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Effect of Adding Recycling Glass on Compressive Strength of Mortar Cement

A research

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By

Bakie Nema Obaid

Supervised by

Asst. Lecture. Rawaa Jabbar Hussein

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بسم الله الرحمن الرحيم

﴿قالوا سبحانك لا علم لنا إلا ما علمتنا إنك
أنت العليم الحكيم﴾

صدق الله العلي العظيم

سورة البقرة – الآية (٣٢)

CERTIFICATION

I certify that this project entitled "**Effect of Adding Recycling Glass on Compressive Strength of Mortar Cement**", was prepared by "**Bakie Nema Obaid**" under my supervision at Babylon University/ College of Materials Engineering/ Department of Ceramic and Building Materials Engineering, in partial fulfillment of the requirements achieve graduate degree in materials engineering.

SUPERVISOR

Signature:

Name : Asst. Lecture.Rawaa Jabbar Hussein

Data: / / 2023

Abstract

There is now a significant world-wide interest to solve the environmental problems caused by industrial waste and other materials by including such materials in the manufacture of concrete. Utilization of waste glass in concrete production not only provides significant environmental benefits but also enhances performance of the concrete when used at optimum amounts.

In this study the compressive strength of mortar containing waste glass as replacement with cement weight at ages (7 and 28) days. in additional the water absorption studied at 28 days. X-Ray diffraction analysis for glass powder used in this study was studied. Four mortar mixtures were prepared in mixing ratios (1:3) with a water (10 %) from weight of (cement and sand together). The percentage of waste glass replacement were (0%, 5%, 10%, 15%) respectively by weight of cement.

The results indicate that the presence of recycling glass with percentage (5%, 10%) improved the compressive strength and decreases water absorption of sample compared with references sample. Also consider as optimum percentage of replacement.

أهداء

ايام مضت من عمرنا بدأناها بخطوة وها نحن اليوم نقطف ثمار مسيرة اعوام كان هدفنا فيها واضحا وكنا نسعى في كل يوم لتحقيقه والوصول اليه مهما كان صعبا وها نحن وصلنا وبيدينا شعلة علم وسنحرص عليها كل الحرص حتى لا تنطفئ.

اهدي هذا الانجاز

الى من كلله الله بالهيبة والوقار.. الى من علمني

العطاء بدون انتظار ..الى من احمل اسمه بكل افتخار

والدي العزيز

الى ملاكي في الحياة ..الى معنى الحب والى معنى

الحنان والتفاني.. الى بسمة الحياة وسر الوجود الى من كان دعائها

سر نجاحي وحنانها بلسم جراحي الى أغلي الحبايب

امي الحبيبة

وايضا اهدي تخرجي إلى من تمنوا لي النجاح والتوفيق أخي وأخواتي الأعزاء

إلى كل من ساندني وإلى كل من تمنى لي الخير والنجاح، عائلتي وأصدقائي وزملائي

والى استاذتي الفاضلة **(رواء جبار)** على مساندتي وارشادي بالنصح

وعلى كل ما قدمه لي من توجيهات ومعلومات قيمه

والذي لم تتأخر بمد يد العون لي في بحثي هذا

شكرا جزيلا لكم جميعا

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CHAPTER ONE

INTRODUCTION

1-1 General

Concrete is the material most used in the construction industry and its mechanical strength depends on the quality and properties of the aggregates, the water–cement ratio and the uniformity of the mixture **[1,2].** The high production of cement generates environmental contamination through carbon dioxide (CO2) emissions. For this, the use of new sustainable materials in the construction sector can contribute to decreasing the CO2 emissions and costs as well as the reuse waste materials **[3].** In order to reduce greenhouse gases emissions, it is necessary to recycle waste materials and conserve the natural resources. The increment in the use of recycled materials with aggregates and cement-based materials can improve the concrete compatibility with the environment **[4,5].** The partial substitution of cement for other sustainable materials may increase the durability of the concrete, reducing the maintenance of structural components **[6].**

Thus, the sustainable concrete can be an important alternative to reuse some waste materials and reduce the problem of waste disposal **[7,8].** Figure (1-1) depicts different recycled materials, organic aggregates and synthetic fibers used in sustainable concrete. The recycled materials include rubber, plastic, glass and industrial waste. The organic aggregates consider the bamboo, coconut fiber and nanocellulose. On the other hand, the synthetic and mineral fibers use steel, glass, carbon and textile fiber and epoxy resins.

Figure (1-1) : depicts different recycled materials

1-2 Advantage of sustainable concrete:

1- It has the same manufacturing steps as regular concrete.
2- It contributes significantly to reducing waste such as fly ash.
3- Reducing carbon dioxide emissions and reducing environmental pollution.
4- It has good resistance to heat and acids and has excellent sound insulation.
5- An excellent solution to the problems of recycling and disposal of the spaces required for the disposal of industrial waste materials.
6- It is considered good for block concrete works because it generates less heat during the hydration reaction.
7- Improved tensile and compressive strength of concrete, depending on the type of recycled materials and additives.

