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STUDYING THE MECHANICAL PROPERTIES OF HYBRID COMPOSITES USING NATURAL ADDITIVES WITH EPOXY

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Abstract: The fundamental goal of the present study is to study the effects of the natural additives with vegetable and animal sources in form (i.e. the short fibers and particle) on mechanical characteristics epoxy. (The wood dust WD, cow bones CB, date palm fiber DP, and sheep wool SW) have been chosen as natural additives with a variety of the weight ratio reinforcements for epoxy matrix, which is based upon the hybrid composites that have been produced by hand lay-up approach. Tensile, compression and flexural tests have been performed based on the American society for the testing and materials (ASTM) for the characterization of hybrid composites it has been discovered that mechanical characteristics may be increased or decreased according to the material additive type, its origins, and the utilized percentage of weight.

Key-words: *epoxy, natural hybrid composites, mechanical properties, tensile strength, compression strength, flexural strength.*

1. Introduction

Natural composite materials could be combination of either the synthetic resin/natural fibers or the bio-resin/natural fiber. The synthetic and bioresin could be either ass thermo-plastic or thermoset resin. The advantage of natural fiber types in comparison with synthetic fibers keeps to increase continuously, as a result of less weight, abundance, low costs, low manufacturing costs, the renewable sources, quite efficient physical and mechanical properties, such as the tensile modulus, bending strength, tensile strength, and bio-degradable and environmentally friendly properties. The natural fibers were cultivated and utilized particularly in the rural developing countries for the creation of the non-structural applications like bags, brooms, filters and fishnets. Moreover, the natural fibers may be utilized as well, as wall insulation and roof material. A wide variation has been discovered when comparing the natural fiber characteristics.

Boopalan et al. [1] have observed the mechanical properties associated with the jute as well as banana fiber reinforced epoxy hybrid composite types. In addition, composites have been prepared with a variety of the fiber loadings of the jute and banana concentrations 100/0, 75/25, 50/50, 25/75 and 0/100 respectively by hand-lay-up approach succeeded via compression molding technique. The composites have been subjected to different mechanical testing like tensile testing by following ASTM D638-03, flexural strength as per ASTM D790 and impact strength by following ASTM D256.

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Yorseng *etal*. [2] have advanced bio-based natural fiber hybrid bio epoxy composite materials for applications of the semi-structure components as well as their mechanical behaviors under a variety of the cases has been observed. The surface morphology has been carried out with the use of characteristics of the contact angle measurements for finding composites' wettability. Results have shown that a reduction in the mechanical characteristics due to degradation of the bio epoxy through the accelerated conditions of weathering and ductile composite nature have been increased and it results in causing a breakdown.

Marimuthu & Chandramohan, [3] banana and Roselle (hybrid), sisal and Roselle (i.e. hybrid) Sisal and banana (hybrid) FRP composites had been produced with the use of hand molding technique, also, the impact of fiber content on the mechanical characteristics, like, hardness and tensile of composites have been reported and examined. Cavalcanti et al. [4] have researched hybridization effects upon mechanical characteristics of the intra-laminar hybrid epoxy composite types based upon the jute. It has been discovered that the values of the tensile strength of the jute+sisal composite and the jute+curauá composite has been increased by about 68% and 77%, respectively, in comparison with the non-hybrid composites of the jute. Chen et al. [5] observed water absorption and mechanical properties of hybrid composites of corn stalk/sisal fibers. It has been shown that hybridization with the sisal fibers has resulted in the significant enhancement of mechanical characteristics (the tensile strength has been increased by 49.50% and the flexural strength by 20%) however, it did not have much effect on the absorption of water**.** Effect on water absorption. Gupta and Srivastava [6] researched thermal and dynamic mechanical characteristics of the jute/sisal hybrid fiber reinforced epoxy composites and have discovered that there has been a positive impact of the hybridization concerning the thermal and dynamic mechanical characteristics. The loss modulus, Tg and storage modulus have been discovered higher for the hybrid composite that has a higher jute fiber percentage. Korjenic et al. [7] have developed an innovative organic thermoinsulating material from the renewable sources (such as flax, hemp and jute) and the binders with similar mechanical properties and building physics like the traditional materials of insulation. Vijay *etal*. [8] have carried out analyses of impact of filler loading on mechanical behaviors of kenaf and coconut spathe fibers/epoxy composite materials. They have found out that composite attributed sufficient mechanical characteristics up to a specific filler content limit, after that, the same characteristics have been decreased as a result of the lack in the bonding between the polymer and the fiber. Oliveira, *etal* [9] have researched the mechanical properties of epoxy hybrid composites that are reinforced by oil palm empty fruit bunches (EFB)/jute fiber, which have shown that the hybrid composite materials are of a considerably higher strength compared to synthetic composite materials. Hybrid composites that have been produced from the natural constituents of fibers/epoxy have shown more sufficient environmental and mechanical advantages and with the hybrid composites' flexural strength have been slightly higher in comparison with pure composites of empty fruit bunches and lower in comparison with the composites of the pure jute. Pappu *etal*. [10] have worked on the unused materials, such as the sisal fiber and fly ash, for the preparation of Nano and micro composites for the multi-functional applications. The approach of the hand lay-up in addition to the compression molding that has been utilized to prepare the composites, the sisal fiber and fly ash have been utilized as the reinforcement and epoxy has been utilized as matrix material. They have made a total of 2 composites that have been fabricated for the purposes of comparison. The results have indicated that existence of the natural fibers and Nano filler results in boosting the composite's performance, in particular, cellulose content in sisal fibers and silica along with the alumina in the fly ash results in a possible increase in the mechanical characteristics.

