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PHYSICAL-MECHANICAL ANALYSIS OF CEMENT-CELLULOSE COMPOSITE MATERIAL

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Abstract: At present, an optimal use of waste from industrial activities is sought, such as in this case the wood industry that generates great waste per year. Therefore, a better use is sought, it is here where composite materials play a fundamental role, since they seek to improve or maintain the properties of an element by including this waste, while significantly reducing the environmental impact that they generate. not knowing a way to use them effectively. For this investigation, a composite material of cement and wood chips was made in a 60/40,70/30, and 80/20 ratio in order to analyze its performance in terms of the mechanical properties of these mixtures to determine its use within of the construction either as a structural or non-structural element in such a way that it is used optimally.
Keywords: Construction, Chips, Cement, Composite Material, Cellulose, Wood

INTRODUCTION

Cellulose is the fundamental component of the plant cell wall in plants, wood, and natural fibers, and is generally found combined with substances such as lignin, hemicelluloses (shorter carbohydrates, mainly pentosans), pectins, and fatty acids. In cotton and linen, the cellulose fibers are of high purity (90-95%) and have textile applications. Cellulose is the most abundant natural organic compound. Wood contains 40 to 60% cellulose and straw 30%. More than 90% of pulp production is obtained from wood and the remaining 10% from other plants. (Sanz Tejedor, 2003)

Chip is a segment of remaining material in the shape of a curved or spiral sheet that is removed by means of a planer or other tools, such as drill bits, when carrying out planing, grinding or drilling work on wood. With an approximate width of the particle of 75mm. (Coronel, J., & Rodriquez, P., 2016)

A composite material results from combining two or more materials in order to obtain a unique combination of their properties, these being different from those of their initial materials. (J. Perez, 2008).

In Mexico, the annual production of wood is approximately 8 million m3. Of this volume, 70% goes to the sawmill industry, generating around 2.8 million m3 of waste, mainly sawdust, shavings and bark. The management of these residues represents a problem at present, since they are used mainly as a source of energy, negatively affecting the environment, generating dust in the air and contributing to the emission of carbon dioxide into the atmosphere. In addition, the waste harms the health of workers and inhabitants of the areas near the sawmills, by generating environmental problems such as fires and self-combustion. (N. Fregoso, 2017).

Here is the need to find a better use for this type of waste, several researchers and universities have dealt with the issue mainly in two types of waste, chips and / or sawdust, in order to find its role within the construction industry.

Eleazar L. found that the high porosity of the material combined between only cement and sawdust produced a low compressive strength when compared to an annealed clay partition, while the annealed clay supports a much higher load. The defects that may have existed in the compaction prior to pressing produced micro-failures at the time of the test, so it is a variant to take care of when making the material. (L. Eleazar, 1980).

O. Sánchez in his results when including sawdust in the mortar show how the higher the percentage of sawdust, the resistance, the modulus of elasticity and the density decrease. It is suggested to use up to 1% sawdust fiber in mortars to avoid a significant reduction in the mechanical properties of the mortars. (A.D. Ortega Sánchez & H. Gil, 2022).

Slim. Y. concluded that the best option is concrete with the addition of 5% sawdust, since its compression and abrasion properties do not differ from concrete, but it improves its flexural properties compared to it.

The most optimal design of the concrete for load-bearing blocks was given to 30% substitution of sand by sawdust, presenting a resistance value of 72 kg/cm2, settlement of 1", absorption of 9.5% and density of 1916 kg/m3. While for the concrete applied in non-bearing blocks, 40% was given with a resistance of 49 kg/cm2, settlement of ¾", absorption of 10.7% and density of 1883 kg/m3. (Y.M. Delgado Espinoza, 2020).

J. Corona, in his work "Physical-mechanical characterization of a composite material based on sawdust and cement", compared two types of brick, one made of annealed clay and the other made of cement-sawdust composite material. The annealed clay partitions present a greater initial maximum absorption than the composite material partitions, this is probably due to the phenomenon of capillarity and to the fact that it is a porous material. However, in the total absorption in 24 hours the percentage in the composite material was higher. In the fire resistance test, it is estimated that for the same test time the partition and it reached the calcination of its components, but without the presence of flame.

