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OYSTER SHELL AS FINE AGGREGATE FOR MORTAR PRODUCTION

OSTION SHELL AS A FINE AGGREGATE FOR THE PREPARATION OF MORTARS

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Abstract **--** In this stage of the research , the physical and mechanical properties of oyster shell (Crassostrea virginica mollusk) were evaluated with the objective of demonstrating its viability as fine aggregate for later use as a percentage substitute for sand in different proportions in mortar mixtures for the manufacture of blocks and pavers. The process was as follows: Stage 1.- The oyster shells were washed with water, Stage 2.- The oyster shells were crushed using manual tools (hammer and/or hammer), Stage 3.- The previously ground shells will be sieved using different meshes, until it is decided which are the most suitable to separate the particles into fine and coarse grains, Stage 5.- Finally, the fine and coarse grains will be stored in containers.

The resulting granulometry was determined and its corresponding granulometric curve was drawn, and we proceeded in a similar way with the commercial sand existing in the region, to compare both results. The statistical analysis was carried out with software and three methods were used, fixing in all cases the 95% confidence index for the means, which allowed us to determine that the raw material of oyster shell is viable for making sustainable products that compete notably with those traditionally used.

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region, in order to compare both results. The statistical analysis was carried out with software and three methods were used, fixing in all cases the 95% confidence index for the means, which allowed us to determine that the raw material of oyster shell is viable for the production of sustainable products that compete notably with those traditionally used.

Key words: shell, oyster, granulometry, aggregate.

Abstract -- In this stage of the research work, the physical and mechanical properties of the oyster shell (mollusk Crassostrea Virgínica) were evaluated with the aim of demonstrating its viability as a fine aggregate to be used later as a percentage replacement for sand in different proportions in the mortar mixtures to finally manufacture blocks and paving stones. The process was as follows: Stage 1.- The oyster shells will be washed with water, Stage 2.- The oyster shells will be crushed using manual tools (hammer and/or hammer), Stage 3.- They will be ground. the oyster shell using two manual mills, Stage 4.- The previously ground shells will be sifted using various meshes, until it is decided which ones are suitable for separating the particles into fine and coarse grains, Stage 5.- Finally, the oyster shells will be stored. fine and coarse grains in containers.

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analysis used was carried out with software and three methods were used, setting in all cases the confidence index of 95% for the means, this allowed us to determine that the oyster shell raw material is viable to produce sustainable products that compete. notably with those traditionally used.

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INTRODUCTION

It is undeniable that climate change is a reality that takes place daily on our planet Earth, as evidenced by several research studies and the World Meteorological Organization, which mention that the indicators of this change are the increase in the heat of the earth and the ocean, the increase in sea level and the melting of ice, attributed to human activity [1].

Practically all over the globe, sand and gravel are exploited, representing the largest volume of solid material extraction; affecting biodiversity, water turbidity, erosion of the earth's crust, water tables, landscape and climate, as it is obtained through destructive or polluting processes with carbon dioxide emissions generated by machinery and transportation [2].

Chapilliquen Li. Edwin Alexis in 2020. He carried out a Design of a mortar in confined masonry with addition of fan shell residues, district of sechura - piura 2020, as an objective they analyzed the influence of the fan shell in the mechanical properties of the mortar; therefore, the properties of workability, retenitividad, compressive strength and adhesion with masonry units were analyzed. Where part of the aggregate referring to sand replaced by fan shell residues in the percentages of 3%, 5%, 7% and 10% with constant and variable w/c correlation. [3].

In Mexico, Construmática in 2019 shared that in the construction sector more than 2 tons of raw materials are needed for each m2 of construction, of which more than half are stone [4].

The authors Godoy and Gándara in 2018 stated that to achieve a house with a bioclimatic design, a previous study of the components of the microclimate (temperature, humidity, topography, light, altitude, latitude and vegetation cover) should be made depending on the area to intervene, the materials to be used, passive waste treatment systems, energy capture or available resources should also be analyzed [5].

