2nd Conference for Engineering
Sciences and Technology -CEST2 29-31
October 2019 - Sabratha –Libya

Sustainable Cement Mortar Using High-Grinding Glass Waste as an Alternative to Cement

Mohamed ali karim[1], Ahmed Atia Salama[2]
[1]omgaon2x@yahoo.com, [2]ahmednewww@yahoo.com
[1,2]Department of Civil Engineering, Faculty of Engineering, Elmergib University, Libya
[1]omgaon2x@yahoo.com

ABSTRACT

Dependency on Normal Portland Cement in most of concrete and mortar fields; causes the depletion of the raw material resources, and increases the emissions of gases and micro particles from cement factories that increase the issue of current global warming as well as the high consumption of fossil fuel. Moreover, the use of cement represents about 90% of the embodied energy in the concrete industry. Yet, the use of some industrial waste as alternatives to cement is becoming evident in this era. For instance, recently, world glass waste estimated around 130 million tons, where the European Union, China and the United States of America produced 33 million tons, 32 million tons and 20 million tons, respectively. Therefore, this study focuses on reducing the negative effect of glass waste on the environment, maintaining sustainability, and joining the industry of what is known today as green concrete. Thus, this study been used high grinding glass waste (Micro Glass Powder- maximum partial size is 45 micron) as an alternative and as additives to cement for the cement mortar industry. As a result, this study showed a good possibility of using micro glass powder as an alternative and as additives to cement by up to 50%. On the other hand, this alternative and as additives may cause a reduction in the capacity of cement mortar depending on the percentage of micro glass powder to be added, which can be neglected if compared to the quantity of cement that will be saved and the quantity of recycled glass. Achieving the main goal of preserving the environment with economically and sustainable cement industry.

Keywords: Cement Mortar, Embodied Energy, Sustainability, High-Grinding Glass Waste

1. Introduction

Since the late 20th century, the world has begun to recognize the link between economic development and the environment. Where specialists have found that the traditional forms of economic development are limited to the negative use and depletion of natural resources as well as the pollutants and harmful residues as is evident in the phenomenon of high temperature of the atmosphere (Global Warming) because of greenhouse gases generated by different industries. Hence, must apply the concept of sustainable development, which is defined as meeting the

needs of current generations without compromising the ability of future generations to meet their needs [1, 2]. However, sins, the use of cement represents about 90% of the embodied energy in the concrete industry [3], it become one of the priorities of the civil engineer to find alternative sources of cement to reduce this negative impact on the environment. Many researchers around the world use industrial and natural waste in the field of concrete technology to produce what is known as environmentally friendly concrete. Researches have carried out to adjust the process of cement manufacturing in order to reduce carbon dioxide emissions from industries, thereby saving fossil fuels combustion for cement production.

On the other hand, in parallel with the process of manufacturing new types of cement additives, a team of researchers is urging the use of alternative materials that can be used as a partial substitute for cement. These are industrial materials such as recycled industrial fibers in concrete, furnace slag, silica dust as well as glass powder, ashes of rice straw [4]. Yet, the wastes continue to heavily accumulate and pollute the environment. For instance, recently, world glass waste estimated around 130 million tons, where the European Union, China and the United States of America produced 33 million tons, 32 million tons and 20 million tons, respectively [5].

Previous studies conducted on the use of grinded glass as alternative to cement. A study conducted by Vijayakumar- H. Vishaliny that found the use of glass powder at different rates up to 40% as an alternative to cement increases the cement mortar compressive, tensile, and bending strengths [6]. In another study researchers Seri Ganis Kanapathypillay- Gunalaan Vasudevan found that the use of glass powder with different percentages of up to 20% as alternative to cement. This increases the resistance of compression at the ages of 7-14 days and decreases slightly in 28 days, where the density gradually reduced by increasing the proportion of glass powder at different ages [7]. NayemKazi-MH Rahman-M. Sadiqul Islam found that the use of glass powder with different percentages in cement mortar reduces the resistance gradually by increasing the proportion in the ages of 7- 28 - 56 days, but, the use of glass powder by percentages more than 20% increase resistance after 90 days [8]. Nevertheless, these studies shows that there is a discrepancy and a lack of harmony in the results.

