

Correlation Between Some Physical Properties Of Glasscrete

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Abstract :

Sheet glass waste can be advantageous in concrete making leads to greener environment .two different series were prepared to accomplish the scope of the study .The first series was prepared by partially substituting the fine aggregates (sand) with fine sheet glass waste (fine sheet glass is a waste glass sheet reduced in size into 2.36-4.75mm) .The substituting of sand in proportions of (10%,20%,30%,40%,50%)by fine sheet glass waste . The second series was prepared by partially substituting the coarse aggregate (gravel) with crushed glass sheet waste (crushed glass sheet is waste glass sheet crushed to size of 9-12mm) .The substituting of gravel in proportions of (10%,20%,30%,40%,50%) by crushed glass sheet waste . The effect of FGA & CGA on Workability ,Hardness , Density and V_p of the concrete with fresh and hardened concrete tests were analyzed .The result of the study conducted ,FGA where determined to have a significant effect upon the workability of the concrete , hardness, density and UPV higher than to the effect of CGA reaction was determined to have a slightly reduction in all properties , the results also showed the better percent of substitution was 40% FGA as a replacement of sand and the better percent of substitution was 20% CGA as a replacement of gravel . This study was an environmental one in consideration to the fact that waste glass could be used in the concrete as fine and coarse aggregate without the need for a big cost or enormous energy.

Key words: Concrete, Waste glass, glass aggregate.

العلاقة بين بعض الخواص الفيزيائية للكونكريت الزجاجي

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الخلاصة :

تعتبر مخلفات الزجاج من المشاكل الحديثة المضره بالبيئة والتي بدأ التوجه باستغلالها كمواد بديله في الصناعات الانشائية يتناول البحث استخدام مخلفات الزجاج في تصنيع نماذج كونكريتية كبدايل تعويضية عن الرمل والحصى بصورة جزئية، لغرض الحصول على هدف البحث تم تحضير نوعين من الاضافات ،النوع الاول يتضمن اضافة جزئيه من الزجاج المطحون الى حجم 2.36-4.75 ملم لاستخدامه كبديل للرمل بنسبة (10% ، 20%، 30% ، 40%، 50%) اما النوع الثاني فيتضمن اضافة جزئيه للزجاج المكسر الى حجم 9-12ملم لاستخدامه كبديل للحصى بنسبة (10% ، 20%، 30% ، 40%، 50%) . ولقد تم تحليل تأثير الزجاج الناعم والزجاج الخشن على قابلية التشغيل، الكثافة ،الصلادة و الموجات فوق الصوتية للخرسانة الطرية والمتصلبة . أظهرت النتائج هناك تأثير واضح

وجيد لاضافة الزجاج الناعم كبديل للرمل اعلى وافضل من تأثير الزجاج الخشن كبديل للحصى حيث اظهر استبداله انخفاض قليل في النتائج هذا بالنسبة لنوع الاضافه اما بالنسبة للنسب المضافه فقد اظهرت الاختبارات بأن اضافة 40% من الزجاج الناعم كبديل للرمل من افضل النسب اما بالنسبة للزجاج الخشن فتعتبر النسبه 20% من افضل نسب اضافة الزجاج الخشن كبديل للحصى . ومن الجدير بالذكر ان هذه الدراسة تهتم بالمحافظه على البيئة من خلال ادراك حقيقة إمكانية استخدام المخلفات الزجاجية في الصناعات الإنشائية بدون الحاجة إلى كلفة عالية واستهلاك كبير للطاقة .

1.Introduction:

Glass is a transparent material produced by melting a mixture of materials such as silica, soda ash, and CaCO_3 at high temperature followed by cooling during which solidification occurs without crystallization. Glass is widely used in our lives through manufactured products such as sheet glass, bottles, glassware, and vacuum tubing.^[1]

During the last decades it has been recognized that Sheet Glass waste is of large quantities and they increasing year by year in the Shops, construction areas and factories. Using waste glass in the concrete construction sector is advantageous, as the production cost of concrete will go down.^[2]

Glass aggregates are considerably different from natural aggregates for a number of reasons .First , it is a manufactured material ,therefore its chemical composition is generally known ,although the chemistry can vary widely between different kind of glass such as (beverage containers ,window glass, neon tubes , wind shields ,etc) and between different producers . Its chemical, physical and mechanical properties are also different from those of natural aggregates because of its amorphous nature .If glass is considered for use as aggregate in concrete ,the following properties are of particular interest .Glass has basically zero water absorption capacity .For the design of concrete mix for a specific applications , this is an advantage ,because the water absorption capacity and therefore water content is no longer a variable or even unknown ,as is the case with most natural aggregates .Because of the lack of water absorption and the smooth surfaces of glass particles ,the flow properties of fresh concrete with glass aggregate are clearly better than those of natural aggregate concrete ,This means that either improved workability can be achieved or ,for a given workability , a lower water –cement ratio can be used ,with resulting improvements in mechanical strength and durability properties ,without the assistance of a super plasticizer. Another advantage of glass is its excellent hardness and abrasion resistance, which makes it a suitable aggregate for paving stones , floor tiles , and other application subject to high wear and tear .The durability and chemical stability of glass are proverbial .

A final advantage of using post-consumer glass as aggregate for concrete is the environmental aspect ,because it has the potential of a noticeable impact on the solid waste streams of major metropolitan areas.^[3]

The biggest problems that needs to be addressed when using glass as an aggregate in concrete is the increase risk of (ASR, alkaline silica reaction).

Topcu and Canbaz (2004) ^[4] found that compressive , flexural , and indirect tensile strengths had the tendency to decrease in proportion to the increase in content of waste glass as coarse

aggregate in concrete mixtures. Hong..etal (2007)^[5] reported that the use of waste glass as aggregate facilitates the development of concrete towards a high architectural level besides the high performances of glass, thereafter, the increasing market in industry. Neithalath and Schwarz (2009)^[6] observed that the replacement of 10% cement with glass powder was found to result in equal or higher compressive strength of the blocks. Sekar (2011) ^[7] found that, the concrete made of waste ceramic tiles produced more strength in compression, split tensile and flexural than ceramic insulator scrap and broken glass material.

