EFFECT OF GLASS WASTE ON PROPERTIES OF CELLULAR CONCRETE WASTE POWDER

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ABSTRACT :-

The research includes making mixtures of cellular concrete (thermostone) waste powder with different percentages of glass waste powder and measuring some mechanical and physical properties of the resulting composite material of glass and thermostone waste. The properties (porosity, absorption, density, compression, and hardness) were tested on two types samples, first type without addition of glass (standard sample) and the second with addition of glass (10, 20, 30)% by weight of thermostone waste.

The results showed that both of porosity and absorption of thermostat waste powder are decreasing with increasing of a glass percent, where porosity decrease from 63.38% to 28.74% and absorptions from 46.88% to 16.78%. Density, compression and hardness were increased with increasing of glass percent, where density increased from 1.351 to 1.712 gm/cm^3, compression from 9.7 to 13.8 Mpa, and hardness from 22.7 to 99.7.

Key words: **cellular concrete, thermostone, glass waste, composite material, thermostone waste.**

تأثير مخلفات الزجاج على خواص مسحوق مخلفات الخرسانة الخلوية

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الخلاصة :-

يتضمن البحث عمل خلطات من مخلفات الخرسانة الخلوية (الثرمستون) الحاوية على نسب مختلفة من مخلفات الزجاج وتقييم سلوك بعض الخواص الميكانيكية والفيزيائية للمادة المركبة لمخلفات الثرمستون والزجاج. تم قياس كل من المسامية ، الامتصاصية ، الكثافة ، الانضغاطية والصلادة على نوعين من نماذج مخلفات الثرمستون، الاول بدون اضافة مخلفات الزجاج والثاني بإضافة الزجاج بنسب (30، 20، 10) % من وزن مخلفات الثرمستون.

اظهرت النتائج ان كل من المسامية والامتصاصية للعينات تنخفض مع زيادة نسبة الزجاج المضافة ، حيث انخفضت المسامية من 73,62% الى 28,74% والامتصاصية من 58,25% الى 16,78% . وازدادت كل من الكثافة والانضغاطية والصلادة مع زيادة نسبة الزجاج، حيث زادت الكثافة من 1,351 الى 1,712 والانضغاطية من 2,93 الى 4,88 والصلادة من 22,75 الى 99,7 .

الكلمات الدالة: الخرسانة الخلوية ، الثرمستون ، مخلفات الزجاج ، المواد المركبة ، مخلفات الثرمستون .

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INTRODUCTION :-

A long time ago, the trend began to take advantage from the recycling of industrial waste. Accumulation of such waste cause damage to the environment by pollution. This research interested in thermostone and glass waste.

Thermostone is one of the most commonly used lightweight construction materials for contemporary buildings, especially due to its low density, unique thermal and breathing properties and high fire resistance (**Narayanan, 2000**).

This material has, however, some disadvantages; for instance, it's very high water absorption capacity makes it susceptible to deteriorations due to weather. It is, therefore, essential to better understand and develop the material properties of cellular concrete for use in both contemporary and historical buildings (**Andulson, 2006**).

The estimated amount of thermostone waste which results from cutting and trimming blocks to the required dimensions about (1-2) % of total production, Hence the importance to take advantage of thermostone waste in the construction field (**عباس الاميري، 2014**).

The common raw materials used for manufacturing thermostone blocks are Portland cement, hydrated lime (calcium oxide), aluminum fine powder, water, and sand. The raw materials are mix into a slurry by a special machine and then poured into greased molds. Aluminum reacts with the hydrated lime and free water to evolve millions of tiny hydrogen gas bubbles (**Hebel, 2009**).

These macroscopic, unconnected cells cause the material to expand to nearly twice its original volume with a cellular structure. It takes from 30 minutes to 4 hours for the mixture to harden enough to be cut by wires into the desired shapes and transported to an autoclave (180C^o and 10-atmosphere pressure) for curing period of 10 hours (**Hussain, 2012**).