In Mexico, the authors Avila, Martinez, Barrera, Ureña & Loza in 2015, stated that the quality of recycled polyethylene terephthalate (PET) can be superior to that of virgin material, depending on the use to which it is destined, the cited research, proposes the application of using PET as aggregate in concrete [6].

In Villahermosa, Tabasco the authors Méndez, Ramón, Rodríguez and Alvarado in 2013, in the research work the reuse EPS, applied in a social interest housing (SIPPA Sistema Prefabricado de Paneles Amigables con el Ambiente); is a prefabricated system of panels to build walls and slabs to be used in the construction industry, made with reuse EPS (stacked EPS plates) that meets the resistances required by the NMX-C-405-1997-ONNCCE standard [7].

From the above and despite efforts to innovate, it is evident that MSW, organic waste such as oyster shell, among others, and the construction industry are sources that generate strong atmospheric, water and land pollution, from the extraction of stone materials, transportation, construction process and even in the operation; the sector is a major generator of greenhouse gases, it is urgent to take measures aligned with the objectives of sustainable development, to address this problem, creating new environmentally friendly materials.

Problem

Environmental impacts of building materials.
Internationally, authors Enshassi, Kochendoerfer and Rizq in 2014, indicate that the construction industry is responsible for 12-16% of water consumption; 25% of harvested wood; 30-40% of energy consumption; 40% extracted virgin materials and 20-30% greenhouse gas emissions [8].

The United Nations Environment Program states that sand and gravel mining is carried out worldwide and represents the largest volume of extraction of solid materials, the most consumed on the planet after water. Formed from erosive processes that require thousands of years, they are currently being exploited much faster than they regenerate. Exploitation affects biodiversity, the

turbidity of water, erosion of the earth's crust, water tables, landscape and climate through carbon dioxide emissions generated by transport, as it is obtained through destructive or polluting processing [2].

In Mexico, Construmática (op. cit.) mentions that the analysis of the life cycle of a building allows us to intuit more easily the environmental consequences resulting from the impact of construction: the buildings resulting from the construction process, as well as the infrastructures necessary to promote accessibility, occupy and transform the environment, the manufacture of construction materials depletes non-renewable resources due to the unlimited extraction of raw materials and the consumption of fossil resources, our natural environment is affected by the emission of pollutants and the deposit of waste [4].

Article 19 of the Regulation of the Law for the Prevention and Integral Management of Waste of the State of Tabasco. The special handling waste mentioned in Article 19 of the Law is subclassified into the following:

Waste from exploration, exploitation, extraction and/or use of stone materials, construction materials and/or mineral substances not reserved to the federation, such as:

Waste gravel and crushed rock; sand and clays or other material of a similar nature to soil; stone cutting and sawing; dust and grit not impregnated with hazardous materials or substances; and metal scrap from the disuse of stone crushing equipment

The General Law of Ecological Balance and Environmental Protection (LEEGPA). Paragraph I defines the Environment: the set of natural and artificial elements or those induced by man that make possible the existence and development of human beings and other living organisms that interact in a determined space and time; in its paragraph III. Sustainable use: The use of natural resources in a manner that respects the functional integrity and carrying capacities of the ecosystems of which such resources form part, for indefinite periods of time; VI: The presence in the environment of one or more pollutants or any combination that causes ecological imbalance; VII.- Pollutant: Any matter or energy in any of its physical states and forms, which upon incorporating or acting in the atmosphere, water, soil, flora, fauna or any element alter or modify its natural composition and condition.

Ramón de los Santos. C. López Rodríguez. A. S. Sifuentes Gallardo. P. Hernández Rivera. M. Ángel. Rivera Trejo J. G. F. & Díaz Flores. L. L. in 2016, presents an alternative to oyster shell waste, consisting of the reuse of oyster shell waste "crassostrea virginica". To obtain a material as a mortar binder from grinding and calcination treatments. [9].

Finally, contextualizing the problems generated by oyster shell, in our country oyster fishery production is in sixth place due to its volume. The production statistics of oyster catch in Mexico, from January to December 2023, reached 20,237.68 tons, with an economic value of 210.92 million pesos, which represents an important resource for thousands of fishermen in the country, informed the National Commission of Aquaculture and Fishing. In aquaculture oysters, preliminary numbers for the same period indicate a production of 7,783.21 tons, with a value of 177.06 million pesos.