8- Sustainable concrete reduces the consumption of cement and other natural resources.
9- Its production cost is low compared to traditional concrete

1.3 Aim and Objective

1- Determine the effect of waste glass on the properties of mortar mixes as a partial replacement of cement weight with percentage (0,5% ,10%, 15%).

2- Determine the influence of waste glass on hardened properties of mortar mixes represented by: compressive strength, water absorption.

3- Select the optimum percentage of the replacement.

CHAPTER TWO

LITERATURE REVIEW

Sustainable construction practice means creation and responsible management of a healthy built environment considering resource efficiency and ecology (Plessis, 2007) **[9].** The use of supplementary cementious materials (SCMs) to offset a portion of the cement in concrete is a promising method for reducing the environmental impact from the industry. Several industrial by- products have been used successfully as SCMs, including silica fume (SF), ground granulated blast furnace slag (GGBS) and fly ash (Islam et al., 2011; Imbabi et al., 2012**)[10,11].** These materials are used to create blended cements which can improve concrete durability, early and long term strength, workability and economy (Detwiler et al., 1996**)[12].** Another material which has potential as a SCM, however, has not yet achieved the same commercial success is waste glass (Rashed, 2014) **[13].**

Researches indicated that glass has a chemical composition and phase comparable to traditional SCMs (Binici et al., 2007; Nassar and Soroushian, 2012) **[14,15].**

2.1 Using Glass as Recycled Materials

Milling of glass to micro-meter scale particle size, for enhancing the reactions between glass and cement hydrates, can bring major energy, environmental and economic benefits when cement is partially replaced with milled waste glass for production of concrete ,Studies also focused on used of waste glass as aggregate in concrete production (Rashed, 2014)**[13].** Study on durability of concrete with waste glass pointed better performance against chloride permeability in long term but there is concern about alkali-silica reaction. Deleterious chemical constituents include sulfides, sulfates, and alkalis (which add more alkali to concrete) creates higher risk of over the life of the concrete. Waste glass can be used as partial clinker replacement in the production of cement, finely grinded glass can be used for its pozzolanic properties by producing Portland-cement blends, or filler replacement in cement-based materials as fine or coarse aggregate in mortar or concrete [16].

Topçu and Canbaz **[17]** wanted to see the Impact of waste glass on firmness and Workability of the concrete. So they added waste glass In the concrete mix as coarse Aggregates. The results showed that it would lower the cost of the concrete Production but it had no notable effect on the workability nor the firmness.

Kou and Poon **[18]** employed the recycled glass to replacement river sand in Different percentage level (10, 20 and 30), and 10 mm granite in different percentage (5 , 10 and 15 .) They reached that there is a positive relationship between the recycled Glass content and air content, blocking ratio, slump flow of the recycled glass self - Compacting concrete mixes. Plus, there is an Inverse relationship between the waste Glass and the drying shrinkage .

On the other hand, Federico and Chidiac **[19]** considered waste bottle glass an Augmenting cementing material and came to an end that there Is a relation between The pozzolanic ASR and the mote size. Plus, adding lithium can hold ASR Increasing In size .

Caijun and Keren **[20]** had different studies and they concluded that waste glass Cannot be used as concrete aggregates for its bad effect on workability, firmness, and Most importantly the breaking of concrete consisting of waste glass. For the sake of Stopping possible abrasion In concrete, Portland cement should be displaced with Pozzolanic materials like fly ash, meta-kaolin. Waste glass can also be used as crude Materials for the production of the cement .

Palmquist **[21]** made utilization of glass, in pulverized structure, as another kind of Reused material, as an aggregate in mortar. This reused material has been examined In mortar work pieces, and tests on mortar with glass aggregate. At the end, the Compressive strength of the mortar with waste glass Is lower than the mortar with Normal aggregate .

Karamanoğlu and Eren **[22]** focused on the production of mortars containing Various proportions of waste glass and limestone filler. Waste glass and limestone Filler was replaced with cement by weight. The mixes were made by Ordinary Portland cement (PÇ52.5), crushed sand, waste glass and limestone filler. The waste Glass passing 75 µm BS sieve was partially replaced with cement by weight at Percentages of 0, 5, 10, 15, 20, 25, 30 and 40. Also, limestone filler passing 75 µm BS sieve was partially replaced with cement by weight at percentages of 0, 5, 10, 15 20 , 25,30 , and 40 . Degirmenci et al., **[23]** concluded that an increase In viscosity leads to a decrease In resistance on tension and pressure as shown in Figure (2-1) while the study prepared from Vidivelli & Mageswari **[24]** indicated that the water content of the concrete core Is decreasing to be matched by an improvement . In resistance to pressure and stress, in response to an increase in the percentage of viscous fluid in the cell . In the same context, Vidivelli & Mageswari showed the amount of regressive delinquency to increase Figure (2-2) in the specific density of concrete with an Increase in the proportion of viscous mortar used as a substitute for sand