In the compression resistance test, it was observed that the annealed clay partition has a higher resistance per area (38.3 kgf/cm2) than the sawdust-cement partition (9.2 kgf/cm2). Regarding acoustic conductivity tests, it is inferred that the sawdust-cement partition probably has better sound absorption characteristics because the wood particles are thicker, with greater spaces between them and that slows down the speed of sound propagation. (J. Corona, 2008)

In 2012 a study was carried out in which adobe blocks were formed. Where it was sought to replace the fertilizer used by ixtle and with a mixture of lime-gypsum as a stabilizer. In this work the blocks were compacted with an adobera at 5 MPa. Plaster and lime were added in a percentage of 6% depending on the amount of clay required for the adobe. The adobes yielded satisfactory results above the parameters stipulated by the NMX-C-508-ONCCE-2005 standard for blocks of compressed earth stabilized with lime. The average resistance obtained was 90.7 kg/cm2. (Algara, M., 2012).

As can be highlighted in the works presented above, the use of this type of waste can reduce the use of cementitious amounts within the construction while presenting particular properties with its addition, which would allow us to obtain a structural element of lower cost and Using this type of waste, at present the ideal dosage of greater participation has not yet been found in terms of the presence of this residue, for which reason wood shavings were chosen as the main element within the composite material, since being a natural fiber this can give a better union within the material with, in order to obtain a competent structural element and that contributes a much more significant reduction of the cementing agent.

METHODOLOGY

To carry out the tests, 10 specimens were made in a 5x5x5 cubic representation in a representative way, with a mixture of 60%, 70% and 80% of the cementing agent with respect to the total weight of both to carry out the mixture, for each different proportion giving a total of 30 hydraulic cement specimens and 40%, 30% and 20% of wood shavings from the waste of local sawmills, since the object of this experimentation is to find the resistance of the material by a simple method, the selection of a specific size or species of wood from the coming shavings. In addition to mixing the quantities in large proportions, that is, for a

50 kg lump of cement, 15 Kg of wood shavings were added, and adding 20 lt of water, as a follow a simple, economical and efficient process in its production.

Dosage of the mixtures with respect to the total weight given into make 3 cubes of 5x5x5 cm		
Mix	cement	Chip
60/40	150	100
70/30	234	100
80/20	440	110

Table 1: dosage of the mixture

Figure 1. Elaboration of the material (case 60/40 with respect to the weight of the material)

Figure 2. Material deposited in the molds

COMPRESSIVE STRENGTH TEST AT 28 DAYS OF AGE

To obtain the results, compression tests were carried out following the procedure with respect to the NMX-C-036-ONNCCE-2013 standard. 10 specimens were tested for each mixture ratio (cement/chip), this ratio was chosen to analyze. said combination with the aim of not compromising the property of mechanical resistance as the main objective, with the help of the Universal machine. And with the reference values of the NMX-C-404-ONNCCE-2012 standard for structural use, they are around 7-11 MPa (71.38-112.16 kg/cm2), to determine if they can be used for this purpose. For this, the reading of the Machine was required and by means of the formula (1).

$$\sigma = \frac{P}{A} \quad (1)$$

Where:
σ= Compression stress (kg/cm2)
P= Pressure exerted (Kg)
A= Acting area under pressure

Figure 3. Tested specimen

TOTAL ABSORPTION TEST

For this test, a scale, bucket or container with water is required where the specimen can be submerged.

For this test, the specimens are weighed before being submerged, then they are introduced and we proceed to wait for 24 hours, after which they are weighed. For the total absorption test, the Mexican standard NMX-C-037-ONNCCE-2013 was used as a basis to determine the water absorption during a period of 24 hours, and this will be represented by means of a percentage obtained through the following formula. (2)

Where:

$$A = \frac{Msss - Ms}{Ms} x100 \quad (2)$$

A= absorption in % (by mass)

Mss = the dry mass of the specimen in grams

Msss = the saturated surface dry mass in grams

The values stipulated in the NMX-C-404-ONNCCE-2012 standard, 23%, (value Maximo) this would not serve as an element of masonry since there would be problems with the mortar joints that are placed since it would absorb water from them, decreasing their resistance, for the case if the value is very small less than 12% there would be problems when joining these two materials with the mortar.

DETERMINATION OF MATERIAL DENSITY

For this test, each specimen in the dry state of the composite material was weighed, said reading was recorded in grams that were subsequently converted to kilograms and by means of a division of the recorded volume of the specimen in cubic meters, the density of the material was obtained through the equation (3).

