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A Study of Mechanical and Microstructures Properties of Autoclaved Aerated Concrete Containing Nano-Graphene

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ABSTRACT: In recent years, autoclaved aerated concrete (AAC) has been widely used in the building construction industry, especially for the construction of infill walls. However, the AAC suffers from several drawbacks such as low compressive and tensile strength, high water absorption as well as insufficient resistance against impacts. To address such issues, this study evaluates the mechanical properties of the AAC blocks in which, the cement has been replaced with nano-graphene. For this purpose, various replacement ratios (0.2, 0.4, and 0.8) were selected and different tests such as compressive and tensile strength (cylindrical specimens with the size of 10×20cm), impact resistance and water absorption (cubic specimens), scanning electron microscope (SEM) and X-ray diffraction (XRD) were carried out. Promisingly, the results indicate that incorporation of the nano-graphene improves the compressive and tensile strength as well as the impact resistance by 45, 81, and 130% compared to the control specimen. Moreover, the water absorption of the specimens was reduced up to 61%. Based on the SEM results, the inclusion of the NG in the AAC, makes the grains stick together firmly and also, downsizes the grains by 30%.

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1- Introduction

Gypsum plaster can be considered an environmentally friendly material and has low energy consumption for production. The slaughter temperature for gypsum plaster is in the temperature range of 125 to 180 degrees Celsius. At this temperature, water vapor disappears and carbon dioxide is released from the material due to the heat of the furnace [11]. During the production and use of gypsum plaster in urban construction, a large amount of gypsum plaster waste (GPW) is produced. GPW is an inactive substance that has the potential to contaminate groundwater. Under anaerobic conditions, the sulfate in the landfill, which causes a bad odor for staff and residents around these neighborhoods and also rusts the pipes, can be converted to hydrogen sulfide (H2S) [12-15]. GPW can be reused or recycled because it has the same function compared to the original gypsum plaster [16, 17]. Killing GPW requires little Word energy. Suarez et al. Showed that the energy used for the gypsum recycling process is 65% less than that used to obtain natural gypsum [18].

2- Methodology

In this research, commercial gypsum plaster (CGP), recycled gypsum plaster (RGP), RC, PW and water from the municipal water supply system were used. RC used in this research is a combination of red body ceramic tile waste. This substance was used without any changes. PW was supplied from the waste of porcelain factories. This material was crushed and ground to obtain a soft powder, then sieved until 95% of it passed through a 45 µm sieve, and finally a homogeneous powder was obtained. CGP was used without any changes. RGP, produced by local construction companies, was collected and dried in the sun to remove moisture, then crushed by hand with a mortar. The material was then milled by a hammer mill and formed into particles less than 3 microns in size. The resulting powder was calcined (killed) in a dryer at constant temperature (150 °C) for 1 hour.

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Table 1. Mix Design of the AAC Blocks (kg/m3)

	Aluminum Powder	Plaster	Lime	Silica	Water	Cement	Nano Graphene
REF.	0.350	0.260	100	300	250	120	0
GP-0.2	0.350	0.260	100	300	250	119.76	0.24
GP-0.4	0.350	0.260	100	300	250	119.52	0.48
GP-0.8	0.350	0.260	100	300	250	119.04	0.96

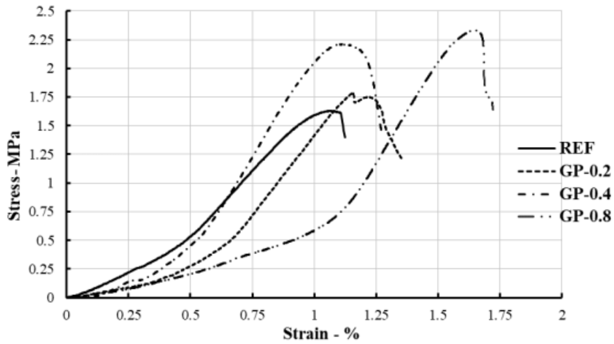

Fig. 1. Stress-Strain Curve of the Specimens

Table 2. The values obtained from Stress-Strain Curve

	Modulus of elasticity (MPa/mm)	Energy Dissipation (N/mm)	Length reduction (%)
REF.	19.1	2.11	1.13
GP-0.2	6.37	2.61	1.35
GP-0.4	1.59	2.92	1.27
GP-0.8	0.54	2.98	1.72

