Diyala Journal of Engineering Sciences

ISSN 1999-8716
Printed in Iraq

Second Engineering Scientific Conference
College of Engineering –University of Diyala
16-17 December. 2015, pp. 1-12

USE ALTERNATIVE RAW MATERIALS FOR CONCRETE PRODUCTION

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ABSTRACT: In line with the development in the construction sector and continuous need for many of concrete structures that meet the need of continuous population increase in Iraq. It became necessary to think in concrete construction to be more economical through the use of alternative raw materials in concrete production. Also it helps to rid of materials that cause environmental problems.

The first objective of this paper is to produce concrete less expensive. Second, reduce pollution of the environment in terms of using a type of glass which cannot be recycled in other industries. This type of glass will be used as a raw material in the concrete production instead of cement or sand by specific rates.

Research results were carrying a good indicator about compressive strength when using a glass powder instead of cement; especially when the glass was grinding at a more time. When the compensation ratio instead of cement was 20%, and using glass was grinding by 16 hour; the results were a good. They were (31.99, 44.9, 51.64) MPa in age (7, 28, 56) respectively, compared with standard samples which were (22.4, 36.51, 43.2) MPa .

Keywords: - Materials Recycling, Construction Sector, Alternative Materials for Concrete Production, Glass Powder.

1. INTRODUCTION.

1.1 Overview

In the past years it found that rubbish is one of the main sources of environmental pollution. This waste caused a huge problem for the environment, because some of these waste materials are non-biodegradable such as glass. Glass is different shapes and chemical compositions. One solution to get rid of the accumulated glass is re-used in other industries. One of these industries is using it in the concrete mix as compensatory rate instead of cement or aggregate after grinding it to a glass powder.

On the other hand, every year around the world is produced about 3.310 billion tons of cement at 2010 [(1)], these a huge amount are causing liberation of gas CO2 in the air, which frees the amount estimated from 5% to 10% of it into the atmosphere. These gases are caused environmental problems and health especially in the huge construction works. Reducing the rate of the gas which is emitted from the use of cement by less than 5% is a second goal for this search.

Recycling of used glass as compensatory rate instead of cement can be reduce the cost of the cement production, in addition to reducing the risk of environmental pollution by getting rid

of accumulated glass. Also, reduce the proportion of the CO2 emitted by the use of cement to the atmosphere.

Glass is transparent material manufactured by melting a mixture of (silica sand, CaCo3, and other materials) at high temperatures followed by cooling. Glass uses extensively in our lives through the use of glass sheets for windows and glass bottles industry.

Through this the chemical composition for glass, glass is chemically unstable in the atmosphere and alkaline conditions, so it be effective in the midst as concrete mixture midst (alkaline midst). it is causing what is called the deleterious as result of chemical reaction between alkaline and silica, in other words, the interaction between alkaline materials such as K2O, Na2O with effective silica lead to the expansion of the material and volumetric increase, this what calling (ASR) (Alkali-Silica-Reaction), which lead us in our research to grind glass into a fine powder to increase its effectiveness through its interaction with alkali, where acts as similar (pazzolanic Materials). In this case we can rid from expansion and in the same time improve the concrete properties.

1.2 Glass's Properties.

1- Transparency: - Glass is characterized by a bright transparent homogeneous, moving through it all the light rays from ultraviolet to X-Infrared. Glass has the ability to reverse and break the light, where refractive index of glass is ranging between 1.467 - 2.179 and the refraction rate in lead glass is biggest what can be.
2- Hardness: - Glass is a body brittle, crash fast, and doesn't change its shape by pressure or trauma..Glass hardness defines on its ability to resist scratching or friction. Glass hardness varies depending on the glass composition where increase the rate of lime and silica lead to increase cruelty.
3- Chemicals resistance: - Generally, Glass is resistant to chemical solvents, except folic acid and alkali fuses which analyze the glass easily. Also, glass affected by water after its contact for too long.
4- Glass coloration- : The reason for glass coloration by a certain color to the presence of colored metal group on the ions form. For example, glass is colored by yellow color or brown due to the presence of trio iron ion. It can convert the green color in the glass to yellow by add dual-manganese dioxide.
5- Chemical composition of glass: - chemical compositions of glass types are Clear, Brown, and Green, as the table (1) [2, 3].

