Study of glass concrete production and its compressive strength

1- Faiz O. M. Akrim 2-Ali H. M. Ali 3-Ali. F. Hussain.Adam
1.Civil Engineering Department - Higher Institute of Science and Technology - El-Marj 2- Civil Engineering Department - Higher Institute of Science and Technology - Al-Bayda 3- College of Engineering Technologies - Alqubbah

الملخص:

إن النفايات الناتجة عن الزجاج تسبب مشاكل بيئية كبيرة تؤثر على صحة الإنسان وللتخلص منها بطريقة مفيدة جاءت فكرة إضافة مسحوق الزجاج إلى الخرسانة وفي هذا البحث تمت دراسة تأثير مسحوق الزجاج على قوة الخرسانة ومقارنته بقوة خليط مرجعي والغرض من البحث هو إعادة استخدام مخلفات الزجاج عن طريق استبدال جزء من الركام الناعم (17%) وجزء من الأسمنت (12%) وجزء منهما بنفس النسب السابقة بمخلفات الزجاج المطحونة بأحجام محددة ومن ثم دراسة قوة الضغط للمنتج النهائي وقد أظهرت النتائج أن قوة الضغط عند عمر (7) أيام للخلطة المرجعية هي (29) ميجا باسكال وللخلطات الخرسانية الزجاجية (3،2،1) هي على التوالي (25.8، 24، 26.7) وعند عمر (28) يوم تكون الخلطة المرجعية (43 ميجا باسكال) وللخلطات الخرسانية الزجاجية (3،2،1) هي على التوالي (39.6، 38.8 و37.2 ميجا باسكال). يلاحظ عدم ظهور فروق كبيرة وملحوظة في مقاومة الضغط بين الخلطات الأربعة، وبسبب إمكانية استبدال كميات من الأسمنت أو الرمل أو كليهما مع مسحوق مخلفات الزجاج، مع عدم ظهور فروق كبيرة في المقاومة، فإن إنتاج الخرسانة الزجاجية اقتصادي مقارنة بالخرسانة العادية التي لها نفس المقاومة. عند إضافة مسحوق الزجاج بنسبة 17%، انخفضت مقاومة الضغط بنسبة 9.76%. عند إضافة مسحوق الزجاج بنسبة 12%، انخفضت مقاومة الضغط بنسبة 7.93% وعند إضافة مسحوق الزجاج بنسبة 29%، انخفضت مقاومة الضغط بنسبة 13.42%. هذه النسب للخلطات بعمر 28 يومًا.

الكلمات المفتاحية: مخلفات، مسحوق الزجاج، مقاومة ضغط الخرسانة

Abstract

The waste resulting from glass causes major environmental problems, which affects human health. In order to dispose of it in a useful way, the idea came about adding glass powder to concrete. In this research, the effect of glass powder on the strength of concrete was studied and compared with the strength of a reference mixture. The purpose of the research is to reuse glass waste by replacing part of the fine aggregate (17%), part of the cement (12%), and part of both in the same previous proportions with glass waste ground to specific sizes, and then studying the compressive strength of the final product. The results showed the compressive strength at the age of (7) days for the reference mix is (29) MPa and for the glass concrete mixes (3,2,1) are respectively (25.8, 24, 26.7). At the age of (28 days) the reference mix is (43 MPa) and for the glass concrete mixes (3,2,1). Are respectively (39.6 38.8 and 37.2 MPa). It is noted that no large and noticeable differences in compressive strength appear between the four mixtures. Because of the possibility of replacing quantities of cement, sand, or both together with glass waste powder, with no significant differences in strength appearing, the production of glass concrete is Economically compared to regular concrete, which has the same resistance. When adding glass powder by 17%, the compressive strength decreased by 9.76%. When adding glass powder by 12%, the compressive strength decreased by 7.93%.

When adding glass powder by 29%, the compressive strength decreased by 13.42%. These percentages for the mixes at 28 days old.

Key words: waste,glass powder,concrete compressive strength

Introduction:

Development plans and implementation of various projects depend on the availability of building materials, and despite the development of building materials used over time, concrete still occupies the forefront, as the methods of its production and manufacture have developed and improved tremendously, and the types of concrete produced have multiplied depending on the requirements of the purposes used for it and in different fields. This was done through the diversity of its components, the use of additives, or the diversity of production methods. This shows the importance of concrete as a construction material on which the urban renaissance in the country has relied and will depend in the future.

