ALBERO POLYMERIC MORTAR AND ITS POSSIBILITIES IN BUILDING CONSTRUCTION

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SUMMARY: The aim of this paper is to analyse the properties and main characteristics of a polymeric mortar made with an specific orange-yellowish aggregate named *Albero*. This aggregate can only be found in the province of Seville. The main objective is to develop a new building material named *Polialbero*, which can face the widely used *Albero* in Sevilian and Andalusian architecture, from façades to granular pedestrian pavements.

KEYWORDS: polymeric mortar, PC mortars, *Albero* fines, building industry, specimens, applications.

1. INTRODUCTION

In Andalusian architecture and more often in Seville (Spain) the use of *Albero* colour is very common in the aesthetic composition of the façades. Besides, *Albero* is a widely used material as a granular pavement in pedestrian's pathways in parks and gardens. Well-known examples of this use are the Plaza de Toros de la Maestranza (Seville's Bullring), the sidewalks of the Feria de Abril (Seville's Spring Fair) and the pathways in Maria Luisa's Park also located in Seville.

It was considered to be very interesting the search of a new material with the same colour and texture of *Albero*, and adequate characteristics to be used in the building industry as a coating material. The purpose was to offer the architects a new material as a response to the widespread use both of the *Albero* fines and the colour itself.

The research was developed in the laboratories of the Escuela Técnica Superior de Arquitectura de Sevilla. A great number of polymeric mortar specimens were done. The mortar was made of a non-saturated polyester resin matrix and filler of *Albero* arid from Alcalá de Guadaira. Besides to a nice appearance and structure, this aggregate provided the mortar with good mechanical strength and good enough behaviour against chemical abrasives.

The results obtained and presented hereby seemed to be very interesting and encourage us to continue the investigation, both with the mixtures already tested and with different kinds of polymers and aggregates. With the proportions studied, a polymeric mortar was obtained, suitable to be used in thick coating tiles and other applications.

2. THE *ALBERO* ROCK

Albero is a rock that can be found just in a very determined Sevillian county: Los Alcores. There, in open-air exploitations, it has been extracted for centuries.

Albero, as we know it nowadays, is used as an aggregate for common mortars and concrete added to lime and Portland cement. But the most important use is as a basement for road construction and drain layer, and most fine parts are used in pedestrians pathways in parks and gardens.

This rare and special rock also named Alcalá limestone can only be found in the Sevillian area of Los Alcores. This rock will be the main row material for the polymeric mortar under study. The very specific geologic section is dated on the mid Miocene. The geological material is composed of a deposit of detritus and fossil limestone, very rich in mollusc shells, Briozoos y equinidus. These fossils are generally bad preserved, withdrawn during the retrogression of the oceans in that era.

This type of rock is of variable compaction, sometimes sandy and always very rough. Its is ochre or yellow coloured. Another of its characteristics is the abundant presence of quartz grain and the absence of clay. The geologic section above mentioned is extended over a length of 40 Km. and 5 Km. wide of average.

According to several tests, the density of the *Albero* rock is between 1.930 and 1.950 Kg/m^3, with a specific weight of 2,65 T/m^3 and an absorption degree of 0,3 %.

The *Albero* composition is quite homogeneous, but in commercial types, crushed or sifted, can be detected great differences, depending on the size of the grain, as the chemical analysis show in table 1.

In our tests we have always used the same grain mixture, sifting to eliminate sizes over 5mm and under 0.16 mm. The row material came form a quarry under exploitation that is usually sell as milled *Albero*. The granulation used is between the rates recommended by ASTM-33 and ACI, well known for conventional high-compactly cement mortars with a minimum quantity of conglomerate.

COMPONENTS	Fraction < 2mm	Fraction > 2mm	Mix
SiO_2	18,9 - 24,3	9,5 - 9,9	12,6 - 13,6
Al_2O_3	1,0 - 1,2	0,8 - 1,0	0,8 - 1,0
Fe_2O_3	1,6 - 2,2	1,8 - 2,2	1,7 - 2,3
CaO	40,4 - 42,2	47,5 - 48,9	45,4 - 47,0
MgO	0,3 - 0,5	0,4 - 0,6	0,4 - 0,6
Loss for calcination (1001C)	32,5 - 34,7	37,9 - 39,7	26,3 - 38,3

Table 1: Crushed or sifted *Albero* chemical composition.

