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INVESTIGATION OF SOME MECHANICAL PROPERTIES FOR NATURAL (EGGSHELL) AND INDUSTRIAL (CALCIUM CARBONATE) MATERIAL / REINFORCED WITH GLASS FIBER WITH POLYMER COMPOSITE

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Abstract: The purpose of this paper is to discuss the influence of adding eggshell and calcium carbonate powder reinforced with glass fibers and epoxy resin. Hand Lay-up method was utilized for the preparation of samples from epoxy resin as a matrix material with (6%weight fraction chopped glass fiber) and (2%,4%, 6% & 8% weight fraction eggshell, $CaCO_3$ powder) as filler material . The tensile and impact properties are tested for the specimens containing calcium carbonate and eggshell powder reinfoced with glass fiber and epoxy resins, also the result analyzed by (SPSS) to determine the specimens have best mechanical properties. The mean particle size analyzer of the eggshell powder and calcium carbonate powder were (12.6µm, 0.4-1µm) respectively. The results showed that the mean values of tensile test, modulus of elasticity, impact strength and fracture toughness (247.50,222.00MPa) (8.450,7.500 GPa) (8.150, 7.500K.J/m^2) (9.1675 , 7.8345 MPa.m$^{1/2}$) respectively increased with the addition (6% glass fiber+8%$CaCO_2$, eggshell), while the mean values of the elongation percentage at break (%) decrease with the addition (6% glass fiber+8%$CaCO_2$). The SPSS statistical shown the values was significantly increased whenever the value (Sig < 0.05).

Keywords: *Epoxy resin, glass fiber, Tensile properties, Impact properties*

1. Introduction

Engineering materials can be divided into three collections: polymers, metals, and ceramics. These materials can be combined from these kinds or also various materials, In order to know the distinguishing properties of materials [1]. The commonly utilized matrix material in composite materials is a polymer due to two reasons, Firstly, their strength and stiffness are less as compared with ceramics and metal, and these weaknesses are succeeded by strengthening another material. Secondly, the processing of polymer matrix composite does not need great pressure and great temperature [2], also polymers have low densities therefore they are used in a great number of industrial applications that need light weight [3]. Epoxy resin is a type of polymer that relies on molecules containing epoxy groups, the epoxy group is an oxirane structure, a three-member ring containing one oxygen atom and two carbon atoms. Nowadays epoxy resin is widely used in many applications due to its exhibiting high elastic modulus, high strength, good insulation, excellent adhesion, good chemical resistance, ease of processing and low shrinkage, but the major disadvantages of epoxy resin are brittleness and lower the properties in the presence of moisture [4-5]. Several

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investigator studied of the influence several fillers on the physical and mechanical characteristics of fiber strengthened composite. *Mukul K.P and Sachin K.C* [6] have investigated the tensile strength for glass fiber and CaCO3 powder are taken as the reinforcement in the epoxy resin matrix. These specimens are manufactured from (epoxy resin, 30%, 40% & 50% weight fraction glass fiber without $CaCO_3$) and (epoxy resin, 50% wt. glass fiber with 5%,10% &20% wt. $CaCO_3$ filler) by using the Hand lay-up method. From results can be found the ultimate tensile strength values in the specimens (epoxy +50% wt. glass fiber) and (epoxy +50%wt. +5% wt. $CaCO_3$). *Aseel B.A, et al.* [7] Have studied mechanical and physical properties for epoxy with 6% V.F woven glass and 3% & 6% v.f of $CaCO_3$, K_2CO_3 & Na_2CO_3 as reinforced material.The density, water absorption, hardness shore D flexural strength, shear stress are studied in this paper. From results can be seen the density, water absorption, hardness, flexural strength, and shear stress values increase with volume fraction increase and smaller particle size, also the specimens (Epoxy + 6% glass fiber + 6% $CaCO_3$) have better mechanical and physical properties than specimens reinforced with 6% K_2CO_3 &Na_2CO_3. *Senthil J. et al.* [8] Have studied the water absorption and several mechanical properties of (15% and 20% w.f) eggshell with (epoxy, polyester, and Vinylester resin matrix). From the results, it was found the addition of eggshell filler into (epoxy, polyester, and vinyl ester resin lead to decrease modulus of elasticity, hardness, and tensile strength, but on the other hand the flexural strength and elongation at break increases. The water absorption increases with the increases in (20% weight fraction) of eggshell. *Raffi Mohammed,et al.* [9] Have studied the mechanical properties of epoxy resin the strengthened 50% wt. glass fiber and 10% wt. from fly Ash from coal, coal powder, Bagasse fiber and Bagasse Ash. The results shown the specimen reinforced from (epoxy+50% g.f+10% B.A) has an ultimate flexural strength, Inter laminar shear strength and tensile strength when compared with (B.F,C.P,C.F.A). The ultimate impact strength and tensile modulus can be found in the specimens respectively(epoxy+50% g.f +10% C.P), (epoxy+ 50% g.f +10% C.F.A). *Srinivas K. R., et al.* [10] Have studied the effect of tamarind shell particles reinforced with epoxy resin matrix on mechanical properties. The specimen of composite materials was prepared from (50%, 60%, 70% & 80%volume fraction tamarind shell particles) with 20%, 30%, 40% & 50% volume fraction epoxy resin). Results show the specimens (70% T.P+30% EP) has a specific gravity and hardness higher when compared to other three configurations, also the maximum values of tensile strength and impact strength can be found in the specimen (80%T.P+20% EP). *Ruua H. and Reem A.* [11] have studied the effect of eggshell particles reinforced with an epoxy polymer on several mechanical properties. The specimen of composite materials was prepared from (4%, 8%, 12% and 16% weight fraction eggshell particles) with epoxy resin. Results show the specimens (epoxy +16% eggshell) has a hardness, tensile strength, impact strength and flexural strength higher when compared to other three configurations. The objective of this research is to use industrial and natural available cheap materials to prepare the polymer composites used in many engineering applications, also study the influence of that additives on the characteristices (tensile properties and impact properties) and analyzing these results by used (SPSS software). The difference in the idea of this searching for other researches is the selection of fiber (glass), natural (eggshell particles) and industrial ($CaCO_3$) material, the average particle size of the reinforcing materials and the type of the polymer resin.