The aim of the research is to exploit glass waste of various types and add it to concrete as a substitute for part of the basic materials involved in the formation of concrete, that is, to produce concrete by replacing part of the cement or fine aggregate, or both, with glass waste ground to certain sizes, and then examining some of the properties of the concrete produced. This issue has a significant impact from an economic standpoint due to the reuse of materials that would have been discarded waste and their use in construction material. Concrete, in a general sense, is any product or block made using a cement medium. In general, this medium results from the interaction between hydraulic cement and water. The components of concrete in general are cement and aggregate, both fine and coarse, and water, in addition to additives. Good concrete must be satisfactory in its solid state as well as in its solid state and soft state when transferred from the mixer to the mold.

Glass concrete: The process of reusing glass is one of the main issues focused on in many countries. Currently, New York City reuses 100,000 tons of glass waste daily in various fields. Glass concrete is considered one of the special types of concrete and is produced by replacing

part of the cement, sand or parts of both with ground glass material to certain sizes. Using crushed glass waste in concrete as aggregate has some problems due to the chemical reaction that occurs between the alkalis in the cement and the silica in the glass. The alkali-silica interaction forms a gel, which in turn will swell in the presence of moisture, causing cracks. And damage to concrete. This reaction can occur in ordinary concrete if the natural aggregate contains a large amount of silica

Literature Review:

First: A previous study at Sabratha University by Dr. Abu Al-Qasim Yahya Abu Sabeh. And Eng: Marwan Al-Keib In this study, ground glass waste was taken, sieved on a 90-micron sieve, and used as a partial replacement for cement in the concrete mixture. Three concrete mixtures were made with ratios of W = 4.045.05.00, concrete cubes were made to test the pressure resistance of the third reference mixtures, and concrete cubes were made by partially replacing cement with ground. Glass as a partial substitute for cement in proportions of 12,963 15% for these three mixtures. Only cement tests were conducted, as well as the cement used in it ground - 126, 69 %3% in glass proportions. It was concluded that the possibility of using ground glass in the concrete mixture, especially in a mixture with a W/C ratio equal to 0.45. When adding 3% and 6% ground glass instead of cement, the increase in concrete strength reached 5.5%, respectively, and 2.8% for the second reference strength of concrete, and tests of cement added instead of cement, its results were in accordance with standard specifications and the possibility of using it in concrete sidewalks, brick making and other works.

Installing tiles second: A previous study at Anbar University by Dr. Akram Shaker Mahmoud This study included the effect of waste glass as partial powder by partial replacement of cement on some properties of concrete. These properties included compressive strength, tensile strength, splitting, bending, impact resistance, and bond strength. The effect of glass was examined in comparison with reference samples without replacing glass powder. Three percentages were tested. 0% (reference), 10% and 15% .

The results showed that the use of glass powder improves the properties of concrete under different types of loading, and the compressive strength increased by 26.34% and 22% when compared to the glass powder reference mixture of 10% and 15%, respectively, while it increased. The tensile strength was 23.5% and 28.7% more than the reference mixture for the 10% and 15% glass powder, respectively. The crushing factor was increased by 17% and 10% for the 10% and 15% glass powder, respectively. The impact resistance of the mixtures was increased by 10%. And 15% of glass powder, with a ratio of 14.3% and 4.76% in pressure with the reference mixture, respectively.

The crushing factor was increased by 17% and 10% for the 10% and 15% glass powder, respectively. The impact resistance of the mixtures was increased by 10%. And 15% of glass powder, with a ratio of 14.3% and 4.76% in pressure with the reference mixture, respectively These properties included compressive strength, tensile strength, splitting, bending, impact resistance, and bond strength. The effect of glass was examined in comparison with reference samples without replacing glass powder. Three percentages were tested. 0% (reference), 10% and 15%. The results showed that the use of glass powder improves the properties of concrete under different types of loading, and the compressive strength increased by 26.34% and 22%

when compared to the glass powder reference mixture of 10% and 15%, respectively, while it increased. The tensile strength was 23.5% and 28.7% more than the reference mixture for the 10% and 15% glass powder, respectively. The crushing factor was increased by 17% and 10% for the 10% and 15% glass powder, respectively. The impact resistance of the mixtures was increased by 10%. And 15% of glass powder, with a ratio of 14.3% and 4.76% in pressure with the reference mixture, respectively.