2. Aims:

- Ø Investigate the possibilities of using waste glass in concrete as aggregate by studying some physical properties.
- Ø Know the better substitution of aggregate (fine or coarse) by waste glass in concrete .
- Ø Find out the suitable percent of substituting and which percent should be avoided

3. Experimental procedure:

3.1 Materials:

3-1-1- Cement

The cement used in this study was Iraqi ordinary Portland cement , commercially known (TASLUJA). It was stored in dry place to minimize the effect of humidity on cement properties. The chemical and physical properties of cement are given in Table (1) which conformed to Iraqi Standard Specification No.5/1984.

3-1-2- Natural Sand Aggregate (N.S)

The fine aggregate used in this study was brought from Ukhaidher area .The grading of fine aggregate is shown in Table (2).The used sand within zone 2 according to the requirements of the Iraqi Standard Specification No.45/1984.

3-1-3- Natural Gravel Aggregate (N.G)

The coarse aggregate used throughout this study was brought from Al-Nibaey region with maximum size of 12mm.

3-1-4- Glass Aggregate (GA)

Transparent sheet glass waste was used in this study , which is minimized in two different sizes. The first size is 9-12mm to use as a partial replacement of N.G , The second size into 2.36-4.75mm to use as partial replacement of N.S.

Table (1) Chemical composition & physical properties of Portland cement

Chemical composition			Physical properties		
Item	Content %	Spec.Limit	Item	Test result	Spec.Limit
SiO ₂	20.66	-	Fineness(m ² /kg)	310	230
Al ₂ O ₃	4.34	-	Autoclave exp	0.24	0.8%
Fe ₂ O ₃	3.40	-	Compressive Strength (MPa) 3-days age 7-days age		
CaO	63.71	-		17.2	15.0
MgO	2.07	5.0 max		26.0	23.0
SO ₃	1.17	2.8max	Time of setting		
L.O.I.	2.52	4.0 max	Initial (min) Final (hour)	75 min.	45
I.R.[Insoluble Residue(%)]	1.03	1.5		4.15	10 max

Table (2) Grading of fine aggregate

Sieve size (mm)	% Passing by Weight	Spec. Limit
4.75	93.2	90-100
2.36	84.2	75-100
1.18	68.0	55-90
0.60	37.8	35-59
0.30	19.6	8-30
0.15	8.8	0-10

3.2 Mixes proportions:

In order to achieve the scope of this study ,The mixes were divided into three sets .These sets include 5 mixes of using waste glass as a partial substitution of natural sand in a percentage (10,20,30,40,50)%, also 5 mixes of using waste glass as a partial substitute of

natural gravel in percentage(10,20,30,40,50)% .The weight of cement and water remain constant throughout the work. The proportion of mixes are shown in **Table (3)**.

Table (3) The details of mixes

Mix No.	C(kg/m ³)	W(kg/m ³)	W/C	N.G(kg/m ³)	N.S(kg/m ³)	FG A	CG A
contro l	350	175	0.5	1050	700	-	-
FGA1 0	350	175	0.5	-	630	70	-
FGA2 0	350	175	0.5	-	560	140	-
FGA3 0	350	175	0.5	-	490	210	-
FGA4 0	350	175	0.5	-	420	280	-
FGA5 0	350	175	0.5	-	350	350	-
CGA1 0	350	175	0.5	945	-	-	105
CGA2 0	350	175	0.5	840	-	-	210
CGA3 0	350	175	0.5	735	-	-	315
CGA4 0	350	175	0.5	630	-	-	420
CGA5 0	350	175	0.5	525	-	-	525

3.3. Preparation of specimens:

The molds were coated with mineral oil to prevent adhesion of concrete. Metal molds of (150*150*150) mm size are used for making cubic specimens .Concrete casting was accomplished in three layers of 50 mm each. Each layer was compacted by using a vibrating table for 1–1.5 min until no air bubbles emerged to the surface of the concrete mold. All the specimens were de-molded after 24 hours from casting , marked and then completely immersed in fresh clean water ,(7,14,28) days, until the time of testing.

4. Tests:

4.1 Slump test

The slump test is done to make sure a concrete mix is workable. The measured slump must be within a set range, or tolerance, from the target slump. This test was carried out according to standard condition B.S.1881: Part 102.

Tools used in this test Standard slump cone (100 mm top diameter x 200 mm bottom diameter x 300 mm high), Small scoop, Bullet-nosed rod (600 mm long x 16 mm diameter), Rule, Slump plate (500 mm x 500 mm).

Method of working, First Clean the cone. wash with water and place on the slump plate. The slump plate should be clean, firm, level and non-absorbent. Second Collect a sample of fresh concrete fill 1/3 the volume of the cone. Compact the concrete by 'rodding' 25 times followed by fill to 2/3 and again rod 25 times, just into the top of the first layer. Fill to overflowing, rodding again this time just into the top of the second layer. Top up the cone till it overflows. Third Level off the surface with the steel rod using a rolling action. Clean any concrete from around the base and top of the cone, push down on the handles Carefully lift the cone straight up making sure not to move the sample. finally Turn the cone upside down and place the rod across the up-turned cone and measure the difference in height by using a ruler.

4.2 Density Test

The density of The concrete cubes (in g/cm^3), was found by weighting these cubes and dividing the values (mass in grams) by the volume of these cubes ($15 \times 15 \times 15 \text{ cm}^3$).