3- Results and Discussion

3- 1- Setting time

The results show that RC and PW delayed setting time. These results are consistent with the results obtained by Khalil et al. Longer setting times occur in samples with RC or PW because these mixtures have a small amount of viscous substance that can react with water, resulting in slower reaction progress. The results show that the effect of increasing lesions on CGP uptake is greater than RGP. In both types of gypsum, RC increases the setting time at a higher rate than PW. In all mixtures, the sensitivity of this effect to the initial setting time was higher than the final setting time. The final setting time of mixtures with recycled gypsum plaster and waste (RGP RC and RGP PW) was very close to the final setting time of mixtures made with only recycled gypsum plaster (RGP).

3- 2- Mechanical properties

Compressive strength results show that CGP had the highest results in terms of compressive and flexural strength at all times. The mechanical coordinates of CGP were higher than RGP, which Bardella and Camarini observed in molds without any loading pressure. The addition of compressive strength lesions reduces CGP samples [17]. At 28 days, CGP RC and CGP PW compressive strength decreased by 52.2% and 58.3% compared to CGP, respectively. The results were consistent with the results of Ayres et al. And San Antonio Gonzalez et al., Who reported that the strength of gypsum plaster composition decreases with the addition of waste [5]. The results showed that adding lesions to RGP did not cause a significant change in compressive strength. The 28-day compressive strength was between 12 MPa and 35 MPa. The compressive strength results of RGP RC in 28 days were slightly higher than the results obtained by Sen Antonio Gonzalez et al. [5] from gypsum composites containing RC and also higher than commercial gypsum plaster (CGP).

3- 3- Absorption of the total water and its disposal

The results of total water uptake and desorption at 28 days showed that CGP samples molded by pressing pressure had lower water uptake and desorption before initial setting compared to CGP, which was made without any pressing pressure.

4- Conclusion

In this research, gypsum mixtures (commercial and recycled) using industrial waste (RC red ceramic and PW porcelain waste) to produce building components were investigated. Mixtures with 50% by weight of adhesive and 50% by weight of waste with water / solid mass ratio were considered 0.22. Prior to setting, uniaxial loading pressure was used to mold the components. Compacted mixtures had better mechanical performance and less porosity compared to conventional gypsum. Microstructural analysis showed high correlation between gypsum crystals. The addition of waste resulted in longer clotting time. In commercial gypsum plaster samples, the addition of waste resulted in less compressive strength, although when recycled gypsum plaster was used, the reference samples showed similar results to the samples made from the waste. The 28-day compressive strength was between 12 MPa and 35 MPa, which provides a favorable outlook for waste recycling. The results show that it is technically possible to produce an environmentally friendly material with good mechanical performance in which recycled gypsum plaster and waste are used. The production of gypsum-based construction components using uniaxial molding loading pressure prior to the initial setting can be an environmentally friendly option for large amounts of gypsum plaster, RC and PW waste.

References

[1] M. Santandrea, I. Imohamed, H. Jahangir, C. Carloni, C. Mazzotti, S. De Miranda, F. Ubertini, P. Casadei, An investigation of the debonding mechanism in steel FRP- and FRCM-concrete joints, in: 4th Workshop on the new boundaries of structural concrete, 2016, pp. 289-298.

[2] H. Jahangir, M.R. Esfahani, Investigating loading rate and fibre densities influence on SRG-concrete bond behaviour, Steel and Composite Structures, 34(6) (2020) 877-889.

[3] H. Jahangir, M.R. Esfahani, Experimental analysis on tensile strengthening properties of steel and glass fiber reinforced inorganic matrix composites, Scientia Iranica, 28(3) (2021) 1152-1166.

[4] H. Jahangir, M.R. Esfahani, Strain of newly–developed composites relationship in flexural tests, Journal of Structural and Construction Engineering, 5(Special Issue 3) (2018) 92-107

[5] M. Bagheri, A. Chahkandi, H. Jahangir, Seismic reliability analysis of RC frames rehabilitated by glass fiber-reinforced polymers, International Journal of Civil Engineering, 17(11) (2019) 1785-1797.