Raw materials used

A. Cement: In this research, ordinary Portland cement was used.

B. Aggregates: The American specifications (69-294-ASTM: C)

C. Water: Potable water was used in the production of the reference mix and glass concrete mixtures.

D. Glass: Finely ground glass waste of certain sizes was used. The glass used instead of a portion of cement had a maximum size of (300) microns. As for the glass used instead of a portion of fine aggregate, its maximum size was (1.18 mm).

The importance of the study

Ridding the environment of harmful glass waste that causes wounds and injuries to individuals and damage to vehicle tires. Producing products that represent a necessary raw material for some industries.

The purpose of the study

The purpose of this paper is An the concrete mixture as a percentage of fine aggregate and cement by replacing a small portion of them, Testing the pressure on the cube regarding concrete after seven days and twenty-eight days after it was immersed in water, and deducing the effect resulting from this process, whether positive or negative.

The problem of the study:

Since concrete is strong in compression and weak in tension, this will lead us to discuss the addition of glass powder in concrete mixtures to increase its ability to resist tension, given that glass is considered strong in tension, which is one of its most prominent properties, although it has become brittle. Glass is able to withstand great pressures without breaking. This is due to the amorphous structure of the glass, which allows the applied forces to be distributed more evenly. The glass has a high tensile strength due to the chemical bonds between the silicon atoms and the oxygen atoms, which are very strong. These bonds prevent the glass from breaking easily. It gives it its distinctive hardness.

Study methodology:

This study relied on the analytical approach, which is specified in various standards, specifications, and rules of practice. The steps followed in the design in most specifications are almost the same, as the design of the concrete mix in this research requires the addition of glass powder, and it is considered to test the appropriate components and determine their relative proportions. With the goals of producing concrete strength and durability as economically as possible.

Addition of glass powder

A colorless material made mainly from silica fused at high temperatures with boric acid or phosphate. Glass is found in nature and is also found in volcanic materials called volcanic glass or materials that originate from meteorites, not Glass is neither solid nor liquid, but is in a special state in which its particles appear randomly, but such that there is sufficient cohesion. To cause a chemical union between them. When the glass is cooled, it reaches its solid state, but without crystallization. When it is exposed to heat, the glass turns into a liquid. Glass is usually transparent, but it may also be opaque or semi-transparent, and its color varies depending on its components. Finely ground glass waste of certain sizes was used. The glass used instead of part of the cement had a maximum size of 300 microns (as for the glass used instead of the fine aggregate part, its maximum size was 1.18 mm). It was done in a concrete mix. Glass: Adopting the same mixture ratios used in the manufacture of loaded concrete building blocks (blocks), which is 4:2:1, and a water to cement ratio (0.4), noting that in Mix No. (1) 17% of the sand was replaced and in Mix No. (2) 12% of the cement was replaced. As for mixture No. (3), both sand and cement were replaced in the same proportions above.

The following table is for the proportions used in designing the concrete mix with the addition of glass:

Table 1. Proportions Used In Designing The Concrete Mix With The Addition Of Glass

W/C	Coarse aggregate kg	Glass powder kg	fine aggregate kg	Cement kg	Glass powder %	Mixtures
0.4	40	0	20	10	0	S
0.4	40	3.4	16.6	10	17	R1
0.4	40	1.2	20	8.8	12	R2
0.4	40	4.6	16.6	8.8	29	R3

Designing concrete mixtures

Determining the proportions of the concrete mixture is considered one of the most important factors that affect the quality of the concrete and the economics of the project. It is possible to obtain concrete of varying quality and for what type, even though they are all composed of the same materials. The relative economy of concrete mixtures depends on the Germaneness of their components, workers' wages, and transportation costs for those components. Cement is considered one of the basic components of concrete, and its presence in the mixture has a significant impact on its costs due to its high price compared to the rest of the components.