4.3 Hardness Test

The hardness of concrete cubes was found by taking six reading on each face of the cube except the face exposure to air and the base due to remaining moisture, The other remaining four faces of the cube was cleaned from dust to ensure probably reading of the device. By taking the average of all 24 reading for each cube in different ages and percentages, The unit of hardness was taken in Rockwell Hardness.

4.4 Ultrasonic Pals Velocity Test (VP)

This test was carried out according to the British standard BS1881:part 203:1986, using the portable ultrasonic non-destructive indicating tester (PUNDIT). In this test a pulse of longitudinal vibration with resonant frequencies of 54KHZ was produced by an electro-acoustical transducer and then converted into an electrical signal by receiver transducer. The transit time of the pulse is displayed by an electronic timing circuit. Grease or petroleum jelly was applied between the tested surfaces of the specimen and the contact faces of the transducers to ensure good contact.

The pulse velocity (V) in (km/sec) was calculated as follows:

$$V = L/t \dots\dots\dots [8]$$

Where:

L= path length (m)

t= transit time (micro sec.)

5. Results And Discussion:

5.1. Slump Test

Slump test was carried out to show The effect of (FGA & CGA) on workability . **Figure(1)** Illustrates the increase in slump value with substitutions of **FGA** . These increase could be due to FGA has a large volume ,cause the mixture to become more consistent .^[9] ,From the figure it observed the decrease in Slump value with substitutions of **CGA** .These decrease could be due to sharp edges ,harsh texture of CGA.^[10] , as the figure suggest the lowest slump value corresponding to the mixture which contain the large waste material, in spite of this lowest value the concrete mixture can be molded appropriately .

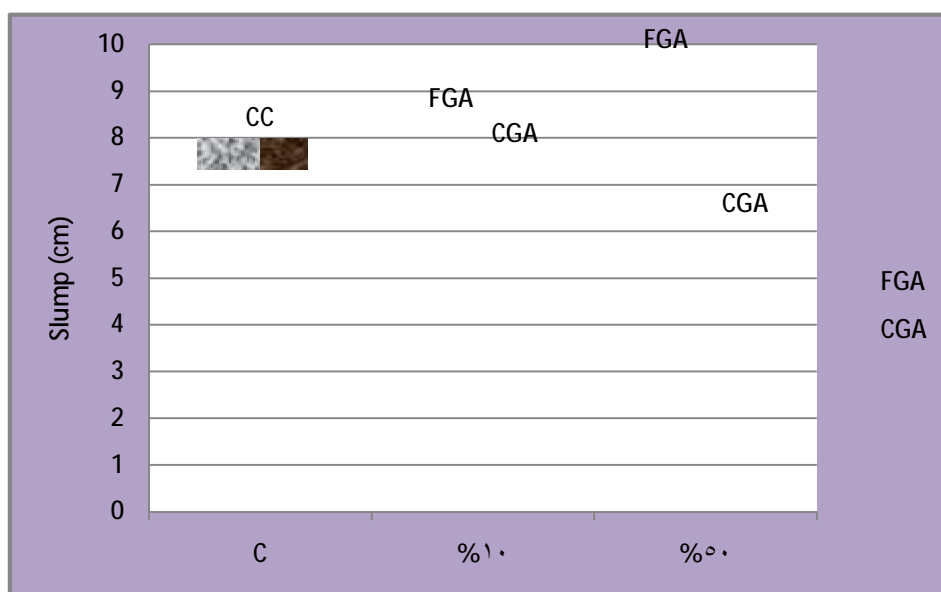


Fig. (1) Relationship between slump value and substituted percent

5.2 Density Test

Bulk density test of concrete contained either fine glass aggregate(FGA) or coarse glass aggregate (CGA)of specimens made of (10,20,30,40,50)% ,showed that there are two factor effecting the density are percentages of substitution and the periods of immersion. The figures (2),(3),(4),(5),(6) showed that for FGA substitution the better density at 40% 28 days

and for CGA substitution the better density at 20% 28 days , and from the resulted data can be concluded FGA substitution were better than of CGA substitution at all percentages . The decrease in the density of the concrete mixes containing coarse glass aggregate can be attributed to the specific gravity of waste glass is much lower than that of crushed aggregate produced with general rock. ^[11]

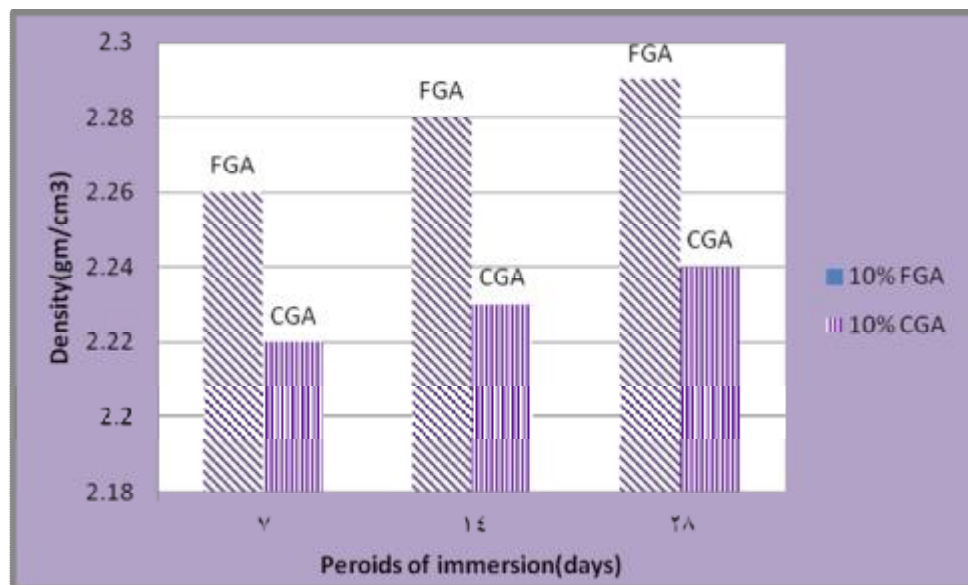


Fig. (2): Comparison between the density of (10% FGA) and (10% CGA) at different periods of immersion .

