzolana samples. A special method called the powder method applies to crumbled samples. It uses a monochromatic X-ray beam.

Table 1: Location and description of the samples

Career	Road	PK	Color	Form	Surface	Structure	designation
Ambohinaorina	RN34	21.75	Purplish black	Scoriaceous	Very rough	Porous	scoria
Tritriva Nord	RN34	6.6	black	scoriaceous	Very rough	Alveolar	scoria
Ambohijatovo	RN34	22	Yellowish black	scoriaceous	Rough	Porous	Basaltic arenas
Amboniatsinanana	RN7	167	Gray	Round and picked up	A little rough	Alveolar	scoria

This operation makes it possible to detect that the powder sample is formed of a large number of small crystals having any orientation. The equipment used is a SIEMENS D500 diffractometer using monochromatic CuKa radiation with a wavelength k = 1.7903 A° at a voltage of 40 kV and a current of 30 mA. The results obtained from Ambohinaorina pozzolans are shown in Fig.2.

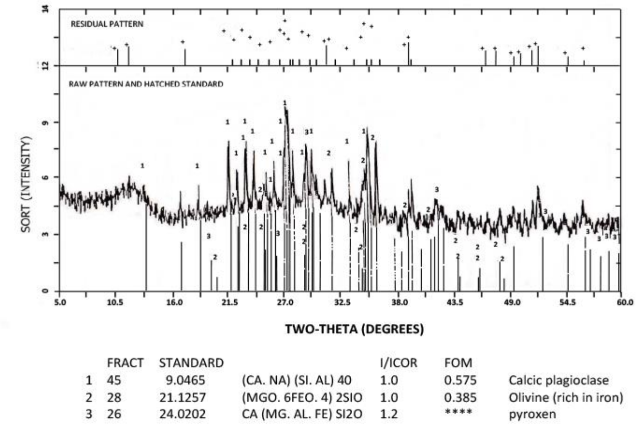

Fig. 2 Diffractogram of the Ambohinaorina sample

Tables 2 to 4 show the results of chemical and mineralogical analyzes on these samples. It should be recalled that the purpose of the NF EN 206-1 standard [8] is to define pozzolan and to fix the characteristics to which it must comply, as well as the tests to be determined. It does not apply to pozzolan intended for uses other than the manufacture of building concretes. Natural rock, usually of a black or red color, consisting of volcanic slags, the average silica, alumina and ferric oxide contents of pozzolan must fall within the following limits: SiO 2 from 43 to 55%; Al203 from 12 to 24%; Fe203 from 8 to 20%. The main purpose of these limits is to ensure good cementation and cohesion between the chemical elements.

Table 2: Results of chemical analyzes of the pozzolans of Antsirabe-Betafo

Eléments	Tritriva-Nord	Ambohijatovo	Ambohinaorina	Amboniatsinanana
SiO_2	48,70	41,48	44,63	48,83
Al_2O_3	20,12	15,25	13,04	18,62
Fe_2O_3	01,13	13,42	12,48	10,64
CaO	10,58	06,37	12,08	05,97
MgO	09,81	07,34	09,56	03,60
K_2O	01,10	00,34	01,33	01,90
SO_3	00,00	00,00	00,02	00,00
TiO_2	02,81	02,42	02,29	02,08
MnO	00,22	00,20	00,21	00,21
Na_2O	02,78	01,01	02,40	04,21
Cr_2O_3	00,10	00,07	00,11	00,01
P_2O_5	00,64	00,45	00,71	00,93
LOI	02,00	11,66	01,15	03,00
TOTAL	99,99	100,01	100,01	100

From this analysis, it can be seen that for the pozzolans of Ambohinaorina, the proportion of alumina, silica and iron oxide perfectly corresponds to the limits of the characteristics fixed by the French standard NF EN 206-1 in the field of pozzolans. The alkali contents calculated in Table 3 are given in Na2O equivalent content usually used by cement manufacturers.

Table 3: Alkali content of slag

Eléments	Tritriva-Nord	Ambohinaorina	Amboniatsinanana
(Na2O +0,66K2O)%	3,506	3,278	5,464

According to these results, the pozzolans of Ambohinaorina are the least rich in alkalis, but in general these granulates contain alkalis.

Table 4: Mineralogical results

Careers	Dominant minerals	Secondary minerals
Tritriva-Nord	Orthose ; Diopside Leucite ; Albite	Chabasite ; Pyromorphique Dolomite ; Ilmenite
Ambohijatovo	Albite ; diopsite Nepheline ; Angite	Calcite ; Magnetite Foresterite ; Muscovite
Ambohinaorina	Nepheline ; orthose ; Magnetite	Diopsite ; Foresterite
Amboniatsinanana	Anorthite ; Magnetite Nepheline ; Sanidine	Calcite ; Diopside ; Hauyne Aegyrine ; Apatite

Each sample collected was finely evaluated for apparent and actual densities as well as for natural moisture content. The average results are shown in Table 5 where:

ρg: apparent density of aggregates in their natural state (intergranular voids are taken into account). This density is essential for the determination of the mass of aggregates to be used in the manufacture of concretes, and in particular for cavernous concretes.