From this point came the idea of this research to deepen further and put this matter under study. This study is part of an integrated study that look at the characteristics of high-grinded glass waste (Micro Glass Powder) as cementations' material, because there is no space here to present full study. Therefore, this paper focuses only on two characteristics: the effect of crushed glass on the flow and pressure resistance of cement mortar. As a result, the use of micro glass powder as an

alternative or additive to cement improves mortar properties in terms of flow and strength, which are so important for the concrete industry. On the other hand, the possibility of benefiting from glass waste is a great economic and environmental achievement.

2. Experimental Work

Ordinary Portland cement used in all the mixtures of this study (Cement 42.5 Elmergib Cement Factory, Libya). Fine aggregate natural sand (dune sand) free of impurities and physical properties in accordance with graded sand requirements ASTM (C778). Drinkable water Used for mixing in accordance with the Libyan Standard Specification (1988 / 294LQS).

3. Micro Waste Glass Powder (MGP)

Transparent glass used which cleaned of impurities, crushed, grinded and sifted with a 45-micron sieve as shown in Fig. 1.

(a) (b) (c)

Figure 1. Micro Waste Glass Powder: (a) initially, glass cracking; (b) glass in the milling machine; (c) glass powder sifted with a 45with sieve

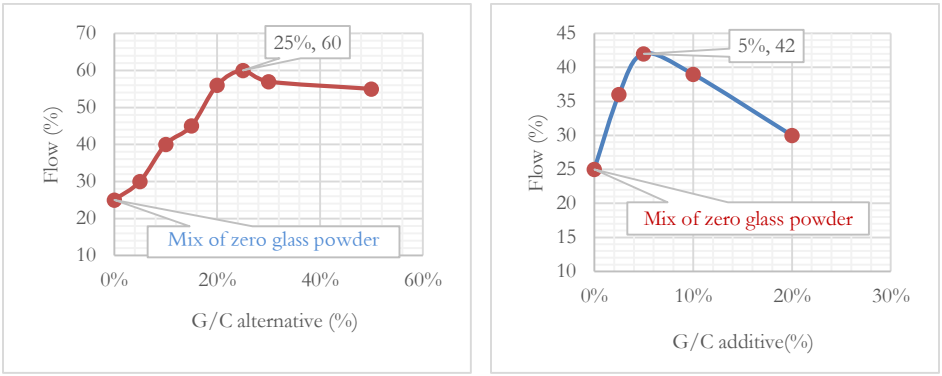
4. Cement Mortar Mixtures:

Several mixtures of cement mortar containing different percentages (by cement weight) of glass powder as alternatives (G/C alternative) of cement (5, 10, 15,20,25,30, and 50). Other mixtures were prepared with different percentages (by cement weight) as additives (G/C additive) to cement (2.5, 5, 10, and 20), where water cement ratio is constant for all mixtures (W / c = 0.5). The cement to fine sand ratio was according to ASTM (C109-02). Then cement mortar flow test conducted according to ASTM (C230/ C230M-98) .Also, 50x50x50 mm cubes used in accordance with ASTM (C109/C 109M-02) for compressive strength test.

5. Results and Discussion

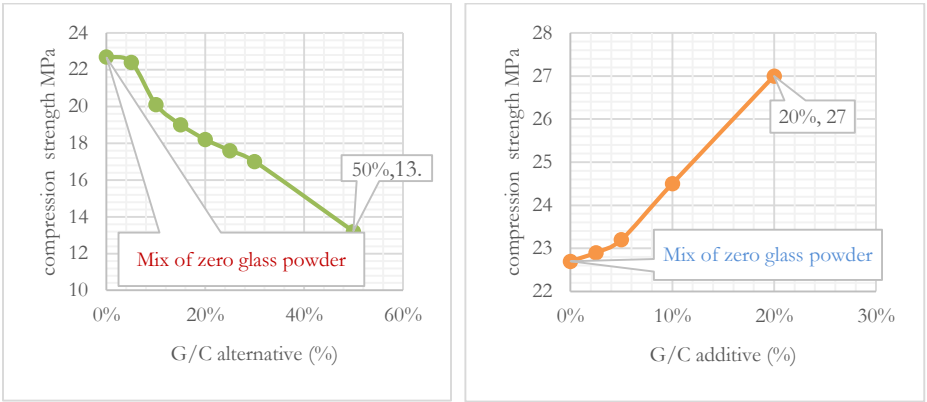
Figure 2-(a) shows the flow results of the cement mortar in relation to the increase in the proportion of micro glass powder as an alternative. While Figure 2-(b) is the