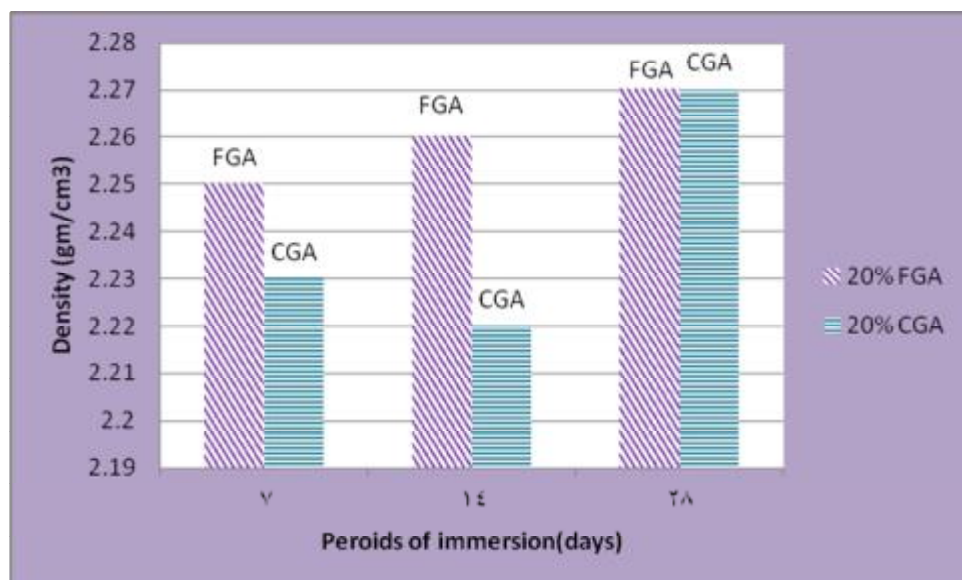


Fig. (3): Comparison between the density of (20% FGA) and (20% CGA) at different periods of immersion

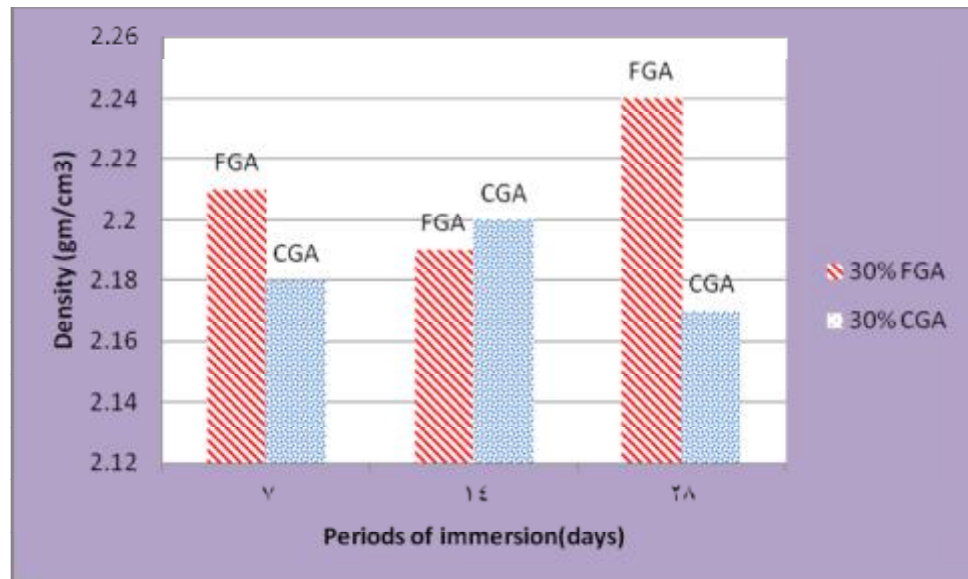


Fig. (4): Comparison between the density of (30%FGA)and(30%CGA) at different periods of immersion

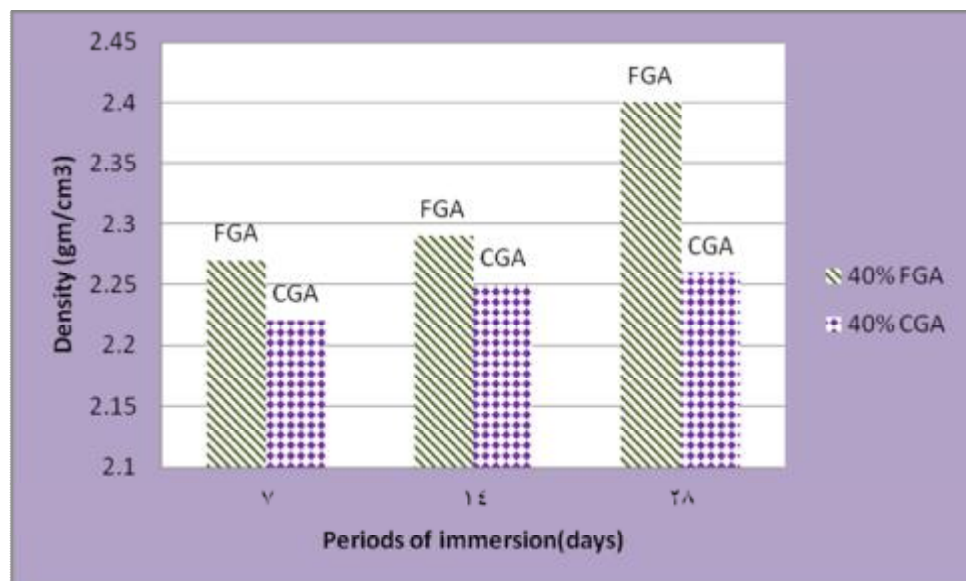


Fig. (5): Comparison between the density of (40% FGA)and(40% CGA) at different periods of immersion