2. Materials

2.1. Epoxy Resin Matrix Material

Epoxy resin (LEYCO-POX101) used in this research has high mechanical strength, low-viscosity solvent-free clear, good abrasion resistance,can be used at low and high temperatures and excellent bond to (concrete, metal, glass). Table 1 presents the mechanical and physical characteristics of epoxy resin was utilized in this research (LEYCO-POX101).It was provided by (LEYCOCHEM LEYDE GMBH GERMANY) [12].

Table 1. Characteristics of epoxy resin [12]

Characteristics	Values
Modulus of elasticity	2000 MPa
Tensile strength	67 MPa
Compressive strength	90
Hardness shore (D)	82
Water absorption	1.3%
Liner shrinkage	1.57 mm/m
Application temperature	8 C°
Density	1.08 gm/cm^3

2.2 Glass Fiber Material

The Table 2 shows some mechanical, physical properties of the chopped E-glass fiber used in this work as reinforced materials provided by “Tenax Company, England made”.

Table 2. Properties of glass fiber [13].

Characteristics	Values
Compressive strength	1080 MPa
Tensile strength	3445 MPa
Thermal expansion	5.4 µm/(m.Ċ)
Young modulus	72.5 Gpa
Percentage elongation	4.3%
Poisson´s ratio	0.22
Softening	846 Ċ
Density	2.58 gm/cm^3

2.3 Calcium Carbonate Material

Calcium carbonate ($CaCO_3$) is single of the common generally available synthetic compounds on earth. Calcium carbonate makes up about (7 percent) of the earth's crust and naturally formed in the earth's crust. Calcium carbonate has various popular titles like limestone, chalk, calcite, pearl, marble, and aragonite, etc. Calcium carbonate is used in this work as filler material provided by Sigma Aldrich, made in Germany. The some properties of calcium carbonate powder are indicated in Table 3 [14].

Table 3. Properties of $CaCO_3$ powder

Molar mass	100 g/mol
Semblance	Fine white powder
Minimum assay	98%
Melting point	825Ċ
Boiling point	Decomposes
Solubility in the water	0.0013 g/100ml (25 Ċ)
Soluble in the dilute acids	Soluble
Density	2.711 g/cm^3
Mean particle size	0.4-1 µm

2.4 Eggshell powder Material:

The eggshells, used in this research are the waste available in all homes and restaurants. Eggshells are washed with water and dried by the sun to remove membranes. "Fig.1" shows the shape of eggs before and after grinding for 2 hours using a mill. Table 4 shown the chemical composition of eggshell powder after milling.

"Fig.2" presents the shape of the device (Mastersizer 2000 ver.5.60) used to measure the particle size of the eggshell after milling, examined at the Ministry of Science and Technology Center, Department of Materials Research, where the mean particle size was 12.6 µm as shown in "Fig.3".

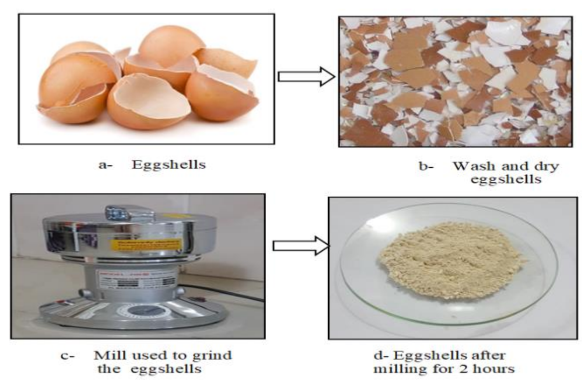


Figure 1 Shown the shape of eggshell before and after grinding

Table 4 Chemical composition of eggshell by using an X-Ray Fluorescence Spectrometer

Chemical Composition	Ratio%
CaO	55.30
SiO_2	0.017
Al_2O_3	0.022
MgO	0.060
Fe_2O_3	0.07
Na_2O	0.27
P_2O_3	0.32
SrO	0.21
NiO	0.0015
SO_3	0.64
Cl	0.023
K_2O	0.09
MnO	0.029
TiO_2	0.0030

