USE OF SAWING AND POLISHING ROCK INDUSTRIAL WASTES FOR LIGHTWEIGHT EXPANDED AGGREGATES PRODUCTION

SOSSIO FABIO GRAZIANO
Dipartimento di Scienze della Terra, Università "Federico II", Via Mezzocannone 8, 80134 Napoli

INTRODUCTION

Wastes produced from geomaterials working processes represent a cost to dump and can have a remarkable environmental impact.

In this light it is clear the importance of scientific researches finalized to the reuse of this wastes as raw material for other industrial purposes.

During this research, sawing and polishing wastes from granitic rocks and ceramics were considered.

Dimension stones working processes generate muds amounts of 25% in weight of the raw material while the grès tiles ones about 50.000 metric tons/year only for Italy (ANPA, 2002).

This muds reveal a low abrasive (SiC) and steel filings amount (1-2%), so CER 010410/13 and 10129 are the corresponding European codes for this kind of wastes.

Nowadays only a small part of this muds are reused even if there is a lot of scientific literature about this matter.

This research prove that ceramic muds chemical composition both with the presence of some SiC percentages cause the expansion of the material after thermical treatments and make it suitable for lightweight aggregates production (de Gennaro *et al.*, 2007a, 2007b).

This muds can be also used like expandent additives in wastes from zeolitized rocks to obtain lightweight aggregates (de Gennaro *et al.*, 2007a, 2007b).

Aim of this research is verify the reusing of working processes granite muds for the production of lightweight expanded aggregates (hereafter LEA) and their behaviour in concrete manufacturing.

RESULTS

The first portion of the research focused on understanding the mechanisms determining the expansion of geomaterials when thermally treated. A wide variety of rock types commonly used in the building industry from a Brazilian and some different Italian industrial districts, having different chemical (carried out by XRF) and mineralogical compositions (carried out by XRD), was selected for study (Table 1). Rocks with high or low silica contents were selected, characterized by different amounts of alkaline and earth alkaline metal oxides and of Fe and Mn. It was thus possible with these samples to evaluate the influence of the SiO_2-Al_2O_3 ratio on fluxing.

Thanks to this characterization it was possible to identify the potentially expandable ones in relation to their chemical composition.

By plotting the chemical composition in the Riley diagram (1951) it was clear that only muds which were in the highlighted area were potentially expandable (Fig. 1).

On pellets produced with this muds, first fire treatments were conducted to verify their expandability.

Table 1 - Muds description.

ITALIAN muds	
AM1	Cutting mud from several marbles
AM2	Cutting mud from several granites
AM3	Cutting mud from several marbles and granites (main pool)
CAB70	Cutting mud from Campanian Ignimbrite
MM1	Cutting mud from several marbles
MM2	Cutting mud from several granites
REV	Cutting mud from Reventino green stone
SER	Cutting mud from Serizzo stone
SIL	Polishing machine mud from Calabrian granite
BRAZILIAN muds	
BRZ1	Polishing machine mud from several granites
BRZ2	Cutting mud from Verde San Francesco & Purangau stones
BRZ3	Cutting mud from Bianco Greco & Purangau stones
BRZ4	Cutting mud from River Giallo & Four Season stones
BRZ5	Cutting mud from Purangau stone
BRZ6	Cutting mud from Verde Ubatuba & Emerald Quartz & Gold fields stones