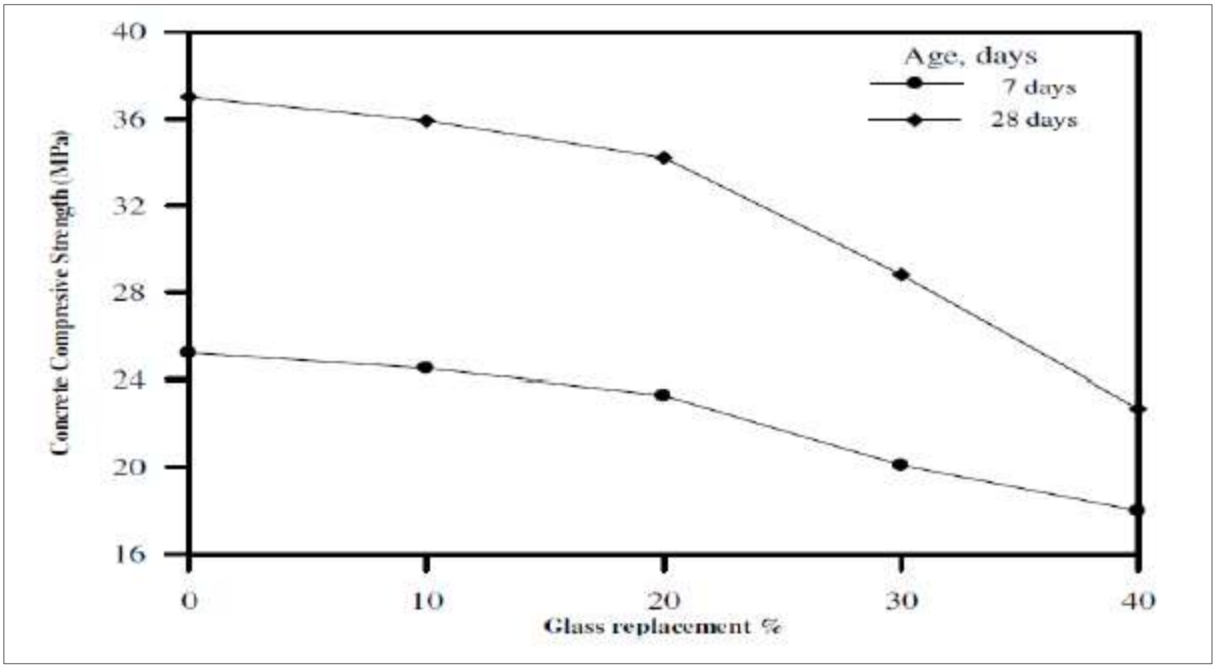


Figure 2-1: The relationship between concrete's pressure resistance and the percentage

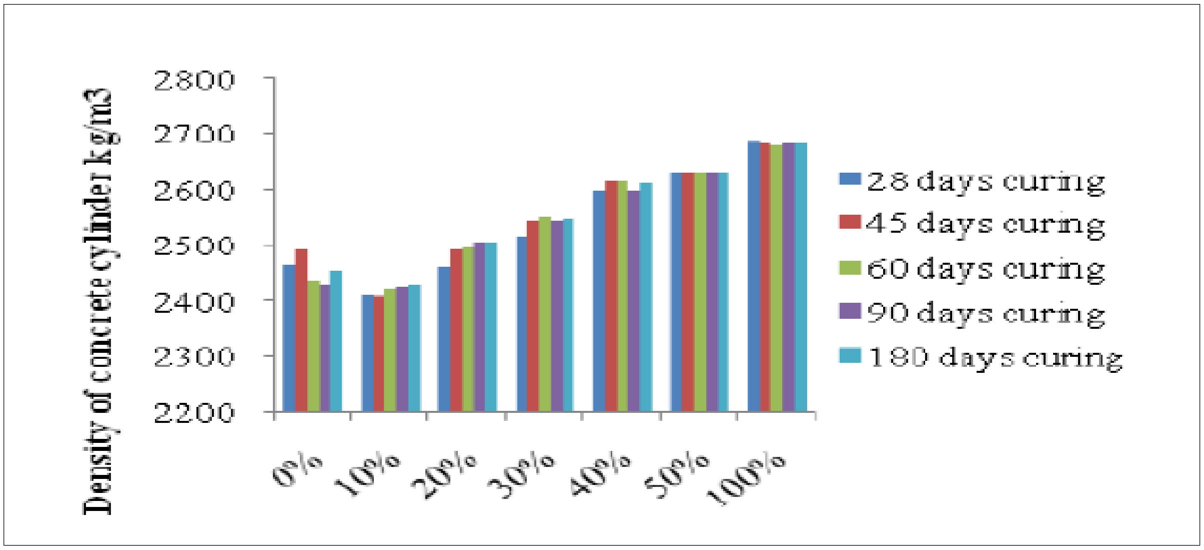


Figure 2-2: The evolution of the specific density with the percentage of glass grinds in the mixture of sand replaced by glass grind.

<u>CHAPTER THREE</u>

EXPERIMENTAL Work

This chapter demonstrates the properties of materials used to make the mortar samples. Also, mixture properties are given together with test methods.