There are three types of glass that can be used in concrete, Rough Glass, Smooth Glass, and Glass Powder. The difference in size of these forms gives as shown in the table (2). Also table (3) shows the properties of waste glasses and aggregates [4], and the table (4) shows the properties waste glass and cement [4].

1.3 Objectives of Research.

1- Reduce cement which is used in the concrete production.
2- Protection of the environment through:-
- Ridding the environment of glass waste by recycle it.
- Lessening the amount of gases emitted into the atmosphere as a result of the concrete production.

3- Decrease the cost of the concrete mixtures.

2. PREVIOUS STUDIES.

A problem of rubbish and its impact on the environment is directly paid a lot of researchers to make efforts to eliminate or to reduce the damage of it. Find an appropriate solution to deal with it or take advantage of them was a goal of researchers for the past several

years. Glass accumulated rubbish is a major source of pollution, because the glass does not degrade with time and cause significant environmental problems.

Studies and Researches which conducted to get rid from cumulative glass have been many especially in the Europe and America countries, and almost a little attention in the Arab countries. In the following is some previous studies in the field of " how to get rid from cumulative glass".

In 1998, a study conducted by Randal [(5)] and a group of researchers and research institutions in the state of North Carolina, USA. The searches result indicated that lime soda which passing through the sieve 150 micron was effective to prevent the (ASR). Another study carried out by (Santur. 1974) [(6)], it proved that fine glass powder less than 200 or 75 microns can be affected such as Buzolanah Materials , and it can be reduced the possibility of extension (ASR). There was a search in 1989, it proved that the glass granules with size 15 mm cause hyperextension, while the granules with a size least 0.25 mm does not cause the expansion in laboratory tests (Bazant. 1989) [(7)].

A study conducted by three researchers, they found that glass particles with the size of 1.2 mm cause more expansion in cement mortar, where the increase ranging was between (4.75 - 0.15) mm for the samples (150 * 150 * 150) mm. Also this study proved that the green color glass different from the normal color glass,it is contain more than 1% of chromium oxide which almost reduces the (ASR). (Baxten, Meyer, and Jin. 2000)[4].

There are a lot of studies on the subject of rubbish glass, the results were dissimilar almost. Where the study conducted by the (Naohiro)[(8)]. He found that the containment of concrete on the 20% of rubbish glass reduces stretch by 40%. Another study proved that the glass powder added up to 30% acts as Buzolanah Materials which was working to cancel the effect of (ASR). (Shayan, Xu) [(9)]. Another study by the researcher (Topcu, Canbaz)[(10)] proved that the remnants of glass with size (4-16)mm which used such as aggregate in concrete reduces the compressive strength of concrete.

A set of researches presented by a group of researchers include (Pakrastubs H, Korjakins, Sprince)[(11)].

This study proved the possibility to use the glass of lamps after grinding it which is called (Lamp Glass Powder. LGP) by 20% and 40% of the cement weight, the samples were examined after 7 and 28 days and the results were as figure (1).

The concrete samples that are checked and containing (LGP) gave less resistance in of 7 days age, but at the age of 28 days gave greater resistance. The study also proved that glass powder gives the concrete mechanical properties higher with long time as shown in figure 2. The addition 40% of the (LGP) for concrete instead of cement gave an increase of 70.6% of the compressive strength and the addition 20% of (LGP) for concrete instead of cement gave an increase 43.4% of the compressive strength, while The standard sample gave only 15.37% increasing in compressive strength for the same time period.

3. METHODOLOGY.

3.1 Prepare Glass Powder.

The mechanism used in this research is to collect rubbish glass. As we mentioned earlier, there are various forms of glass. The glass are used in our research was a green color glass which contains on a proportion of chromium oxide; it almost reduces the incidence (ASR**).**

Glass rubbish collects in small containers, wash it well and clean it from pending materials, then conduct grinding process. Conducting milling is processing in three stages. First stage is manual grinding using a hammer where will be obtaining a particles of glass with diameters ranging between (0.5 - 1.5 mm), the second stage will be using Disk Mill and the third stage will be using Jar Mill. Jar Mill is a pot of porcelain which is contained different sizes of a porcelain balls. The third stage grinds glass into two types, the first type for 8 hours grinding, the second type for 16 hours grinding. Figure (3) show the stages of glass grind.