The Food and Agriculture Organization of the United Nations (FAO) states in its records that Mexico is among the top 10 places in world production of farmed oysters.

The main states with oyster catch production are Veracruz, with 13,183.21 tons; Tabasco 4,873.66; Sinaloa 863.24; Nayarit 323.29; Tamaulipas, with 13,183.21; Sinaloa 863.24; Nayarit 323.29; Tamaulipas 286.40; Guerrero 264.68; Oaxaca 157.04; Baja California South 136.16; Jalisco 83.89; Michoacán 57.70; and Colima with 8.40 tons [10].

According to the results of an investigation conducted by four researchers from the Universidad Juárez Autónoma de Tabasco (UJAT), both the water and the mollusk Crassostrea Virgínica, which is commercially exploited in Tabasco, represent contamination problem. After consuming the edible part of the oyster, people discard the shells in the streets or in public places and even in landfills, causing a bad appearance, poor hygiene and the spread of pests [11].

Overall objective

To demonstrate that the present granulometry of the oyster serves as fine aggregate for the elaboration of mortars.

Hypothesis

Crushing oyster shell to a suitable particle size will make it possible to replace sand as a percentage in mortar mixes.

DEVELOPMENT

To obtain the oyster shell, a trip was made to Paraíso, Tabasco, Mexico to the production area known as El Chivero, contacting some of people who live in the area. We hope to obtain at least 10 sacks of oyster shell, which will be enough to carry out the research.

The identified raw materials were then transformed into fine aggregates (oyster shell).
The oyster shells were subjected to a sanitation and transformation process that will consist of the following stages:

Stage 1.- The oyster shells will be washed with water.
Stage 2.- The oyster shells will be crushed using manual tools (hammer and/or hammer).
Stage 3.- The oyster shell is ground using two manual mills.
Stage 4.- The previously ground shells will be washed and sieved using different meshes, until it is decided which ones are indicated to separate the particles into fine and coarse grains.
Stage 5.- Finally, the fine and coarse grains will be stored in containers.
Granulometric analysis (oyster shell).

Taking as a guide the standard NMX-C-111-ONNCCE-2017 [12]. A granulometric analysis will be made to the material known as fine aggregate, such as sand together with oyster shell, to sieve them and separate the particles, in this way what results will be used in mixtures that will pass through the 50 mesh with diameters less than 0.297 mm, thus ensuring homogeneous particles.

Figure 1. Unprocessed oyster shell in fine aggregate.
Figure 1 shows the oyster shells with a first wash with water and bicarbonate to remove residual edible matter.

Figure 2. Oyster shells transformed into washed fine aggregate.

Figure 2 shows the oyster shells crushed with a mallet and mechanical mill to be subjected to a second washing.

Figure 3. Washed oyster shells transformed into fine aggregate and granulometric test performed.

Figure 3. Illustrates the crushed oyster shell washed a second time and sieved through the mesh specified in NMX-C-111-ONNCCE-2017 [12].

Table 1. Granulometric analysis of oyster shell.

MESH No.	OPENING mm	% WHAT HAPPENS
3"	76.200	100.00
2"	50.800	100.00
1 1/2"	38.100	100.00
1"	25.400	100.00
3/4"	19.050	100.00
1/2"	12.700	100.00
3/8"	9.525	100.00
4	4.760	100.00
10	2.000	51.74
20	0.840	29.47
40	0.420	15.61
60	0.250	12.71
100	0.149	8.36
200	0.074	5.04

Table 1 shows the meshes through which the oyster shell transformed into fine aggregate was sieved and the data obtained from the sieving were noted and the results of percentage passing the mesh in question were calculated.