3.1 Materials

3.1.1 Cement

In this research, Ordinary Portland Cement known by **KARASTA** was used. This cement meets the Iraq specification **IQS NO.5-1984** and the international standards **BS EN 197-1:2011 C\\EM II/A-L 42.5 R**. The cement is manufactured in the north of Iraq (Kurdistan region). It must be kept in a dry place in order to prevent exposure to atmospheric conditions.

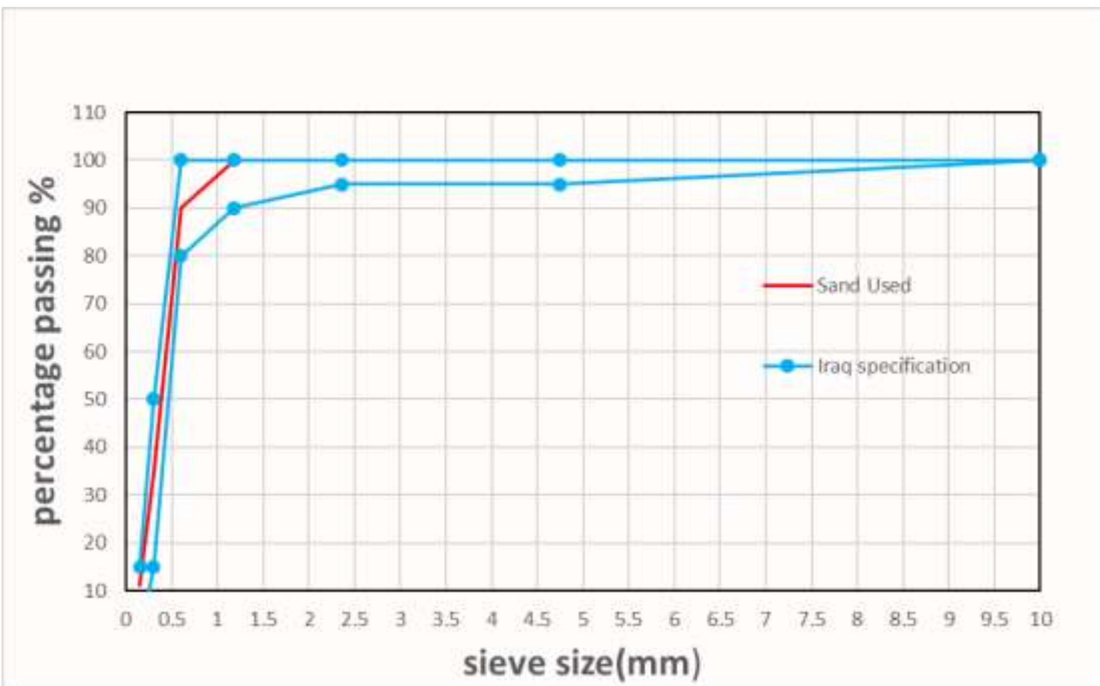
3.1.2 Fine Aggregate (Sand)

Natural sand from (Al-Ekhaider region) was used as fine aggregate. The grading of fine aggregate is shown in Table (3-1) and Figure (3-1). Results of sieve analysis show that fine aggregate grading is agreed with the Iraqi Specification (**IQS No.45, /1984 (Zone 4)**).

Table (3-1): The original fine sand grading compared with the requirements of the Iraqi Specifications No.45/1984.

Size of the Sieve (mm)	Cumulative Passing	Limits of IQS No.45/1984 as in (Zone 4)
10	100	100
4.75	100	95-100
2.36	97	95-100
1.18	93	90-100
0.60	95	80-100
0.30	35	15-50
0.15	11	0-15

Figure (3-1): Grading curves for fine aggregate compared with requirements of



(IQS No.45/1984, Zone 4).

3.1.3 Recycle Glass and Prepared

All of the glasses used for this study were obtained by crushing glass bottles consisting primarily of soft drink bottles (green and white). The initial treatment of the bottles consisted of a hot bath where labels and all other foreign materials were removed, after allowing the bottles to dry, crushed by hammer to get the required size, after that put in loss-angelus machine to get a powder glass. Then use the sieve 200 μm in order to get gradation conforms.

Figure (3-2): Recycle glass powder

3.1.4 X-ray Diffraction (XRD):

first step of the study was to test the products responsible for getting the resistance to compression of different samples of mortars and pastes using X-ray diffraction.

Figure (3-3) shows XRD patterns of the glass powder in the range of 20^{o} to 80^{o} diffracted angle. X-Ray diffraction analysis was performed by using a D2 PHASER 2^{nd} generation diffractometer (XRD).