Glass is a material that does not decompose over time. Glass waste is existing in significant amounts and cannot get rid of it easily. Therefore, it was necessary to find the right technical method to take advantage of this waste. It could be crushed and re-use this powder in the manufacture of some glass products exploit in certain public purposes which have no harmful effect on human or animal health. This can preserve the environment from the vast amount of accumulated waste of glass products discarded by the people for not needed. In this way, it is possible to use the glass waste and glass defective product again for other purposes **(Eric, and Bourhis, 2008).**

The research focuses on re-using cellular concrete (thermostone) and glass waste by adding percentages of waste glass powder by weight of thermostone waste, and study some physical and mechanical properties of the new composite material that were get .

EXPERIMENTAL WORK :-

a- Materials

1- Cellular Concrete (thermostone)

Pieces of waste thermostone were take which cleaned by soft brush, then crushed into small pieces and grinded by hand mill.

After that, the grinded thermostone waste powder was sieve. The powder, which passed through (150-micron) sieve and retained on (140-micron) sieve was taken .

2- Glass

It includes taking the glass windows and crushed it into small pieces with a manual hammer then grinded by hand mill. The grinded glass powder, sieved. The powder, which passed through (125-micron) sieve and retained on (120-micron) sieve was taken.

Each thermostone and glass powder tested for grain size analysis by Bettersize 2000 laser particle size analyzer.

3- PVA

It is a binder material used to facilitate the mixing of composite materials and the compression process.

b- Samples

12 samples were done, three of them were standard samples, contain only a thermostone powder, and three samples for each percent of glass addition (10, 20, and 30) % by weight of thermostone powder. **(Table 1)** shows the samples details.

c- Prepared Samples

1- Standard Samples

- An amount of thermostone powder was taken and mixed with (3 cc) of PVA, after that it put in cleaned and oiled molds with radius (30 mm). The specimen compressed in a compression machine at (20 kN) (after several trails, the suitable compression load was 20 kN) and (0.3 kN/min) rate.
- Drying specimens in drying oven at 110 C^o for 24 hour.
- Sintering specimens in sintering oven at 900 C^o for 2 hour.
- Finishing Specimens Surfaces by whetting with soften paper to ensure accuracy in testing.

2- Composite Samples

- Weight an amount of thermostone powder and glass powder according to specified addition percent.
- Mixing the two powders by electric mixer for 4 hours to ensure good homogenous, then a (3 cc) of PVA was added to each sample.
- Putting the mixture in cleaned and oiled molds with radius (30 mm). The specimen compressed in a compression machine at (20 kN) (after several trails, the suitable compression load was 20 kN) and (0.3 kN/min) rate.
- Drying specimens in drying oven at 110 C^o for 24 hour.
- Sintering specimens in sintering oven at 900 C^o for 2 hour.
    - Finishing specimens Surfaces by whetting with soften paper to ensure accuracy in testing**.**

d- Laboratory Tests

1- Porosity And Absorption Test

This test was done by drying samples in drying oven at 110 C^o for 24 hours, leaving them to cool at room temperature, and recording the dry weight for each sample. Thereafter, Samples were placed in a heat-resistant glass flask, flooded with distilled water and boiled for five hours, taking into consideration that samples were immersed in water during boiling by compensating the evaporated water, then leave them immersed in water for 24 hours.

Floating weight was recorded by using a mesh connected to the balance (Model: DJJ-S, China), **(Fig. 1)** shows the balance, and then the sample's surface was dried from water drops that suspended on them by a piece of cotton cloth. Subsequently, The water Saturated weight was recorded. All weights were calculate using a sensitive balance.

2- Density

It is one of important physical tests, because its effect on many properties of cellular concrete such as thermal properties. It done by taking drying and water saturated weight for samples.

3- Compression strength

The compression strength machine (Model: WP-310, Gunt, Germany), shown in **(Fig. 2)**, was used for this test. It done by applying a load at (0.8 kN/min) rate until failure.