3.2 Materials Preparation to Pour Examination Cubes

After the glass powder preparation process to use in concrete admixtures, we begin the process to pour examination cubes which has 63 samples. The pour process was on a mix ratio 1:1.5:1.8 (Cement: Sand: Aggregate) respectively. Cement which used was Normal Portland Cement. Sand used in concrete mixing was moved from sieve 4.75, and the coarse aggregate have a size of about 10 mm. Size of cubic which used for testing was (100 * 100 * 100)mm. glass powder uses in concrete mixing was in two type (8,16) grind hour. Figure (4) show materials preparation and pour examination cubes.

3.3 Results of Samples Examined.

After we are completed the process of cubic pouring (100*100*100) mm by a rate of mixing as we mentioned and with standard ways, Iron cubic opened after 24 hours from pouring process, then we placed all of cubes in treatment container (curing). The period of time to measure compressive strength of the cubes was in age (7, 28, and 56) days. We have got the following results, which represent the results of compressive strength of the cubic, the results were as shown in the tables (5) (6) and figures (5) (6).

4. CONCLUSION.

We noticed through the cubes test results that we have obtained from compression test equipment, that the samples containing a glass powder instead of sand gave good results in terms of compression strength which was more than the standard samples and the samples containing glass powder instead of cement was unsatisfactory results.

Glass is silica materials works as a pazzolanic Materials which it does not have connective properties, but when it is finely grind with water presence, it will be react chemically with calcium hydroxide (Ca (OH)2) in the normal temperature degree to form compounds with the cement properties.

Pazzolanic materials reduce the speed gain rate of concrete strength at early times, so the cement which are contain pazzolanic materials such as glass acquires a slowly strength, so it should have treatment for longer period of time. But its final strength is similar almost to normal cement strength. This is the reason that made cubes which are contained a glass powder instead of cement isn't give good results. See figure (7) [(12)].

On the other hand, also through the results of the tests, the samples which are contained on glass powder with 16 grind hours instead of sand gave the best results of the samples which are contained on glass powder with 8 grind hours instead of sand as well as for the glass powder instead of cement, the glass which grinds with 16 hours was the best from the glass which grinds with 8 hours.

Through our research we can be concluded that:-

- We can improve the compressive strength of concrete with adding a glass powder to the concrete mix.
- Whenever we increase the smoothness of glass powder through grinding it for longer period, we will get the best results.
- The compensation ratio of 20% of the cement weight with glass powder gives good results for the compressive strength of the cubes dimensions (100 * 100 * 100 mm) on the long term of sample age.
- Using a glass powder as a compensatory amount of 10% of the sand weight will give a very good compressive strength, and largest of the standard sample.

So from our research we can recommend the following points:-

1- We should conduct similar tests for long periods of time (3 months, 6 months, 1 year).
2- Using other types of glass which have a varying chemical compositions to see the effect of chemical composition of glass on the mechanical properties of concrete.
3- We need to use the equipment to check the particle distribution for glass powder, and impact it accurately on the mechanical properties or at less to measure the surface area for the milled material.