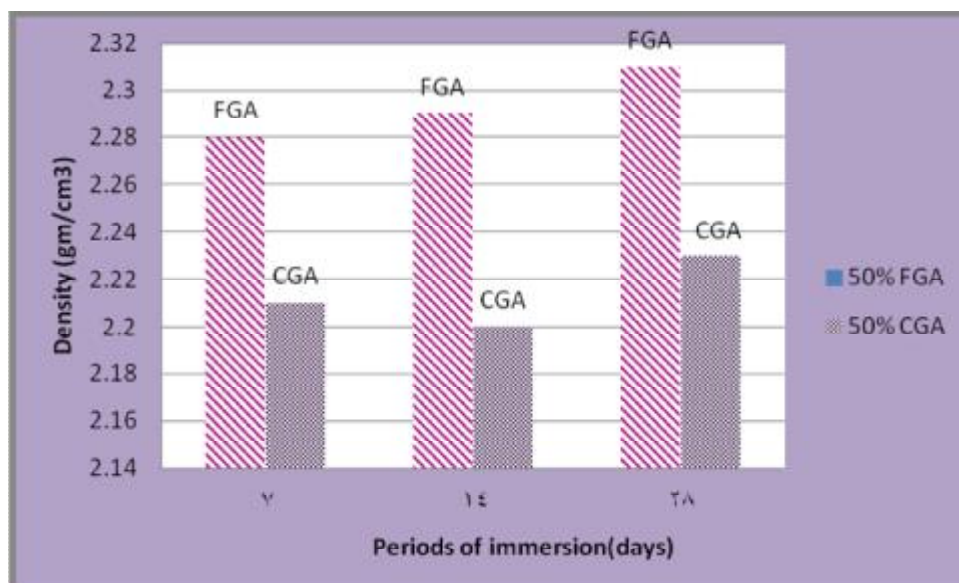


Fig. (6): Comparison between the density of (50% FGA) and (50% CGA) at different periods of immersion.

5.3. Hardness Test

Hardness test of concrete contained either (FGA or CGA) with different percentages showed that for FGA substitution the better hardness at 20% 28 days and for CGA substitution the better hardness at 10% 28 days, and from the resulted data can be concluded FGA substitution were better than of CGA substitution at all percentages. The decrease in hardness of concrete containing coarse glass aggregate can be attributed to the poor geometry of CGA a homogenous distribution of glass aggregate could not be achieved^[12]

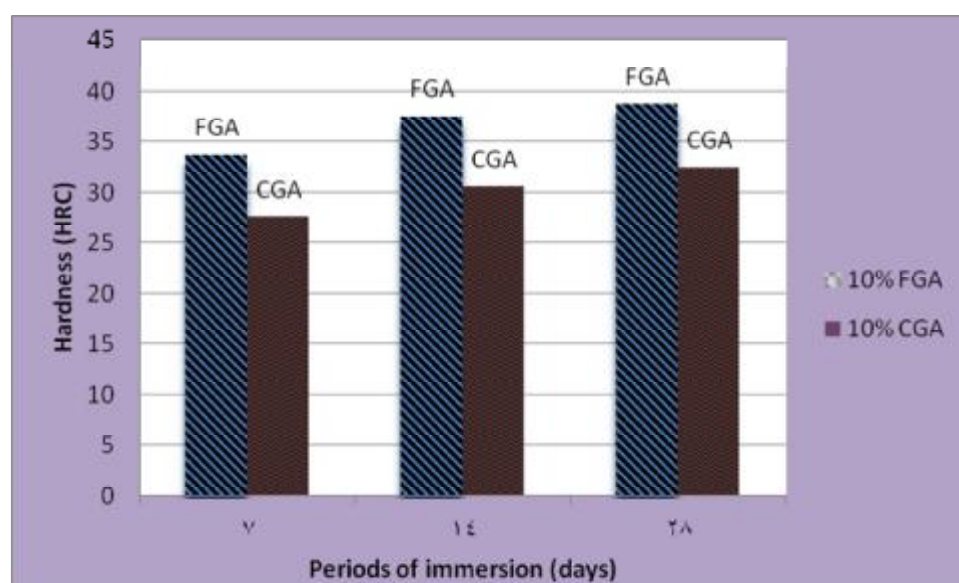


Fig. (7): Comparison between the hardness of (10% FGA) & (10% CGA) at different periods of immersion.

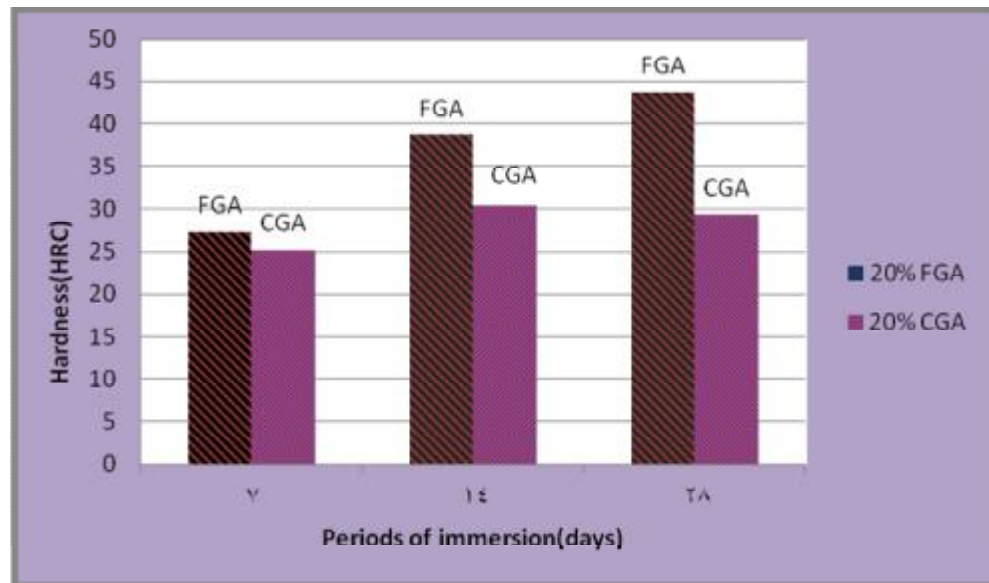


Fig. (8): Comparison between the hardness of (20%FGA)&(20%CGA) at different periods of immersion