3. THE RESIN.

The non-saturated polyester resin used was chosen after analysing the resins available, and concluding that this type of resin is the one that is most often used in building industry by experts and researchers, due to its very good rate prize/quality.

The same trademark and type of resin was always used: ortoftalmic resin, liquid form named ESTRATIL AL-100, composed of UP non-saturated polyester, in an estiren dissolution (30-33 % estiren). It is already accelerated to decrease the hardening time. When using it must be mixture with the catalyst and immediately afterwards add the *Albero*. This mixture gives rise, after a copolymerization process under atmosphere temperature, to the material named polialbero,

The reticulation process, also named set or hardening process, is activated with the catalyst named PERÓXIDO DE MEK. It is essentially metiletilcetone peroxide with a 33% of dimetil ftalate. This catalyst is added in weight proportion between 3 and 5% to polyester liquid resin. The catalyst activates the resin that starts the reticulation process at normal temperature up to harden.

The main characteristics of the ESTRATIL AL-100 resin are shown in Table 2 and 3.

CHARACTERISTICS	**VALUES**
Liquid density	1,15 - 0,04 g/cc a23 1C
Liquid viscosity	5-6 poises a 251C
Aspect	Uncoloured
Acid rate (UNE 53304)	23 - 25

Table 2: Liquid resin characteristics.

CHARACTERISTICS		**VALUES** (average or peaks)
Density		1,18 -1,27 g/cc a 25 1C
Mechanical Strength	Compression strength	70 - 120 N/mm^2
	Flexural strength	40 - 60 N/mm^2
	Tensile strength	20 - 30 N/mm^2
	Dilatation coefficient	20 4 x 10^{-5} (30-80 1C)

Table 3: Reticulated resin characteristics.

4- PROPORTIONS.

As the arid granulation was constant during all the investigations, the same proportion mixture/aggregate was used in all mixes. After some previous tests with proportion mixture/aggregate between 1:1,5 to 1:5, the proportion 1:4 was chosen. This mix was the easiest to deal with, and ensured the maximum compacity of the mix. This proportion is also used is most of the real applications of the polymeric mortars. It is also important to note that the resin doses depend also in the arid maximum size. As the tests show, in weight percentage (mixture + arid) the resin shouldn’t be less than the 20% for polymeric mortars, and a bit less, 14-15% for polymeric concrete.

As a consequence of experimental tests and real applications it has to be admitted that maximum compacity in polymeric mortars like polialbero is obtained with a proportion of 20% of mixture (resin + filler) and 80% of aggregate *Albero*. This means a basic proportion 1:4.

5. MEASUREMENTS AND TESTS.

RILEM Symposium was held in Ostende (Belgium) July 1995 (RILEM TC-113, 1995. This Symposium, just a few days after the 81st International Congress on Polymers in Concrete, was specifically developed on properties and test procedures for polymeric concrete. The TOPIC-2 includes a first proposal for PC Standards.

The tests referred to the main aspects of polialbero are shown in Table 4, under the RILEM PC Standards given in this Symposium.

TESTS OR MESUREMENTS		STANDARDS
Abrasion		UNE 67154/85. UNE 67154/92
Absorption		UNE 67154/85. UNE 67154/92. UNE 127002/90
Surface appearance		PTT Test.
Density		UNE 83814 (exp)-1992. UNE 83821 (p). 1994
Specific Weight		Harvard method. Hidrostatic balance. Volumeter. Picnometer.
Grane		AFNOR P-18304.
Permeability		E.B.G. method
Soften		Controlled and gauged temperature heater
Mechanical Strength	Compression strength	UNE 83821/92. DIN 53454
	Flexural strength	DIN 53452. UNE 127006/90
	Flexural-Tensile strength	UNE 82821
	Tensile strength	Test UNE 83306/85
Chemical Strength		UNE 67122/85. UNE 67154/92.