Table 2. Sand particle size analysis

MESH No.	OPENING mm	% WHAT HAPPENS
3"	76.2	100
2"	50.8	100
1 1/2"	38.1	100
1"	25.4	100
3/4"	19.05	100
1/2"	12.7	100
3/8"	9.525	100
4	4.76	98.5
10	2	93.282
20	0.84	79.704
40	0.42	54.606
60	0.25	19.13
100	0.149	2.892
200	0.074	1.458

Table 2, the sieving of the conventional fine aggregate commercial sand from the Arcosa sand bank located on the La Isla - Comalcalco highway at km 4+950, ejido San Pedro - 2nd section, Cunduacán, Tabasco, coordinates x= 485056.17 y=1991961.71 was performed in a similar manner.

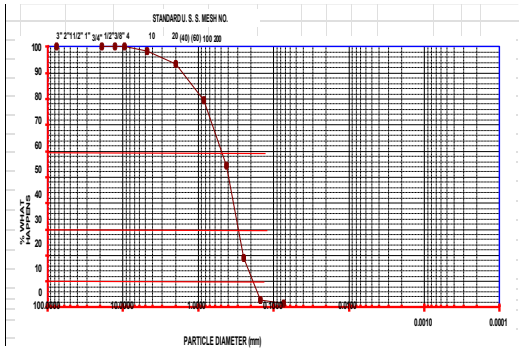

Figure 4. Oyster shell granulometric graph.

ARCOSA SAND BANK IS LOCATED ON THE ROAD LA ISLA - COMALCALCO AT KM 4+950 OF THE EJIDO SAN PEDRO - 2ND SECTION, CUNDUACAN, TABASCO, COORDINATES X= 485056.17 Y=1991961.71

Figures 4 and 5 show the particle size curves resulting from the screening process of the oyster shell and sand aggregates, respectively.

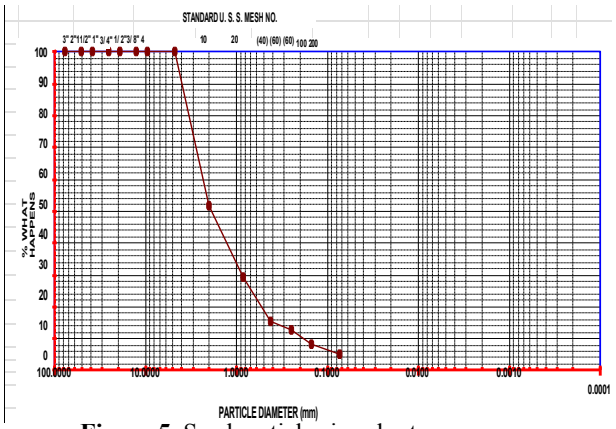

Figure 5. Sand particle size chart

This report presents the results obtained from the granulometry and shows the behavior of the oyster shell and sand. can be observed that both materials are completely moldable and that this allows them to be combined with other stone materials, which will allow the elaboration and design of non-structural mortars to lead us to a block that has a resistance allowed by the current construction regulations.

DISCUSSION AND ANALYSIS OF RESULTS

Analysis of results

Specific Relative Apparent Specific Mass of Solids or bulk density = 1.94

Results obtained in Minitab 18 [13].

A one-factor ANOVA analysis of variance was performed on two populations (2 levels) of the oyster shell and Arcosa sandbar, taking two samples of size 14 from each population and considering equality of variances, from the granulometric analysis in Table1 and 2 the measure of the percentage passing the mesh is taken and the following hypotheses are posed with a significance level $\alpha = 0.05$.

Null hypothesis	The two averages of the percentage passing the screen are equal.
Alternative hypothesis	The two averages of the percentage passing the screen are not equal.

Using Minitab 18, the following results are obtained.

Table 3. Factor information.

Factor	Levels	Values

Type	2	Sand, Oyster Shell

In Table 3, where the Type factor is considered at two levels, Arcosa Sand Bank and Oyster Shell.

Table 4. Analysis of Variance from Minitab 18.

Source	GL	SC Adj.	MC Adj.	F-value	
Type	1	572.8	572.8	0.35	0.560
Error	26	42631.9	1639.7		
Total	27	43204.6			

From Table 4 it indicates that the F value is less than the critical value of the F distribution with 1 and 26 degrees of freedom, $F0_{.05}(1,26) = 4.23$ similarly the p-value is greater than $\alpha = 0.05$, with a confidence level of 95% then, the null hypothesis is not rejected, it indicates that there is a high probability that the means of the percentages passing the mesh for both Sand and Oyster Shell may be equal.