How to state the ratios of concrete components Proportions Expressing

The components of concrete are shown from granular materials, which are cement, small aggregates, and large aggregates, usually in the form of ratios by weight or volume. For example, when it is said mix, it means: cement: sand: asphalt 4:2:1 That is, it contains one part of cement, two parts of sand, and four parts of asphalt. It is preferable that

these percentages be by weight because it is not possible to accurately determine the amount of cement by volume, as well as the aggregate, as a result of changing the amount absorbed by a specific volume by changing the extent of compaction used. However, small aggregates may change in size due to the phenomenon of bulking with moisture. Granular materials may be shown as a ratio between cement and aggregate (Ratio Aggregates/Cement)

compressive strength

Compressive strength is the most important property of reinforced concrete at all, and it grows through its quality, suitability, and pressure resistance in the main strength of concrete, as most of the other properties and resistances, such as God, bending, shear, and cohesion with reinforcing steel, improve and increase with increasing pressure resistance and vice versa, so pressure testing is done. For the purpose of controlling the quality of concrete production at the project site, this test is also used for structural design purposes to determine the characteristic resistance and operating stress of concrete in compression, which is standardized as a percentage of the maximum resistance to compression.

Factors affecting compressive strenght. Compressive strenght is dispersed by many and varied factors, summarized in four main groups:

1- Constituent materials and mixing ratio (nominal - aggregates - mixing - additives). Pour your blood.

2- Concrete manufacturing methods (mixing – transporting).

3- Processing conditions (humidity - temperature - processing methods).

4- Age and testing conditions (rate and direction of loading - moisture in the sample - size and shape of the sample - condition of the surface of the sample in contact with the machine).

Types of choices potential for concrete under the influence of compressive load.

The collapses that occur in samples of different shapes as a result of compression tests are rarely due to compressive stresses only, but rather are mostly due to shear or rib tension options. In addition, the collapses that occur in the selection samples are completely different in their shapes from Possible changes that may occur in concrete members in the structure. Through laboratory studies, it can be noted that relatively short compression test specimens, such as cubes and standard cylinders, are affected by the lateral enclosing stresses imposed on them from the friction of their end with the head of the machine, so they collapse in the form of an incomplete cone, and this conical work results from the effect of the amplitude stress. Axial plus lateral bounding stresses.

Tests that will be explained in the paper Compressive Strength Test .

Compressive strength test:

The test to determine the compressive strength of reinforced concrete is usually conducted 28 days after pouring. Samples or after another period as needed. Selection samples: a cube with a side length of 15 cm according to British specifications, or a cylinder with a diameter of 15 cm and a height of 30 cm, all American specifications.

How to conduct the test:

1- Weigh the necessary quantities of cement, small aggregate, large aggregate, and water. When calculating the weight, it should be taken into account that the amount of mixed concrete exceeds the concrete needed to fill the molds by about 15% in order to compensate for any loss or damage that may occur during the test.

2- After the test mold, the inner sides of the mold are given a layer. A thin layer of light oil

3- Mix the concrete components either mechanically or manually, mixing well until the color becomes homogeneous. After testing the fresh concrete.

4- fill the mold directly with concrete in 3 layers, and each layer can either be vibrated or manually until the concrete is compacted without granular separation occurring.

5- This gives the molds are immediately after being poured and placed in a place with a moderate temperature for a period of 24 hours. It is noted that they are not exposed to any vibrations.

6- Mark the concrete samples after that, then remove them from the molds and immerse them immediately in pure water. Leave them until the time of selection. It is preferable to leave spaces between the cubes and each other in the treatment basins is recommended. Do not place the cubes on top of each other.

7- The sample is tested by placing it in the testing machine where its axis is in line with the axis of the machine head. In the case of a cubic sample, the two sides of the sample must be in contact with the two surfaces of the machine head, which are the two faces opposite the inner surface of the metal mold to ensure their flatness and parallelism. In the case of a cylindrical sample, it is necessary to make a cushion for the surface of each

end of the cylinder. In such a way that the surfaces of the two ends are two parallel planes.

8- For each test, three samples are tested and the average value of the results is taken.

9- The load is applied gradually and continuously until it breaks at an equal application speed. 0.35_0.15 MPa/s Writing the report: The report must contain: the number of samples & the dimensions of the sample & the area of the sample & the maximum load on the compressive strength, rounded to the nearest (0.12) the form of melting if it is different from normal, the defects in the sample and the age of the sample.

Compressive strength

The pressure test is considered the most important of the tests used on concrete. The dimensions of the cubes used in the test are (15 cm x 15cm x 15cm). It should be taken into account that the test sample subjected to pressure is as smooth as possible so that friction between the surfaces of the bed and the device does not affect the results. Compressive strength is calculated from the following relationship: Compressive strength - maximum load / cross-sectional area of the cube. In all tests, the cross-sectional area will be 225 cm^2.