Figure 2. Particle size analyzer device

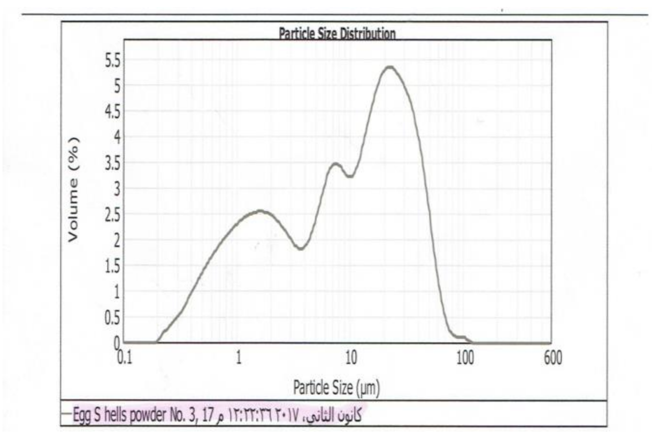


Figure 3. Particle size analyzer of eggshell powder

3. Fabrication Procedure of Specimens Composite Materials

The "Hand lay-up" method is utilized to manufacture samplings composite material from epoxy resin with different proportions of calcium carbonate and eggshell along with chopped glass fiber. A mold of size 15 cm x 15cm x 0.5 cm is prepared from the glass and covered with a layer of nylon to ensure no-adhesion of the resin with the mold as shown in "Fig. 4". Mixing the powders (CaCO3 and eggshells) with epoxy resin at room temperature to obtain a homogeneous mixture and then adding the hardener to the mixture and stirring it for a period 10-15 minutes for obtaining a homogeneous mixture. After (24 hours) that the laminate is extracted of the mold and heat treated in the oven at 60 c for 60 minutes in order to get better cross-linking between polymer and filler materials [15-16], then is cut into various standards as per ASTM (D 638 tensile test and ISO-180 impact test) of the samplings. The designation and composition of epoxy resin, glass fiber and fillers are shown in Table 5.

Table 5 Designation and component of composite materials

Specimens	Designation	Composition
A0	Pure epoxy	100%
A1	EP+G.F	94% EP+6% G.F
B1	EP+G.F+$CaCO_3$	92%EP+ 6%G.F+2% $CaCO_3$
B2	EP+G.F+$CaCO_3$	90%EP+ 6%G.F+4% $CaCO_3$
B3	EP+G.F+$CaCO_3$	88%EP+ 6%G.F+6% $CaCO_3$
B4	EP+G.F+$CaCO_3$	86%EP+ 6%G.F+8% $CaCO_3$
C1	EP+G.F+ES	92%EP+ 6%G.F+2% ES
C2	EP+G.F+ES	90%EP+ 6%G.F+4% ES
C3	EP+G.F+ES	88%EP+ 6%G.F+6% ES
C4	EP+G.F+ES	86%EP+ 6%G.F+8% ES

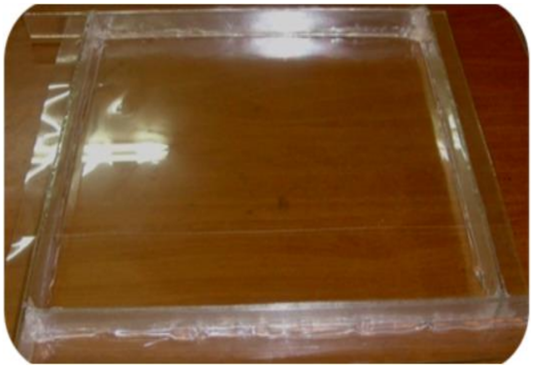


Figure 4. The shape of the prepared mold

4. Mechanical Properties Test

4.1 Tensile properties Test

The tensile test was examined by employ the (universal tensile instrument type "LARYEE" with a capacity load 50 KN) as shown in "Fig. 5" according to ASTM D 638 [17]. "Fig.6" displays the dimensions of the specimen tensile. The tensile strength can be examined according on the "Eq. (1 and 2)", also from the tensile test can be calculated the elongation percentage at break and modulus of elasticity [18].

Figure 5. Tensile test device

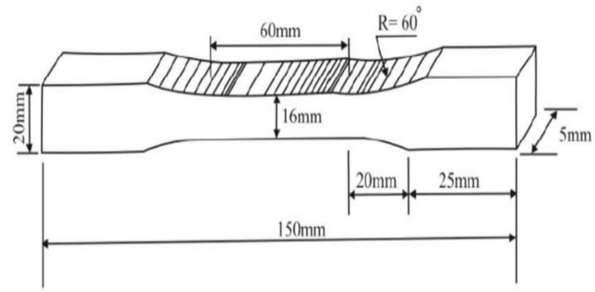


Figure 6. Dimension of the specimen tensile

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

Where:
δ: Longitudinal stress for specimen (MPa).
P: applied load (N).
A: original cross sectional area before testing (m^2).

$$\in = \frac{\Delta L}{L^{\circ}} \quad (2)$$

Where :
E = Strain
$\Delta L = L - L^{\circ}$
Where:
L: Final length (m).
$L_{\circ}$: Orriginal length (m).

4.2 Impact properties Test

The impact test was examined by using the Izod Impact test machine type (XJU series pendulum Izod/Charpy impact testing machine) as exhibited in "Fig. 7" according to ASTM ISO-180 [19]. "Fig.8" illustrates the dimensions of the specimen impact test. The values of impact strength and fracture toughness can calculate from "Eq. (3) (4)" [20-21].

Figure 7. Impact test device

Figure 8. Dimension of the specimen impact

$$Gc = \frac{Uc}{A} \quad (3)$$

Where;

Gc: Toughness of material / (J\m^2) .

Uc: Impact energy / (J).

A: Cross- sectional area of specimen / (m^2).

$$Kc = \sqrt{Gc * Eb} \quad (4)$$

Where;

Kc: Fracture toughness of material / (MPa.m$^{1/2}$).