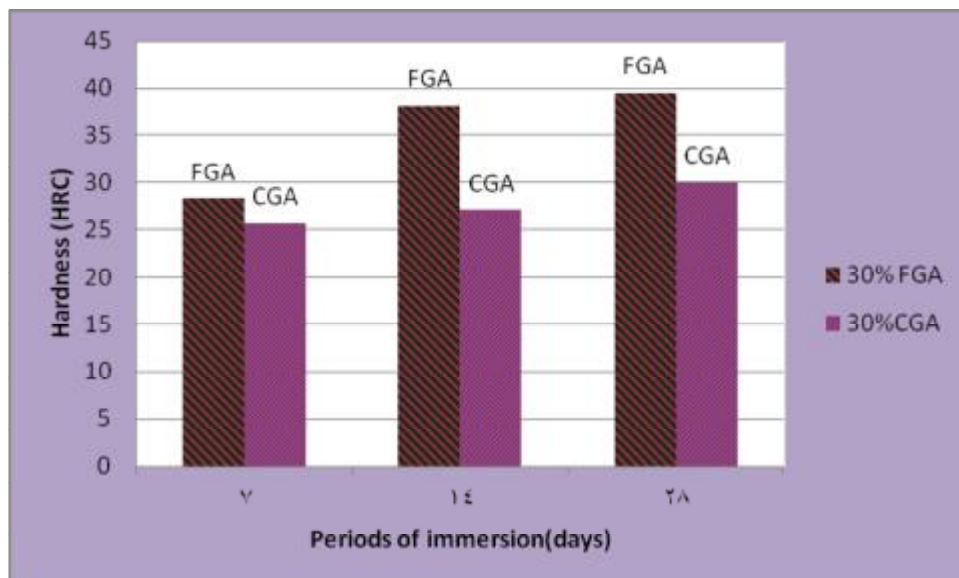


Fig. (9): Comparison between the hardness of (30%FGA)&(30%CGA) at different periods of immersion

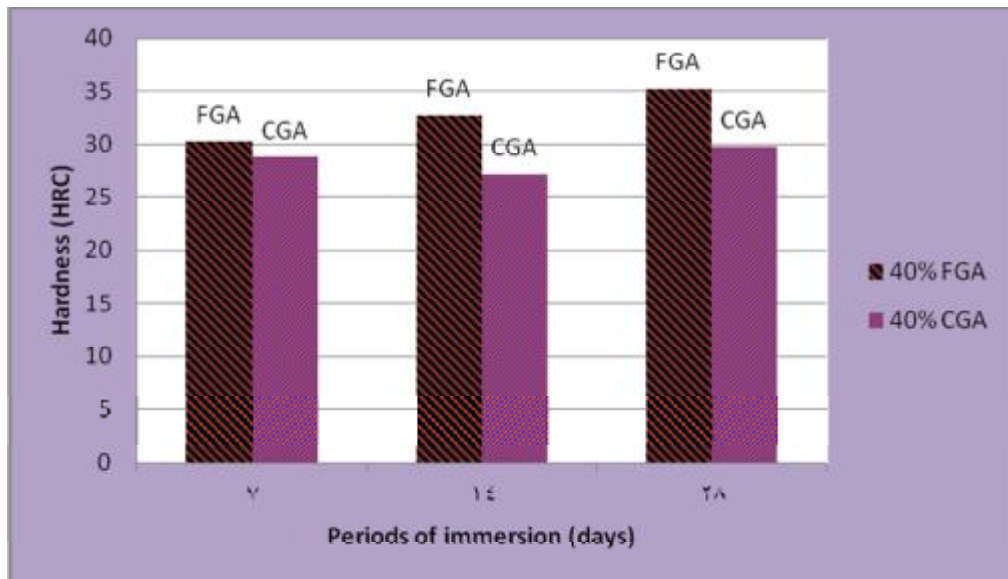


Fig. (10): Comparison between the hardness of(40%FGA)&(40%CGA) at different periods of immersion.

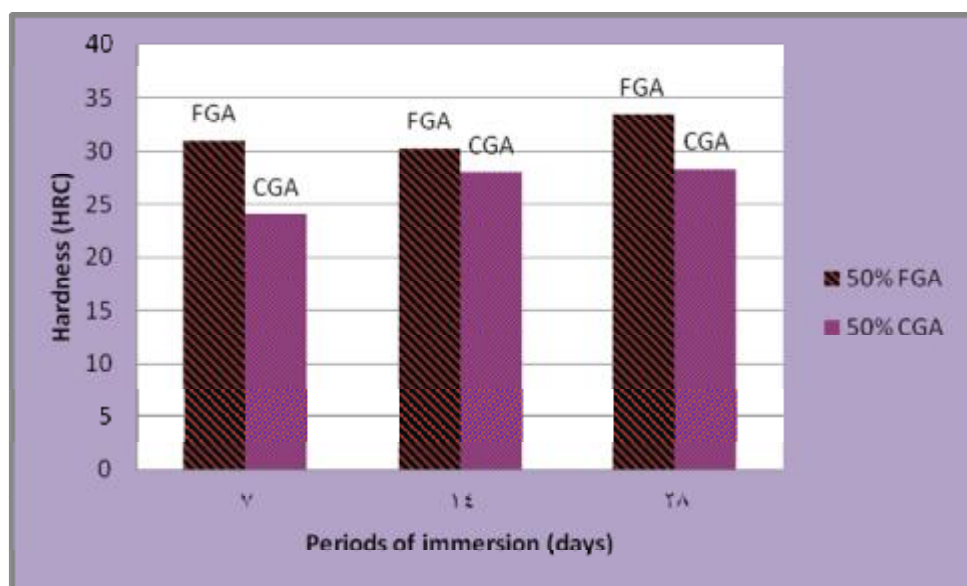


Fig. (11): Comparison between the hardness of (50% FGA)&(50% CGA) at different Periods of immersion