Table 4: Test Standards.

6. EXPERIMENTAL RESULTS.

The tests results and experimental works shown are average values, calculated from 3 to 6 specimens, and are indicated among with the variance or values obtained with probability >90%. These results are shown in Table 5 to 11.

4 X 4 X 16 cm. PRISMATIC SPECIMENS TESTS RESULTS			
Characteristic values	Density (Gr/cm^3)	Compression (Mpa)	Flexo - Tensile (MPa)
Average	1,67	27,6	7,2
Number of specimens	12	12	12
Deflection	0,14	1,0	0,3
Variation	8,5	4,5	4,5
Values with a probability ≥0,9	1,44 a 1,90	26,0 a 29,4	6,7 a 7,7

Table 5: Flexural–Tensile and compression tests on prismatic specimens.

5 X 10 cm. CYLINDRICAL SPECIMENS TESTS RESULTS			
Characteristic values	Density (Gr/cm^3)	Compression (Mpa)	Strain (%)
Average	1,61	15,3	3,41
Number of specimens	6	6	6
Deflection	0,15	0,3	0,15
Variation	9,5	2	4,3
Values with a probability ≥0,9	1,36 a 1,86	14,8 a 15,8	3,16 a 3,66

Table 6: Compression tests results on cylindrical specimens.

5 X 10 cm. CYLINDRICAL SPECIMENS BRASILIAN TEST RESULTS		
Characteristic values	Density (Gr/cm^3)	Tensile (Mpa)
Average	1,50	3,4
Number of specimens	6	6
Deflection	0,10	0,60
Variation	7,0	18
Values with a probability ≥0,9	1,34 a 1,66	2,4 a 4,4

Table 7: Brazilian tensile tests.

15 X 15 X 1 cm. FLAT SPECIMENS TEST RESULTS		
Characteristic values	Density (Gr/cm^3)	Flexural (Mpa)
Average	1,76	14,3
Number of specimens	9	9

Deflection	0,15	0,4
Variation	8,5	3,0
Values with a probability ≥0,9	1,51 a 2,01	13,7 a 15,0

Table 8: Flat specimens flexural test results.

ABSORPTION TESTS				
	(On prismatic specimens)		(On flat specimens)	
Characteristic values	Density (Gr/cm^3)	Absorption (%)	Density (Gr/cm^3)	Absorption (%)
Average	1,67	3,8	1,76	4,8
Number of specimens	12	12	8	8
Deflection	0,14	0,2	0,15	0,4
Variation	8,5	5,5	8,5	9,0
Values with a probability ≥0,9	1,44 a 1,90	3,5 a 4,1	1,51 a 2,1	4,1 a 5,3

Table 9: Absorption tests on prismatic specimens.

PHISICAL AND CHEMICAL CARACTERISTICS			
Characteristic values	Permeability (cm/min)	Abrasion (Class)	Chemical resistance (Class)
Average	0	I / II	A / AA
Number of specimens	4	4	4

Table 10: Other test results for Polialbero.

Classification:

Abrasion:

- Class I: Non visible defects after 500 revolutions.
- Class II: Non visible defects after 1000 revolutions.

Chemical resistance:

- Class AA: Non visible effects.
- Class A: Slight surface changes.

OTHER POLIALBERO CHARACTERISTICS			
ADHERENCE	Wrinkled faces	Lime	Excellent
		Cement	Excellent
	Smooth faces	Lime	Good
		Cement	Good
HEAT BEHAVIOUR	Periods less than < 2 hours	Up to 150 ºC without soften	
	More than 2 hours	Soften at 110 ºC	

Table 11: Other Polialbero behaviour characteristics.

7. TEST RESULTS ANALYSIS.

Comparative studies between *Albero* PC (1:4 proportion) test results and other well-known mortars commonly used in building industry, through different applications that can be adequate for this new material. This comparative study is shown in tables 12 to 16.