Table 5. Confidence intervals.

Stockings

Type	N	Mean	St.dev.	95% CI
Arena	14	75.0	38.7	(52.7, 97.2)
Oyster Shell	14	65.9	42.2	(43.7, 88.2)

Grouped standard deviation= 40.4930

From Table 4 confirms the result of the analysis of variance, analyzing the 95% confidence intervals, Figure 6 shows that there is not much difference between the two intervals and the intersection is very wide in the percentages of the two types of data.

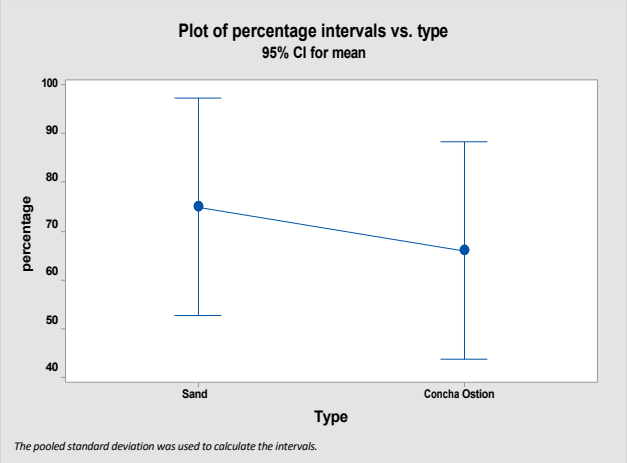

Figure 6. Plot of percentage intervals vs 95% CI type for the mean.

To confirm the previous results, pairwise comparisons were also performed by Tukey's method and Fisher's method in Minitab 18 with the following results.

Table 6. Grouping information using Tukey's method and 95% confidence.

Type	N	Mean	Grouping
Sand	14	75.0	A
Oyster Shell	14	65.9	A

From Table 6 the means that do not share a letter are significantly different. This means that at a 95% confidence level Tukey's method detected no difference in the means of the Sand Type and the Oyster Shell Type.

Table 7. Tukey's simultaneous tests for mean differences.

Difference in levels	Difference in averages	EE of difference	95% CI	Valor T	Adjusted p value
Oyster Shell - Sand	-9.0	15.3	(-40.5, 22.4)	-0.59	0.560

Individual confidence level= 95.00%.

Similarly, performing a Tukey test for the difference of the means of Oyster Shell and Sand, where the null hypothesis stated is, the difference of the means is zero against the alternative hypothesis that the difference of the means is different from zero, according to the result of table 7 the adjusted p-value is greater than
0.05 which is the significance level, therefore, the null hypothesis that the difference is zero is not rejected, which implies that the two means can be equal with a confidence level of 95%.

Graphically it can be seen in Figure 7 that the 95% confidence interval contains zero, that means that the difference of the means can be zero and therefore the means of the two types of Oyster Shell and Sand can be equal.

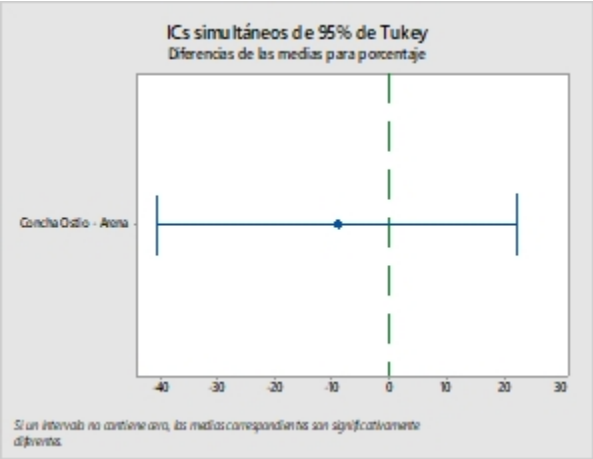

Figure 7. Tukey 95% CI paired comparisons plot for the mean.