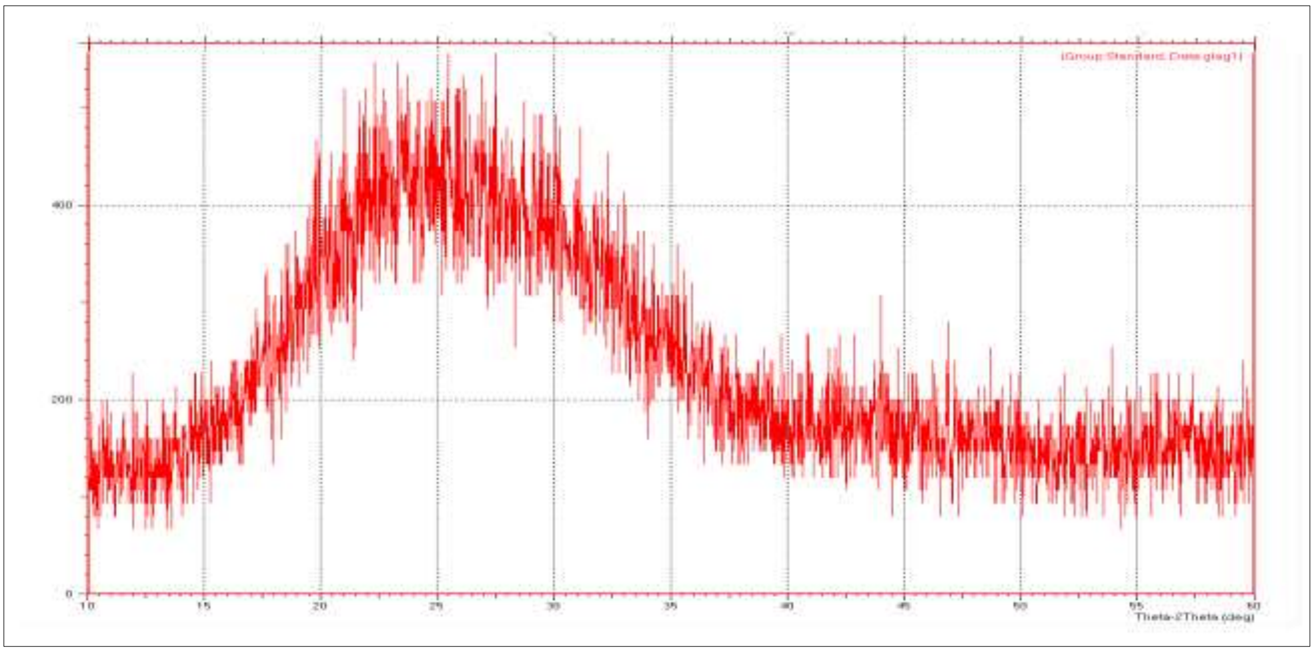


Figure (3-3) : XRD pattern for waste glass powder

It was observed from XRD patterns that glass powder was amorphous, and have a high content of calcium (Ca), silicon (Si), and aluminum (Al) in the powder. In the same of time Ordinary Portland Cement have almost the same content but with different percentages. These results encouraged us to utilize it as a partial replacement of aggregate and study its effect in the field of mechanical and physical properties.

3.1.5 Water of Mixture

In this work, ordinary clean tap water was used for both mixing and curing all the concrete specimens with a temperature should not be lesser than (23±5)ºC.

3.2 Preparation of Mortar Mixtures

Four different mixtures of mortar were prepared with a mixing ratio (1 cement: 3 fine aggregate) with a water (10 %) from weight of (cement and sand together). The raw materials in the four mixtures consisted of the following: -

Table (3-3) : Proportioning of mortar mixes

Name of mixture	Cement Kg	Fine aggregate Kg	Waste glass Kg	Percentage of replacement %
1	600	1800	------	0
2	570	1800	30	5%
3	540	1800	60	10%
4	510	1800	90	15%

The mixtures were blended in a mortar mixer and the mixture components placed in the following order; put the cement and aggregate in bowl and mixed at slow speed for 30 seconds, then the water will be added slowly and mixed for 4 min. After that, casted the sample with vibration for 2 min. Specimens were kept in moulds for one day in the moisture room and after 24 hours, specimens were removed from the moulds and put in water curing tank until testing age (7 and 28 days). Figure (3-4) show the mixer used and figure (3-5) show the moulds used.

Figure (3-4): the mixer used in this work and the vibration.

Figure (3-5): The samples used for this study.

3.3 TESTS:

3.3.1 Compressive strength test

Compressive strength test for the cement mortar cubes for ages of 7,28 days, conforms to the standard **ASTM C109-13**, The average value of compression strength for these cubes was taken to determine the compressive strength to determine the compressive strength. Cubes with dimensions (70×70×70) mm. These cubes were tested at age (7 and 28) days by using a digital hydraulic compression machine with capacity of 1900kN and rate of load 0.3 kN/sec. figure (3-6) show Compressive Test Machine.

Figure (3-6) : Compressive strength test machine and sample.

3.3.2 Absorption ***test:***

The absorption test was carried out according to (**BS1881-122:2011**). It is concerned with determining the percentage of concrete absorption of water so that the sample is dried until its weight is proven in the oven at a temperature of 100 C^0 to 105 C^0, then it cools down and weight (W_d), then the sample is immersed directly in water after an 72 hour and its weight (W_w). Taking care to dry the surface of the sample with a cloth before weighing. The absorption test was calculated by Equation (3-1). Figure (3-7) show the oven used in this test. This test doing at 28 days.

$$\text{Water absorption } (\%) = \frac{W_w - W_d}{W_d} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3\text{-}1)$$

.