ρr: actual density of pre-milled aggregates (intergranular voids are not considered). It is necessary in the field of calculating the granular mass to be used in the composition of concretes.

W: water content of aggregates in their natural state. The amount of water to admit to have a good mortar is that strictly necessary to obtain a plastic mortar.

If the pozzolans are too dry, we obtain high compacities and high strengths, but the mortar is not very adherent and very unwieldy. Any excess of water, on the other hand, causes a drop of resistance, impermeability [9] and an additional consumption of cement.

Table 5: Density values and water contents

	Tritriva-Nord	Ambohinaorina	Ambohijatovo	Amboniatsinanana
ρg [T /m^3]	1,46	1,47	1,46	1,40
ρr [T /m^3]	2,80	2,89	2,78	2,52
W %	8	6	6	10

These results show that the value of the water content is about 6%. The water content of aggregates coming from the same quarry is a function of the sampling point which is located either in surface area or at depth. The hygrometric effect of the site also affects the water content of aggregates as humidity increases this effect.

2.1.2. Cement

The cement used in our experiments is of type I [10]. The physical properties and chemical composition of this cement are listed in Table 6.

2.1.3 Water

Drinking water meeting the requirements of ASTM C 1602-06 [11] was used to mix the concrete, and saturated lime water [12] was used to harden the samples

Table 6: Physical and chemical properties of cement

Specific gravity (g/ cm^3)		3,15	ASTM C 188-03
Specific surface (cm^2/g)		3897	ASTM C 204-05
Initial setting time (min)		30	ASTM C 191-04
Compressive strength (MPa)			
	1 d	10,4	
	3 d	21,3	
	7 d	33,5	
	28 d	43,6	
Chemical composition, % by weight			
	SiO2	20,5	
	Al2O3	4.52	
	Fe2O3	2.71	
	CaO	63.93	
	MgO	2.39	
	K2O	1.01	
	SO3	3.3	
	Na2O	0.19	
	LOI	0.97	

2.2 Test methods

2.2.1. Binary and ternary mixtures

From the theoretical and experimental point of view, a number of authors [13-15] have carried out work on the behavior of granular mixtures in order to obtain an optimal formulation of concretes. In our research, an experimental protocol defined rules for the fine study of the composition of our concretes.

For common concretes, the main objective is to make and obtain concrete with minimal porosity. Indeed, these concretes offer the best mechanical resistance. For lightweight concrete aggregates (pozzolan) which differs slightly from common concretes is to obtain mixing rules compatible with the composition of common concretes, to obtain a low density and good physical and mechanical characteristics. However, there is an incompatibility between these features that prevents the optimization of the mixture. What is actually gained in thermal resistance is always more or less lost in terms of mechanical strength.

The rule of linear variation of the theoretical void ratio governs the rule of mixtures of two aggregates, at least one of which is porous. So we have a relationship:

$$e = \alpha V_{abs} + \beta \quad (1)$$

Where, α and β are function coefficients of the grain void index as well as their shape and Vab the absolute volume of the aggregates in 1m^3 of concrete.

By observation, the shape of the grains has a certain influence on the void index corroborated with the effects of the walls and the interference of aggregates. An experimental study is therefore imperative to better know the interaction between fine aggregates and coarse aggregates. This behavior is observed on a scoriaceous form such as natural pozzolans.

In the case of ternary mixtures, the parameters to be analyzed are the following: sand, fines and gravels with their interaction. On the one hand, for sands, fines and gravels, their two-by-two grip confirms their behavior as binary mixtures. On the other hand, as far as interactions are concerned, they are more generalized between these aggregates because of the different influences depending on the case. For binary mixtures, the actual volume (Vg) of pozzolan aggregates is constant for the variants noted in batches bc.1 to bc.6. From this consideration, we proceeded to a gradual decrease of the cement dosage in order to be satisfied on the results of index of voids. The amount of pozzolanic fines used was calculated to satisfy the value of the total absolute volume of the mixture (in substitution of the cement). It should be noted that for lots bc.7 and bc.8, we have reduced the quantity of Vg so that its efficiency is significant on the void index. Table 7 gives the composition of the mixtures made in the present study.

Table 7: Composition of the binary concretes.

Dénomination	bc.1	bc.2	bc.3	bc.4	bc.5	bc.6	bc.7	bc.8
[0l] Vc	146	140	122	120	115	85	134	120
[0l] Vf	182	222	139	77	00	00	254	287
[0l] Vab	301	301	301	301	301	301	243	188
[0l] Vg	537	537	537	537	537	537	433	335

Vc is the volume of the cement, Vf is the volume of the fines, Vab is the absolute volume of the aggregates in 1 m^3 of concrete and Vg is the actual volume of the granules of pozzolan

For ternary mixtures, the experimental volumetric method is determined according to AFNOR N.F.P. 18-301. According to this standard, for the determination of solid components; coarse aggregates are considered by their actual volume as a result of prewetting. These aggregates are class 5/10 pozzolanic grit. The sand used is of the normal type. The cement is also a CPJ35 from the HOLCIM cement plant. The fines used for certain mixtures are constituents at 100 ° from the grinding of pozzolans. The compositions of the various concretes are shown in Table 8.