Gc: Impact strength of material / (J/m^2).

Eb: Flexural Modulus of Material (MPa).

5.Discussion of Results:

5.1 Tensile properties Test:

5.1.1 Ultimate Tensile Strength

Fig.9" and Tables 6 & 7 show the descriptive and ANOVA values for results ultimate tensile strength all specimens, of the observed results, a pure epoxy composite has value ultimate tensile strength (67 MPa) lower when compared with specimens reinforced with (6% w.f glass fiber and 2%, 4%, 6% & 8% for both ($CaCO_3$ and eggshell). Due to the epoxy resin often is less in strength than specimens reinforced with fibers and particles, as resin has only been incapable to withstand tensile force applied on it and fails with strength [22]. Table 6 indicated that the highest tensile strength was present of the specimens (Epoxy + G.F+8% $CaCO_3$, 8% Eggshell), due to the presence of fiber and particle with polymer matrix to give the composites the ability carrying the load from the polymer matrix to filler materials, thus increase the strength of this composites this results agree with [23-24]. Table 7 shows the ANOVA test significant differences between all specimens, from ANOVA can be noticed that it's the value (Sig) less than 0.05 (0.001, 0.002 < 0.05) this means that the fiber and particle from ($CaCO_3$ and eggshell) have a positive effect on the ultimate tensile strength compared with epoxy

Table 6 Descriptive of ultimate tensile strength

(A) Ultimate tensile strength for specimens reinforced with ($CaCO_3$)

Specimens	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
A0	1	67	.	.	.	.	67	67
A1	2	106.00	5.657	4.000	55.18	156.82	102	110
B1	2	140.00	7.071	5.000	76.47	203.53	135	145
B2	2	177.50	10.607	7.500	82.20	272.80	170	185
B3	2	209.00	12.728	9.000	94.64	323.36	200	218
B4	2	247.50	24.749	17.500	25.14	469.86	230	265

(B) Ultimate tensile strength for specimens reinforced with (Eggshell powder)

Specimens	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
A0	1	67	0	0	0	0	0	0
A1	2	106.00	5.657	4.000	55.18	156.82	102	110
C1	2	131.50	9.192	6.500	48.91	214.09	125	138
C2	2	161.50	9.192	6.500	78.91	244.09	155	168
C3	2	196.50	16.263	11.500	50.38	342.62	185	208
C4	2	222.00	9.899	7.000	133.06	310.94	215	229

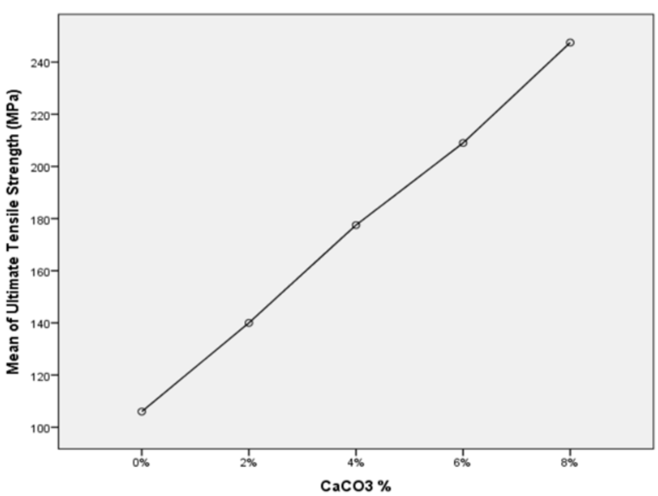
Table 7 Results ultimate tensile strength of all specimens with ANOVA Statistics

(A) ANOVA Statistics for specimens reinforced with ($CaCO_3$)

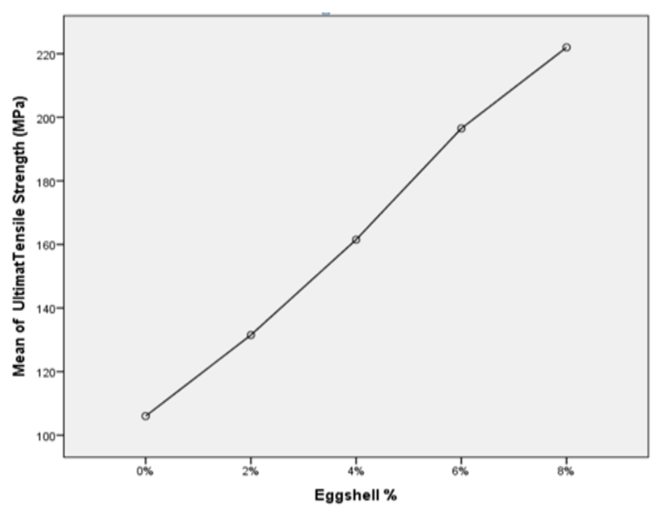
Specimens	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24799.000	4	6199.750	31.990	.001
Within Groups	969.000	5	193.800		
Total	25768.000	9			

(B) ANOVA Statistics for specimens reinforced with (Eggshell)

Specimens	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17691.000	4	4422.750	39.244	.001
Within Groups	563.500	5	112.700		
Total	18254.500	9			



(A) Mean ultimate tensile strength for specimens reinforced with (6% GF) and with different values of $CaCO_3$ powder



(B) Mean ultimate tensile strength of specimens reinforced with (6% GF) and with different values of