$$\rho = \frac{M}{V} \qquad (3)$$

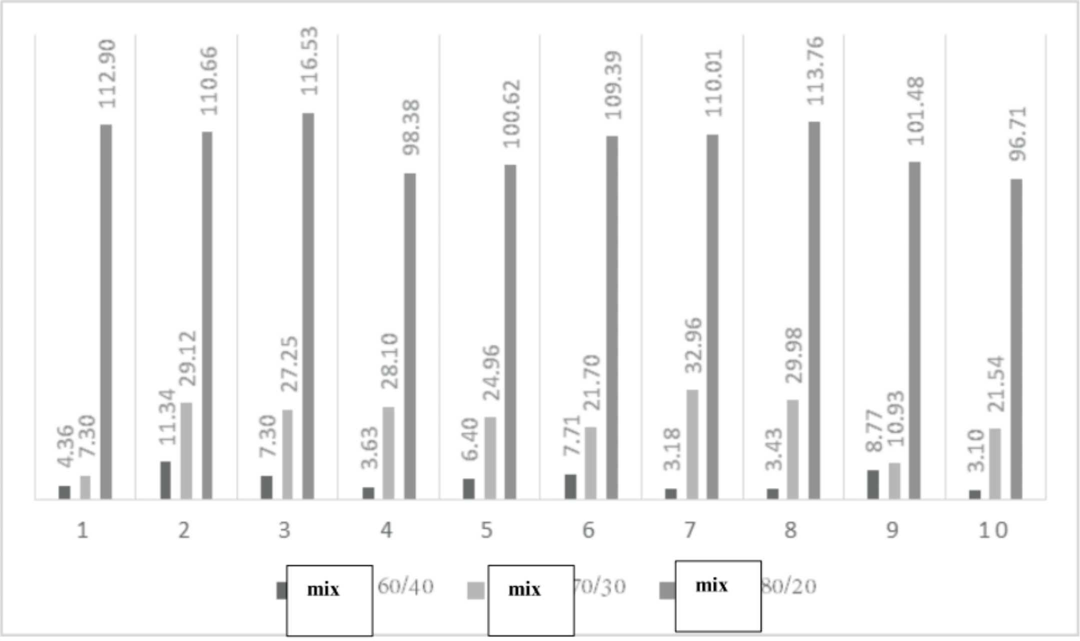
Where:
ρ = Densidty (kg/m^3)
M= Mass (kg)
V=Volume (m^3)

RESULTS AND DISCUSSIONS

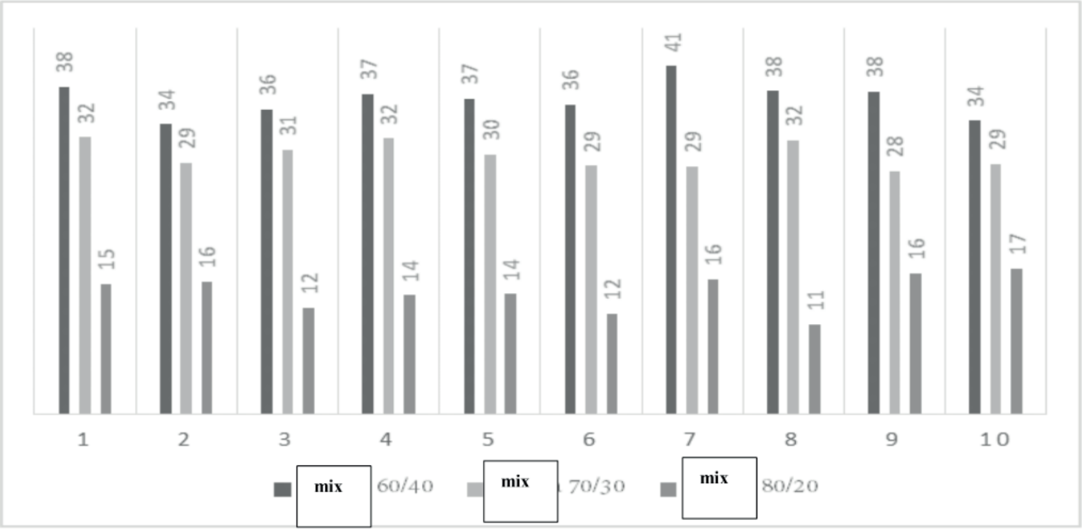
For the compression test at 28 days of age of the specimens, the results obtained are those presented in Table 1. Where it is observed that for the cases of the 60/40, 70/30 ratio, the values obtained do not meet for an element of structural masonry, but if for the use of dividing walls, or any other such as partitions or a substitute for a drywall panel, while in the case of the 80/20 ratio they satisfactorily fulfill their virtual role as material intended for elements of structural masonry, just as a value stands out between the borders of the relationships obtained in of 70/30 and 80/20 that can achieve the required compressive strength and in turn achieve further reduction of the cementitious material in the composite material.

En cuanto a la prueba de absorción total con los datos Table 2. It was obtained that for the ratios of 60/40 and 70/30 did not pass this test for structural use since they did not fall within the range of values obtained from the standard of 12-23% of total absorption, however the ratio 80/20, does fall on said interval, so it can be used for this purpose, but in the same way these two relationships can be used in non-load-bearing elements since their absorption values are not very far from the standard values.