Table 8: Volume of the constituents of ternary concretes in liters for 1 m^3

Denomination	A.				B					C				
Lots n°	1	2	3	4	1	2	3	4	5	1	2	3	4	5
Dosage (Kg/m^3)	250	350	350	300	450	425	400	350	450	450	450	450	450	350
Sand	69	105	162	231	72	191	252	292	332	71	139	237	291	361
Cement	81	115	114	92	147	132	132	116	115	137	136	123	114	111
Fines	00	00	00	00	50	34	13	00	00	156	136	98	110	47
Water	120	160	160	120	175	175	170	155	160	216	221	187	136	187
Gravel Pozzolan	537	537	537	493	537	469	384	357	300	465	401	332	231	261

For each series, we proceeded to a gradual and quantitative addition of sands.

For series A, the fines are not used and the quantity of chippings is kept fixed for batches 1, 2 and 3. During the operations, the quantity of sand and the cement dosage are increased. Lot No. 04; we have reduced the amount of gravel while increasing the amount of sand compared to previous ones. The cement dosage is 300 Kg/m^3.

For the B series, we did not use fine pozzolans for batches 4 and 5. This operation corresponds to the increase content of sands used. The peculiarity of the tests lies in the fact that the quantity of gravel, fines and cement have been reduced. These concretes are obtained from a binary concrete which classifies as semi cavernous.

For the C series, we did a cement dosage set at 450 Kg/m^3, for batches 1 to 4, gradually increasing the amount of sand. On the other hand, the cement dosage is decreased to 350 kg/m^3 in batch 5. Its particularity is the sequential reduction of fines.

It should be noted that this procedure has been used to obtain results with nuances for better analysis.

2.2.2 Apparent mass analysis

At light concrete, bulk density is considered one of the main properties of the material. In our study, the determination of the bulk density is obtained by the determination of the mass using a precision balance (Perrier, France), hardened 4 * 4 * 16 cm parallelepiped test pieces.

2.2.3 Acoustic property

The different elements available at this stage of the study show that pozzolan concrete is a material with a high porosity. Given the similarities with wood concrete, the study of acoustic properties was oriented towards the absorption behavior. Measurements of acoustic characteristics are made through the measurement of its absorption coefficient, which is defined as the ratio between the absorbed acoustic intensity and the incident acoustic intensity. The method of measuring the absorption coefficient in the most classical reverberation chamber is Sabine's method [16], by comparing the reverberation times T. The equivalent absorption area A in m2 for each third d octave is given by:

$$A = 0{,}16\,\frac{V}{T} \qquad (2)$$

where: V is the volume of this room in m^3.

As part of this work, several molds were used depending on the type of tests to be performed. prisms 10, 20 and 30 cm high and side 8.5 cm are used. These different sample sizes are related to measurement devices whose dimensions are imposed.

3.Results and discussion

3.1 Indices of the voids

Concrete is a composite material characterized by a porous microstructure with pores of different sizes and random distribution. The porous structure and the pore distribution within the concrete play a very important role not only on the mechanical strength, but also on the acoustic characteristics. The porous network is also the container of liquid water, water in the form of steam and dry air. For these reasons, porosity (and its distribution) becomes a very important parameter for the characterization of concrete.

Table 9 represents the indices of intergranular and absolute voids.

Table 9: voids indices of binary concretes

Mélange n°	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
eab	0,16	0,11	0,25	0,36	0,53	0,61	0,22	**0,35**
ei	0,59	0,51	0,78	1,01	1,40	1,59	0,58	**0,68**
Vr / (Vr + Vf + Vc)	0,62	0,60	0,67	0,73	0,82	0,86	0,53	**0,45**
Vab /(Vab + Vf + Vc)	**0,48**	**0,45**	**0,54**	**0,60**	**0,72**	**0,78**	**0,39**	**0,32**

ei: index of intergranular voids
eab: index of absolute voids

The variations of the void indices are presented in figure n ° 03:

- Curve (a) shows the variations of the absolute voids index as a function of the ratio of the absolute volume of pozzolanic chippings to the absolute volume of aggregates and cement.
- $e_{ab}=f(V_{ab}/(V_{ab}+V_f+V_c)$ (3)
  Curve (b) shows variations in the index of voids between aggregates as a function of the ratio of the actual volume of pozzolanic chippings to the actual total volume of aggregates and cement.
  $e_i=f(V_r/(Vr+V_f+V_c)$ (4)

Various points which are quite important are to be exposed:

- The point B relating to the minimum porosity mixture corresponds to the ratio Vr / (Vr + Vf + Vc) = 0.6 approximately, however, according to Francisco [17] this minimum corresponds to 0.8 for common aggregates.
- The BC branch is almost rectilinear, which means that the fine grains completely occupy the interstices between the coarse aggregates. The consequence of granular interference is almost non-existent.