Performing pairwise comparisons by Fisher's method generated the following result.

Table 8. Grouping information using Fisher's LSD method and 95% confidence.

Type	N	Media	Grouping
Sand	14	75.0	A
Oyster Shell	14	65.9	A

Means that do not share a letter are significantly different. From Table 8 it is observed that the Sand Type and Oyster Shell Type belong to the same group, this means that with a confidence level of 95% Fisher's method did not detect a difference in the means of the Sand Type and the Oyster Shell Type.

Table 9. Fisher's individual tests for differences in means.

Difference in levels	Difference in averages	EE of difference	95% CI	Valor T	Adjusted p value
Oyster Shell - Sand	-9.0	15.3	(-40.5, 22.4)	-0.59	0.560

Simultaneous confidence level= 95.00%.

As in the Tukey test, the same hypothesis test for the difference of the means is proposed in Fisher test, according to the result in Table 9, the adjusted p-value is greater than $\alpha = 0.05$, therefore, with a confidence level of 95%, the null hypothesis that the difference of the means is zero is not rejected, which implies that the two means of the percentages of the Oyster Shell Type and Sand Type can be equal.

As can be seen in Figure 8, the Fisher 95% confidence interval contains zero, which means that the difference of the means can be zero and the difference of the means can be zero.

therefore the mean percentages of the two types of oyster shell and sand can be equal.

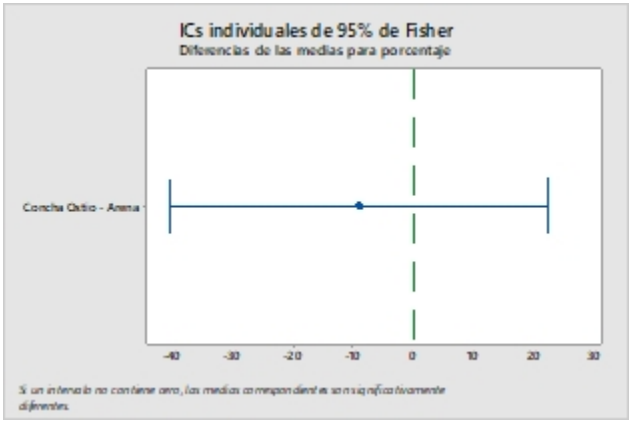

Figure 8. Fisher 95% CI individual comparisons plot for the mean.

According to the analysis of variance ANOVA, Tukey's test and Fisher's test, we conclude that there is no difference in the mean of the percentages that pass the mesh of the granulometric analysis performed on the Sand and the oyster shell.

Discussion

In Spain, Simeon Vallve, 2023 in his paper "Estudio de la usabilidad del material extraído de las conchas de mejillón para la construcción de un arrecife artificial" in this research work the objective was to assess the feasibility of using this waste for the design of an artificial reef. [14]

Undoubtedly, this work shows us the different applications that can be made to a waste that is little used nowadays and reinsert it as a sustainable construction material in a new use, obviously.
the proposed application very innovative, it is totally different from the paper presented in this article, as a point of intersection will be given a new use, but in the manufacture of mortars for the industry of la construction, transforming the oyster shells by means mechanical into aggregate fine for replace percentage of the commercial arena.

Chapilliquen, 2020. In Peru, the research "Design of a confined masonry mortar with the addition of fan shell residues, district of Sechura - Piura 2020" analyzed the influence of the fan shell on the mechanical properties of the mortar, such as: workability, retentivity, compressive strength and adherence. Where part of the aggregate referring to the sand replaced by fan shell residues in the percentages of 3%, 5%, 7% and 10%, it was demonstrated that the fan shell influences the retentive and consistent property of the mortar that is feasible to use the

residues of fan shell as a construction element to replace sand [15].

Comparing this research with ours, they do not report studies of granulometric analysis, so the substitution of fine aggregate was conservative, in the future line of research larger substitution percentages can be handled since the statistical analysis of the granulometric test shows a great similarity between the new proposal fine aggregate and the one currently used commercially.

