Effect of Waste Glass on Properties of Old Cellular Concrete Powder

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Abstract

The research includes making mixtures of cellular concrete (thermostone) waste with different percentages of waste glass and evolution the behavior of some mechanical and physical properties of the composite materials for glass and thermostat waste. The properties (porosity, absorption, density, compression, and hardness) were measured on two types of waste thermostone samples, first type without the addition of glass and the second with the addition of glass (10 , 20, 30)% by weight of thermostone waste.

The results show that both of porosity and absorption of thermostat waste powder are decreasing with increasing of a glass addition percent, where porosity decrease from 63.38% to 28.74% and absorbs 46.88% to 16.78%. Density, compression and hardness were increased with increasing of glass addition percent, where density increased from 1.351 to 1.712, compression from [illegible] to 4.88 and hardness from 22.7 to 99.7.

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

[illegible]

سلوك□عض الخواص الميكانيكية والفيزيائية للمادة المركبة لمخلفات الثر□ستون والزجاج. تم قياس كل□ن المسا□ية الا□تصاصية ، الكثافة ، الانضغاطية والصلادة على نوعين□ن نماذج□خلفات الثر□ستون، الاو□□دون اضافة□خلفات الزجاج والثاني□اضافة الزجاج□نسب (٣٠ ، ٢٠ ، ١٠) %□ن وزن□خلفات الثر□ستون..

اظهرت النتائج ان كل□ن المسا□ية والا□تصاصية للعينات تنخفض□ع زيادة نسبة الزجاج المضافة ، حيث انخفضت المسا□ية □ن ٧٣,٦٢% الى ٢٨,٧٤% والا□تصاصية□ن ٥٨,٢٥% الى ١٦,٧٨% . وازدادت كل□ن الكثافة والانضغاطية والصلادة □ع زيادة نسبة الزجاج ، حيث زادت الكثافة□ن ١,٣٥١ الى ١,٧١٢ والانضغاطية□ن ٢,٩٣ الى ٤,٨٨ والصلادة□ن ٢٢,٧٥ الى ٩٩,٧.

الكلمات الدالة: البنية الخلوية ، الثر□ستون، الزجاج ، المواد المركبة.

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 [1].

Thermostone is one of the most commonly used light-weight construction materials for contemporary buildings, especially due to its low density, unique thermal and breathing properties and high fire resistance [2].

This material has, however, some disadvantages; for instance, it's very high water absorption capacity makes it susceptible to deteriorations due to water. It is, therefore, essential to better understand and develop the material properties of AAC for use in both contemporary and historical buildings [3].

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 [1].

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 mixed 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 [4].

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° and 10 atmosphere pressure) for curing period of 10 hours [5].

Gla[illegible] space and cannot get rid of it easily. So it was necessary to find the right techn[illegible]ake advantage of this waste recycled crushed again w[illegible] this powder in the manufacture of some glass products used in [illegible] pub[illegible] purpos[illegible] that do not affect human or animal health. [illegible] preserve the environment from [illegible] not needed. [illegible] glass defective product again for other [illegible]

Objective

The research care for 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 composite material that we get after addition.

Experimental Work

a- Materials

1- Cellular concrete (thermostone)

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

After that the grinded thermostone waste powder was sieved. 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- **BVA**

It's a binder material used to facilitate the mixing of composite materials and the compression process

b- **Samples**

12 samples were done, 3 of them were controlled samples, contain only a thermostone powder, and 3 samples for each percent of glass addition (10, 20, and 30) by weight of thermostone powder. Table (1) shows the samples details.

Table (1) samples details

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

c- **Prepared samples**

- Weight an amount of thermostone powder and glass powder according to specified addition percent
- Mixing the two powders by elec[illegible]
- [illegible] cc) of BVA w[illegible]
- Putting the mixture in cleaned and [illegible] mm). The specimen compressed in a compression machine at (20 kN) and (0.3 kN/min) rate.
- Drying specimens in drying oven at 110 C^o for 24 hours.
- Sintering specimens in a sintering oven at 900 C^o for 2 hours.
- Surface finishes to the specimens by wetting with soft whiting paper to ensure accuracy in testing.

d- **Laboratory tests**

1- **Porosity and absorption test**

This test is 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 are placed in a heat-resistant glass flask, flooded with distilled water and boiled for five hours while ensuring that they always immersed in water 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, plate (1) shows the balance, 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 are calculated using a sensitive balance.

Fig (1) balance with mesh

2- Density

It is [illegible] concrete such as thermal properties. It was done by taking drying [illegible] weight for samples.