2. Materials and Method

2.1. Composites with Hybrid Fillers

First was selected the type of epoxy (QuickMast 105) (Hardener & Base) as can be seen from Plate (1) for the current search from accompany (DCP) and mixing in room temperature.

Plate (1) Epoxy QuickMast 105

Natural vegetables and after that, animal particle materials have been prepared then mixed with the epoxy using the (hand layup approach) due to the fact that it's the oldest and simplest approach that is utilized at the temperature of the room. The first part is the preparation of epoxy with mix base and hardener through the mixing of (2:1). The weight in gram at the temperature of the room, where that epoxy with no additives undergoes a comparison to the epoxy through the addition of the natural materials based on the mechanical characteristics. We begin with the preparation of natural compound material with the use of the WD and CB particle with a (600µm) diameter and short fibers with a mean length of (5mm-10mm) were washed by using the distilled water for the removal of impurities from surface. Concerning CB, they have been boiled in the distilled water for the removal of stuck fat and meat pieces. After that, the materials have been dried in the oven at a 60^{o}C temperature for 2 hrs and after that, dried for 24hrs at the temperature of the room. Afterwards, CBs have been crushed with a Hammer to small pieces and after that, grinded with the sawdust using a grinder, followed by mixing (2:1). The weight has been measured in the grams at the temperature of the room. Molds have been prepared of (28x22x1.50cm) size silicon rubber with a (15g/cm3) density for preparing the needed composite, as can be seen from Plate2. A clean smoothed surfaced. After that, wax will be applied on it because of the easy removal of the composite material's specimen. Based on ASTM Standards, the variety of the samples have been conducted as can be seen from Plate3. Preparation has been be in multiple weight ratio values, as can be seen from Table1 and Plates (4-7) exhibited natural animal and vegetable particles and short fibers. The samples stay in mold for a 72hrs period.

Plate (2) prepare the molding

(a) (b)

Plate (3) Molding from Silicon Rubber

Table1. Mixing weight ratios with the Epoxy

Hybrid composites	Percentage
Wood dust + cow bones	%2.5+%2.5
Wood dust + cow bones	%2.5+%5
Wood dust + cow bones	%5+%2.5
Date palm + sheep wool	%2.5+%2.5
Date palm + sheep wool	%2.5+%5
Date palm + sheep wool	%5+%2.5
Wood dust + date palm	%2.5+%2.5
Wood dust + date palm	%2.5+%5
Wood dust + date palm	%5+%2.5
Cow bones + sheep wool	%2.5+%2.5
Cow bones + sheep wool	%2.5+%5
Cow bones + sheep wool	%5+%2.5
Cow bones + date palm	%2.5+%2.5
Cow bones + date palm	%2.5+%5
Cow bones + date palm	%5+%2.5

Plate (4) WD particles

Plate (5) CB particles

Plate (6) date palm fiber

Plate (7) SW

3. Mechanical Tests

3.1. Tensile Strength

Tensile test is carried out by (JIANQIAO TESTING EQUIPMENT) model (CZL203-2000 Kg) and capacity (2000 Kg), accuracy (0.03 %), sensitivity (2.0465) type of tensile test at the University of Technology / Dept. of applied science. Specimens have been made based on the standards of (ASTM -D 638) [11]. Where examination has been performed on 2 samples and the mean value of results has been taken. Tensile specimen dimensions are (160 length x12width x5 thickness) mm. as shown in Plate (8-10).