ABBREVIATION	**STRENGHT**	**OBSERVED EFFECTS**
MB	Very Good	No effect was observed
B	Good	Short number of spots can be appreciated
R	Regular	Short number of spots and some deterioration can be appreciated
M	Bad	Great number of spots and surface deterioration
MM	Very Bad	Important deterioration. The tile is not adequate for using.

Table 12: Chemical Tests under UNE 67122-85.

MATERIAL	**TESTED SOLUTIONS**				
Floor tiles of	**WATER**	**OIL**	**ClH 5%**	**NaOH 5%**	**SPECIMENS**
Portland Cement	MB	R	MM	B	3
Alumina Cement	B	R	MM	R	3
Polialbero (1:4)	MB	B	B	R	3

Table 13: Comparison of chemical resistance for cement mortar and Polialbero floor tiles.

Specifications for ceramic floor tiles (under Standards UNE 67157/85)						**Results obtained for *Albero* PM**
Material	**CERAMIC**					**POLIALBERO**
Flexion (MPa)	≥ 27	≥ 22	≥17,5	≥15	≥12	14,3
Thickness (mm)	----	----	----	≥ 7,5	> 7,5	10
Absorption (%)	≥ 3	3-6	6-10	> 10		3,8- 4,8

Table 14: Comparison between ceramic floor tiles specifications and the results obtained for polialbero tiles.

Specifications for hydraulic floor tiles (under Standards UNE 127001-90)					**Results obtained for *Albero* PM**
Material	**Hydraulic floor tiles**				**Polialbero**
Pavement	Normal use		Outdoors use		----
Flexion (MPa)	Side	Back	Side	Back	14,3
	3,5	2,5	5,0	4,0	
Absorption (%)	10		7,5		3,8- 4,8

Table 15: Comparison between hydraulic tile specifications and the results obtained for polialbero.

Specifications for Portland cement floor tiles (under Standards UNE 127001-90)							Results for *Albero* PM
Material	**TERRAZZO**				**SIGLE LAYER**		**Polialbero**
Pavement	Normal use		Outdoors use		Normal	Outdoors	----
	Side	Back	Side	Back			
Flexion (MPa)	4,5	3,5	6,0	4,5	4,5	6,0	14,3
Absorption (%)	10		7,5		10	7,5	3,8- 4,8

Table 16: Comparison between the specifications for Portland cement floor tiles and Polialbero results.

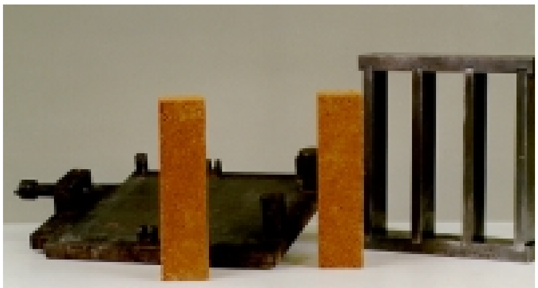

Figure 1: Prismatic specimens

Figure 2: Cylindric specimens

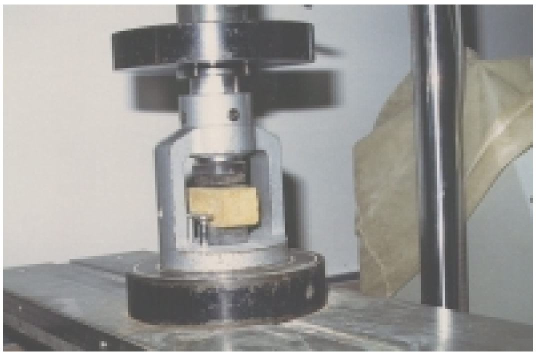

Figure 3: Prismatic specimens compression test.