3- Compression strength

The [illegible] machine shown in [illegible] by applying a load at (0.8 kN/min) rate until [illegible]

Fig: (2) compression strength machine

4- Hardness

Vickers device 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. Plate (3) shows the hardness test machine.

Fig (3) the hardness test machine.

Results

1- Porosity and absorption

The porosity could be computed by using the fo

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

While absorption could be found by following equation [7] :

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

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 (1) and Fig (2) show the relation between porosity and absorption with glass addition.

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

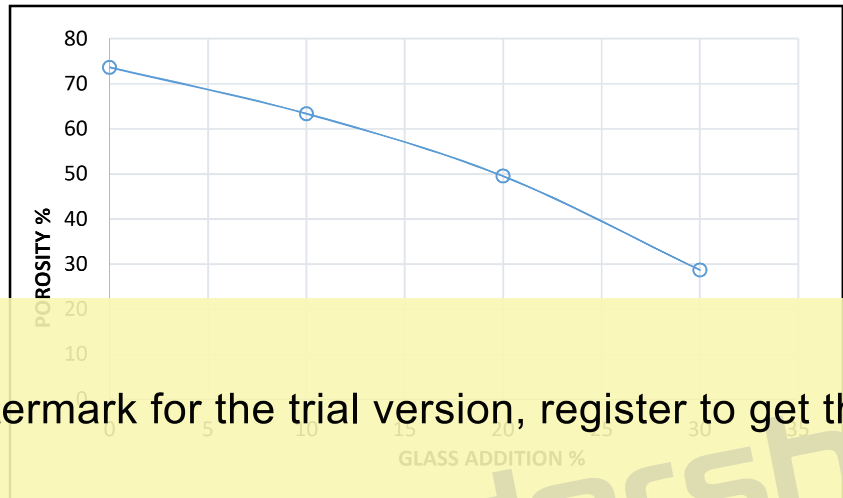

Fig (1) relation between porosity and glass addition

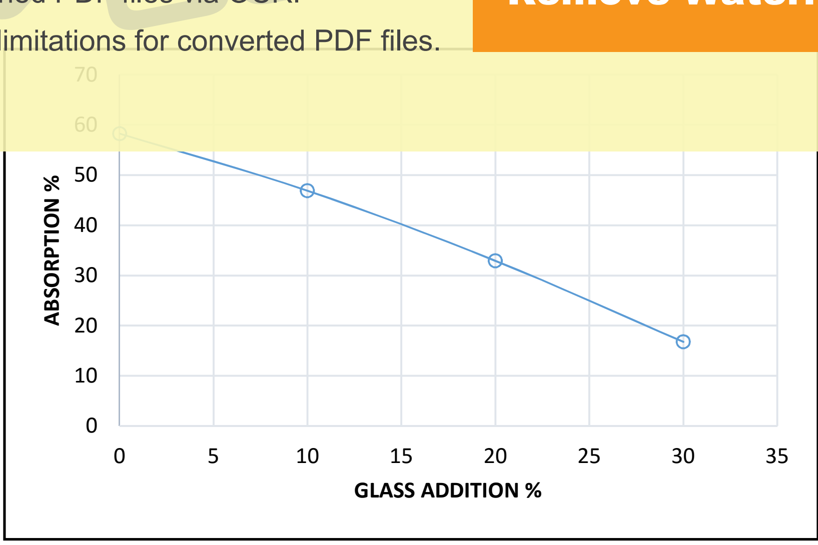

Fig (2) relation between absorption and glass addition

2- Density

The following equation used for determining the density of samples [7]:

$$De = \frac{M - D}{V}$$

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 control samples for (10 , 20 , and 30) % of glass respectively. This behavior is expected due to the decline in porosity and absorption as mentioned above. Table (2) shows the results of density and Fig (3) show the relation between glass addition and bulk density.

Table (2) results of density

Sample	Glass addition %	Bulk density gm/cm^3
A	0	1.245
B	10	[illegible]
C	20	[illegible]
D	30	[illegible]