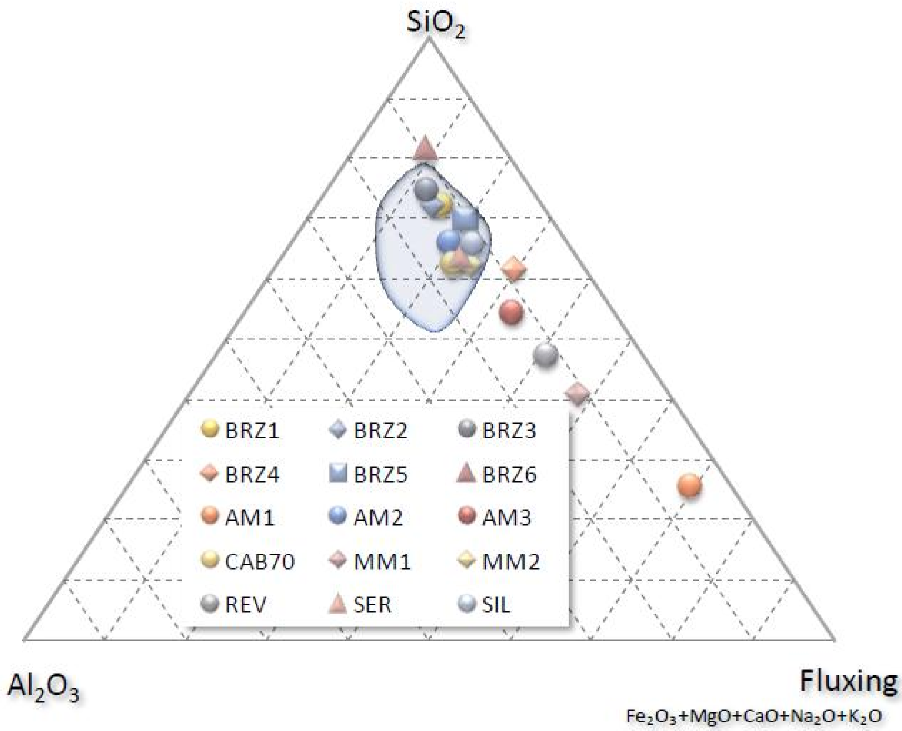

Fig.1 - Riley diagram (1951).

The working conditions for this tests were: temperature 1300°C and firing time 300 sec. The physical parameters of the aggregates are shown in Table 2.

Those aggregates present bulk density values almost always more than unit (>1 g/cm^3) , only BRZ1 and SIL specimens, respectively produced from a Brazilian and an Italian granite polishing machine mud and got from two different plants both using SiC like abrasive, were expandable.

If expansion did not occur spontaneously or if the resulting aggregates did not possess the required features, an expanding agent was chosen for addition. Among the available expanding agents, SiC was used, either on the basis of previous results or because SiC can be present in those materials as a result of polishing processes.

Table 2 - Produced aggregates bulk density.

Brazilian muds	g/cm^3	Italian muds	g/cm^3
BRZ1	0,73	AM1	1,46
BRZ2	1,03	AM2	1,59
BRZ3	1,14	AM3	1,65
BRZ4	melted	CAB70	1,41
BRZ5	1,67	MM1	3,31
BRZ6	1,52	MM2	1,37
		REV	1,82
		SER	1,11
		SIL	0,74

New tests were repeated, mixing dimension stones muds with grès polishing muds (hereafter GPM) like expanding additive.

The main physical features of all lightweight aggregates produced with these mixtures are shown in Table 3.

Table 3 - Produced aggregates physical features.

%	BRZ1	BRZ2	CAB70	SER	SIL	GPM	Bulk Density (g/cm^3)	Compressive Strength Single Grain (kN)
Mix1	35	35				30	0,87	0,55
Mix2	25	25				50	0,83	1,35
Mix3	25	25	25			25	0,95	0,51
Mix4				70		30	1,16	0,91
Mix5				50		50	0,68	0,32
Mix6			25	25	25	25	0,73	0,18
Mix7				25	25	50	0,62	0,12
Mix8				35	35	30	0,7	0,04
ALFA				50		50	Bulk Density (g/cm^3)	Weight stack (kg/m^3)
							0,8-0,9	500
							H_2O absorption (%)	Strength in pile (1lt) (MPa)
							2,1	2,0

On the basis of physical property results and of data analysis, a multivariate statistical analysis was carried out to obtain an empirical model for the dependence of bloating on chemical and mineralogical composition of the raw materials, grain size and packing of the crude powders, the amount and quality of the glassy phase, and the microstructure of the fired product.