5.4.Ultrasonic Pulse Velocity Test (V_p)

Ultrasonic pulse velocity test of concrete contained either FGA or CGA as partial replacement for sand and gravel respectively of specimens made of (10,20,30,40,50)% showed that for FGA substitution the better velocity at 50% 28 days and for CGA substitution the better velocity at 40% 28 days , and from the resulted data can be concluded FGA substitution were

better than of CGA substitution at all percentages. The homogenous placing of the concrete failed due to the poor geometry of CGA, and as the proportion of CGA increased, ultrasonic velocity decreased only in consistently when compared with concrete containing FGA. The increase in velocity in case of FGA addition, because of finally divided FGA effect to bond properties positively. ^[4]

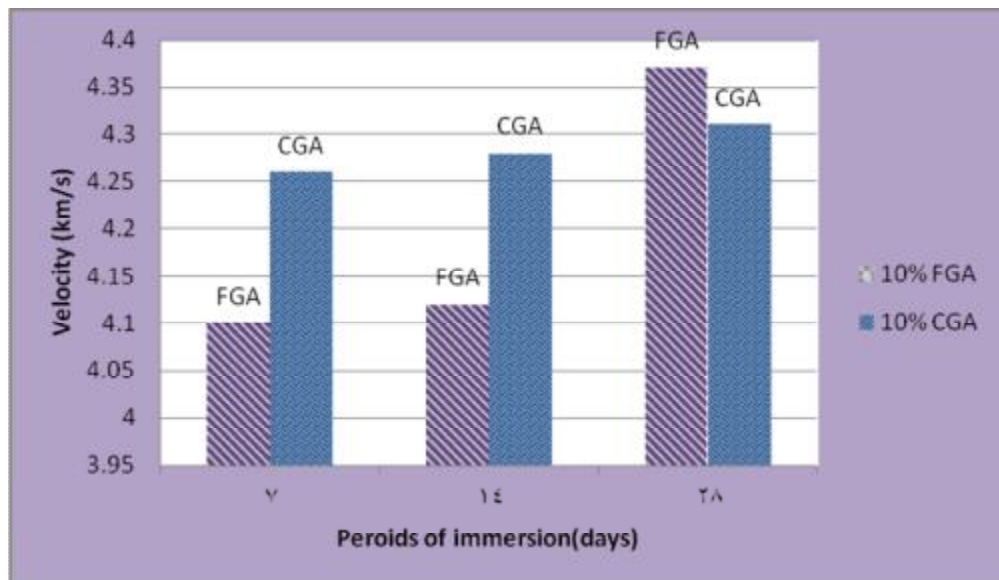


Fig.(12) : Comparison between the V_p of (10% FGA)&(10% CGA) at different periods if immersion.

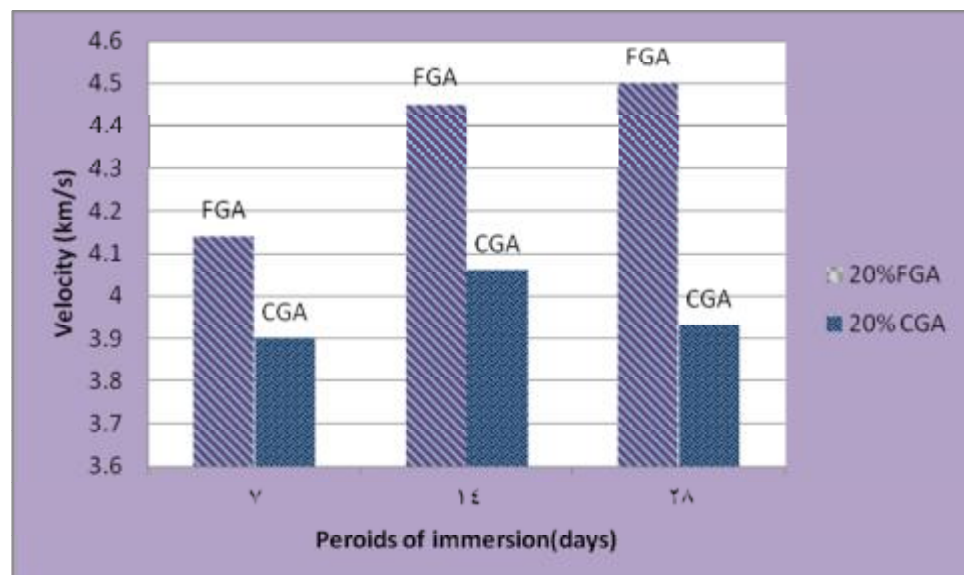


Fig. (13): Comparison the UPV of (20% FGA)&(20%CGA) at different periods of immersion.