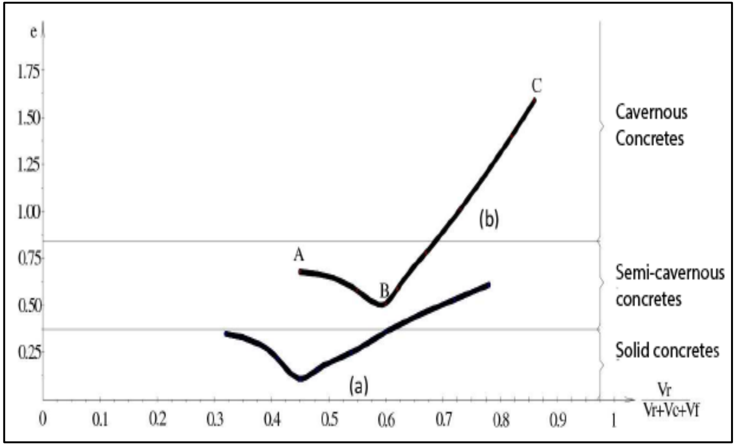

Fig. 3 Variation of the void index

This property is justified by the jagged form of gravel grains that can admit the insertion of fines in the hollows that (1) surface presents. Thus, it can be said that the law governing the variation of the absolute void index is the most suitable for lightweight concretes because it considers the voids in the grains.

As for ordinary concretes, it is possible to use one or the other of the curves of Fig. 3 in order to obtain the desired void ratio mixture. However, since the aims pursued are not the same for ordinary concretes, in which the minimum porosity mixtures and the light concretes are sought, it is necessary to define the useful range of the porous aggregate mixtures. In the case of the porous aggregate concrete which is the subject of this study, the useful range of concretes widens logically between the minimum porosity mix and the minimum cement mix. In this domain limitation, the following subdomains can be successively defined according to the variations of the void index:

- A solid concrete domain where the void index is low;
- A field of cavernous concretes where the void index is high;
- A field of semi-cavernous concretes between the two previous domains.

The variations of the absolute and intergranular void indices are given as a function of the proportion of sand to be able to follow the disturbance of the sand on the voids of the concrete. Table 10 shows the results of ternary concrete index measurements.

Table 10: Voids indices of ternary concretes

Série	*n°*	*ei*	eab
A	1	1,22	0,46
	2	0,92	0,32
	3	0,74	0,23
	4	0,66	0,23
B	1	0,76	0,24
	2	0,61	0,21
	3	0,63	0,28
	4	0,64	0,31
	5	0,63	0,34
C	1	0,60	0,21
	2	0,57	0,23
	3	0,55	0,27
	4	0,49	0,26
	5	0,50	0,28

Series A concretes are developed from cavernous concretes. During the increase in the proportion of sand, the void indices show an initial variation more or less brutal, which then gradually decreases.

Absolute voids go through a fairly important minimum for proportions that are between 20 and 28%.

B-series concrete is obtained from a binary concrete that is classified as semi-cavernous. Each category of void indices begins to decrease with the introduction of sand. There is a gradual decrease with the ratio s / (s + g + f) of the difference between the index of absolute voids and the index of intergranular voids.

The first concrete in C-series concrete is defined by solid concrete and minimal porosity. We have limited this study in the context of the zone of concretes which are qualified to be useful for the various dosages.

3.2 Acoustic absorption coefficients

Fig. 4 to 7 give the absorption coefficients of Ambohinaorina light pozzolan concrete in the frequency range 125 to 2000 Hz, measured using a standing wave tube called "kundt tube".