Figure (3-7): The oven used in this test.

CHAPTER FOUR

RESULTS AND DISCUSSION

In this chapter, the results are discussed the effect of adding waste glass powder on the properties of cement mortar in hardened state.

4.1 Compressive Strength (fcu):

It is clear from the results of Table (4-1), that samples strength rapidly during the early age (gained 70 % of the compressive strength achieved at 7 days and continues until about 99 % of the compressive strength achieved at 28 days). This is a result of the slow reaction of the calcium-silicate-hydrate (C-S-H), which takes a long period to complete its hydration, up to several months or years, as it has a major role in the development of strength **[25].**

Table (4-1): Test values of cube compressive strengths of NSC samples

Name of mixture	Percentage of waste glass replacement %	Compressive strength (7 days) MPa	Compressive strength (28 days) MPa
1	0	56.5	74.7
2	5%	63.5	84.4
3	10%	60	79.2
4	15%	52.1	69.7

Through Figure (4-1), which shows the relationship between the compressive strength and the percentage of replacement of glass powder %, It is clear that the percentage (5% and 10%) enhanced compressive strength for both ages, which can be due to glass powder's role as a natural pozzolans material in mortar, which improves mechanical and durability properties. **[26]** Glass powder controls Alkali-silica reaction (ASR) by increasing the level of aluminum in the liquid mixture to reduce the dissolution of formless silica from responsive aggregates.**[27]**the amorphous silica in glass powder slowly dissolves under the alkaline environment and reacts to form Ca(OH)2 in the pore solution C-S-H gels **[28].**

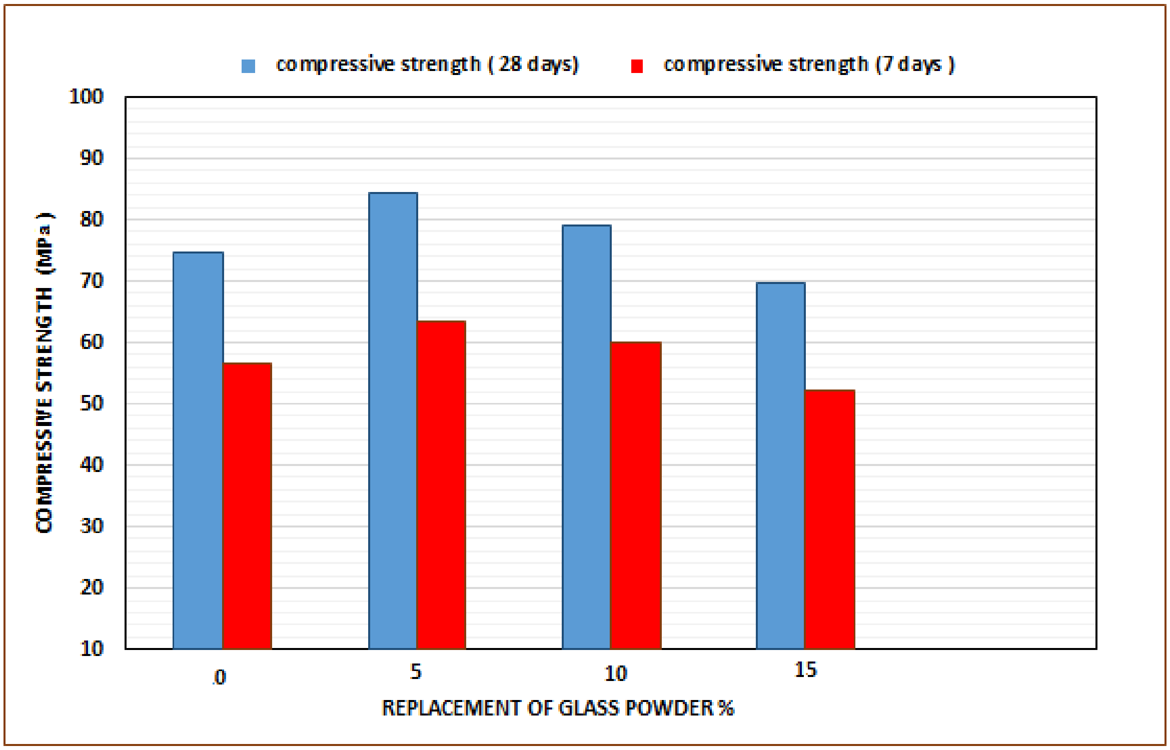


Figure (4-1) : Compressive strength of samples at 7 days and 28 days.