5. REFERENCES.

1. INDEX MUNDI. "Hydraulic Cement: World Production, By Country". http://www.indexmundi.com/en/commodities/minerals/cement/cement_t22.html.
2. LUNAR SAMPLE COMPENDIUM, "Green Glass Clods 500 Grams". 15425-15427, 15365-15377. 2004.
3. Burchard. F. Ernest. "The Requirements of Sand and Limestone for Glass Making". pp. 452-475.
4. Keryou, A. Bakos. (2014). "Effect of Using Windows Waste Glass as Coarse Aggregate on some Properties of Concrete". Eng & Tech. journal, Vol. 32, part (A), No.6, 2014.
5. Randal J. report by recycling manager, Dane country, Dept. of public works, madison, USA, August 1998.
6. Santur H. R. Glass recycling and reuse, University of Wisconsin, Madin institute for Environmental studies, report No.17, March 1974.
7. Bazant, ZP. In Jin, W. and Meyer, C. Fracture Mechanics of concrete structures Proc, Framcos. Vol.3, 1998 pp. 1687-1693.
8. S. Naohire. "The Strength Characteristics of Mortar Containing Glass Powder" in Proc. 49th cement Technology Conf, Tokyo 1995 pp.114-119.
9. A. Shayan and A. Xu value added utilization of waste glass in concrete "Cement and concrete research Vol.34 pp.81-89, Jan.2004.
10. I.B. Topcu and M. Conbaz, "Properties of Concrete Containing Waste Glass" Cement and concrete research Vol.34 pp.267-274, Feb.2004.
11. A. Sprince and L. Pakrantish, righa Tec. Uni. Dep. Of Str. Eng. Lativia and A. Karakinos Riga Tec. Uni. Ins. Of Mat. And Strc. Lativia, "Creep behaviors of concrete with glass waste micro filler VOl.11 pp.125-131, 2011.
12. Khalaf, M. N, Yessiv, H. A. (1984) "Concrete Technology" Bagdad University of Technology. pp. 121-123. 1984.

Table (1): Chemical composition for three types of glass as a weight percentage.

No	Composition	Clear Glass	Brown Glass	Green Glass
1	SiO2	72.42	72.21	72.38
2	Al2O3	1.44	1.37	1.49
3	TiO2	0.035	0.041	0.04
4	Cr2O3	0.002	0.026	0.13
5	Fe2O3	0.07	0.26	0.29
6	CaO	11.5	11.57	11.26
7	MgO	0.32	0.46	0.54
8	Na2O	13.64	13.75	13.52
9	K2O	0.35	0.2	0.27
10	So3	0.21	0.1	0.07

Table (2): Represents the rate of volumes of glass granules.

Naming	Volume	Production
CGA	(12 - 4.75) mm	Rough Glass
FGA	(4.75 - 0.15) mm	Smooth Glass
GLP	Less than 1 μm	Glass powder

Table (3): The properties of waste glasses and aggregates.

Materials	Specific Gravity (SSD)	Absorption (%)
FA (0 - 4.75) mm	2.63	0.5
CA(4.75 - 12.5) mm	2.67	1.5
FG(0 - 1.18) mm	2.42	0.4
CG (0 - 4.75) mm	2.42	0.3

Table (4): The properties waste glass and cement.

Properties	Waste glass	Cement
SiO2	70.22	23.71
CaO	11.13	57.27
MgO	-	3.85
Al2O3	1.64	4.51
Fe2O3	0.52	4.83
SO3	-	2.73
Na2O	15.29	-
K2O	-	0.37
CI	-	0.0068
Loss on ignition	0.8	7.24
Undetermined	-	0.94
Density	2.42	3.03
Specific	133	437.6
Comp. Str. For 28 days (Mpa)	-	50.9

Table (5): Results of samples test for glass powder instead of cement.

Type of Sample	Standard Cubes			Cubes contained on 10% of glass powder by 8 h. instead of cement			Cubes contained on 20% of glass powder by 8 h. instead of cement			Cubes contained on 10% of glass powder by 16 h. instead of cement			Cubes contained on 20% of glass powder by 16 h. instead of cement		
Comp. Strength for 7 days. MPa .	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
	22.53	23.41	21.26	27.54	25.24	26.07	27.82	28.21	28.4	28.99	29.54	27.8	32.22	32.25	31.5
Average (MPa)	22.40			26.28			28.14			28.78			31.99		
Comp. Strength for 28 days. MPa.	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
	36.42	36.01	37.11	38.61	37.32	36.5	36.51	37.53	36.9	43.2	42.16	41.7	45.71	44.3	44.7
Average (KN.)	36.51			37.48			36.98			42.35			44.90		
Comp. Strength for 56 days. MPa.	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
	42.8	44.2	42.6	46.42	45.3	50.5	40.5	41.66	40	45.5	47.3	46.4	50.8	53.53	50.6
Average (MPa)	43.20			47.41			40.72			46.40			51.64		

Table (6): Results of samples test for glass powder instead of sand.