Table 2. Average Test Results of Samples After 7 Days of Age

Compressive strength (Mpa)	Percentage Decrease in Compressive strength %	Breaking Strength(KN)	Cube Dimensions (Cm)	Age of Concrete Per Day	Glass Powder %	Mixtures
29	0	652.5	15×15×15	7	0	S
25.8	11.03	580.5	15×15×15	7	17	R1
26.7	7.93	600.75	15×15×15	7	12	R2
24	17.24	540	15×15×15	7	29	R3

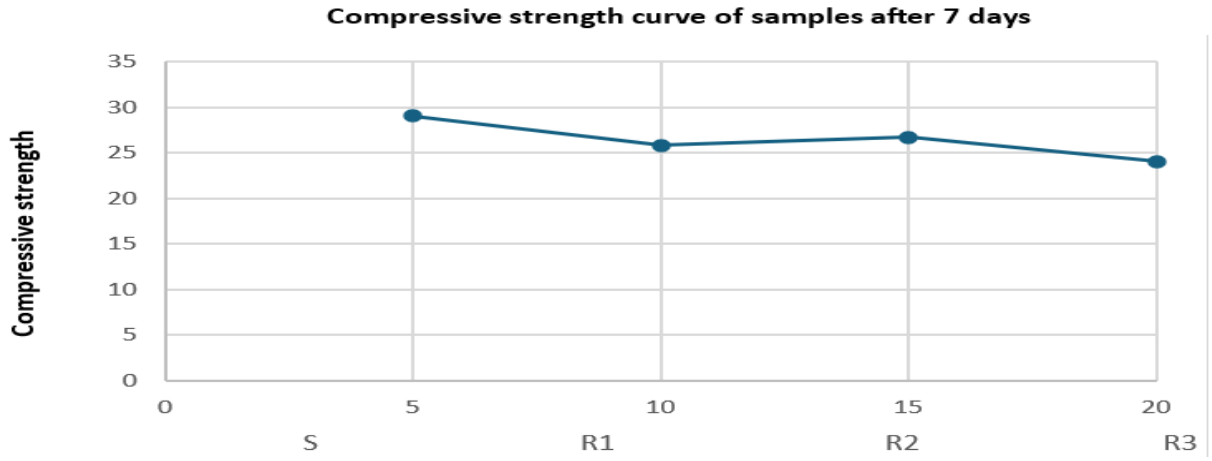

Figure 1. Compressive Strength Curve of Samples After 7 Days

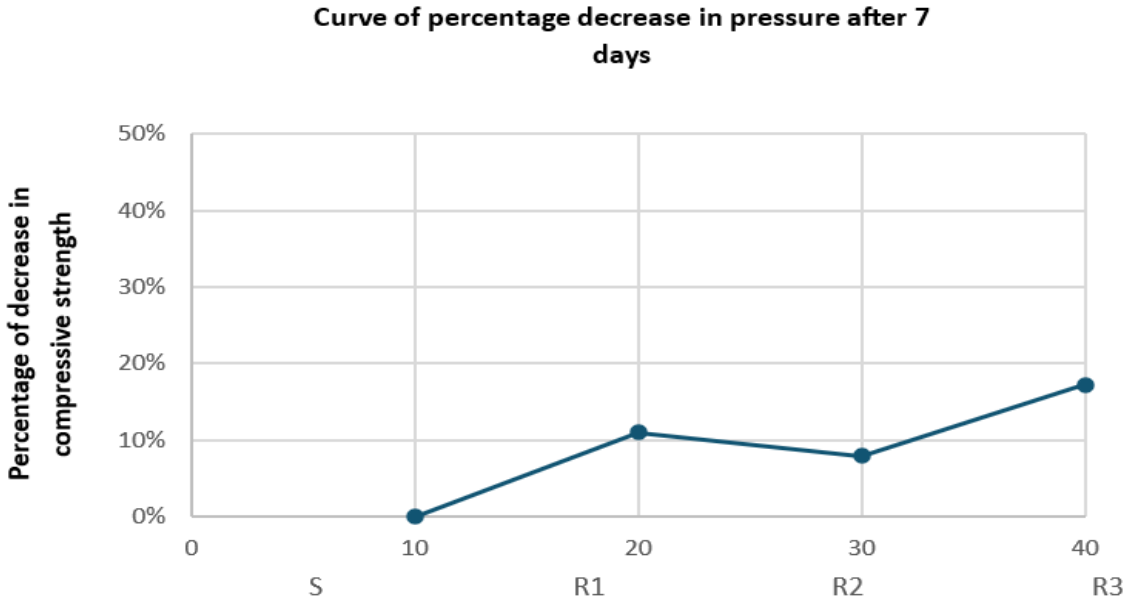

Figure 2. Curve of Percentage Decrease in Pressure After 7 Days