4.2 Water Absorption Test:

The results of water absorption percentage of all mixes at the age of 28 days are presented in Table (4-2). Its observed from the results that the percentage of absorption decreases in mixture with percentage 5% and 10%, while its increases in percentage 15% with compared with standard sample. The reason for this can be attributed to the fact that the small amount of glass powder plays as an impermeable material. This behavior is attributed to the fact that the glass powder might have filled the micro-cracks and the pores in the mortar, which leads to decreased voids being otherwise occupied with water, so it could be assumed that the presence of glass particles in mortar can reduce the permeability of the mortar mixture **[29]**. While with increases percentage at 15% the irregular shapes of the glass granules effect on the surface area of mortar and this produced higher porosity of mortar when glass is at its highest amount **[30].**

Table (4-2): Water absorption results

Name of mixture	Percentage of waste glass replacement %	Water Absorption (28 days)%
1	0	3.8
2	5%	3
3	10%	3.4
4	15%	4.2

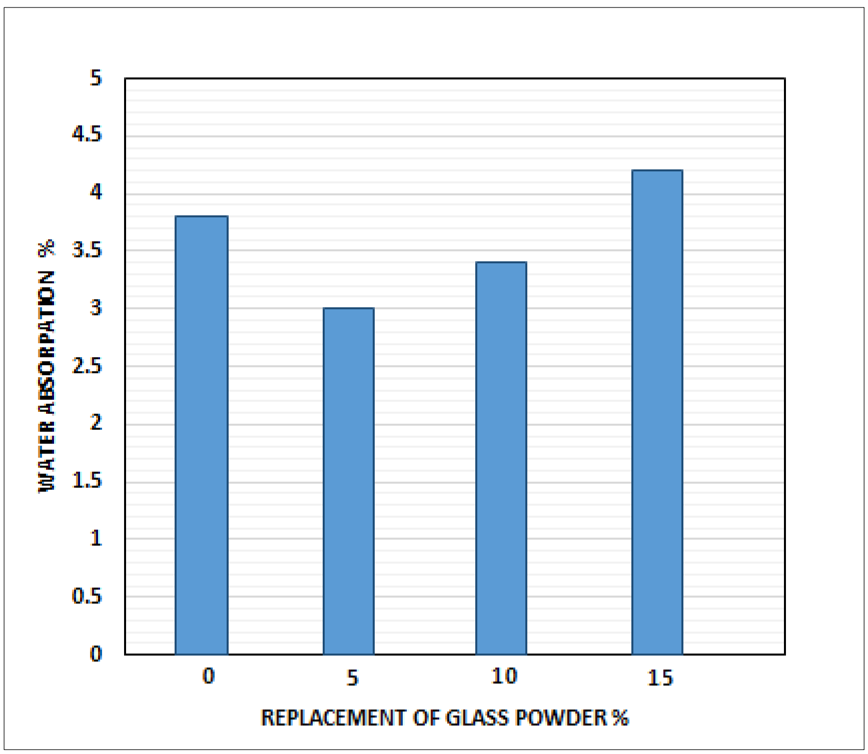


Figure (4-2): Relation between percentage of glass powder and water absorption of samples.

CHAPTER FIVE

CONCLUSIONS

Through this study, the following points can be concluded and summarized:

1. Compressive strength increases with age of concrete.
2. The results showed that it is possible to dispensing on little quantities of cement with waste glass.
3. The compressive strength increases at percentage of replacement (5% and 10%) glass powder. However, decreases in (15%) as compared with references sample.
4. The water absorption decreases in percentage (5% and 10%) and increases with 15% percentage of glass powder replacement.
5. The use of 5% of glass powder as partial replacement of cement by weight in mortar can consider as an optimum value to improve most of the properties of mortar.

References

1. Nagrockienė, D.; Girskas, G.; Skripkiūnas, G. Properties of concrete modified with mineral additives. *Constr. Build. Mater.* **2017**, *135*, 37–42. [**Google Scholar**] [**CrossRef**]

2. Sharma, N.K.; Kumar, P.; Kumar, S.; Thomas, B.S.; Gupta, R.C. Properties of concrete containing polished granite waste as partial substitution of coarse aggregate. *Constr. Build. Mater.* **2017**, *151*, 158–163. [**Google Scholar**] [**CrossRef**]

3. Rashid, K.; Razzaq, A.; Ahmad, M.; Rashid, T.; Tariq, S. Experimental and analytical selection of sustainable recycled concrete with ceramic waste aggregate. *Constr. Build. Mater.* **2017**, *154*, 829–840. [**Google Scholar**] [**CrossRef**]
4. Kubissa, W.; Jaskulski, R.; Reiterman, P.; Supera, M. Ecological high performance concrete. *Procedia Eng.* **2017**, *172*, 595–603. [**Google Scholar**] [**CrossRef**]
5. Torres, A.; Bartlett, L.; Pilgrim, C. Effect of foundry waste on the mechanical properties of Portland Cement Concrete. *Constr. Build. Mater.* **2017**, *135*, 674–681. [**Google Scholar**] [**CrossRef**]
6. Markiv, T.; Sobol, K.; Franus, M.; Franus, W. Mechanical and durability properties of concretes incorporating natural zeolite. *Arch. Civil. Mech. Eng.* **2016**, *16*, 554–562. [**Google Scholar**] [**CrossRef**]
7. Popek, M.; Sadowskia, L. Selected physical properties of concrete modified using mineral Powders. Procedia Eng. 2017, 172, 891–896. [Google Scholar] [CrossRef]