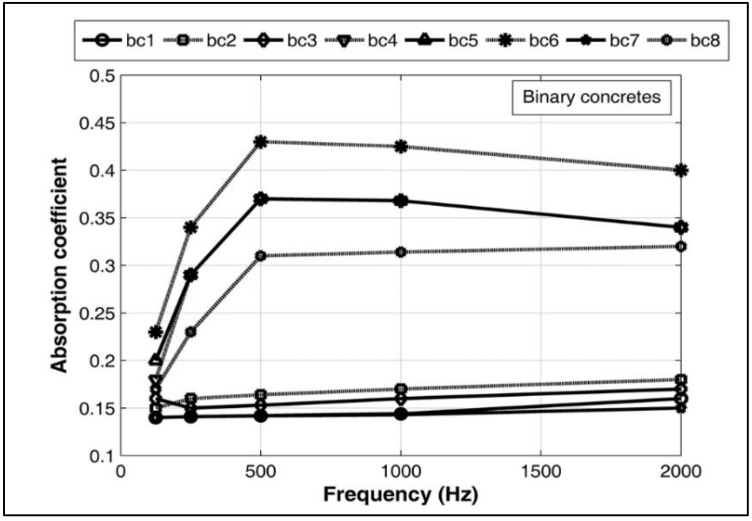

Fig. 4 Absorption coefficients "α" of concretes without sand

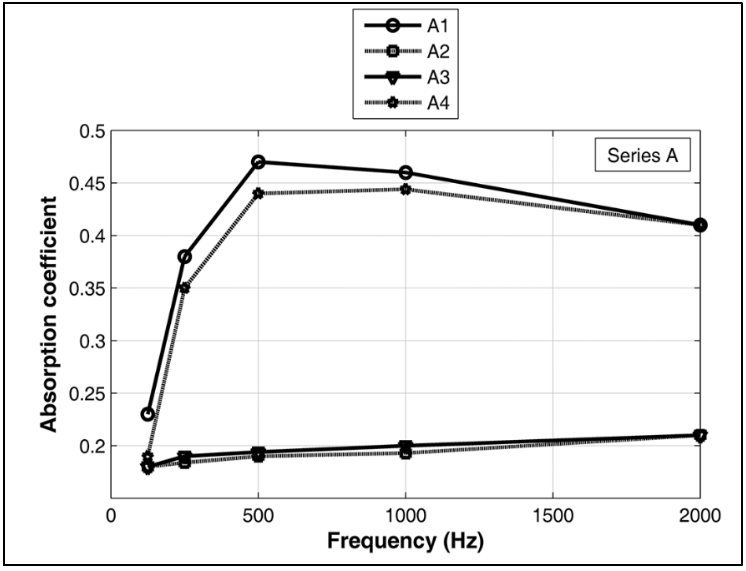

Fig. 5 Absorption coefficients of ternary concrete series A

In general, the absorption coefficient increases with frequency except at frequencies above 1 kHz. Concretes of lower dosage absorb more at low frequencies, that is to say the most interesting in practice, while often at higher frequencies it is the concretes of the highest dosages that are the most absorbent. By comparing the absorption coefficients obtained with the binary mixtures with those obtained with the ternary mixtures of the series A, we conclude that the absorption coefficients obtained with the fine pozzolans, with equal porosity of the concrete, are lower. Indeed, for a low absolute void index equal to about 23% (corresponding to ternary concrete of series A, apparent density equal to about 1400 kg / m3), we observed an increase of about 50% of the coefficients. of absorptions obtained with cement dosage 350 Kg / m3 compared to those obtained with cement dosage 300 Kg / m3, average frequency. For samples bc1, bc2, and B1, the level of absorption is relatively stable over the entire frequency range.

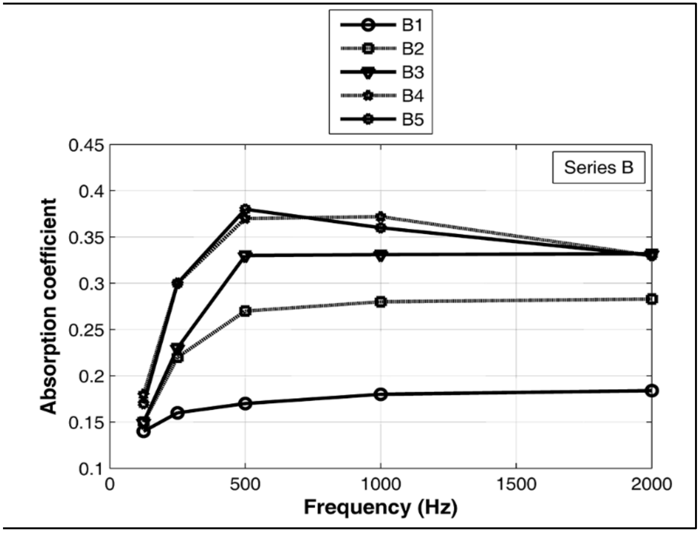

Fig. 6 Absorption coefficients of ternary concrete series B

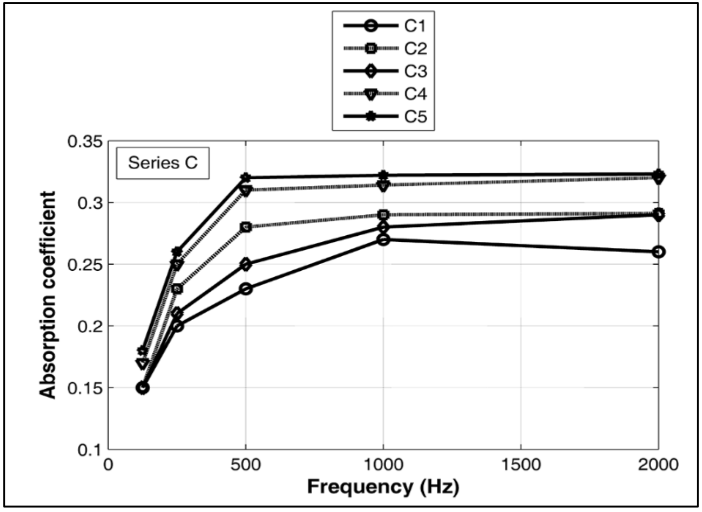

Fig. 7 Absorption coefficients of ternary concrete C series

The lower dosages absorb medium and high frequency sounds, i.e., bc4, bc5, bc6, A1 and A4 can be used for acoustic correction of local. Their good absorption characteristics in medium and high frequencies are well adapted to the dominant frequencies of industrial noise to be attenuated. The absorption coefficients αmax obtained are of the order of 0.27 for concrete C-1, that is to say that about 27% of the sound is absorbed by the samples. The porous network consists of micro-bubbles of air. The waves are thus reflected on the low permeability surface of the samples and cannot penetrate the material to amortize. Concretes bc1, bc2 and B1 have absorption coefficients αmax ranging between 0.14 and 0.18. This could be explained by the presence of a higher amount of fines in the mixture which would make bc1, bc2 and B1 concretes more impervious than concrete C1.