4- Hardness

Vickers device (Model: XHV-1000, Response, china) is used for testing samples after and before glass addition. This test depends on applying (9.8 kN) load and determining the depth of impression. **(Fig. 3)** shows the hardness test machine.

RESULTS AND DISCUSSION :-

1- Porosity And Absorption

The porosity could be compute by using the following equation (**ASTM C373, 1988**):

$$P\ (\%) = \frac{M-D}{M-S} * 100 \quad (1)$$

While absorption could be fined by following equation (**ASTM C373, 1988**):

$$A\ (\%) = \frac{M-D}{D} * 100 \quad (2)$$

Where:

P = apparent porosity (%)

A = absorption (%)

M = water saturated weight (gm)

D = dry weight (gm)

S = floating weight (gm)

The results show that both of porosity and absorption decrease with increasing of glass addition, this increment are due to glass fusing during the flocculation process, which helps filling the pores of thermostone powder. **(Table 2)** shows the results of porosity and absorption for samples. **(Fig. 4)** and **(Fig. 5)** show the relation between porosity and absorption with glass addition .

2- Density

The following equation used for determining the density of samples (**ASTM C373, 1988**):

$$De = \frac{M-D}{V} \quad (3)$$

Where:
De = Bulk density (gm/cm^3)
M = water saturated weight (gm)
D = dry weight (gm)
V = volume of sample (cm^3)
It was noticed that density increased by increasing the proportion of the glass addition. The increment are (8.5, 22.2 and 37.5) % of standard samples for (10, 20, and 30) % of glass respectively. This behavior was expected due to the decline in porosity and absorption as mentioned above. **(Table 3)** shows the results of density and **(Fig. 6)** show the relation between glass addition and bulk density.

3- Compression Strength

It can be compute by the following equation **(ASTM C1424, 2015)**:

$$\sigma = \frac{F}{A} \quad (4)$$

Where:
σ = compression strength (N/mm^2)
F= applied load (N)
A= sample area (mm^2)

The compression strength improved with increasing of glass percent, this is because the degree of sintering temperature smelted glass and fills the pores in the material leads to increase density, and it increases the adhesion strength between the components of composite materials, which reflects on compressive strength. **(Table 4)** and **(Fig. 7)** show the results of compression strength and the relation between it with glass addition respectively.

4- Hardness

Hardness improved significantly with the augmentation of the glass ،which means greater material's resistance to deformation by wear, cut, scratching, penetration and indentation. This improvement belongs to high strength bond between the parts of composite materials. The results of the samples in the Vickers hardness test are show in **(Table 5)**. **(Fig. 8)** shows the relation between glass addition and Vickers's hardness .

CONCLUSIONS :-

1- The porosity of a composite material of thermostone and glass waste reduced by (13.9 , 32.7, and 60.9) % of standard sample for (10 , 20 , 30) % of glass addition respectively, which leads to reduction in absorption by (19.5, 43.5, and 71.2) % of the standard sample.
2- Compression strength increased with increasing glass addition
3- The density increased by (8.5, 22.2 and 37.5) % of standard samples (10 , 20 , 30) % of glass addition respectively.
4- Vickers's hardness, improved with increasing of glass.
5- It can produce a new building material which used in many applications that thermostone could not use such high moisture places and high load like loaded walls.
6- Economically appropriate and reduces environmental pollution because the materials used are of waste.