Plate (8) tensile test samples before testing

Plate (9) tensile test machine

Plate (10) tensile test samples after testing

3.2. Flexural Strength

Flexural test is carried out by (JIANQIAO TESTING EQUIPMENT) model (CZL203-2000 Kg) and rang (2000 Kg), accuracy (0.03 %) , sensitivity (2.0465) flexural testing type at Univ. of Technology / Dept. of applied science. Specimens have been produced based on the (ASTM -D790) [12]. Where examinations have been conducted on 2 samples and mean value of results has been taken. The flexural specimen dimensions were (100x12x5) mm as can be seen from Plates (11-13).

Plate (11) flexural test machine

Plate (12) flexural test samples before testing

Plate (13) flexural test samples after testing

3.3. Compression Strength

The manual hydraulic press maximal compression test capacity has been (7.5KN) type of the compression test at Univ. of Technology / Dept. of applied science. Samples have been produced based on the standards of (ASTM -D695) [13]. Where examinations have been conducted on 2 samples and mean value of results has been obtained. The compression specimens' dimensions is (14 x 7 x 7mm) as can be seen from Plate (14-16).

Plate (14) Compression test machine

Plate (15) Compression test samples before testing

Plate (16) Compression test samples during testing

4. Results

4.1. Tensile Strength

Tensile strength Hybrid Natural Composites in various percentages, which have been listed in table2 and figure (1).

Table 2. Tensile Strength Hybrid Natural Composites

Sample	T.S (Mpa)	Elongation%
Epoxy without additives	13.09	22.39
Epoxy +%2.5wood dust+%2.5cow bones	25.15	12.99
Epoxy +%2.5wood dust+%5cow bones	20.95	14.66
Epoxy +%5 wood dust+%2.5cow bones	21.14	15.74
Epoxy +%2.5date palm fiber +%2.5sheep wool	23.23	13.65
Epoxy +%2.5date palm fiber +%5 sheep wool	17.94	7.02
Epoxy +%5date palm fiber +%2.5sheep wool	19.18	5.92
Epoxy +%2.5wood dust+%2.5date palm fiber	23.42	9.68
Epoxy +%2.5wood dust+%5date palm fiber	24.31	7.83
Epoxy +%5wood dust+%2.5date palm fiber	14.94	12.80
Epoxy +%2.5cow bones+%2.5sheep wool	21.96	13.91
Epoxy +%2.5cow bones+%5sheep wool	19.58	12.25
Epoxy +%5cow bones+%2.5sheep wool	22.90	14.14
Epoxy +%2.5cow bones+%2.5date palm fiber	18.42	12.01
Epoxy +%2.5cow bones+%5 date palm fiber	21.99	9.37
Epoxy +%5cow bones+%2.5date palm fiber	17.98	11.71

All the ratio of hybrid natural composites (wood dust + cow bones) adding to epoxy a large increase in tensile strength but the best ratio is (%2.5 wood dust +% 2.5 cow bones) .

All the ratio of hybrid natural composites(date palm fiber + sheep wool) adding to epoxy a large increase in tensile strength but the best ratio is (%2.5 date palm fiber +% 2.5 sheep wool).

All the ratio of hybrid natural composites(wood dust + date palm fiber) adding to epoxy increase in tensile strength but the best ratio is (%2.5 date palm fiber +% 2.5wood dust) and (% 2.5 wood dust + % 5 date palm fiber) large increase in tensile strength .