The variation of the absorption coefficients of some materials is given by Table 11 as a function of frequency.

Table 11: Absorption coefficient of some materials

Description	Frequency in Hz				
	125	250	500	1000	2000
Plastic	0,07	0,17	0,50	0,60	0,68
Bricks	0,03	0,03	0,03	0,04	0,05
Wood concrete	0,62	0,68	0,77	0,65	0,59
Aerated concrete	0,24	0,29	0,32	0,28	0,23

Of the lightweight concrete, only wood concrete is currently used for its acoustic qualities. It absorbs more than 75% of the energy of the incident wave at medium frequency. Some materials such as bricks and poured concrete are not very permeable and do not allow penetration of the acoustic wave. Cellular concrete does not absorb more than 35% of the sound passing through it. For the 350 kg/m^3 pozzolan concrete, the absorption coefficients are between 0.32 and 0.44, values which are high compared to other building materials.

The insulation between the rooms of a dwelling is seldom the subject of a particular treatment although it constitutes a desired element of comfort. The realization of two close walls without rigid connection poses practical problems. It is then necessary to adopt a design of the walls (walls and floors) adapted to the uses and the sound environment. Complex systems are proposed in the literature to improve the absorption of walls, among others Chunqi [18] proposes to use microperforated plates with different hole diameters in order to widen the absorption band of a coupled microperforated plate system by a cavity to a rigid wall. Thomas [19] also studied acoustic transmission of perforated panels coupled with granular materials. Tests were therefore made leaving between the concrete A-1 and the bottom of the lid closing the pipe a certain layer of air. The results are given in Fig 8.

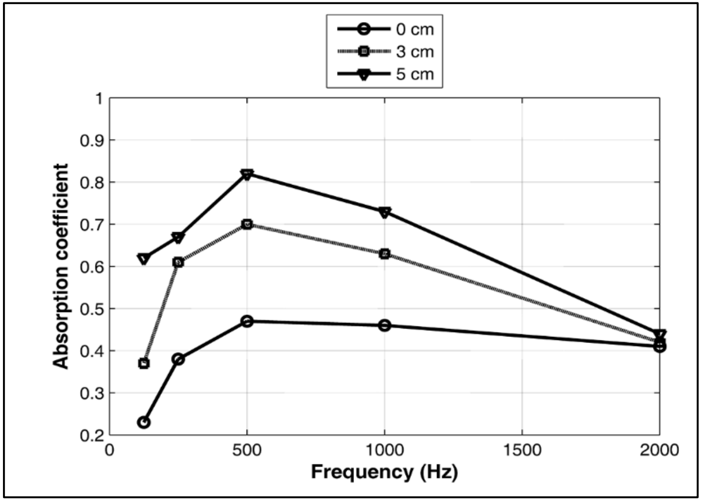

Fig. 8 Absorption coefficients of concrete A-1 with a certain layer of air

The absorption increases regularly with the thickness of the air layer but less and less quickly. Given these results, the tests were continued using the two most absorbent concretes, ternary concrete A-1 and concrete Bb-6, separated by 5 cm of air layer, the last plate being against the bottom of the lid. Table 12 shows the results obtained as a function of frequencies.

Table 12: Absorption coefficient of acoustic bridges according to frequencies

Couche d'air (cm)	**Fréquence en Hz**				
	125	250	500	1000	**2000**
5	**0,81**	**0,87**	**0,92**	**0,62**	**0,37**

It is important to note that ternary concrete A1 placed behind bc6 concrete improves absorption at low and medium frequency. It seems that there is a way to have a considerable absorption of the sound and improve in this respect the efficiency of the concrete used.

On all frequencies, pozzolan concrete shows a small decrease in the absorption coefficient compared with wood concrete:

- At low frequency the difference varies from 3 to 5%
- At medium frequency the absorption coefficients of these materials are almost the same.

At high frequency, the wood concrete has a surcharge of 4 to 7%

3.3. Acoustic test induced by a shock

The noise caused by a shock is directly related to the vibration of a structure. When walking, dragging chairs or furniture, the occupants produce impacts that give rise to a noise emission in adjacent rooms. Shock noises pose larger and more complex problems than airborne noise. A first principle of intervention consists in preventing the structure from vibrating when it is stressed by the impact of an object [20] in which the modification of a parameter of a vibrating plate influences the perception of the object radiated noise? According to Faure J [21], this parameter is geometric (plate dimensions) or mechanical (Young's modulus, Poisson's ratio, damping). ChuanmengYang and al [22] studied for plate signals the influence on the perception of three parameters: damping, thickness and boundary conditions.