Type of Sample	Cubes contained on 10% of glass powder by 8 h. instead of sand.									Cubes contained on 10% of glass powder by 16 h. instead of sand.								
	Comp. Strength for 7 days. MPa.			Comp. Strength for 28 days. MPa.			Comp. Strength for 56 days. MPa.			Comp. Strength for 7 days. MPa.			Comp. Strength for 28 days. MPa.			Comp. Strength for 56 days. MPa.		
Comp. Strength KN.	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
	28.23	28.01	27.11	40.88	41.05	41.18	49.2	47.5	49.7	35.31	35.97	36.02	48.91	49.12	48.58	52.9	54.35	53.86
Average (KN.)	27.78			41.04			48.80			35.77			48.87			53.70		

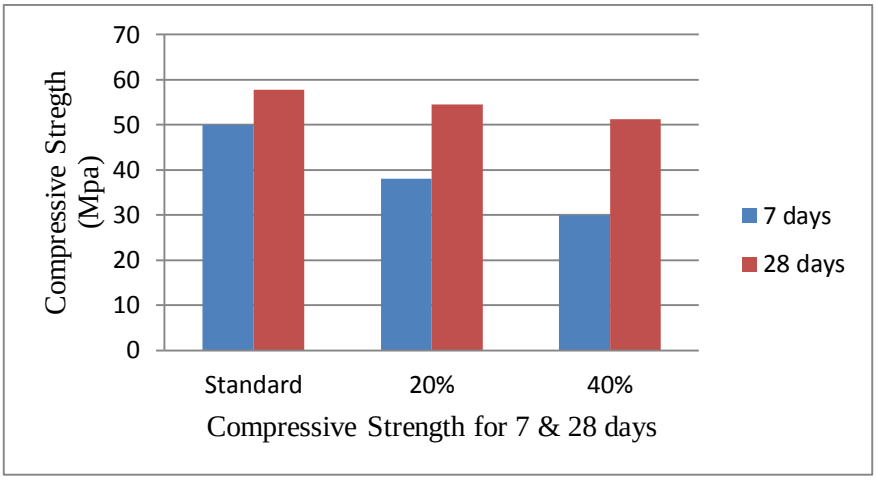

Figure (1): Compression Strength for 7 & 28 days.

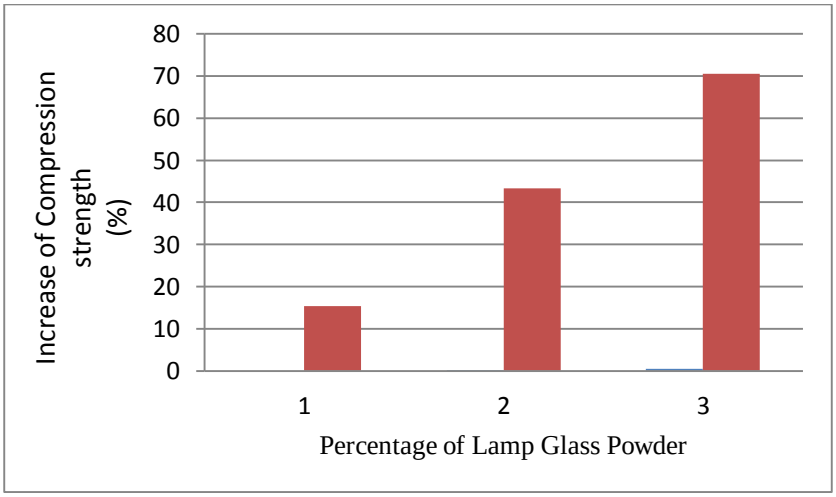

Figure (2): Increasing in compressive strength from 7 to 28 days.

Figure (3): Stages of glass grind

Figure (4): Materials Preparation and Pour Examination Cubes.