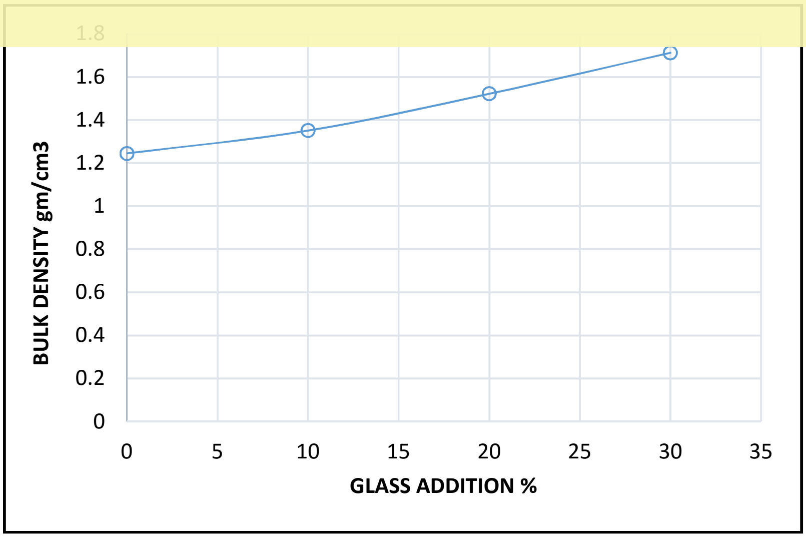

Fig (3) relation between bulk density and glass addition

3- Compression strength

It can be computed by the following equation [8]:

$$v\sigma = \frac{F}{A}$$

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, also it increases the adhesion strength between the components of composite materials, which reflects its effect on compressive strength. Table (3) and fig (4) show the results of compression strength and the relation between it with glass addition respectively.

Table (3) results of compression strength

Sample	Glass addition %	Compression strength (N/mm^2)
A	0	8[illegible]
B	10	9.[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	30	[illegible]

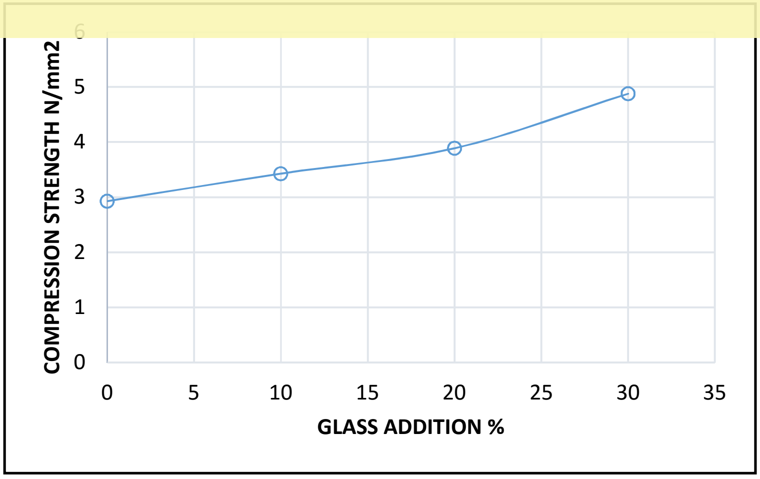

Fig (4) relation between glass addition and compression strength

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 shown in table (4). Fig (5) shows the relation between glass addition and Vickers’s hardness.

Table (4) 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

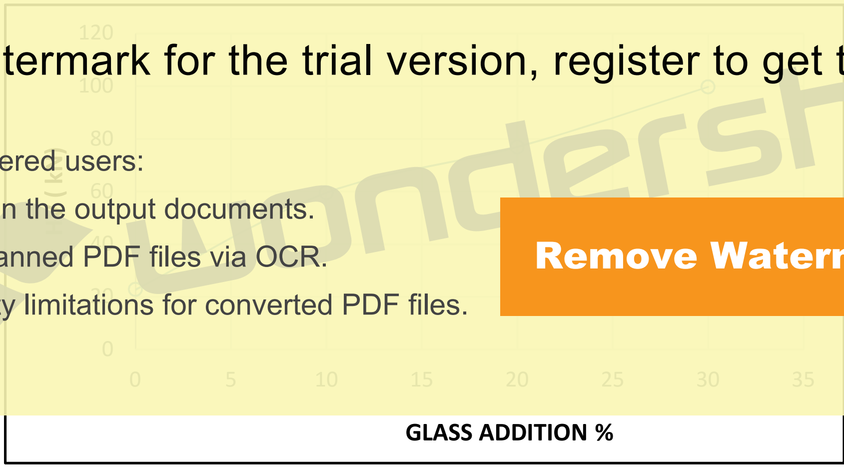

Fig (5) relation between glass addition and Vickers’s hardness

Conclusion

1- The porosity of a composite material of thermostone and glass waste reduced by (13.9 , 32.7, and 60.9) % of control 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 control sample.
2- Compression strength increased with increasing glass addition
3- The density increased by (8.5, 22.2 and 37.5) % of control 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 couldn’t 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.

Recommendation

1. Increasing the addition of glass powder waste.
2. Increasing sintering degree.
3. Change the compression load and how its effect on properties.
4. Conduct additional tests such as thermal and mechanical shock.

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