Figure 5: Prismatic specimens flexural test

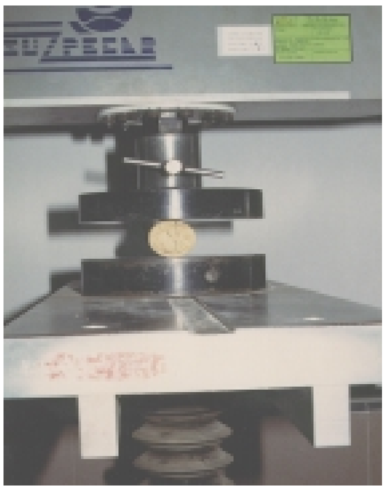

Figure 4: Cilindric specimens compression test.

Figure 6: Chemical tests results

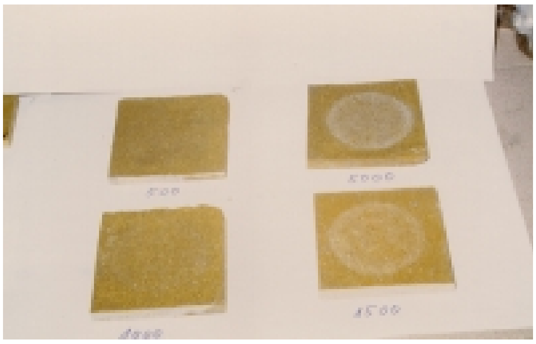

Figure 7: Abrasion tests results

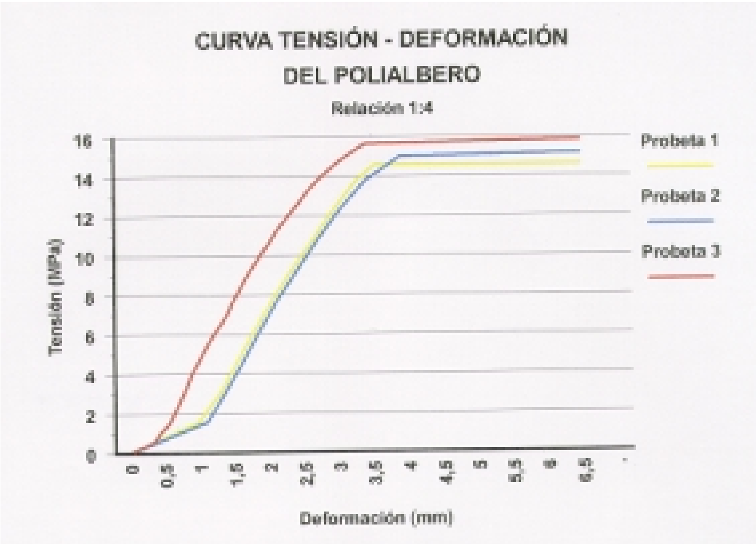

Figure 8: Stress/Strain Polialbero curve.

8. CONCLUSIONS.

Experimental results were demonstrative enough of the main aspects of the investigation. The conclusions above mentioned are obtained after analysing the results shown in the previous pages:

- The external aspects of the specimens are identifiable with granular *Albero*, one of the main objectives of the investigation: the search of an *Albero*-like material, with the same colour and texture.

- *Albero* polymeric mortar can be used as a thick coating material for floor and wall tiles as the test results show.

- Abrasion, absorption, permeability and temperature resistance test results show that *Albero* polymeric mortar can be used outdoors.

- *Albero* can be done in situ like cement mortars, so it can be used for continuous coating both in and outdoors.
- As any polymeric mortar, sets and hardens under the cast shape. Any kind of shape and texture can be obtained.
- The possibilities of outdoor use, casting facilities, colour and texture make *Albero* mortars very adequate for urban furniture.
- The adherence with conventional mortars is excellent but in smooth surfaces it is advisable the use of an adhesive.
- Good chemical resistance as most polymeric mortars. So the use of *Albero* mortar can be very appreciate in aggressive environments.
- Influence of the compacity degree (porosity) in the strength results. The higher values correspond to the specimens that have better compacity according to the cast size.
- Up to moisture degrees of the aggregates of 7% strong enough results are obtained. According to this, for some applications in the building industry it will not be necessary to dry the aggregates before their addition to the polymeric mortar.
- All this acceptable results (compared to other materials) have been obtained with rather high moisture degrees and manual compaction. In a factory precast production much better results are expected.

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