Al the ratio of hybrid natural composites(cow bones + sheep wool) adding to epoxy increase in tensile strength but the best ratio is (%2.5 cow bones +% 2.5sheep wool) and (% 2.5 sheep wool + % 5 cow bones) large increase in tensile strength .

all the ratio of hybrid natural composites(cow bones + date palm fiber) adding to epoxy increase in tensile strength but the best ratio is (%2.5 cow bones +% 5 date palm fiber) large increase in tensile strength .

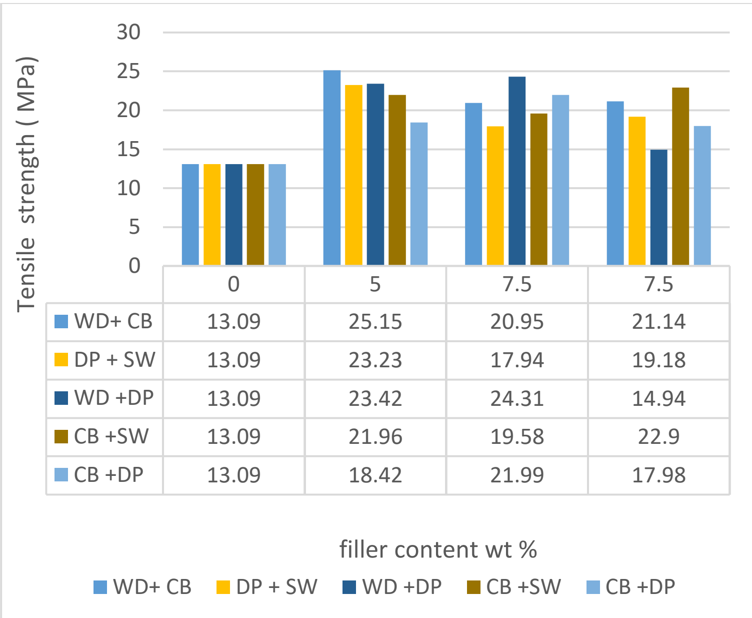


Figure 1. Variations of tensile strength with different filler contents

4.2. Compression Strength

Compression strength hybrid Natural Composite materials in various percentages, which have been shown in Table3 and figure (2).

Table 3. The compression strength Hybrid Natural Composite materials

Samples	compression strength (Mpa)	Strains
Epoxy with no additives	41.06	0.169
Epoxy +%2.5wood dust +%2.5cow bones	49.429	0.154
Epoxy +%2.5wood dust +%5cow bones	46.767	0.195
Epoxy +%5 wood dust +%2.5cow bones	47.311	0.111
Epoxy +%2.5date palm fiber +%2.5sheep wool	42.869	0.281
Epoxy +%2.5date palm fiber +%5 sheep wool	49.972	0.166
Epoxy +%5date palm fiber +%2.5sheep wool	56.917	0.265
Epoxy +%2.5wood dust+%2.5date palm fiber	39.597	0.193
Epoxy +%2.5wood dust+%5date palm fiber	50.800	0.258
Epoxy +%5wood dust+%2.5date palm fiber	52.687	0.246
Epoxy +%2.5cow bones+%2.5sheep wool	47.323	0.163
Epoxy +%2.5cow bones+%5sheep wool	44.893	0.286
Epoxy +%5cow bones+%2.5sheep wool	49.275	0.169
Epoxy +%2.5cow bones+%2.5date palm fiber	46.671	0.198
Epoxy +%2.5cow bones+%5 date palm fiber	47.689	0.252
Epoxy +%5cow bones+%2.5date palm fiber	55.994	0.167

All the ratio of hybrid composites (wood dust + cow bones) when adding to epoxy increase in compression strength but the best ratio is (%2.5 wood dust +% 2.5 cow bones) large increase in compression strength.

all the ratio of hybrid composites (date palm fiber + sheep wool) when adding to epoxy increase in compression strength but the best ratio is (%5 date palm fiber +% 2.5 sheep wool) large increase in compression strength .

the ratio of hybrid composites (%2.5 date palm fiber + % 5wood dust) and (%5 date palm fiber + %2.5 wood dust) when adding to epoxy increase in compression strength but the ratio (%2.5 date palm fiber +% 2.5 wood dust) decrease in compression strength .

All the ratio of hybrid composites (cow bones + sheep wool) when adding to epoxy increase in compression strength but the best ratio is (%5 cow bones +% 2.5 sheep wool) large increase in compression strength.