Trollé [23] presents in his work on a plate / cavity system. Between each sound, the variant parameters of the structure are the thickness of the plate, the type of absorbent material and the boundary conditions of the plate. We used concrete slabs to analyze hammer strike sounds applied to multiple faces. Shock tests are carried out according to the following procedure:

A concrete slab of rectangular section is slightly embedded in one point and excited with a small hammer of shock to solicit the plate with transverse vibration. The perceived sound is analyzed from the software "sound forge", whose height depends on the density of the concrete, as well as the dimensions of the plate.

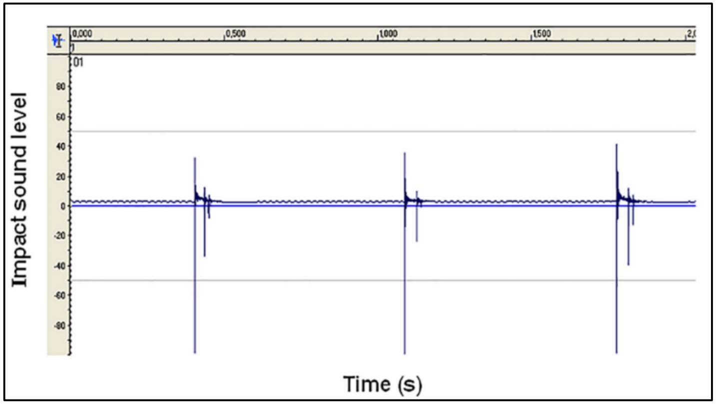

Fig.9 Vibration of the plate in the direction of the thickness

There remains in the plate a sound trail more or less long depending on whether this plate contains less or more pozzolan. The rectilinear parts mean that pozzolans are networks where will be lost the sounds whose wavelengths are sufficiently small. Whenever an acoustic wave hits an obstacle, part of the energy it carries is absorbed by the obstacle, which explains the decrease in sound. The variation of α is at most a little more than 37% at low frequency and almost 47% for f = 500Hz, for both types of void index. The higher the void ratio, the easier the sound passes through the concrete.

For all frequencies, for a value of the index of intergranular voids equal to 0.5, α between 0.14 and 0.36, or about a value of 0.25 ± 0.11. Acoustically intergranular voids thus play a large role in the behavior of concrete.

The physical characteristics, that is to say the dimensions, the density have consequences on the vibratory modes of the plate from where on the absorption coefficient of this same material. This analysis of the experimental results led to a reflection on the acoustic behavior of the material.