With the data from the Density test collected from Tala 3, it is observed that the more chips are added to the composite material, the lighter it is, the opposite in the addition of more cementing agent, where values are almost doubled in the ratio that contains more cement.



Graph 1. Results obtained from the specimens in the compression test given in kg/cm2 at 28 days of age.



Graph 2. Results obtained from the specimens in the total absorption test after 24 hours expressed as a percentage (%).

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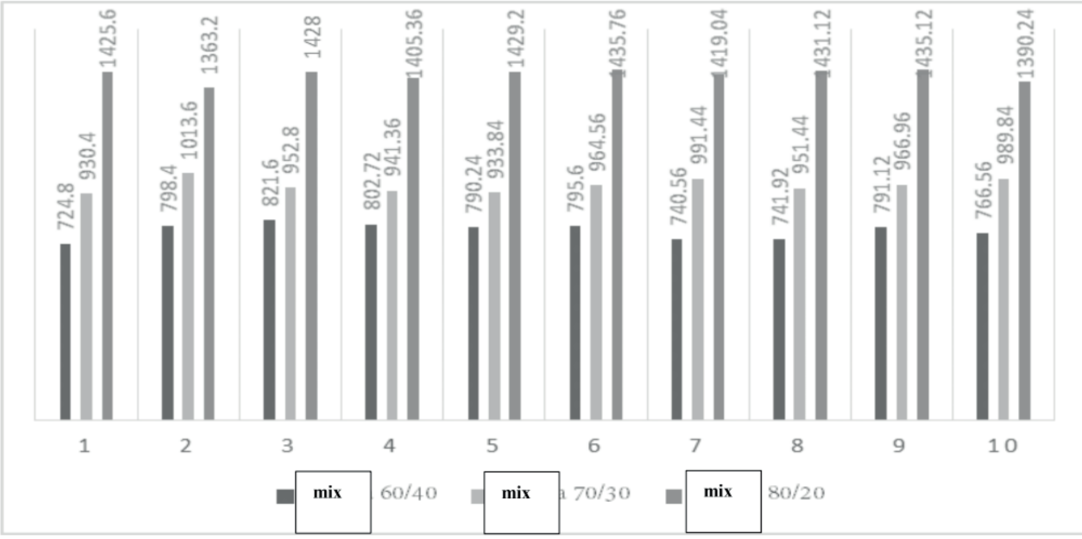

Graph 3. Results obtained from the specimens when calculating their density of each one expressed in kg/m3.

compression test (kg/cm2)								
60/40	Min.	3.10	Max.	11.34	Medium	5.92	Deviation.	2.83161304
70/30	Min.	7.30	Max.	32.96	Medium	23.38	Deviation.	8.35150942
80/20	Min.	96.71	Max.	116.53	Medium	107.04	Deviation.	7.07724236

Table 2. Statistical data of the results obtained from the specimens in the compression test at 28 days of

Total Absorption Test (%)								
60/40	Min.	34	Max.	41	Medium	37	Deviation.	1.98689286
70/30	Min.	28	Max.	32	Medium	30	Deviation.	1.48443886
80/20	Min.	11	Max.	17	Medium	14	Deviation.	2.13798743

Table 3. Statistical data of the results obtained from the specimens in the total absorption test in 24 hours submerged in water.

material density (kg/m3)								
60/40	Min.	724.8	Max.	821.6	Medium	777.352	Deviation.	32.0075424
70/30	Min.	930.4	Max.	1013.6	Medium	963.624	Deviation.	27.330954
80/20	Min.	1363.2	Max.	1435.76	Medium	1416.264	Deviation.	23.4951963

Table 4. Statistical data of the results obtained from the specimens of the test for obtaining the density of the composite material.

CONCLUSIONS

With the data obtained through experimentation, it can be concluded that the composite material with a ratio of 80/20 is

It approached the compression value stipulated by the standard, however the other ratios can be used for masonry for non-structural use, or other elements where loads do not fall, whether for decorative uses, ceiling lights or any other non-load-bearing use. Regarding the density, the lightness that the material gained by including more wood shavings was highlighted, but in turn it directly affected its mechanical property of resistance to compression as well as absorption, this because this material tends to absorb water, due to the porosity that is generated, leaving voids that affect its composition, thus making the material more brittle to compressive strength and tend to adsorb more water.

In conclusion, this material from the waste of the wood industry can be used to make a composite material within the construction branch, whether for structural or non-structural use. Thus giving a better use of this type of waste by knowing how the inclusion ratio of this material alters the behavior of the material, thus taking advantage of this for different purposes within the construction, and by default more economical and sustainable.

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