result of flow in case of micro glass powder as an additive. These figures are also shows the flow of the reference mix that contains 0% micro glass powder. The use of glass powder as a replacement of cement increases the flow of mortar compared with the reference mixture. Moreover, by comparing the substitution ratios, the best ratio achieved the highest flow of 25 %(see figure 2-a). on the other hand, the use of glass powder as an additive to cement , it also increases the overall flow compared to the reference mixture and the best ratio achieved the highest flow is 5%, and then decrease the flow rate gradually (see figure 2-b). The reason might be that the fineness of micro glass powder lad to absorb mixing water, which led to decrease the flow rate. A set of three cubes were tasted in each case and the average value of these three was reported. For booth, cases of using MGP, samples were tested for compressive strength at 28 days (see Figure 3).



(a) (b)

Figure 2. Results of cement mortar flow test: (a) MGP as alternative; (b) MGP as additive



(a) (b)

Figure 3. Results of cement mortar compression-strength test: (a) MGP as alternative; (b) MGP as additive

As a result, the use of the micro glass powder as alternative or additive increases the mortar flow within certain limits. On the other hand, the compressive strength gradually reduced in the case of using MGP as alternative, whilst the opposite occurs in the case of using MGP as additive. This is a good indicator behavior in the field of concrete, where this situation is required in the cases of self-compacted concrete as well as in the case of good/high workability concrete needed. Moreover, this decrease in strength are treatable with special additives or sometimes neglected in some construction cases such as finishing work, partition, and floor finishing.

Where in Libya State Normal Portland Cement about 40% use in buildings for partition walls, tiles and plaster works, while the remainder is for the work of reinforced concrete. Therefore, as example, the cement factory of Zeitain produces about 9 million tons of cement annually. Therefore, 3.6 million tons (40%×9=3.9) are used for cement mortar work. If use high-grinding Glass waste as a replacement of cement up to 30%, this will save 1.08 million tons per annum of cement, in addition to save raw materials and energy for the manufacture of cement (sources of materials, fossil fuels, and embodied energy…etc.).

5. Conclusions

Through the results obtained, it conclude that the use of micro glass powder as an alternative of cement increases the flow of mortar and slightly (at low present of replacement) reduces compressive strength. The use of micro glass powder as an additive to cement increases the flow of mortar compared to the reference mixture and increases the compressive strength gradually, where by adding 20% of the cement weight, the strength increased to 18.9%. The use of micro glass powder as an alternative of cement achieved better results to increase the flow of the used as an additive, where highest flow percent 140% achieved by replacing 25% of the cement weight. The use of micro glass powder as alternative of the cement by 30% might save more than one million tons per year in one plant. In addition to save, the natural sources of materials and embodied energy needed for structural industry. This is a great achievement on the economic and environmental levels, which is the main objective of applying the principle of sustainability. Where the economic and environmental stabilizing of the current generations with the conservation of resources for future generations.

References

[1] K. Yeang, "The Green Skyscraper,". *Prestel*, Munich, 1999

[2] R. William, "*The Integrative design guide to green building*," *Hoboken*, N.J, 2009

[3] A. Erin, L. Lionel, "Concrete's contribution to sustainable development," *The Journal of Green Building* 1552-6100, 2008

[4] M.Dirk, G.Jennifer, L.Emily, "Sustainability Guidelines for the Structural Engineer," *American Society of Civil*

Engineers, US, 2010

[5] G. M. Sadiqul, M. H. Rahman, K. Nayem, "Waste glass powder as partial replacement of cement for sustainable concrete practice," *International Journal of Sustainable Built Environment*, *Elsevier*, 37–44, 6 2017.

[6] G.Vijayakumar, H. Vishaliny, D. Govindarajulu, "Studies on glass powder as partial replacement of cement in concrete production." *International Journal of Emerging Technology and Advanced Engineering*, 2013

[7] Vasudevan, Gunalaan, G. Seri, "Performance of using waste glass powder in concrete as replacement of cement," *American journal of engineering research*, 2013

[8] Islam, G. Sadiqul, M. Rahman, K. Nayem, "Waste glass powder as partial replacement of cement for sustainable concrete practice," *International Journal of Sustainable Built Environment*, 2016