Table 3. Average Test Results of Samples After 28 Days of Age

Compressive Resistance (Mpa)	Percentage Decrease in Compressive % strength	Cube Dimensions (Cm)	Age of Concrete Per Day	Glass Powder %	Mixtures
43	0	967.5	15×15×15	28	S
38.8	9.76	873	15×15×15	28	R1
39.6	7.9 3	891	15×15×15	28	R2
37.2	13.42	837	15×15×15	28	R3

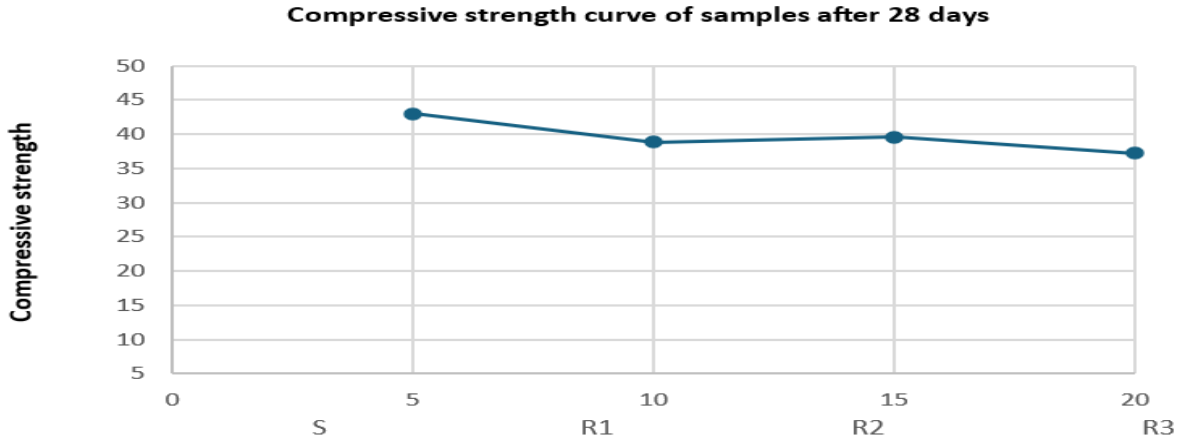

Figure 3. Compressive Strength Curve of Samples After 28 Days

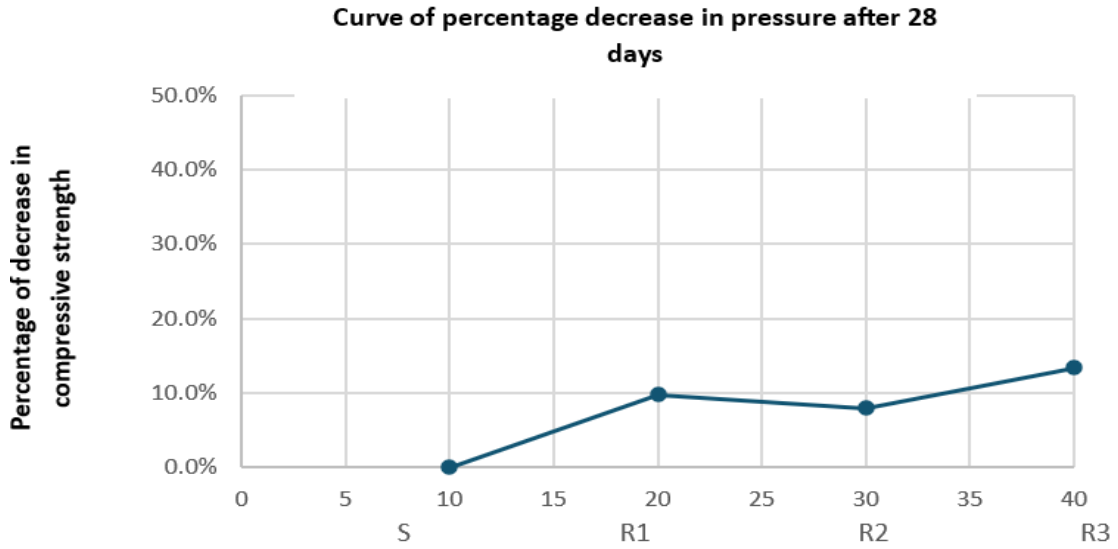

Figure 4. Curve of Percentage Decrease in Pressure After 28 Days

Conclusions:

Based on the results of the laboratory work, which included the production of glass concrete and the study of some of its properties, and in comparisons with the results of the reference mixture, the following can be concluded:

1) It is possible to produce concrete by replacing part of the fine aggregate, part of the cement, or parts of both, with glass waste powder after grinding it to Certain sizes.
2) The compressive strength of the glass concrete mixes was slightly lower than that of the reference mix. The compressive strength of the reference mix at the age of (28 days) was equal to (43) MPa), and for mix 1 it was (38.8) MPa), and for mix R2 it was (39.6) megapascals), and for mix 3 it was (37.2) megapascals). The percentage of decrease for mixtures (3,2,1) was (9.76%, 7.93%, 13.42%), respectively.
3) The results showed that replacing part of the cement with glass powder gives a compressive strength closer to that of the reference mixture compared to other glass concrete mixtures.
4) The results showed that it is possible to dispense with quantities of cement or sand, or both, by replacing them with glass waste powder, with no significant and noticeable differences in compressive strength between the reference mix and glass concrete mixes. In fact, from an economic standpoint, it is preferable to benefit from glass waste by reusing it in the production of concrete. Satisfactory in terms of endurance.

Recommendations :

From all of the above and through the experiments and results obtained, and for the purpose of developing this paper , we recommend the following:

1- Study of the effect of glass waste powder on permeability, porosity, tensile strength, and the effect of temperature.
2- Encouraging the local market to use ground glass.
3- Continue research in this field because of its positive impact on mixtures, provided that glass waste is gradually replaced or added to observe changes more accurately with slight increases.
4- Increasing the number of samples studied to reach real values for changes in concrete properties.
5- Discussing other properties of concrete and studying their change as a result of the addition or replacement process.
6- Verify the chemical composition of the glass used, as well as the cement and aggregate.
7- Study the effect of time on concrete containing glass waste.

Reference:

-1- Al-Khalaf, Moayed Nouri and Youssef Hanaa, “Concrete Technology,” Arabization and Publishing Center, University of Technology, 1984 AD.

2- Ahmed Bello, University of Zaria, Nigeria.

3- Mohsen Abdel Salam Ben Hassouna, The effect of the properties of the geometric shape of granular aggregates on me Mechanical properties, research submitted to fulfill the requirements for studying for a “Master’s” degree.In Civil Engineering, Garyounis University, spring semester 1999.

4-Civil Materials Technology, General Administration for Curriculum Design and Development, Kingdom of Saudi Arabia

5-Properties and testing of materials, General Administration of Curriculum Design and Development, Kingdom of Saudi Arabia

6- Neville, The Properties of Concrete, Pitman Publishing Limited, London, 1981 AD

-7- Mayer C and the research team on concrete and concrete materials research at the University of Columbia, New York, August 2000

8-Meyer C. "Concrete with Waste Glass Aggregate," Columbia University, 2001

9- 1260-87 ASTM C Standard Test Method for Potential Alkali Reactive Aggregates

(mortar method).

-10- British Standards Institution, BSc 1881 Part (5) 1983, "Method Determine the compressive strength of cubes.

-11- Amir Abdul Rahman Hilal Al-Dulaimi, Saadi Sharouh Sharqi Al-Muhammadi, "Study of glass concrete production and its compressive strength," Iraqi Journal of Civil Engineering, ninth issue. December 2007

-12- Mundar Ali Kerio, Salim Khoso, Jam Shahrib Khan Abdul Aziz Al-Ansari, Nadeem Al-Karim Bahaei, "The effect of waste glass as a partial substitute for cement on the properties of concrete", Engineering Sciences and International Research in Technology Journal, April 2017

-13- Israa Al-Radayra "Recycling glass, saving energy and preserving natural resources" Amman Jordan 2011