Granulometric distribution, weight stack, strength in pile (European-suggested standards UNI EN 13055-1, 2002), and water absorption (European-suggested standards UNI EN 1097-6, 2002) of the mixture with the best bulk density and single grain compressive strength results were determined.

Five litres of aggregates were prepared using a rotative kiln model. Nannetti TO-R150-15 with working conditions: temperature 1300°C and rotational speed 3.5 laps/min.

The compositions giving the best LEA physical properties were then used to produce larger amounts necessary for complete characterization and, finally, for evaluating their use in the production of structural lightweight concretes.

The physical parameters of the selected mixture are almost similar even if the mixture Mix5, made by Serizzo (50%) and grès tiles muds (50%), show suitable values for concrete producing (de Gennaro *et al.*, 2007).

With this mixture, hereafter ALFA ("first letter in Greek alphabet" for first kind of those aggregates) 36 litres of aggregates were produced using new sintering conditions to obtain grains bulk density values between 0.8 and 0.9 g/cm^3 (Table 3).

According to European-suggested standards UNI EN 11013, two concrete mixtures C1 and C2, were prepared and some ingredients amounts were corrected for experimental requirements.

The compositions of the two mixtures are shown in Table 4.

Sand Normal (European-suggested standards UNI EN 196-1); Cement CEMENTIR CEM II/A-LL 42.5R; ALFA aggregate; Additive ADDIMENT 39/T40 (only in C1 mixture) were used.

The use of the additive lowered water requirement in C1 mixture. For this reason the water/cement ratios are 0.53 for C2 and 0.49 for C1.

The Slump test (European-suggested standards UNI EN 12350-2 and UNI EN 206-1) permitted to evaluate the fresh mixtures consistence by measuring the fresh dough falling from the Abrams cone.

A set of five cubic specimens (15 cm sided) were prepared for both the mixtures.

Concrete drying had two phases, the first one (3 days) in air atmosphere with costant temperature (20°C), the second one (till 28 days) in water pools always with constant temperature (20°C).

Table 4 - Mixtures components and concretes physical features.

Mixtures	C1	Corr.	C2	Corr.	Unit
Cement	7		7		kg
Normal sand	10		10		kg
Water	3,5	-0,56	3,5	+0,21	l
ALFA	9		9		kg
Additive	0,07		0		cc
w/c Ratio	0,49*		0,53		
Concretes					
Slump test (mm)	250		160		
Consistency class	S5		S4		
Wet mass (kg/m^3)	1630		1610		
Dry mass 7d – 28d (kg/m^3)	1620 -1600		1610 - 1600		
Compressive strength 7d (MPa)	27,5		22,9		
Compressive strength 28d (MPa)	29,73		30,2		

* w/c Ratio + additive according to UNI EN 11013

Dry mass (European-suggested standards UNI EN 12350-6) and compressive strength (7 days and 28 days after hydration beginning) on dried specimens were evaluated (Table 4).

The physical features of C1 and C2 concretes can be included in lightweight structural concrete field (Compressive strength 28 days > 20 MPa and Dry mass 1400-2000 kg/m^3) and they are similar to other commercial concretes (Fig. 2).