Figure 9. Mean ultimate tensile strength values of all specimens

5.1.2 Results Modulus of Elasticity:

Variation modulus of elasticity with a different weight fraction of ($CaCO_3$ and eggshell powder) with chopped glass-epoxy resin matrix composite material is shown in Tables 8 & 9 and "Fig. 10". According to the Table 8 results it can be seen that the modulus of elasticity composites improves significantly with the addition (8% $CaCO_3$, 8% eggshell) this is due to the decrease in the deformation (δ) by increasing the surface contact area between the reinforcement and matrix [18-25]. Table 9 shown the ANOVA to determine significant differences between all specimens, from ANOVA can be notice that it's the value (Sig) less than 0.05 (0.005 , 0.014 < 0.05) this means that the fiber and particle from ($CaCO_3$ and eggshell) have a positive effect on the modulus of elasticity compared with specimen epoxy resin matrix.

Table 8 Descriptive Modulus of Elasticity for all specimens

(A) Modulus of elasticity for specimens reinforced ($CaCO_3$)

Specimens	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
A0	1	2	.	.	.	.	2	2
A1	2	3.200	.4243	.3000	.612	7.012	2.9	3.5
C1	2	4.400	.7071	.5000	1.953	10.753	3.9	4.9
C2	2	5.350	.7778	.5500	1.638	12.338	4.8	5.9
C3	2	6.300	.7071	.5000	.053	12.653	5.8	6.8
C4	2	7.400	.9899	.7000	1.494	16.294	6.7	8.1

(B) Modulus of Elasticity for specimens reinforced (Eggshell)

Specimens	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
A0	1	2	.	.	.	.	2	2
A1	2	3.200	.4243	.3000	.612	7.012	2.9	3.5
B1	2	4.850	.4950	.3500	.403	9.297	4.5	5.2
B2	2	6.200	.7071	.5000	.135	12.553	5.7	6.7
B3	2	7.200	.8485	.6000	.424	14.824	6.6	7.8
B4	2	8.450	1.0607	.7500	1.080	17.980	7.7	9.2

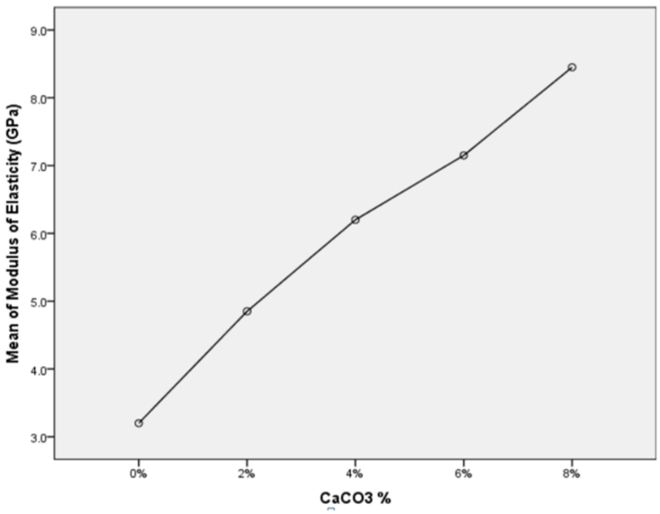
Table 9 Results Modulus of Elasticity for all specimens with ANOVA statistics

(A) ANOVA statistics for specimens reinforced with ($CaCO_3$)

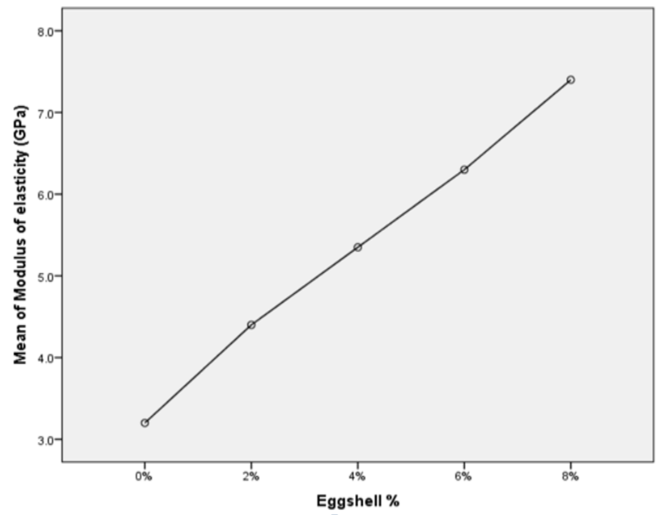
Specimens	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	33.286	4	8.321	15.021	.005
Within Groups	2.770	5	.554		
Total	36.056	9			

(B)ANOVA statistics for specimens reinforced with (Eggshell)

Specimens	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	21.256	4	5.314	9.609	.014
Within Groups	2.765	5	.553		
Total	24.021	9			



(A) Modulus of elasticity for specimens reinforced with (6% GF) and with different values of $CaCO_3$ powder



(B) Modulus of elasticity values of specimens reinforced with (6% GF) and with different values of Eggshell powder

(C)

Figure 10. Modulus of elasticity values for all specimens

5.1.3 Elongation Percentage at Break

Table 10 show results the elongation percentage at the break for specimens reinforced with $CaCO_3$ and eggshell / 6% chopped glass fiber into the epoxy resin matrix. From this Table, it is observed that the increase weight fraction of filler material decreases the value elongation percentage at the break, because with the addition of filler ($CaCO_3$ and eggshell) increases hardness surfaces of the composite material and reduce from elongation percentage at break this results agree with [11]. Also from ANOVA Table 11 can be notice that it's the values (Sig) less than 0.05 (0.001, 0.011< 0.05) this means that the glass fiber and filler materials ($CaCO_3$ and eggshell) have an effect on the elongation percentage at break. From "Fig.11" can be seen that the powder added to the polymer resin matrix increases the brittleness and clustering of particles, thus reduces the elongation percentage at break [26], therefor the lowest weight fraction for specimens (epoxy +6%g.f +2% CaCO3, 2% Eggshell) gives the highest elongation percentage at break.