Table (1) samples details

Sample	No. of sample	% Glass addition
A	3	0
B	3	10
C	3	20
D	3	30

Table (2) results of porosity and absorption

Sample	Glass addition %	Porosity %	Absorption %
A	0	73.63	58.25
B	10	63.38	46.88
C	20	49.52	32.92
D	30	28.74	16.78

Table (3) results of density

Sample	Glass addition %	Bulk density (gm/cm^3)
A	0	1.245
B	10	1.351
C	20	1.522
D	30	1.712

Table (4) results of compression strength

Sample	Glass addition %	Compression strength (N/mm^2)
A	0	8.3
B	10	9.7
C	20	11
D	30	13.8

Table (5) results in Vickers's hardness

Sample	Glass addition%	Average Vickers's hardness
A	0	22.7
B	10	29.5
C	20	53.9
D	30	99.7

Fig (1) balance with mesh

Fig (2) compression strength machine

Fig (3) the hardness test machine

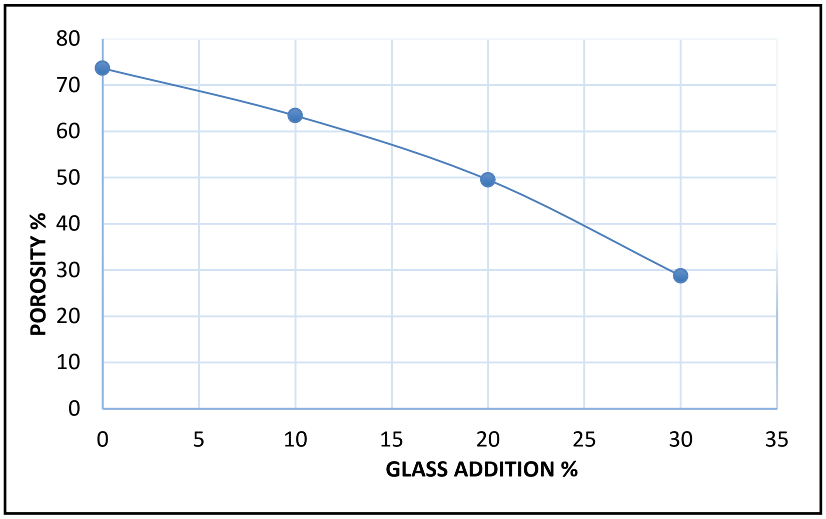

Fig (4) relation between porosity and glass addition

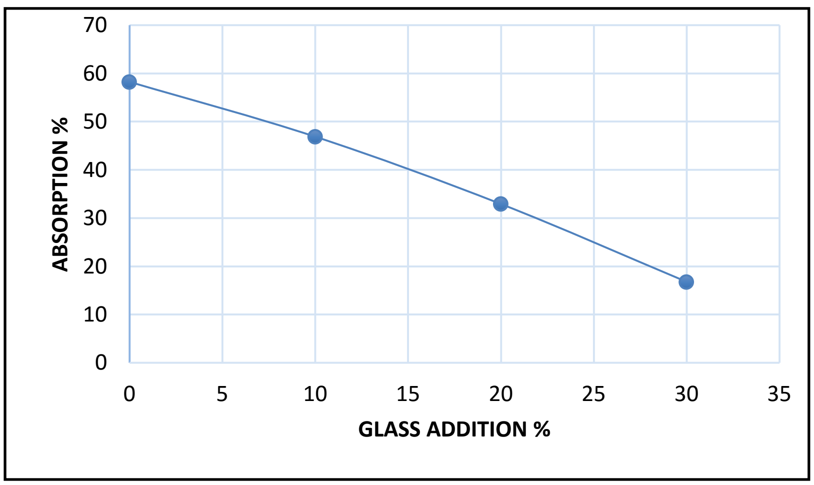

Fig (5) relation between absorption and glass addition

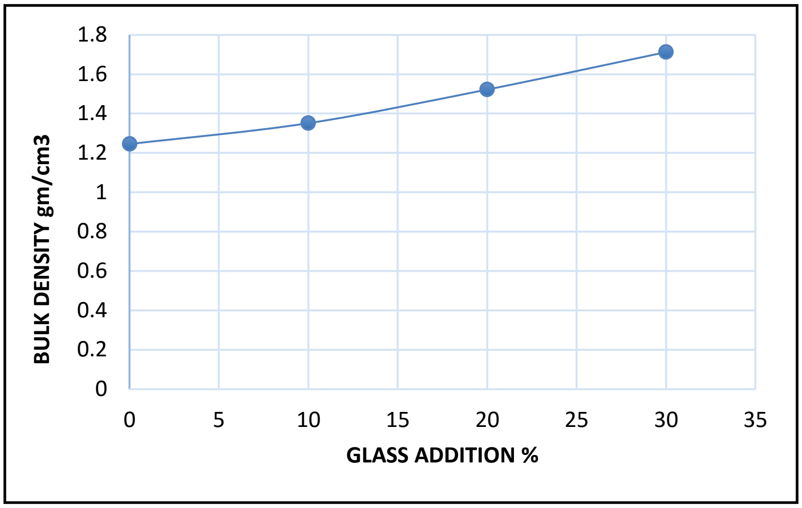

Fig (6) relation between bulk density and glass addition

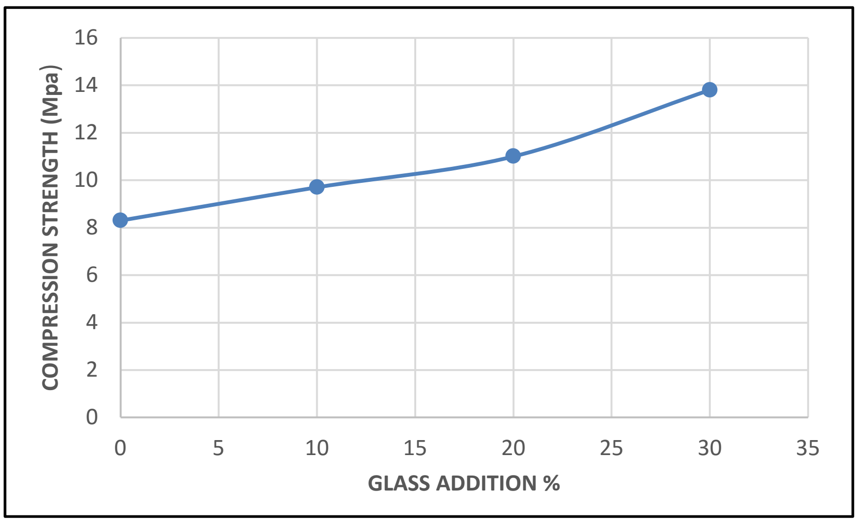

Fig (7) relation between glass addition and compression strength

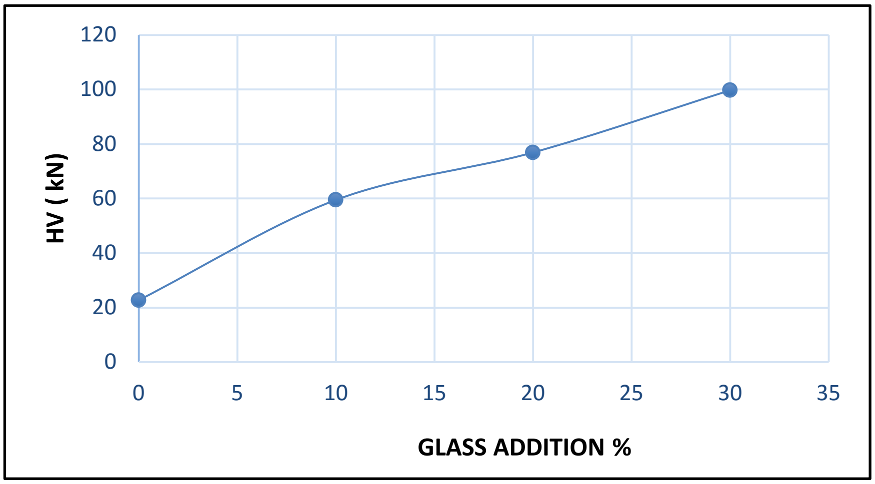

Fig (8) relation between glass addition and Vickers's hardness

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