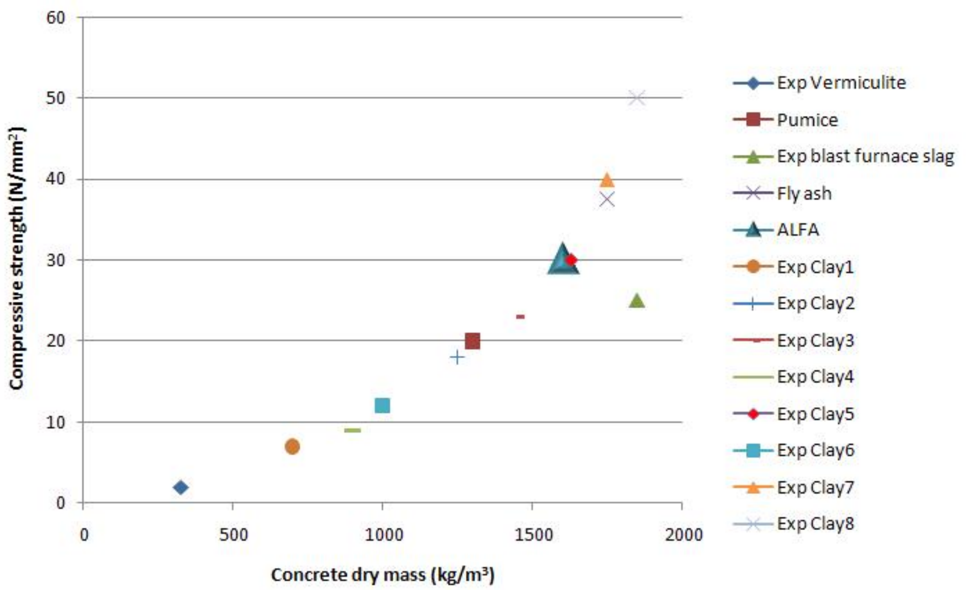

Fig. 2 - Comparison between some lightweight concretes and ALFA concrete (1Mpa = 1 N/mm^2).

DISCUSSION AND CONCLUSIONS

Wastes from dimension stone and grès tiles working processes represent a great environmental problem due to the founding of idoneous dumping sites.

This is also a cost that greatly affect the finished product.

It should be helpful propose alternative solutions for the reuse and the transformation of this wastes.

This research demonstrates that there is a concrete possibility of reuse in the production of lightweight aggregate suitable for the preparation of structural lightweight concrete.

Specifically sludge used with a chemical composition that allows for expansion into kitchen and a small percentage of abrasive used in any process which produces gas at a temperature of softening.

The main difference between the clusters obtained in the manner proposed in this research and those made from expanded clay is the low water absorption of the first due to the vitrified surface, compact and homogeneous.

This feature, together with good strength values in the heap, makes the lightweight aggregate used in the preparation of structural lightweight concrete as demonstrated by the tests in compression and the bulk density, falling perfectly within the limits suggested by the European-suggested standards UNI EN 196-1 (> 20 MPa; 1400-2000 kg/m^3).

Since the use of additive is now routine in achieving concrete results in an acceleration of the drying of these, it is believed that the good results already obtained could be further improved by appropriately adjusting of additive and water amounts in C1 mixture.

The benefits that this proposal would have to be recognized as a possible use in a continuous development of safe waste sawing and polishing that are currently available on the landfill by allocating the product thus obtained processing to packaging to obtain a structural CLS product of excellent quality with an economy likely cost of manufacture.

The replacement of the traditional clay with industrial wastes entails the added benefit of reducing the environmental impact caused by mining for the supply of raw materials.

REFERENCES

ANPA (2002): Rapporti - 18/02 - Rifiuti industriali, metodologie di calcolo dei coefficienti di produzione.

de Gennaro, R., Cappelletti, P., Cerri, G., de' Gennaro, M., Dondi, M., Graziano, S.F., Langella, A. (2007): Campanian Ignimbrite as raw material for lightweight aggregates. *Appl. Clay Sci.*, **37**, 115-126.

Riley, C.M. (1951): Relation of chemical properties to the bloating of clays. *J. Am. Ceram. Soc.*, **34**, 121-128.

UNI EN 12350-6 (2001): Massa volumica del calcestruzzo fresco.

UNI EN 12350-2 (2001): Prova di abbassamento al cono (Slump test).

UNI EN 1097-6 (2002): Prove per determinare le proprietà meccaniche e fisiche degli aggregati. Determinazione della massa volumica dei granuli e dell'assorbimento d'acqua.

UNI EN 11013 (2005): Aggregati leggeri. Argillo e Scisto espanso. Valutazione delle proprietà mediante prove su calcestruzzo convenzionale.

UNI EN 196-1 (2005): Metodi di prova dei cementi - Parte 1: Determinazione delle resistenze meccaniche.

UNI EN 206-1 (2006): Calcestruzzo - Specificazione, prestazione, produzione e conformità.