[6] H. Jahangir, D.R. Eidgahee, A new and robust hybrid artificial bee colony algorithm–ANN model for FRP-concrete bond strength evaluation, Composite Structures, 257 (2021) 113160.

[7] R.H. Geraldo, S.M. Pinheiro, J.S. Silva, H.M. Andrade, J. Dweck, J.P. Gonçalves, G. Camarini, Gypsum plaster waste recycling: A potential environmental and industrial solution, Journal of Cleaner Production, 164 (2017) 288-300.

[8] J. Rivero, R. Sathre, J.G. Navarro, Life cycle energy and material flow implications of gypsum plasterboard recycling in the European Union, Resources, Conservation and Recycling, 108 (2016) 171-181.

[9] C. Leiva, C.G. Arenas, L. Vilches, J. Vale, A. Gimenez, J. Ballesteros, C. Fernández-Pereira, Use of FGD gypsum in fire resistant panels, Waste Management, 30(6) (2010) 1123-1129.

[10] M. Singh, M. Garg, Activation of fluorogypsum for building materials, (2009).

[11] [11] M. Arikan, K. Sobolev, The optimization of a gypsum-based composite material, Cement and Concrete Research, 32(11) (2002) 1725-1728.

[12] L.M. Baltar, C.A.M. Baltar, M. Benachour, Effect of carboxymethylcellulose on gypsum re-hydration process, International Journal of Mineral Processing, 125 (2013) 5-9.

[13] N. Singh, B. Middendorf, Calcium sulphate hemihydrate hydration leading to gypsum crystallization, Progress in crystal growth and characterization of materials, 53(1) (2007) 57-77.

[14] A. Vimmrova, M. Keppert, O. Michalko, R. Černý, Calcined gypsum–lime–metakaolin binders: Design of optimal composition, Cement and Concrete Composites, 52 (2014) 91-96.

[15] K. Condeixa, E. Qualharini, D. Boer, A. Haddad, An inquiry into the life cycle of systems of inner walls: Comparison of masonry and drywall, Sustainability, 7(6) (2015) 7904-7925.

[16] P. Kijjanapanich, A.P. Annachhatre, G. Esposito, E.D. van Hullebusch, P.N. Lens, Biological sulfate removal from gypsum contaminated construction and demolition debris, Journal of environmental management, 131 (2013) 82-91.

[17] P.S. Bardella, G. Camarini, Recycled plaster: physical and mechanical properties, in: Advanced Materials Research, Trans Tech Publ, 2012, pp. 1307-1310.

[18] S. Suarez, X. Roca, S. Gasso, Product-specific life cycle assessment of recycled gypsum as a replacement for natural gypsum in ordinary Portland cement: application to the Spanish context, Journal of Cleaner Production, 117 (2016) 150-159.

[19] G. Camarini, K.D. dos Santos Lima, S.M. Pinheiro, Investigation on gypsum plaster waste recycling: An eco-friendly material, Green Materials, 3(4) (2016) 104-112.

[20] L. Reig, M. Tashima, L. Soriano, M. Borrachero, J. Monzó, J. Payá, Alkaline activation of ceramic waste materials, Waste and Biomass Valorization, 4(4) (2013) 729-736.

[21] Y. Abadou, R. Mitiche-Kettab, A. Ghrieb, Ceramic waste influence on dune sand mortar performance, Construction and Building Materials, 125 (2016) 703-713.

[22] M.S. Khan, M. Sohail, N.S. Khattak, M. Sayed, Industrial ceramic waste in Pakistan, valuable material for possible applications, Journal of Cleaner Production, 139 (2016) 1520-1528.

[23] E. GARCIA, M. CABRAL JUNIOR, V. Quarcioni, F.F. Chotoli, Resíduo de cerâmica vermelha (RCV): uma alternativa como material pozolânico, Cerâmica Industrial, 19(4) (2014) 31-38.

[24] V.A. Mantovani, C.S. Franco, S.D. Mancini, H.L. Haseagawa, B.F. Gianelli, V.X. Batista, L.L. Rodrigues, Comparison of polymers and ceramics in new and discarded electrical insulators: reuse and recycling possibilities, Matéria (Rio de Janeiro), 18 (2013) 1549-1562.

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