All the ratio of hybrid composites (cow bones + date palm fiber) when adding to epoxy increase in compression strength but the best ratio is (%5 cow bones +% 2.5 date palm fiber) large increase in compression strength.

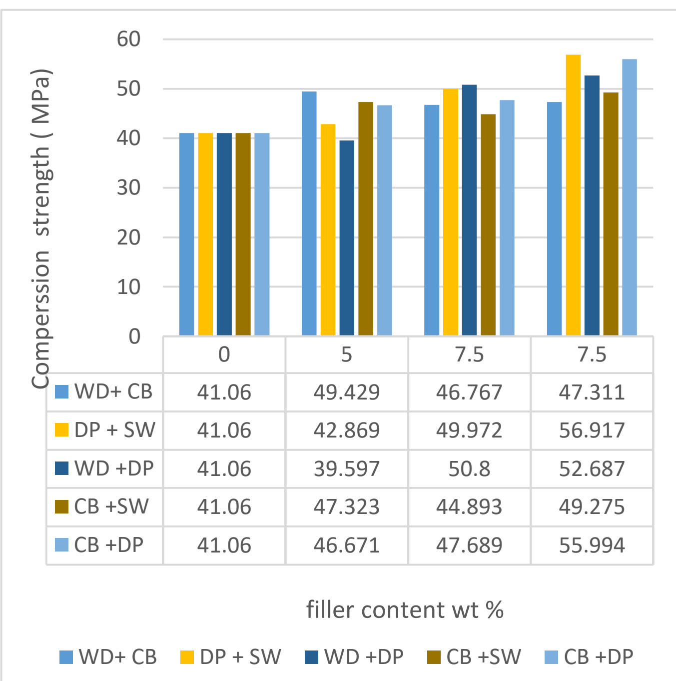


Figure 2. Variation of compression strength with different filler content

4.3. Flexural Strength

Flexural strength hybrid Natural Composite materials in various percentages that have been given in Table4 and figure (3).

Table 4. Flexural strength Hybrid Natural Composites

Sample	Flexural strength (Mpa)
Epoxy without additives	27.39
Epoxy +%2.5wood dust +%2.5cow bones	39.07
Epoxy +%2.5wood dust +%5cow bones	43.70
Epoxy +%5 wood dust +%2.5cow bones	35.45
Epoxy +%2.5date palm fiber +%2.5sheep wool	47.91
Epoxy +%2.5date palm fiber +%5 sheep wool	34.78
Epoxy +%5date palm fiber +%2.5sheep wool	23.60
Epoxy +%2.5wood dust+%2.5date palm fiber	48.21
Epoxy +%2.5wood dust+%5date palm fiber	28.88
Epoxy +%5wood dust+%2.5date palm fiber	31.86
Epoxy +%2.5cow bones+%2.5sheep wool	37.70
Epoxy +%2.5cow bones+%5sheep wool	47.06
Epoxy +%5cow bones+%2.5sheep wool	33.32
Epoxy +%2.5cow bones+%2.5date palm fiber	41.71

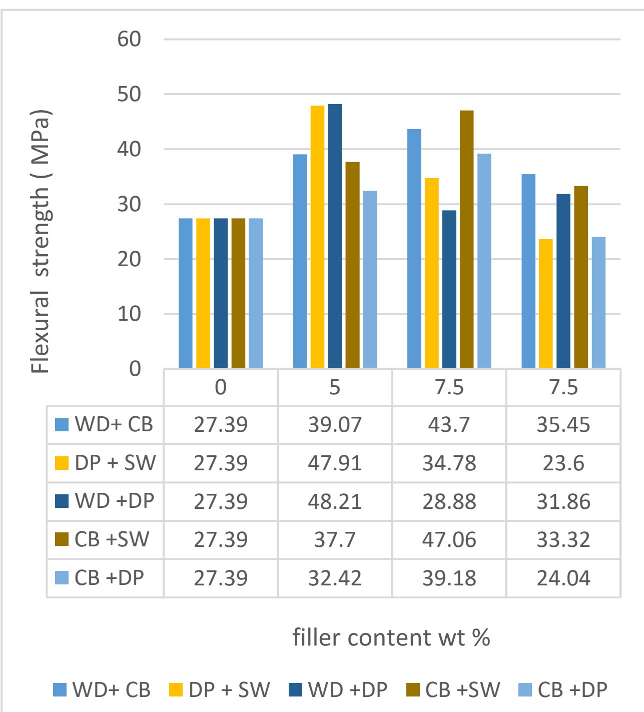
All the ratio of hybrid composites (wood dust + cow bones) when adding to epoxy large increase in flexural strength but the best ratio is (%2.5 wood dust +% 5 cow bones).