8. Maier, P.L.; Durham, S. Beneficial use of recycled materials in concrete mixtures. Constr. Build. Mater. 2012, 29, 428–437. [Google Scholar] [CrossRef]
9. Plessis, C.D., 2007. A strategic framework for sustainable construction in developing countries. Constr. Manage. Econ. 25 (1), 67–76.
10. Imbabi, M.S., Carrigan, C., McKenna, S., 2012. Trends and developments in green cement and concrete technology. Int. J. Sustain. Built Environ. 1, 194–216.
11. Islam, G.M.S., Islam, M.M., Akter, A., Islam, M.S., 2011. Green construction materials-Bangladesh perspective. In: Proceedings of the International Conference on Mechanical Engineering and Renewable Energy 2011, (ICMERE2011) 22–24 December 2011, Chittagong, Bangladesh (ID-063).
12. Detwiler, R., Bhatty, J.I., Bhattacharja, S., 1996. Supplementary Cementing Materials for Use in Blended Cements. Research and Development Bulletin Rd112t, Portland Cement Association, Skokie, Illinois, USA.
13. Rashed, A.M., 2014. Recycled waste glass as fine aggregate replacement in cementitious materials based on Portland cement. Constr. Build. Mater. 72, 340–357.
14. Binici, H., Aksogan, O., Cagatay, I.H., Tokyay, M., Emsen, E., 2007. The effect of particle size distribution on the properties of blended cements incorporating GGBFS and natural pozzolan (NP). Powder Technol. 177, 140–147.
15. A. A. Aliabdo, A. E.M. Abd Elmoaty, A.Y. Aboshama. Utilization of waste glass powder in the production of cement and concrete. Constr. Build. Mater. 2016; 124: 866-877.
16. Topçu, I. B., & Canbaz, M. (2004). Properties of concrete containing waste glass. Cement and Concrete Research Journal, Vol. 34, pp. 267 – 274.

17. Kou, S. C., & Poon, C. S. (2009). Properties of self-compacting concrete prepared with recycled glass aggregate. Cement and Concrete Composites Journal, Vol. 31, pp. 107 – 113.
18. Federico, L. M., & Chidiac, S. E. (2009). Waste glass as a supplementary cementitious material in concrete-Critical review of treatment methods. Cement & Concrete Composites, Vol. 31, pp. 606–610.
19. Shi, C., & Zheng, K. (2007). A review on the use of waste glasses in the production of cement and concrete. The Journal of Resources, Conservation, and Recycling, Vol. 52, pp. 234–247.
20. Palmquist, S. M. (2003). Compressive behavior of concrete with recycled aggregates (Doctoral dissertation, Tufts University).
21. Karamanoğlu, B. (2007). MS Thesis, Properties of Mortar Containing Waste Glass and Limestone Filler, Gazimağusa, North Cyprus.
22. Degirmenci, N., Yilaz, A., & Cakir, O.A., Utilization of waste glass as sand replecment in cement mortar. Indian J. of Eng. & Materials sciences, Vol. 18, August 2011, pp 303-308, 2011.
23. D. Double, A. Hellawell, and S. Perry, "The hydration of Portland cement," Proceedings of the Royal Society of London. A. Mathematical and Physical Sciences, vol. 359, pp. 435-451, 1978.
24. S. Nahi, N. Leklou, A. Khelidj, M. N. Oudjit, and A. Zenati, "Properties of cement pastes and mortars containing recycled green glass powder," Construction and Building Materials, vol. 262, p. 120875, 2020.
25. D. Double, A. Hellawell, and S. Perry, "The hydration of Portland cement," Proceedings of the Royal Society of London. A. Mathematical and Physical Sciences, vol. 359, pp. 435-451, 1978.

26. S. Nahi, N. Leklou, A. Khelidj, M. N. Oudjit, and A. Zenati, "Properties of cement pastes and mortars containing recycled green glass powder," *Construction and Building Materials*, vol. 262, p. 120875, 2020.

27. Mirzahosseini, M., & Riding, K. A. (2014). Effect of curing temperature and glass type on the pozzolanic reactivity of glass powder. *Cement and Concrete Research*, *58*, 103-111.

28. H. Du and K. H. Tan, "Transport properties of concrete with glass powder as supplementary cementitious material," *ACI Materials Journal*, vol. 112, p. 429, 2015.

29. A. A. Aliabdo, M. Abd Elmoaty, and A. Y. Aboshama, "Utilization of waste glass powder in the production of cement and concrete," Construction and Building Materials, vol. 124, pp. 866-877, 2016.

30. B. S. Shekhawat and D. V. Aggarwal, "Utilisation of waste glass powder in concrete–A Literature Review," International Journal of Innovative Research in Science, Engineering and Technology, vol. 3, 2014.