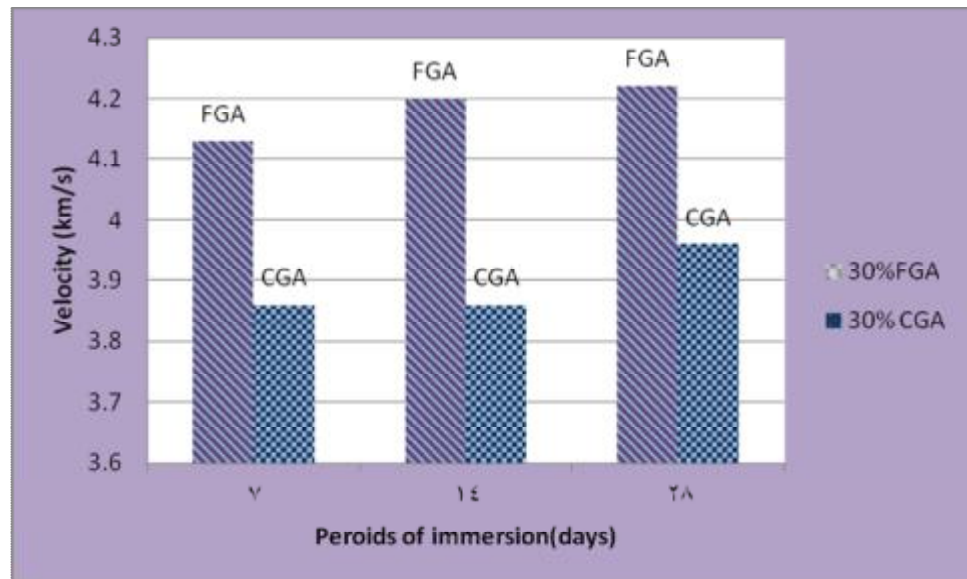


Fig. (14) : Comparison the UPV of (30% FGA) & (30% CGA) at different periods of immersion

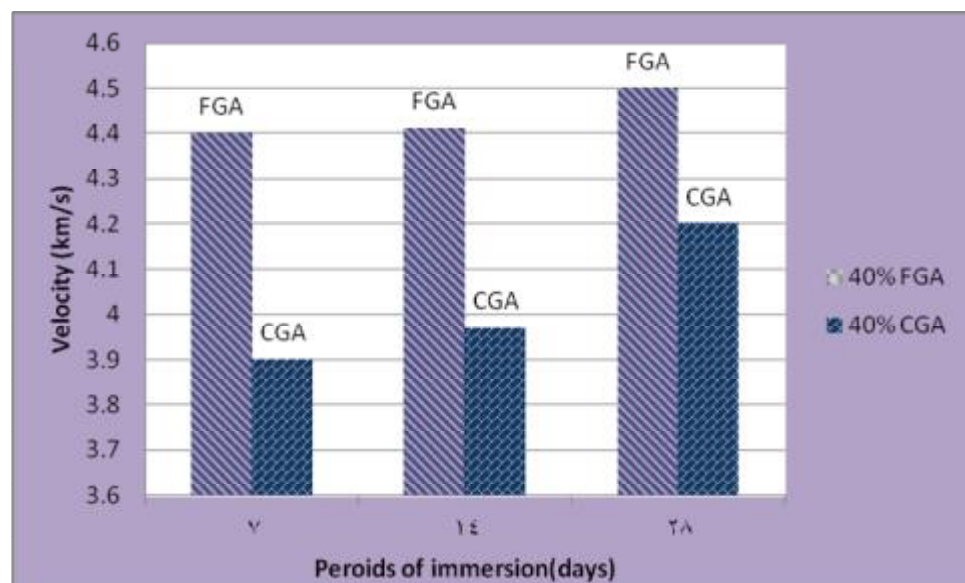


Fig. (15): Comparison between the UPV of (40% FGA) & (40% CGA) at different periods of immersion.

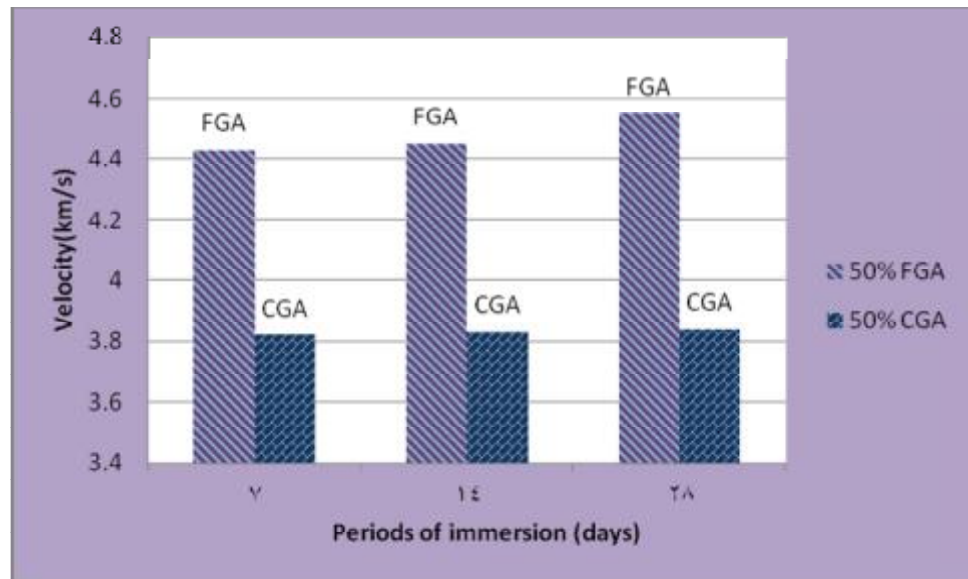


Fig. (16): Comparison between the UPV of (50% FGA) &(50% CGA) at different periods of immersion.

6. Conclusion:

the following main conclusion were achieved from this study :

- Ø Clear glass waste can be substitute the natural aggregates.
- Ø The substitution of fine aggregate is more beneficial than the coarse aggregate.
- Ø The homogeneity can play a major role in evaluating such substitution.
- Ø Recycling of glass waste by converting it to aggregate not only saves landfill space but also reduces the demand of extraction natural raw material for construction activity.

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