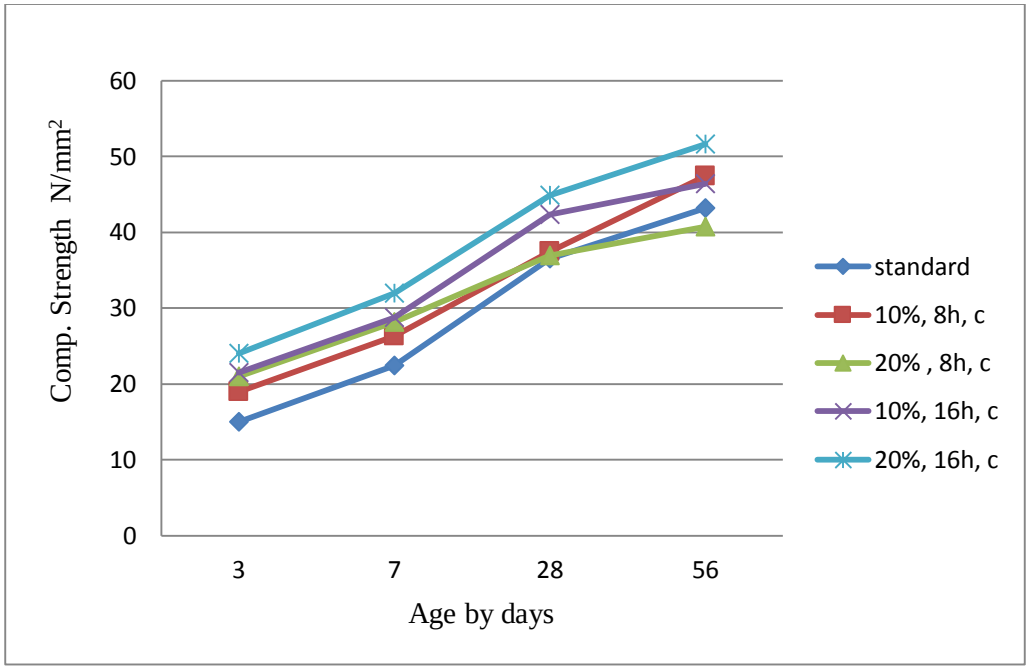

Figure (5): Compressive strength for standard samples and the samples which contain the ratios of glass powder instead of cement.

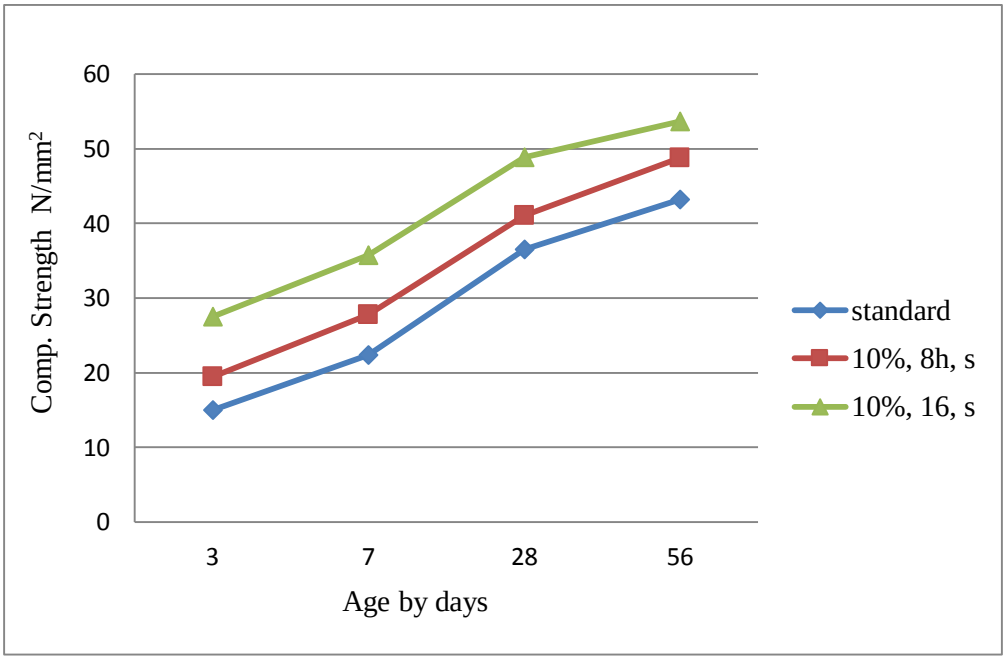

Figure (6): Compressive strength for standard samples and the samples which contain the ratios of glass powder instead of sand.