the ratio of hybrid composites (%2.5 date palm fiber +% 2.5 sheep wool) and (%2.5 date palm fiber +% 5 sheep wool) when adding to epoxy large increase in flexural strength but the ratio (%5 date palm fiber +% 2.5 sheep wool) decrease in flexural strength .

all the ratio of hybrid composites (wood dust + date palm fiber) when adding to epoxy increase in flexural strength but the best ratio is (%2.5 wood dust +% 2.5 date palm fiber) large increase in flexural strength .

all the ratio of hybrid composites (cow bones + sheep wool) when adding to epoxy large increase in flexural strength but the best ratio is (%2.5 cow bones +% 5 sheep wool) .

the ratio of hybrid composites (%2.5 date palm fiber +% 2.5 cow bones) and (%5 date palm fiber +% 2.5 cow bones) when adding to epoxy increase in flexural strength but the ratio (%2.5 date palm fiber +% 5 cow bones) decrease in flexural strength .



	0	5	7.5	7.5
WD+ CB	27.39	39.07	43.7	35.45
DP + SW	27.39	47.91	34.78	23.6
WD +DP	27.39	48.21	28.88	31.86
CB +SW	27.39	37.7	47.06	33.32
CB +DP	27.39	32.42	39.18	24.04

Figure 3. Variation of flexural strength with different filler content

5. Discussion

5.1. Tensile Strength Test:-

1. When adding WD + cow bones to epoxy to all of mentioned ratios results in an increase in tensile strength of epoxy due to a high adhesion and homogeneity between wood dust + cow bones in epoxy, and optimal ratio is (%5 WD +%2.5 cow bones) to epoxy.
2. In the case of the addition of the date palm + sheep wool into epoxy to all of the mentioned ratios results in increasing epoxy tensile strength due to a high adhesion and homogeneity besides high absorbency of fiber between date palm + sheep wool in epoxy, and the best ratio is (%2.5 date palm +%2.5 sheep wool) to epoxy.
3. When adding date palm + WD into epoxy to all of the mentioned ratios results in increasing tensile strength of epoxy due to the fact that they are from a vegetable source and a high adhesion and homogeneity between wood dust + date palm in epoxy, and the best ratio is(%5 date palm +%2.5 wood dust) to epoxy.
4. When adding cow bones + sheep wool to epoxy to all of the mentioned ratios results in increasing tensile strength of epoxy due to they are from animal source and the high adhesion and homogeneity between cow bones + sheep wool in epoxy, and the best ratio is(%5 cow bones +%2.5 sheep wool) to epoxy.
5. In the case of the addition of date palm + cow bones to epoxy to all of the mentioned ratios results in increasing tensile strength of epoxy due to a high adhesion and high absorbency of that fiber and homogeneity between cow bones + date palm in epoxy, and the best ratio

is(%5 date palm +%2.5 cow bones) to epoxy.

5.2. Compression Strength Test:-

1- In the case of the addition of the WD + cow bones to the epoxy to all of the mentioned ratios results in increasing compression strength of epoxy due to a high adhesion and homogeneity between wood dust + cow bones in epoxy, and the best ratio is(%2.5 wood dust +%2.5 cow bones) to epoxy.
2- In the case of the addition to the date palm + sheep wool to epoxy to all of the mentioned ratios results in increasing compression strength of epoxy due to a high adhesion and high absorbency of that fiber and homogeneity between date palm + sheep wool in epoxy, and the best ratio is(%5 date palm +%2.5 sheep wool) to epoxy.
3- In the case of the addition of the date palm + wood dust to the epoxy the ratios (%2.5 wood dust +%2.5 date palm) leads to an small reduction in epoxy compression strength but the other ratio increase in the compression strength of epoxy due to they are From a vegetable source and high adhesion and homogeneity between wood dust + date palm in epoxy at this ratios, and the best ratio is (%2.5 date palm +%5 wood dust) to epoxy.
4- When adding cow bones + sheep wool to epoxy to all of the mentioned ratios results in increasing compression strength of epoxy due to the fact that they are from a vegetable source and high adhesion and homogeneity between cow bones + sheep wool in epoxy, and the best ratio is(%5 cow bones +%2.5 sheep wool) to epoxy.
5- When adding cow bones + palm fiber to epoxy to all of the mentioned ratios results in the increase of compression strength of epoxy due to a high adhesion and homogeneity between cow bones + sheep wool in epoxy, and the best ratio is(%5 cow bones +%2.5 date palm) to epoxy.