Table 10 Descriptive of elongation percentage at break for all specimens

(A) Elongation percentage at break for specimens reinforced with ($CaCO_3$)

Specimens	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
A0	1	4	.	.	.	.	4	4
A1	2	3.750	.0707	.0500	3.115	4.385	3.7	3.8
B1	2	3.650	.2121	.1500	1.744	5.556	3.5	3.8
B2	2	3.450	.2121	.1500	1.544	5.356	3.3	3.6
B3	2	3.250	.2121	.1500	1.344	5.156	3.1	3.4
B4	2	2.750	.0707	.0500	2.115	3.385	2.7	2.8

(B) Elongation percentage at break for specimens reinforced with (Eggshell)

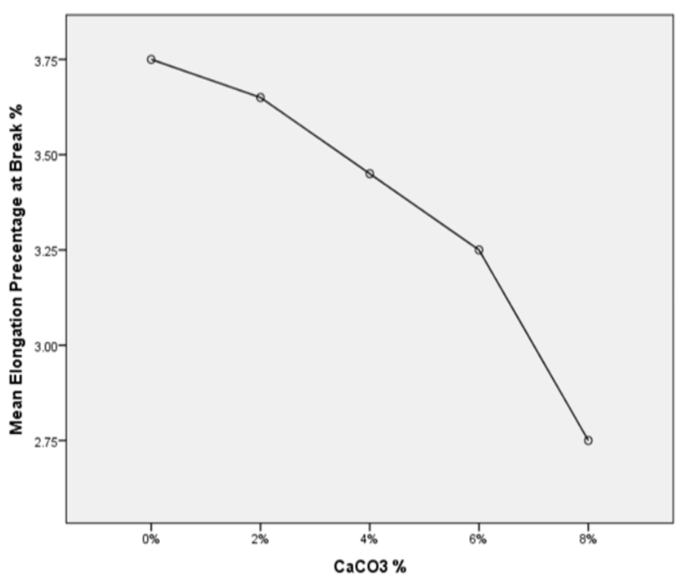
Specimens	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
A0	1	4	.	.	.	.	4	4
A1	2	3.750	.0707	.0500	3.115	4.385	3.7	3.8
C1	2	3.400	.1414	.1000	2.129	4.671	3.3	3.5
C2	2	3.300	.1414	.1000	2.029	4.571	3.2	3.4
C3	2	3.700	.1414	.1000	1.429	3.971	2.6	2.8
C4	2	2.400	.1414	.1000	1.129	3.671	2.3	2.5

Table 11 Results elongation percentage at break % of all specimens with ANOVA statistics
(A) ANOVA statistics for specimens reinforced with ($CaCO_3$)

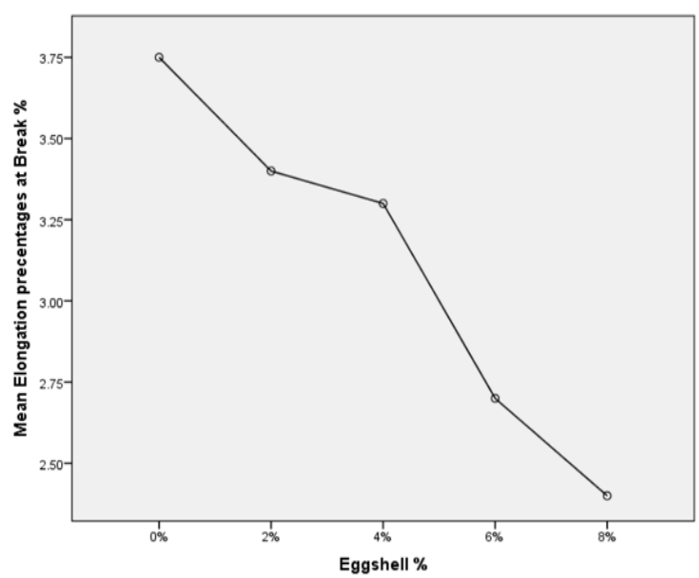
Specimens	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.256	4	.314	10.828	.011
Within Groups	.145	5	.029		
Total	1.401	9			

(B) ANOVA statistics for specimens reinforced with (Eggshell)

Specimens	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.404	4	.601	35.353	.001
Within Groups	.085	5	.017		
Total	2.489	9			



(A) Elongation percentage at break for specimens reinforced with (6% GF) and with different values of $CaCO_3$ powder



(B) Elongation percentage at break for specimens reinforced with (6% GF) and with different values of eggshell powder