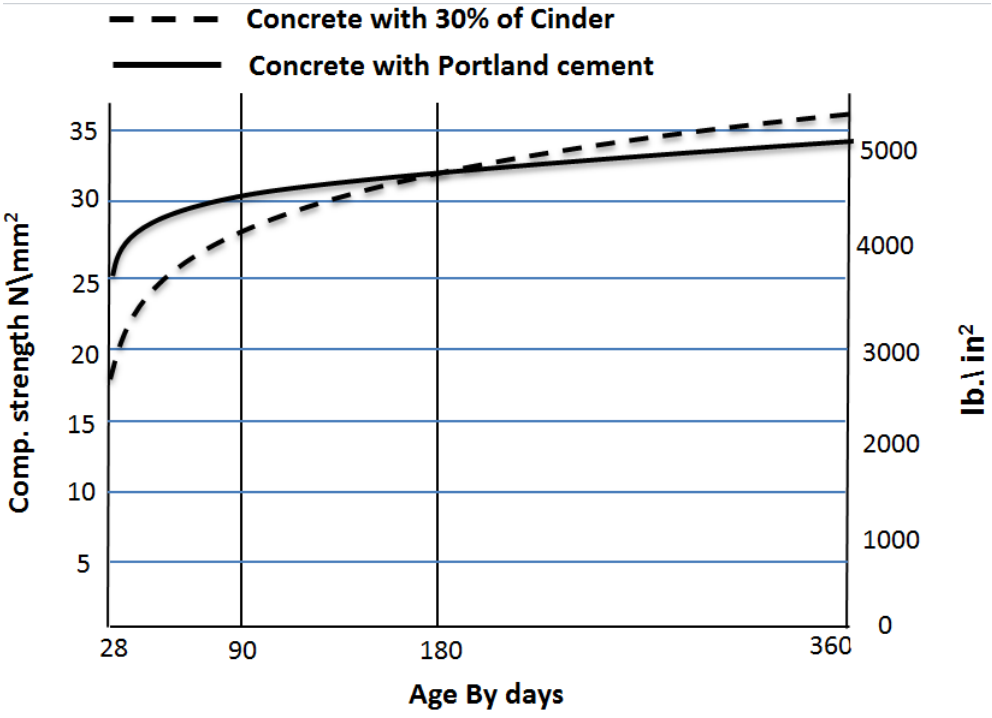

Figure (7): Effects of compensation pazzolanic materials as a part of the cement on the compression strength of concrete.

أستعمال مواد أولية بديلة في أنتاج الخرسانة

الخلاصة:

تماشيا مع التطور الحاصل في قطاع الانشاءات, والحاجة المستمرة للعديد من المنشات الخرسانية التي تلبي حاجة الزيادة السكانية المستمرة في العراق. اصبح من الظروري التفكير في منشئات خرسانية تكون اكثر اقتصادية من خلال استعمال مواد اولية بديلة تدخل في صناعة انتاج الخرسانة. وايضا تساعد في التخلص من المواد التي تسبب مشاكل بيئية.

الهدف الاول من هذا البحث هو انتاج خرسانة مع اقل تكلفة. ثانياً, التقليل من التلوث البيئي عن طريق استعمال نوع من انواع الزجاج الذي لايمكن اعادة تدويره في صناعات اخرى. هذا النوع من الزجاج يستعمل كمواد اولية في انتاج الخرسانية بدل الاسمنت او الرمل بنسب محددة.

نتائج البحث كانت تحمل مؤشرات جيدة عن مقاومة الانضغاط عند استخدام مسحوق الزجاج بدل الاسمنت, خاصة عندما يكون الزجاج مطحون لفترة اطول. عندما كانت نسبة التعويض بدل الاسمنت 20%, ومسحوق زجاج مطحون لمدة 16 ساعة; النتائج كانت جيدة. انها كانت (31.99 , 44.9, 51.64) ميكا باسكال بعمر (7, 28, 56) بالترتيب, مقارنة مع النماذج القياسية والتي كانت (22.4, 36.51, 43.2) ميكا باسكال .

الكلمات الدلالية:– اعادة تدوير المواد, قطاع الانشاءات, المواد البديلة لإنتاج الخرسانة, الزجاج المطحون.