In Ecuador Calderón, 2018 in his work "Mampuestos con con concha de ostión para la comunidad de Tambillo, provincia de Esmeraldas", the research work proposes the use of clay soil, sea sand, oyster shell powder and cement, for the elaboration of compacted block-type soil masonry. [16]

As in the previous comparison, this study does not report a granulometric analysis of the fine aggregate of oyster shell and the mixture that they propose includes clayey soil, sand, cement and water, our research in this first stage only compares the granulometry obtained with the sand of a commercial bank and prospectively the mortar mixture is proposed to be integrated by cement, sand, oyster shell and water.

CONCLUSIONS

Table 9. Standards used for laboratory tests.

Assaye	Standard applied	
	NMX	ASTM
Visual and tactile identification of soils	NMX-C-416-ONNCCE-2003	D 2487-06
		D 2488-06
Water content in earthen materials	NMX-C-416-ONNCCE-2003	D 2216-05
Liquid limit, plastic limit and plasticity index plasticity	NMX-C-416-ONNCCE-2003	D 4318-05
Sieve particle size analysis	NMX-C-416-ONNCCE-2003	D 422-63(2007)
Percentage of fines		D1140-00(2006)
Determination of specific mass	NMX-C-416-ONNCCE-2003	D 854-06
Triaxial Controlled deformation test		D 4767-04 D 2850-03a(07)
One-dimensional consolidation test		D 2435-04

Based on the crushing and pulverization of oyster shells as a sustainable raw material to manufacture blocks and pavers, granulometric analysis tests were carried out using the NMX-C-416- ONNCCE-2003 and/or ASTM D 422-63 [17] and [18] standards,
resulting in a sandy type material classified SUCS as SP poorly graded sand of low compactness, the result was 94.96% sand and 5.04 of fines, which is considered as sands see laboratory test.

1.- Consistency limit tests (liquid limit, plastic limit and plasticity index) were not carried out on the

The test indicates that in order to perform this test it is necessary that the material retains 30% of fines, and in this case it only retained 5.04%, so it does not comply and is considered and classified as a poorly graded sandy soil.

2.- Triaxial tests of controlled deformation to the pulverization of the oyster shell were not performed, since it does not comply with ASTM D 4767-04 [20] and ASTM D2850-03 [21] where it is indicated that in order to perform such test it is necessary to perform a specimen of
3.00 cm in diameter and 9.00 cm in height approximately, and this material is only frictional cohesive soils and this material is only frictional soils and this material is only frictional soils and this material is only frictional soils and therefore does not comply, it is considered and classified as a poorly graded sandy soil.

3.- One-dimensional consolidation tests were not performed to the pulverization of the oyster shells, since it does not comply with ASTM D 2435-04 [22], where it indicates that to perform this test it is necessary to perform only frictional cohesive soils and in a saturated state (Terzagui consolidation theory) and this material is only frictional, so it does not comply, it is considered and classified as a poorly graded sandy soil.

In this way it can be demonstrated that the granulometry of the different materials is very similar, the statistical analysis of Anova, Tukey and Fisher confirm this, we can affirm that at an experimental level that the oyster shell with the data obtained from this granulometric analysis it is possible to carry out an investigation about a mortar mixture to be used for the elaboration of blocks and/or paving stones for sustainable pieces that allow healthier materials for the planet.

On the basis of these results, as a future line of
research will be carried out to design mixtures for
to elaborate mortar specimens inserting in the mixture a percentage of oyster shell in substitution of sand, prior to the elaboration of the mixtures, the densities of the materials to be used in the same, as well as the dosage of each one of the treatments, will be determined.

These specimens will reach the ages of 7, 14 and 28 days after manufacture and will be subjected to compression tests to determine the treatment with the highest stress resistance. The selection of the specimens for the test will be carried out randomly, guaranteeing the integrity and veracity of the results obtained.

Based on these new results, it is possible to manufacture blocks and pavers with the mortar mixture with higher compressive strength and even use the mortar for masonry use, this use can be structural or non-structural.

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