Figure 11 Elongation percentage at break values of all specimens

5.2 Impact Strengths and Fracture Toughness:

Tables 12-15 and Figures 12&13 show the results of fracture toughness (Kc) and impact strength (Gc) for epoxy resin reinforced with different weight fraction (2%, 4%,6%, 8% $CaCO_3$, Eggshell) powder with 6% weight fraction glass fiber. Adding glass fibers with the filler powder has a positive effect on the impact of the shocks and thus increasing the impact energy needed to break the specimens, therfore the results of (Gc) & (Kc) for pure epoxy are lower than other specimens [27], as shows in "Fig.12&13". From Tables (12&13)can be note the shock resistance and durability increases with increases weight fraction from (CaCO3, Eggshell) in epoxy resin with glass fiber. From ANOVA Tables 14&15 can be notice that it's the values (Sig) less than 0.05 (0.001, 0.006, 0.001, 0.012< 0.05) this means that the fiber and particle from ($CaCO_3$ and eggshell) have an effect on the impact properties compared with neat specimen. There are two reasons for improving the impact properties of these samples. First, the good interconnection between particle fillings and matrix resin, second, the acute angle of uniformly shaped molecules lead to a lower stress concentration at the base of the matrix [28].

Table 12 Descriptive of impact strength for all specimens

(A) Impact strength of specimens reinforced with ($CaCO_3$)

Specimens	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
A0	1	2.7	0	0	0	0	2.7	2.7
A1	2	3.350	.2121	.1500	1.444	5.256	3.2	3.5
B1	2	5.150	.7778	.5500	1.838	12.138	4.6	5.7
B2	2	6.000	.7071	.5000	4.353	12.353	5.5	6.5
B3	2	7.200	.8485	.6000	2.424	14.824	6.6	7.8
B4	2	8.150	.7778	.5500	1.162	15.138	7.6	8.7

(B) Impact strength of specimens reinforced with (Eggshell)

Specimens	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
A0	1	2.7	0	0	0	0	2.7	2.7
A1	2	3.350	.2121	.1500	1.444	5.256	3.2	3.5
C1	2	4.550	.4950	.3500	.103	8.997	4.2	4.9
C2	2	5.400	.1414	.1000	4.129	6.671	5.3	5.5
C3	2	6.600	.4243	.3000	2.788	10.412	6.3	6.9
C4	2	7.500	.4243	.3000	3.688	11.312	7.2	7.8

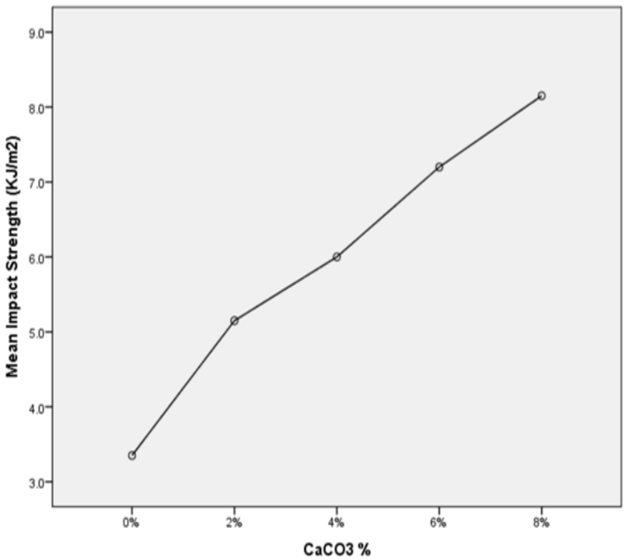
Table 13 Results impact strength of all specimens with ANOVA statistics

(A) ANOVA statistics for specimens reinforced with ($CaCO_3$)

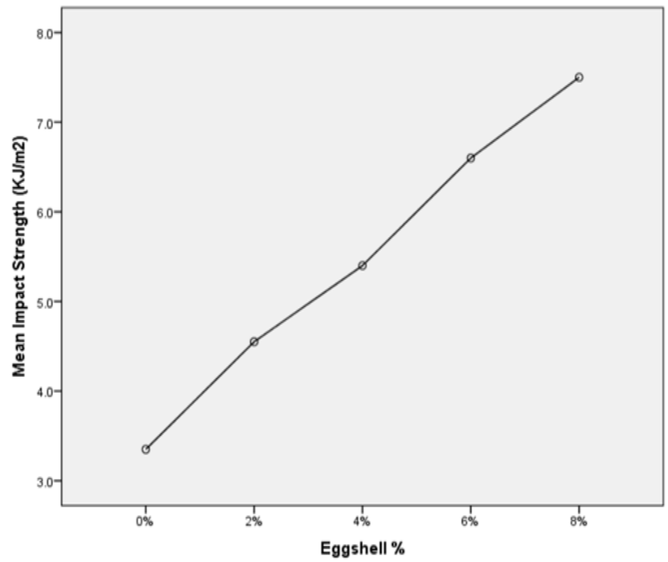
Specimens	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	21.486	4	5.371	13.942	.001
Within Groups	.670	5	.134		
Total	22.156	9			

(B) ANOVA statistics for specimens reinforced with (Eggshell)

Specimens	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	27.606	4	6.901	40.086	.006
Within Groups	2.475	5	.495		
Total	30.081	9			



(A) Impact strength of specimens reinforced with (6% GF) and with different values of $CaCO_3$ powder



(B) Impact strength of specimens reinforced with (6% GF) and with different values of eggshell powder

Figure 12 Impact strength values of all specimens

Table 14 (A-B) Descriptive of fracture toughness for all specimens

(A) Fracture toughness for specimens reinforced with ($CaCO_3$)