5.3. Flexural Strength Test:-

1- When adding wood dust + cow bones to epoxy to all of the mentioned ratios leads to an increase in Flexural strength of epoxy as a result of the high adhesion and homogeneity between wood dust + cow bones in epoxy, and the best ratio is(%2.5 wood dust +%5 cow bones) to epoxy.
2- In the case of the addition of the date palm + sheep wool to epoxy the ratios (% 2.5 sheep wool +% 5 date palm) leads to an decrease in the Flexural strength of epoxy but the other ratio increase in the Flexural strength of epoxy due to the high adhesion and homogeneity between SW + date palm in epoxy at this ratios, and the best ratio is (% 2.5 date palm +% 2.5 sheep wool) to epoxy.
3- In the case of the addition of the WD + date palm to the epoxy to all of the mentioned ratios leads to an increase in the Flexural strength of epoxy due to the high adhesion and homogeneity between wood dust + date palm in epoxy, and the best ratio is(%2.5 wood dust +%2.5 date palm) to epoxy.
4- When adding cow bones + sheep wool to epoxy to all of the mentioned ratios leads to an increase in the Flexural strength of epoxy due to the high adhesion and homogeneity between cow bones + sheep wool in epoxy, and the best ratio is(%2.5 cow bones +%5 sheep wool) to epoxy.
5- When adding date palm + CB to the epoxy the ratios (% 5 cow bones +% 2.5

date palm) leads to an decrease in the Flexural strength of epoxy but the other ratio increase in the Flexural strength of epoxy due to the high adhesion and homogeneity between sheep wool + date palm in epoxy at this ratios, and the best ratio is (% 5 date palm +% 2.5 cow bones) to epoxy.

6. Conclusion

Three mechanical tests were conducted on composite materials that consist of natural materials of animal and vegetable origin in the form of short fibers and granules and mixed with epoxy, and the following was concluded, Tensile Strength: - Best added weight percentage to epoxy has been (%2.5 wood dust+ %2.5 cow bones). Best added percentage of the weight to the epoxy is (% 2.5 date palm + %2.5 sheep wool). Best added weight percentage to epoxy is (% 2.5 wood dust+ %5 date palm). Best added weight percentage to epoxy is (% 2.5 sheep wool+ %5 cow bones). Best added weight percentage to epoxy is (% 5 date palm + %2.5 cow bones). Compression Strength: - Best added weight percentage to epoxy is (%2.5 wood dust+ %2.5 cow bones). Best added weight percentage to the epoxy has been (%2.5 sheep wool + %5 date palm). Best added weight percentage to the epoxy is (% 5 wood dust+ %2.5 date palm). Best added weight percentage to epoxy is (% 2.5 sheep wool + %5 cow bones). Best added weight percentage to epoxy is (% 2.5 date palm + %5 cow bones).

Flexural Strength: - Best added weight percentage to epoxy is (%2.5 wood dust+ %5 cow bones). Best added weight percentage to epoxy is (%2.5 date palm + %2.5 sheep wool). Best-added percentage of weight to the epoxy has been (%2.5 wood dust+ %2.5 date palm). Best added weight percentage to the epoxy has been (%5 SW + %2.5 cow bones) .Best added weight percentage to the epoxy has been (% 5 date palm + %2.5 cow bones). In addition, the best addition of the weight of natural (is % 2.5 material (1) + %5 material (2) to the epoxy when performing the mechanical tests mentioned above.

Conflicts of Interest

The authors confirm that the publication of this article causes no conflicts of interest.

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