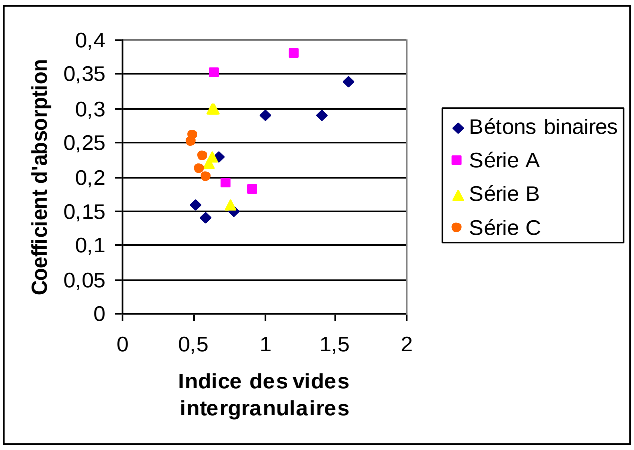

Fig. 10-a : α=f (e$_i$) : frequency 250 Hz

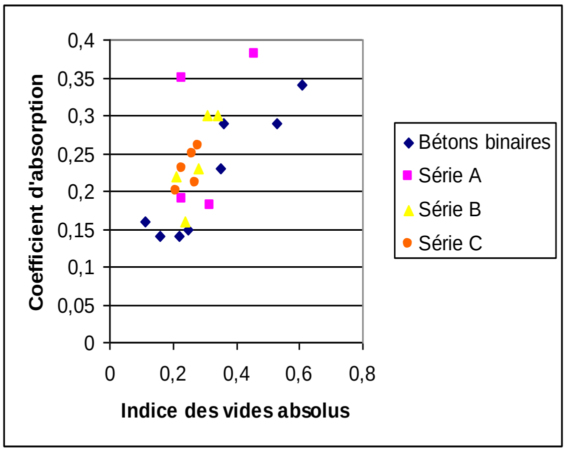

Fig. 10-b : α=f (e_{ab}) : frequency 250 Hz

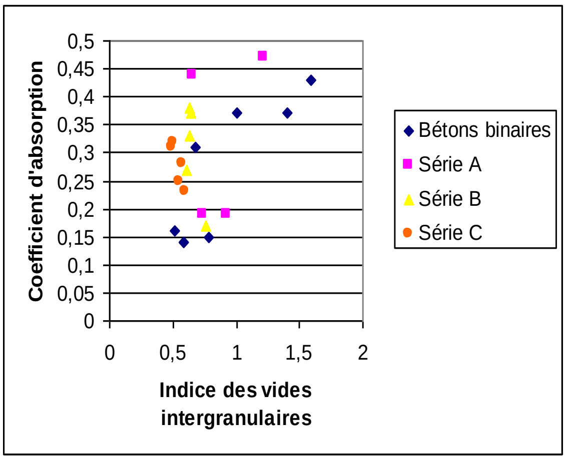

Fig. 10-c : α=f (e_i) : frequency 500 Hz

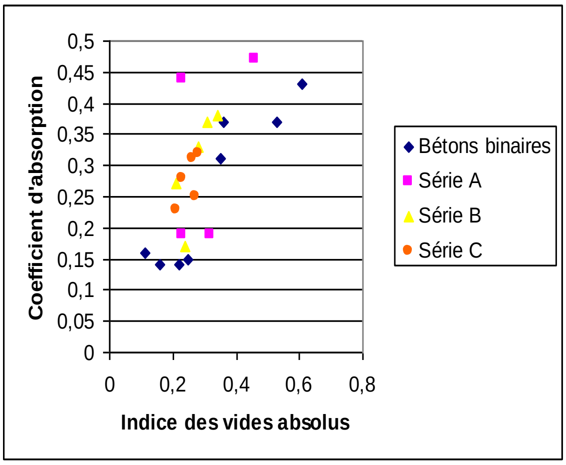

Fig. 10-d : α=f (e_{ab}) : frequency 500 Hz

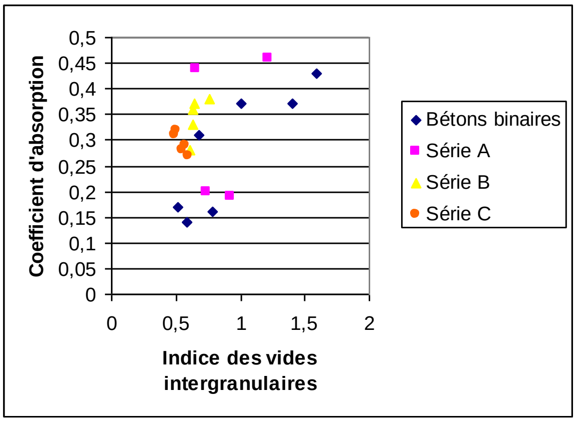

Fig. 10-e : α=f (e_i) : frequency 1000 Hz

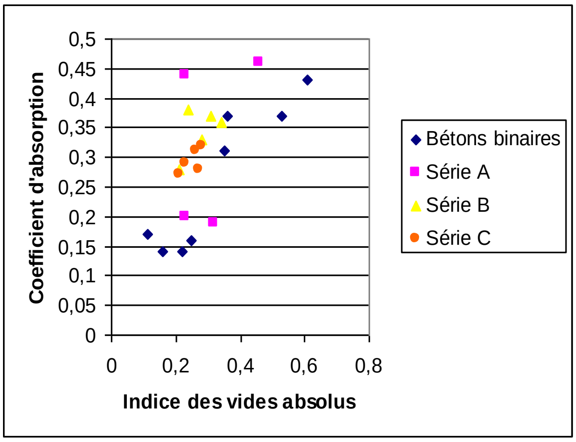

Fig. 10-f : α=f (e_{ab}) : frequency 1000 Hz

Fig.10 Variation of the absorption coefficients according to the voids of the concrete

By definition, α is a dimensionless coefficient, varying between 0 and 1. The value 0 corresponds to a totally reflecting material and the value 1 corresponds to a totally absorbing material. The absorption depends on the frequency mainly. This means that the same sample can be, for example, weakly absorbing at low frequencies and strongly at high frequencies. This explains why the value of α must always be accompanied by the frequency with which the measurement is carried out.

The following figure illustrates the variation of the absorption coefficient α as a function of the concrete voids for the 3 frequencies 250 Hz, 500 Hz and 1000 Hz.

The variation of α is at most a little more than 37% at low frequency and almost 47% for f = 500Hz, for both types of void index. The higher the void ratio, the easier the sound passes through the concrete. For all frequencies, for a value of the index of intergranular voids equal to 0.5, α between 0.14 and 0.36, or about a value of 0.25 ± 0.11. Acoustically intergranular voids thus play a large role in the behavior of concrete.

4.Conclusions

This study focuses mainly on lightweight concrete from pozzolanic aggregates while considering the law of aggregates mixtures and scrupulously monitoring, monitoring and control of the variation of the void index of concrete.

The absorption coefficient varies between 0.14 and 0.47 depending on the dosage and the frequency.

The concretes corresponding to almost all studied combinations of chippings, sand and fines were made in such a way that the cement dosages remain reasonable as far as possible.

The present study meets the expectations of the industrialists because the judgments relating to it are multiple with an inestimable amount. However, they are disparate in the highlands-Malagasy, such as in the site subject to the present study. All the physicochemical characteristics described and analyzed on this material testify to its practicability.

In a word, the quality and quantity of this material can satisfy the needs and the demand of the industrialists eager for an available resource. Therefore, sustainable development, which is launched in the field of road construction, buildings among others, finds a directly exploitable and promising element.

Our prospects are none other than to rationalize the exploitation and uses of this material. It is not enough to publish the various utilities pozzolans, the main thing is to offer its practices in the world of construction. In other words, push pozzolanas into the markets while continuing our research related to it, because the competition is placing on the market.

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