Specimens	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
A0	1	2.324	0	0	0	0	2.324	2.324
A1	2	3.57700	.442649	.313000	.40004	7.55404	3.264	3.890
B1	2	6.33150	.775696	.548500	.63785	13.30085	5.783	6.880
B2	2	7.49300	.701450	.496000	1.19072	13.79528	6.997	7.989
B3	2	8.23955	.068519	.048450	7.62393	8.85517	8.191	8.288
B4	2	9.16750	.088388	.062500	8.37336	9.96164	9.105	9.230

(B) Fracture toughness for specimens reinforced with (Eggshell)

Specimens	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
A0	1	2.324	0	0	0	0	2.324	2.324
A1	2	3.57700	.442649	.313000	.40004	7.55404	3.264	3.890
C1	2	4.88750	.809637	.572500	2.38680	12.16180	4.315	5.460
C2	2	5.93150	.796909	.563500	1.22845	13.09145	5.368	6.495
C3	2	7.02650	.794081	.561500	.10803	14.16103	6.465	7.588
C4	2	7.83450	.796909	.563500	.67455	14.99445	7.271	8.398

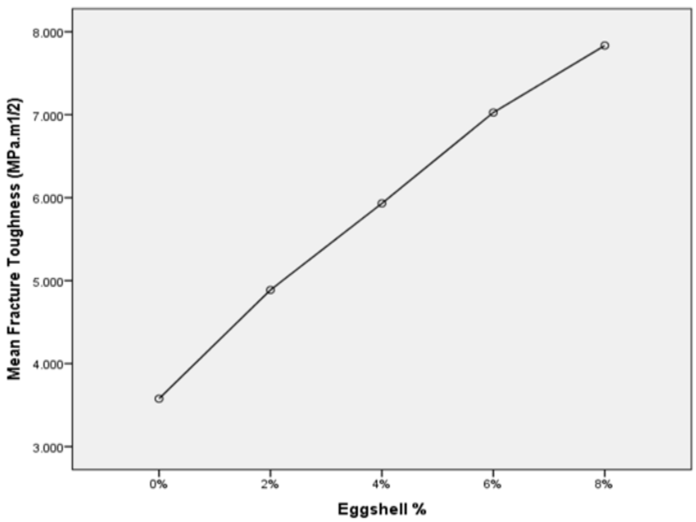
Table 15 (A-B) Results fracture toughness of all specimens with ANOVA statistics

(A) ANOVA statistics for specimens reinforced with ($CaCO_3$)

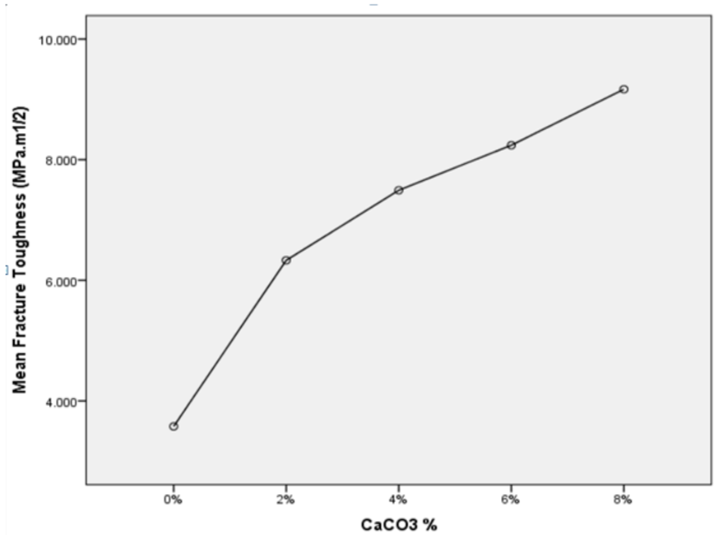
Specimens	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	37.268	4	9.317	35.775	.001
Within Groups	1.302	5	.260		
Total	38.570	9			

(B) ANOVA statistics for specimens reinforced with (Eggshell)

Specimens	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	22.844	4	5.711	10.376	.012
Within Groups	2.752	5	.550		
Total	25.596	9			



(B) Fracture toughness of specimens



(A) Fracture toughness of specimens reinforced with (6% GF) and with different values of $CaCO_3$ powder

Figure 13. Fracture toughness of all specimens

6. Conclusions

This work includes the estimated influence of natural and industrial material, glass fiber strengthened with epoxy resin matrix on properties of ultimate tensile strength, elastic modulus, elongation ratio at break, impact strength and fracture resistance, the following conclusions can be included:

- Manufacture a unique class of $CaCO_3$ and eggshell powder filled with glass chopped /epoxy resin matrix composites by hand lay-up technique.
- The ultimate tensile strength and modulus of elasticity values for specimen reinforced with the addition (8%) weight fraction $CaCO_3$ was higher than (8%) weight fraction eggshell powder.
- Elongation percentage at break values decrease with the addition (8%) weight fraction of $CaCO_3$ and eggshell powder.
- The impact strength and fracture toughness increase with the addition of filler material. Also the results shown that impact strength and fracture toughness is more for composites filled with $CaCO_3$ compared to the composites filled with eggshell.
- SPSS statistical analysis is used to select the best specimens from a set of alternatives. Whenever the samples have values (Sig) less than 0.05 these sample best mechanical properties.

Conflict of interest

There are not conflicts to declare.

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